Geology and Religion

A History of Harmony and Hostility

Edited by

M. Kölbl-Ebert

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Contents

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Geology and Religion: A History of Harmony and Hostility

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For thousands of years, religious ideas have shaped the thoughts and actions of human beings. Many of the early geological concepts were initially developed within this context. The long-standing relationship between geology and religious thought, which has been sometimes indifferent, sometimes fruitful and sometimes full of conflict, is discussed from a historical point of view. This relationship continues into the present. Although Christian fundamentalists attack evolution and related palaeontological findings as well as the geological evidence for the age of the Earth, mainstream theologians strive for a fruitful dialogue between science and religion. Much of what is written and discussed today can only be understood within the historical perspective.

This book considers the development of geology from mythological approaches towards the European Enlightenment, biblical or geological Flood and the age of the Earth, geology within ‘religious’ organizations, biographical case studies of geological clerics and religious geologists, religion and evolution, and historical aspects of creationism and its motives.

Geology and religion: a historical perspective on current problems

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Today, when referring to the relationship between geology and religion, people usually think immediately of Christian (and other) fundamentalists and their chronic palaeontological illiteracy leading to creationism, to intelligent design, and to a distrust of science in general and especially geology, palaeontology and evolutionary biology.[1] Thus the relationship of geology and religion is usually considered to be under strain. However, outside this very specific field of conflict, there does not seem to be a relationship at all. Among geologists, as well as among other scientists, it is not customary to talk about one's faith, and so it is hard to tell whether a colleague is practising a religious faith or at least adhering to it in private, or whether he or she wishes to be counted among atheists or agnostics. Such knowledge does not seem to be relevant to our joint scientific efforts. Geology as well as other sciences operates from a methodological naturalism, regardless of whether one is an atheist, theist, or something else. Centuries of observation, collection and experiment have taught us to trust these methods. We no longer expect disruptive miracles to upset the chain of natural causes and consequences. This is not because of any system of belief or disbelief, it is simply from experience, and we certainly have come a long way on this basis.

From mythological approaches to independent geological expertise

In former times, things used to be very different, and for most of human history the observation of geological phenomena and the acquisition of geological expertise was intimately connected with religious ideas. Earthquakes and volcanoes, towering mountains and conspicuous rock formations, fossils and ore veins were regarded either as due to direct divine action and intervention or as manifestations of the divine itself (**Mazadiego *et al.***; **Barbaro**). It was God (or Gods), who had created the Earth as 'home' for humans, providing the necessary resources (animals and plants, but also water, rocks and metals), or who might be suspected to exert punishment on sinners by means of natural disasters (Kölbl-Ebert 2005; **Udías** on earthquakes).

Although accepting flint and pyrite in prehistoric time, or later copper and other ores, to be gifts of divine providence (**Norris**) is some sort of explanation for their existence, that assumption was clearly not sufficient to enable adequate strategies for the search for new deposits to be devised. Observational skills and arrangement of observations according to rules and guidelines (involving the formulation of theories) were required, and eventually such knowledge was accumulated and became part of the craft knowledge of miners.

Also, from an intellectual point of view, invoking divine action as a general and all-fitting explanation of phenomena was unsatisfying for an intellectual, and even for the devout theist who would like to know how God 'did it'. After all, curiosity is a decidedly human trait. For this more theoretical part of 'geological expertise', the late Medieval and Renaissance intellectual world turned to the remnants of much older knowledge, that of the antiquity, which apparently had been a golden, better and much more knowledgeable age, judging from the ruins that were still around. Why not trust the explanatory power and authority of ancient texts (including the Bible) that had been produced by these obviously advanced civilizations?

This intimate link between early geo-theory and Christian philosophy proved to be very fruitful for some time, because the Christian tradition of visualizing the history of humans on Earth from the creation, via global revolutions such as the biblical Flood up to historical times (Rudwick 1992; **Magruder**) and the Judaeo-Christian sense of a finite Earth history (**Rudwick**; see also Rudwick 2005) prepared the ground for accepting the Earth's different strata as testimony to the development of our globe through time. It was this religious, theological framework from which the early geology started to evolve, and that provided the tools used in popularization of the new science of the seventeenth century. It is understandable why, for example, geological phenomena such as erratic blocks and other debris covering much of Europe were initially seen as a consequence of events mentioned in the Bible and other ancient texts. However, with increasing observations there was a growing mismatch between what was expected according to ancient

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authorities (**Godard**; **Luzzini**) and the actual data. This was not necessarily a problem, since influential theologians, such as Augustine of Hippo (AD 354–430) or the medieval theological scholar Thomas Aquinas (1225–1274), knew that biblical texts needed to be interpreted and that adopting a naive literal reading might do more harm than good to the Christian faith:

> In discussing questions of this kind two rules are to be observed, as Augustine teaches. The first is, to hold to the truth of Scripture without wavering. The second is that since Holy Scripture can be explained in a multiplicity of senses, one should adhere to a particular explanation only in such measure as to be ready to abandon it if it be proved with certainty to be false,[2] lest Holy Scripture be exposed to the ridicule of unbelievers, and obstacles be placed to their believing (Aquinas 1273, 1st part, question 68).

Subsequently, attempts to reconcile the growing timescale of geology with biblical chronology became widespread in the eighteenth and nineteenth centuries. The most popular, apart from more metaphorical interpretations of the biblical creation stories, were possibly the 'gap theory' (or 'chaos/restitution theory'[3]), claiming an indefinitely long time span between Genesis 1: 1–2 or 2–3 and the 'day–age theory' (or concordance theory), which interpreted the days of biblical creation as seven long eras, which might be equated with different geological formations (see **Roberts**, on Sedgwick).[4]

Geology and religion drifting apart

The release of geology from religious connotations or associations was a development closely connected with the Enlightenment, when geology and religion started to drift apart not with a violent rupture but in a subtle and sometimes circuitous manner. The Enlightenment was not about science versus religion, nor just about reason against superstition, as some of us may have learned at school. Enlightenment was much more about emancipation from the unquestioned, antique authorities, trusting your senses and your own reasoning, and regarding problems (including social, political, and psychological) as being solvable by natural means and the application of reason. Not only did science, medicine and technology prosper through the Enlightenment but philosophy and theology also developed new methods (Sheehan 2005; **Ostermann**), employing other academic disciplines such as linguistic studies, philology, history, archaeology, and even science. The scholarly skills and methods that theology acquired in turn inspired geology through the numerous geological clerics who shaped early geology around the beginning of the nineteenth century (**Rudwick**; **Roberts** on Sedgwick), especially where the age of the Earth and the nature of the supposed relics of the geological 'deluge' were discussed. From case studies such as those by **Luzzini**, **Pinto & Amador**, **Schweizer**, **Lewis** and **Taquet**, it can be seen how the geological features (which were later reinterpreted as traces of an Ice Age) were:

> eventually recognized as having been far earlier in Earth history than any event recorded by literate human societies. Among geologists, although not always among the wider public, this gradual dissociation between biblical Flood and geological deluge was generally amicable, not acrimonious. It was facilitated by the concurrent development of biblical scholarship, which showed that earlier literalistic interpretations were no longer tenable (and were also destructive of religious meaning). What was transposed into geology in the course of these debates was the strong Judaeo-Christian sense that the world has had a directional and contingent history, which might have been punctuated by occasional catastrophic events (**Rudwick**).

However, outside the group of people with geological expertise, not all was smooth and peaceful, and some conservative clergymen as well as laypersons were shocked by the new ideas that came with geology: the immensity of the timescale, a dynamic Earth, not just a ruin shaped by the Deluge, and a dynamic biology along with the Darwinian theory of evolution, which was founded in part on palaeontological evidence and the assumption of a long geological timescale.

Two such skirmishes make an especially good story, and therefore are often retold. Dean Cockburn of York (1774–1858) took the opportunity of the 1844 meeting of the British Association for the Advancement of Science (BAAS) in York to attack William Buckland (1784–1856) and Adam Sedgwick (1785–1873) (see **Roberts**), two influential clerical geologists, who were not orthodox enough for his taste. However, they were not the only people Cockburn publicly abused. The science writer and mathematician Mary Somerville (1780–1872), for example, wrote in her autobiography:

> Geologists had excited public attention, and had shocked the clergy and the more scrupulous of the laity by proving beyond a doubt that the formation of the globe extended through enormous periods of time. The contest was even more keen then than it is at the present time about the various races of pre-historic men. It lasted very long, too; for after I had published my work on Physical Geography [in 1848], I was preached against by name in York Cathedral. Our friend, Dr. Buckland, committed himself by taking the clerical view in his "Bridgewater Treatise"; [Buckland 1836] but facts are such stubborn things, that he was obliged to join the geologists at last (Somerville 1873, p. 129).

Even more notorious was the debate between the Bishop of Oxford, Samuel Wilberforce (1805–1873) and Thomas Henry Huxley (1825–1895) on evolution and Charles Darwin's (1809–1882) new book *On the Origin of Species* (Darwin 1859) at the BAAS meeting in Oxford in 1860. Closer inspection of the case, however, makes clear that this piece of history was not about simple 'war' between science and religion, as such, but that clerics were present on both sides (James 2005), and that the dissociation involved just as much an 'internal' theological debate about how to interpret the Bible as a battle between science and religion. Although the wealthy and independent British gentlemen geologists of that time had little to fear from such skirmishes, things were much more difficult for those early professional geologists who happened to be dependent on religious authorities. For example, the botanist and geologist James Buckman (1814–1884) lost his job, a professorship at the Royal Agricultural College in Cirencester, because he provided evidence for the variability of plants and was cited favourably by Darwin. His boss, a theologian, obviously was not pleased with the promulgation of such ideas at his college (**Torrens**).

Such are the dangers wherever science is not independent but is conducted under the 'umbrella' of an institution that sets other priorities.[5] Then conflicting loyalties may lead either to corruption of science or to censorship, as in the Buckman case, although this is not inevitable. Some hundred years of seismological research by Jesuits, for example, have yielded considerable scientific fruit, acknowledged widely by the scientific community, without any obvious problems between the scientific and spiritual life of the people involved (**Udías**).

Many religious centres of learning used to teach not only theology and philosophy to their students but also science. For example, the (Roman Catholic) Bishop's Seminary in Eichstätt (Germany), which hosted the 2007 INHIGEO meeting, was re-established in 1843 after the turmoil of secularization. In 1844, among the first things done by the seminary was the purchase of a scientific collection to be used as a teaching aid, as the theology students were required to study not only all the relevant theological subjects but also philosophy, history of philosophy, psychology, history, physics, chemistry, natural history (including biology, anthropology, geology and mineralogy) and pedagogy. The lectures were given by men who were priests as well as scientists (see, e.g. **Viohl**). The motivation for this was basically a continuation of the older idea of natural theology (see, e.g. **Bork**): studying God not only in the Bible but also in the 'book of nature'; and also to simply stay 'up to date'.

Although teaching of natural history at Eichstätt was discontinued in the late 1960s, the Seminary still hosts a splendid palaeontological collection of fossils from the Solnhofen Limestone (accessible to and frequently visited by various fossil specialists), and it co-finances the Jura-Museum Eichstätt, which has among its holdings the famous Eichstätt specimen of *Archaeopteryx* on display in an exhibition on bird evolution, a specimen that belongs to the Seminary and thus to the Church.

From such basic openness towards science, and especially geology, we may gather that historical conflicts have often originated not necessarily from theological or scientific reasons alone, but have at times been enhanced by personal antipathies or peculiarities. So it is valuable for a historian of science to investigate the biographies of geologists in all their depth, highlighting not only scientific achievements but considering also the spiritual life of the protagonists (**Roberts** on Sedgwick, **Branagan**, **Mayer**, **Viohl**, **Seibold & Seibold** and **Turner**).

Creationism

Considering the somewhat strained relationship between geology and a certain variety of religion that currently exists, we might ask why and when such conflicts originated, because the creationism we face today is a fairly recent phenomenon (see **Roberts**, both papers). Historically, conflict between geology (or science in general) and religion has often developed from questions about power and (church) politics. It was in times of crisis that religious authorities tended to react with suspicion to any kind of science that seemed to undermine their influence and to collide with traditional teachings. This is particularly apparent when reviewing the relationship between the Roman Catholic Church and geology (or science in general), be it the often-cited Galileo case in the aftermath of the Reformation (**Ostermann**) or the minor skirmishes that took place after the secularization of the early nineteenth century (**Klemun**) or during the *Kulturkampf* (culture struggle) around the start of the twentieth century (**Vaccari**).

At present, there is a certain lingering sympathy (for example, on the part of Cardinal Schönborn of Vienna) for intelligent design (e.g. Horn & Wiedenhofer 2007),[6] much to the distress of many academic theologians (see www.forum-grenzfragen.de; compare also **Ostermann**), which airs a deep distrust of the secular world with its apparent loss of moral values (and concomitant neglect of moral authorities) and spiritual meaning. Although Cardinal Schönborn has publicly dismissed creationism as nonsense, he does not seem to be aware of the historical roots of intelligent design, which began in the late 1980s as a case of camouflaging the religious nature of creationism to gain access to the US educational system (see www.talkorigins.org/, www.talk.design.org/; see also **Roberts** (an Anglican priest's perspective)). It seems that intelligent design is regarded by Schönborn as a suitable way to give (alleged) scientific blessing to faith, and thus rationalize it by means of scientific or philosophical argument. For this purpose, intelligent design, whose scientific sounding rhetoric is not easily exposed by the average theologian, seems to be a more suitable ally than mainstream science. Readers may want to contemplate the similarities of this modern case of apologetics and the promotion of Neptunism in late eighteenth-century Italy (**Candela**).

The more traditional creationism was, until recently, a mostly Protestant feature (**Young** and **Moshier** ***et al.***). However, it is no longer a problem of minor free churches but also occurs increasingly in mainstream Protestant churches to a worrying extent (see Hemminger 2007; **Roberts**).

People become (or remain) creationists for many reasons. **Peters** explores one reason which seems to be especially relevant to the US situation:

> [W]hat unites the radical creationists is a need to declare God innocent of the charge of creating an already fallen world, a world full of suffering and death and futility from the beginning. Large numbers of Westerners profess belief in God; I will argue that what separates radical creationists from the rest is their conviction that contemporary scientific orthodoxy renders belief in a loving, personal Creator deeply implausible, and a burning desire to make it less so.

The immense diversity of opinions among creationists regarding geology, palaeontology and evolution 'can be accounted for by the fact that radical creationism is organized around and motivated by a quest to show God [to be] innocent of natural evils' (**Peters**). The natural evil is blamed on the sinfulness of humans instead.

However, there are other factors, apart from problems with theodicy, which should not be neglected. The motto of the Enlightenment, *sapere aude* or 'dare to know',[7] causes fear in some people: fear of taking up the responsibility that comes with freedom and that is then delegated elsewhere, either to religious authorities or, these days, to secular (scientific or esoteric) experts. Simple answers are what such people crave, and creationists, and the ever-increasing business of 'esotericism', provide ostensibly simple recipes for life as well as a feeling of (false) security in a world that is difficult to understand and to manage.

It is the fear of the secular world, with all its complicated decisions to be made for oneself, the fear of getting lost in the maze of theological and spiritual possibilities, where no one tells you what to do or what to believe, the fear of losing sight of moral values and spiritual meaning in an economic system where value is attached only to money and productivity, that encourages the expectation of the apocalypse around the end of the second millennium after Christ, with its strange and dark mixture of dread and satisfaction in those who hope to be caught in 'the rapture'. Of course, there are also those who make money and gain political influence by exploiting the spiritual needs, troubles and sometimes despair of unsophisticated people (Hedges 2006). This has also been noticed by the Council of Europe, which on 4 October 2007 passed a resolution (Number 1580) on the dangers of creationism in education, pointing out that:

> The total rejection of science is definitely one of the most serious threats to human and civic rights. . . . The war on the theory of evolution and on its proponents most often originates in forms of religious extremism closely linked to extreme right-wing political movements. The creationist movements possess real political power. The fact of the matter, and this has been exposed on several occasions, is that some advocates of strict creationism are out to replace democracy by theocracy (Council of Europe 2007).

Uneducated people are easy prey for the political wing of the creationist movement. Their desire for security or theodicy is satisfied neither by science nor by modern scholarly theology (**Peters**), and they are usually unaware of the achievements of both science and post-Enlightenment theology (**Ostermann** and **Roberts**).

From my personal involvement with young theological students at the Catholic University of Eichstätt-Ingolstadt (Germany), I often get the impression that many of them do not really have an idea of what science means and how it works, and why should they? In school, their teachers knew everything and they simply had to believe them. Their textbooks told them what to learn by heart for use in the examinations. They studied physics, chemistry and biology but never conducted an experiment without knowing how it would turn out, and never asked a question or researched it themselves by observations or other means. How should they understand the difference between a physical or biological problem and the opinions offered in a newspaper or some dogma of the Church?[8] It is not only the deeply religious who are affected by this ignorance. In Germany, and as far as I understand, in other countries too, we also have a huge surge in 'esotericism'.

It is important to question not only the way we teach science (Pigliucci 2007) but also how we teach and reflect about religion and faith, as there may be another reason contributing to the problem of creationism. Science is not atheistic as such, but it may be damaging to the simple faith of our childhood. Embarking on the adventure of science will necessarily shake this belief, but by perseverance on our personal path in science, casting away easy answers and unreasonable superstitions, we might gain more than we lose and our faith may grow stronger and more mature. In the words of the former director of the Vatican Observatory, George Coyne:

> I would essentially like to share with you two convictions . . . : (1) that the Intelligent Design (ID) movement [or other forms of creationism], while evoking a God of power and might, a designer

God, actually belittles God, makes her/him too small and paltry; (2) that our scientific understanding of the universe, untainted by religious considerations, provides for those who believe in God a marvellous opportunity to reflect upon their beliefs.

So why does there seem to be a persistent retreat in the Church from attempts to establish a dialogue with the community of scientists, religious believers or otherwise? There appears to exist a nagging fear in the Church that a universe, which science has established as evolving for 13.7×1 billion years since the Big Bang and in which life, beginning in its most primitive forms at about 12×1 billion years from the Big Bang, evolved through a process of random genetic mutations and natural selection, escapes God's dominion. That fear is groundless. Science is completely neutral with respect to philosophical or theological implications that may be drawn from its conclusions. Those conclusions are always subject to improvement. That is why science is such an interesting adventure and scientists curiously interesting creatures. But for someone to deny the best of today's science on religious grounds is to live in that groundless fear just mentioned (Coyne 2005).

Conclusion

From such thoughts, and of course the papers assembled in this volume, the reader may gather that the relationship between geology and religion is much more complex than might be supposed at first glance. Both geology and religion have evolved through time, often intensely entwined, and mutually influencing one another. For much of the time needed for the development of geological methods and expertise, geology and religion cannot be considered separately by historians of science, as the historical protagonists were often both geologists and theologians; and in other cases the theological laymen among early geologists considered their geological discoveries in the light of their faith.

With these historical considerations in mind, we may better understand the current situation and offer a dialogue between geology and modern theology, bearing in mind that the current debate, if there has to be one, should not be about geology versus theology but about enlightenment versus fundamentalism. It is important that geologists should be aware that many theologians are just as appalled by the recent rise of Christian fundamentalism as they are.

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Notes

[1]Outside the USA, this is a new phenomenon. In Germany, for example, the debate reached the media only about 5 or 6 years ago. There has always been a small group of creationists among Jehovah's Witnesses, Seventh-day Adventist or certain evangelicals, but they have been an almost silent minority. Now there is a vocal minority striving for publicity.

[2]This is the idea of 'falsifiable theology', a notion that possibly every scientist should be able to live with.

[3]So called, because after the initial act of creation ('In the beginning God created the heaven and the earth'; Genesis 1:1), the 'Earth was without form' (Genesis 1:2, i.e. it was chaotic), and only later, starting with day 1 and the creation of light, was the Earth moulded into the planet we know today, implying a time gap either between the initial creation (of a perfect Earth) and rendering it chaotic (with later restoration of a habitable Earth) or between an initially chaotic Earth and the ordering process of days 1 to 6. Other creationists prefer to locate the time gap within Chapter 2 of Genesis after the seventh day and before the account of the fall of Adam and Eve.

[4]Historians of science must be aware of their own subjective religious worldview, which may sometimes influence their interpretation of such pre- or proto-scientific ideas. For a case study see **Oldroyd**.

[5]This need not necessarily be a traditional religious institution (see, e.g. **Zhang & Oldroyd**).

[6]It is disturbing that Russell *et al.* (1998), documenting a highly professional and inspiring interdisciplinary conference on evolutionary and molecular biology, which had been organized and hosted by the Vatican Observatory, was not quoted in this book, pointing to a serious neglect of the previously intense interdisciplinary and ecumenical dialogue between science and religion that existed under Pope John Paul II.

[7]A phrase from Horace, used by Immanuel Kant (1724–1804) in his essay 'What is Enlightenment?' (Kant 1784).

[8]On the other hand, the media expose students to scientists who argue for philosophical atheism (e.g. Dawkins 2006), depicting it as a logical consequence of scientific method, an opinion that obviously has much to answer from a philosophical or theological point of view. This kind of atheism immediately proves to be counter-productive. The students are only strengthened in their

prejudice that 'science is just as dogmatic as those scientists claim religion to be', and they cannot fail to note that the scientists have at best a shaky grasp of modern theology and ignore its manifold attempts at a fruitful dialogue between science and religion (see Russell *et al.* 1998; Peters & Hewlett 2003; Schärtl 2008).

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Jean-André de Luc (1727–1817): an atheist's comparative view of the historiography

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Abstract: The paper considers issues arising when historians of different theological persuasions write about geologists whose religious principles influenced their geological work. For illustrative purposes, three accounts of the work of Jean-André de Luc are discussed, written by a freethinker (Charles Gillispie); an Anglican (Martin Rudwick); and two co-authors, one a Calvinist (François Ellenberger) and the other an atheist (Gabriel Gohau). The issue of understanding or empathizing (or otherwise) with one's subject in writing the history of geology is raised. It is suggested that the accounts of de Luc discussed here show the marks of the religious views of the different historians. In discussing this suggestion, the concepts of 'emic' and 'etic' from cultural anthropology are deployed. (These terms indicate, respectively, an 'insider's' or an 'outsider's' approach to a subject.) Older geological writings commonly reflected their authors' religious perspectives; but this is much less common in modern work. Therefore the science–religion issue will become of less importance for historians writing about the history of geology for the twentieth century onwards.

An author's philosophical position when studying the history of science is as important and potentially influential as that involved in studying any other intellectual activity. My position is that of 'naturalism'; and I am an atheist. Reasons for being an atheist are discussed at book length in many texts, for example the provocative and controversial books by Dawkins (2006) or Hitchens (2007). A brief statement of my own position, which is pretty much the same as that of these two authors, has been given elsewhere (Oldroyd 2005). I acknowledge that philosophical naturalism cannot be proved, but I believe that it is an intellectually honest position, and best for both scientists and historians. The situation is different for (say) political historians. One can write from a liberal or conservative perspective, both of which can have legitimacy. So either a liberal or a conservative account of, for example, World War I can be instructive and the two can complement one another. Neither should have an 'absolute' superiority. Is the situation similar for historians of different philosophical or religious persuasions writing about the history of the Earth sciences?

In this paper I examine some writings in the history of geology, suggesting how they appear to me to be influenced, for better or worse, by the philosophical or religious perspectives of the historians concerned. My discussion is illustrated by consideration of some writings on the Genevan naturalist Jean-André de Luc (1727–1817). The question of empathizing (or otherwise) with the persons about whom one is writing is raised, along with some wider questions of historiographic practice.

Stephen Gould (1997) attempted to argue that scientific knowledge and spiritual knowledge belong to two mutually exclusive categories or domains, which he dubbed 'non-overlapping magisteria'. However, as John Hedley Brooke pointed out at the XXII International Congress for the History of Science in Beijing (24–30 July 2005), this is implausible for anyone (including Gould) who holds that the form of science is inescapably shaped by the social context within which it is developed. Clearly, there has been a huge amount of 'overlapping' in the history of geology, especially in the earlier stages of its development. If, then, the 'magisteria' do overlap, then any scientist or historian of science should try to get the philosophical–religious–spiritual issues right. We cannot evade the problems simply by invoking Gould's 'dichotomy'.

Anachronism and the problem of analysing religious practices and phenomena

It is obvious that much important science has been produced by religious people. Steno, Faraday, Lyell, etc., provide striking examples. So in studying the history of science, and specifically geology, the atheist historian should not automatically judge past science that was conducted within a religious context in a negative light, simply by reason of that context. To do so can lead to historiographical anachronism and biased,

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inaccurate history. So, although I think that, for example, what Thomas Burnet (*c.* 1635–1715) suggested about the Earth's history was false, I do not judge him adversely on that account. He was a product of his time and place, and he thought in a way similar to many educated Englishman in the seventeenth century. My task, as a historian of science, is to understand what he wrote, and to explain how it fitted into the context of his time. However, it is also appropriate for me to say why I think he got things wrong; and the reasons had to do with his religion and its political associations as much as the limited empirical knowledge about the Earth that was available in the seventeenth century.

I have suggested above that one should have a 'correct' philosophical (or metaphysical) position in order to write good history. However, this may seem presumptuous, for who is to judge what is philosophically 'correct'? And can atheists ever write about religion satisfactorily if they have never experienced whatever it is that religious people say they experience? This is a problem.

Anthropologists distinguish between two approaches to their subject, for which they use the terms 'emic' and 'etic'.[1] The researcher adopting the emic approach tries to understand the cultural distinctions that are meaningful to the people being studied. However, strictly, only the members of the culture themselves can properly understand the practices and beliefs of that culture and which category distinctions are significant or relevant to it. Therefore the emic anthropologist should learn the language of the people being studied and should perhaps 'become a member of the tribe' at least for a time. This is the 'insider's' approach. It involves or requires empathy on the part of the investigator for the people being studied.

In contrast, the 'etic anthropologist' studies a culture as an 'outsider'. The categories used in the description are ones that have meaning or significance for the outside observer, although they may seem absurd to the insider. A classic example of such an approach in the 'science studies' was provided in the book *Laboratory Life* (Latour & Woolgar 1979), although it was in a sense 'emic' in that the two authors had joined a research laboratory as lab assistants for a period to see what went on in scientific research. This guise gave them (I suppose) a kind of invisibility in the laboratory. However, they had ideas about what was going on that were completely different from those of the scientific researchers. The latter, if asked, would have said that they were examining the chemical substances produced by brains in very small quantities and the physiological effects produced by these substances. However, for Latour & Woolgar the researchers' main activity appeared to be writing, getting things published, and getting other scientists to agree with their results and their arguments. Latour & Woolgar's interests were 'etic' in character. Likewise, Dawkins and Hitchens, mentioned above, evidently take an etic approach to their topic, and apparently without empathy.

So Christians may, and often do, assert that the outsider who has no experience of Christian spirituality cannot understand its nature and hence cannot comprehend the essence of Christianity. They reject external analysis as being uninformed and therefore misguided, and consider that the non-Christian is not in a position to understand what Christianity is all about. The more positivistic etic student of the sociology of religion would say, however, that interesting generalizations can be made about religious practices by those who do not adhere to the faiths of the people studied. The etic anthropologist can examine the empirical aspects of ritual, the efficacy of prayer, the truth or falsity of miraculous claims, the philanthropic activity of believers and non-believers, ecclesiastical architecture, and so forth. They can examine the philosophical and scientific coherence or intelligibility of religious doctrine, and the social effects of religious beliefs. They may well regard theology as a 'science' about 'nothingness', or a discipline with nothing to study, for the simple reason that God does not exist. So it is a non-science, or 'a nonsense'. This is almost akin to Blondlot's poignant study of non-existent 'N-rays' (there is a large literature on this topic; see, e.g. Klotz 1980). However, they can still say interesting things about religion, religious practices, and the sociology of religion.

Any historian, regardless of their special field of interest, is inevitably driven in the direction of etic studies. We cannot fully enter the minds of the people of the past whom we study. Not even today's committed Christian can fully enter into the thoughts of long-past, devoutly Christian scientists, or become a member of the community of seventeenth-century theorists of the Earth, such as Burnet. One cannot conduct wholly emic studies of the past, although I would accept that the Christian can probably 'get closer' to Burnet than I can.

As regards geology, I have urged in print that geohistorians should, as far as possible, put themselves 'in the boots' of the geologists being studied, by visiting the localities they visited, looking at the fossils or rock specimens that they collected, and so on (Oldroyd 1999). Such activities assuredly help historical understanding, but still provide only a partial and imperfect aid to 'emicity'.

Nevertheless, do empathy and 'emicity' produce more 'valid' or accurate interpretations, or 'better' history? We cannot hope to achieve a 'perfect historiography', but is 'emicity' helpful or preferable for writing about former geologists whose work was strongly influenced by religious beliefs and a religious environment?

The case of Jean-André de Luc

To focus our attention more closely on these questions, I now consider a specific case in the history of geology, that of the Genevan naturalist Jean-André de Luc (1727–1817). Three accounts of him will be discussed: by Gillispie (1959), Rudwick (2001) and Ellenberger & Gohau (1981). Charles C. Gillispie was and still is a freethinker (Gillispie, pers. comm.). François Ellenberger, now deceased, was a Calvinist and Gabriel Gohau is an atheist (G. Gohau, pers. comm.), whereas Martin Rudwick is an (Anglican) Protestant (Rudwick 1998).

Charles Gillispie

I first heard of de Luc when I read *Genesis and Geology* (Gillispie 1959) in the early 1960s. Already then an atheist, I was 'charmed' by the negative account of de Luc for it suited my intellectual outlook. I enjoyed being told that religious folk such as Richard Kirwan and de Luc produced what Gillispie evidently regarded as stupid geology. However, I did not at that time read de Luc himself, for I was not then thinking of becoming a historian of science, and even when I did become one I focused my attention on other topics. Recently, in preparing for the present paper, I wondered what Gillispie's religious opinions were. It seemed to me that he was almost certainly an atheist or agnostic, so I wrote to him and enquired about the matter. It was no surprise to learn that he was and is a free thinker, although whether an atheist or agnostic he did not say (C. C. Gillispie, pers. comm.). It was what I had expected to be the case on the basis of his book.

Gillispie (1959, p. 58) pointed out that de Luc divided the Earth's history into two distinct parts: (1) the period prior to the formation of the present continents; (2) that which followed. Gillispie gave a good deal of attention to the earlier phase, in which he envisaged the Earth's crust as being 'laid down in six successive stages' (in accord with Mosaic history, although according to de Luc his analysis was based on sound empirical evidence and was independent of the book of Genesis). Moreover, '[t]hough Deluc never acknowledged it, these stages present[ed] only minor modifications in the standard Wernerian formation suites' (Gillispie 1959, p. 58). Gillispie's account of de Luc's 'tectonic' theory of the divide between the two parts of Earth history was as follows:

> Four thousand years ago, however—using 1800 as the datum—there took place the notable event which produced the present state of the world. Previously our continents had been the bottom of the sea. Then quite suddenly, the ancient land subsided in a catastrophic convulsion, the waters poured onto the newly sunken areas, and the modern continents were left exposed. Only a few primordial islands, now become mountain tops, escaped depression and preserved the continuity of vegetable and animal life. Deluc had to spare these islands, because he was too honest to ignore the known deposits of terrestrial fossil forms overlying, here and there, marine remains. Fortunately for him no human relics had yet been found in them (Gillispie 1959, p. 59).

Gillispie went on to underscore the point that de Luc believed that his 'modern' geology (the term that he himself coined,[2] although Gillispie did not mention this) provided scientific confirmation of Mosaic history, which showed to de Luc's satisfaction that that history was not just a myth. Moses got the story right because he was divinely inspired.

If de Luc's account of pre-catastrophe geology was achieved through a combination of observation, Wernerian theory, and reading of Genesis, which (as Gillispie would have us believe) was by no means 'purely' scientific, what of his account of post-catastrophe geology (the date of the catastrophe, or the biblical Flood, being set at 2200 BC)? This date was arrived at by the use of what de Luc called 'natural chronometers' such as the estimate for the times taken to build deltas into lakes, form peat deposits, and so on. Gillispie had little respect for de Luc's efforts in this direction, describing the part of his work where they appeared as 'one of the weakest sections' of de Luc's *Treatise*:

> [T]hese chronometers were very vague. They were connected somehow with the rate at which currently observable causes operate. Here is the one point where the reader wonders whether Deluc really could have believed in his own objectivity. Probably he did, however. In any case, he had very little choice, for if the continents had been formed in time out of mind, obviously Genesis could not be historically true (Gillispie 1959, p. 65).

So de Luc was treated with little sympathy by a geohistorian of the 1950s.

Perhaps not even consistently, Gillispie wrote further:

> And if his [de Luc's] system was only a theological exercise, at least he never formally introduced his conclusions into his argument. The deluge, however, must be literal: man was represented as remembering it, and it had to be such that man could remember it (Gillispie 1959, p. 66).

So, it seems to me, Gillispie was also saying that de Luc obtained his dates for the time since the Deluge by reference to the Bible as much as the evidence of lake infillings. Therefore he probably was introducing his conclusions into his arguments.

With these considerations in mind, it seems to me that Gillispie was anything but 'emic' with respect to de Luc's thinking. Perhaps he understood what de Luc was doing, but he did so with the advantage of hindsight. Gillispie's historiography was anachronistic and whiggish (although by the historiographic standards or practices of the 1950s it was perhaps as might be expected). He said more about de Luc's antediluvian geology than his post-diluvian, and played down, or even denigrated, the significance of the latter. Gillispie apparently did not empathize with de Luc at all.

If not emic, was Gillispie's historical analysis 'etic' in character? Was he an impartial and dispassionate reporter of the historical record? I think not. Although it might seem, from his analysis of de Luc, Kirwan, Robert Jameson, and others, that Gillispie was discerning a kind of law-like pattern in the behaviour or thinking of 'physico-theologists' of the late eighteenth or early nineteenth centuries he did so through the prism of his own metaphysical views, which meant that his account was not historically objective. He was, so to speak, dealing with two distinct 'tribes': the fideists such as de Luc and the deists such as Hutton. One metaphysic could not fit both tribes.

Martin Rudwick

Since Gillispie's book appeared, de Luc's reputation has been substantially restored by the Cambridge geohistorian Martin Rudwick, who has described what de Luc did within the frame of his religious perspective in several publications (e.g. Rudwick 1972, 2001, 2005). As a Christian, Rudwick is evidently much more sympathetic to de Luc than was Gillispie, and I think Rudwick's religious proclivities have provided a valuable motivation for giving de Luc a sympathetic hearing and a clearer understanding of what he was about and what he achieved. Rudwick can, compared with Gillispie, be 'emic' as regards de Luc, even though he obviously cannot join or live with the 'fideist tribe' of physico-theologists of de Luc's time.

In *Bursting the Limits of Time*, Rudwick (2005) sought to describe the emergence of geology as a science around 1800; and he saw the emergence of what he called 'historical thinking' as being the thing that mattered in that emergence. (Whether that is correct is discussable. It need not be debated here, but see Oldroyd (2006).) This emergence of modern geoscience occurred at a time when there was much interest in 'Flood geology' and the biblical Flood was commonly seen as an important geological agent. For one such as Gillispie, Flood geology was something that retarded geological progress (although it did give, in Darwin's words, a theory with which to work). For Rudwick, in contrast, geology emerged from within the context of discussions about the Flood (among other things) as much as in opposition to them. However, he argued that there were many strands to the emerging 'historicization' of geology (see Oldroyd 1979). These have been teased out in Rudwick's immensely detailed investigations, and then interwoven in his narrative. The new breed of geologists began to think historically about the Earth and dig into it, to examine its archives, just as they excavated at Herculaneum and Pompeii to find out what happened in Roman history. Thus the emergence of historical geology was seen by Rudwick to be part and parcel of a general intellectual movement in the latter part of the Enlightenment.

Rudwick has given numerous examples of the emergence of this geohistorical approach. Researchers had to piece together all the elements of the story of the Earth's history by looking at fragments of evidence in the form of, for example, layered lava flows, different fossils characteristic of different environments (e.g. fresh water or marine), or different rock types (such as coal, limestone or sand). So, in the work of Cuvier & Brongniart (1808, 1811) we see the story of the geohistory of the region of the Paris Basin unravelled. In their work, the present was used as the key to the past (actualism).[3] The work on the gradual reconstruction of the geohistory of the Paris Basin has been described in detail by Rudwick, with the contributions of the many who were involved duly recorded.

Let us here consider particularly the case of de Luc in the historicization of the study of the Earth. He is given considerable attention in *Bursting the Limits of Time* (Rudwick 2005). However, for the present purposes, it will be more convenient to focus on an earlier paper by Rudwick (2001), as it was specifically concerned with de Luc, and Rudwick's ideas of 2001 were carried over into his large book of 2005. Rudwick coined the useful term 'binary history' to refer to de Luc's geohistory. There was pre-Flood time of indefinite extent; and post-Flood time, which by de Luc's calculation might have lasted about 4000 years. Rudwick chose to focus largely on the post-Flood geology, which had been treated so dismissively by Gillispie.

The calculations of the extent of post-Flood time were, as mentioned above, made on the basis of such phenomena as the infilling of lakes by the growth of deltas at measurable rates or the accumulation of peat. The accumulation of screes was also considered. Such processes served as de Luc's 'geochronometers'. They relied on the theory of actualism, plus the theory that modern geohistory started post-Flood, following crustal collapses of the areas that are now occupied by oceans and when what is now dry land became exposed. De Luc's geochronometers allowed him to make 'absolute' datings to arrive at a figure of about 4000 years for the time since the Flood. The coherence of the results from calculations and measurements using different and independent chronometers (deltas, peat beds, screes) was surely a good argument for the validity of the result (although we now think that the measurements were tending to the date of the end of the last Ice Age, and I think, with Gillispie, that de Luc 'leaned' towards the figure of 4000 years, which was the sort of value that Old Testament history suggested). Pre-Flood time, the other part of the binary division of history, was long and indeterminable, and de Luc recognized that the accumulation of large thicknesses of sediments that we see in the older strata would have taken an immense time. Rudwick saw intimations of biostratigraphy too in de Luc's discussions of the fossils found in these pre-Flood sediments.

All this is very good. De Luc was apparently beginning to think like a modern geologist for post-Flood time (although his geochronometry had been foreshadowed by Edmund Halley's (1656–1742) ideas on the increase of the salinity of the oceans (Halley 1715), or even Herodotus's (*c*. 484–*c*. 425 BC) discussion of the growth of the Nile Delta (Herodotus 1920–1924, **2**, Book 4). Rudwick thus saw de Luc as an important figure in the emergence of modern geology as a historical science.

However, by invoking and emphasizing the idea of de Luc's binary history, Rudwick was able to sidestep the substantial archaic features in his pre-Flood geology. Gillispie, on the other hand, chose to dwell on this earlier epoch, largely omitting discussion of the post-Flood studies. In fact, he represented de Luc as a benighted obscurantist and a somewhat poignant figure. Rudwick, in contrast, treated de Luc's pre-Flood ideas relatively lightly (although certainly mentioning them), and heaped praise on his post-Flood work. Indeed, he saw de Luc as a respected investigator and represented his theory as 'immensely influential' in the early nineteenth century, above all 'because it was adopted by the great French naturalist Georges Cuvier' (Rudwick 2001, p. 58). Moreover, de Luc's method of 'actual causes' was used by Charles Lyell, although he had used it to argue that there had been no catastrophic event that had disturbed earlier Earth history. As Rudwick put it: 'de Luc's method for analysing and calibrating geohistory got a second wind, and became the basis for Lyell's own geotheoretical model, later dubbed uniformitarianism' (Rudwick 2001, p. 58). Here he was thinking of what he (Rudwick 1978) had earlier called Lyell's 'statistical palaeontology'.

François Ellenberger and Gabriel Gohau

Another important analysis of de Luc's work was provided by the French historian of geology François Ellenberger (1915–2000), working with his one-time doctoral student Gabriel Gohau (Ellenberger & Gohau 1981). Gohau (pers. comm.) is an atheist; and I have been informed by Jean Gaudant (pers. comm.) that Ellenberger was a Calvinist whose family came from the Canton of Bern. His father had been a Calvinist missionary in Africa, who married the daughter of a Calvinist minister from the Geneva area. According to Gaudant, who knew Ellenberger well, he belonged to the 'strict Calvinist tradition'.

According to Gohau's recollection, it was he who first became interested in de Luc's *Lettres à Blumenbach* (1798). When Ellenberger became aware of Gohau's study of the *Lettres* they began a collaborative study, partly because Ellenberger had greater familiarity with the stratigraphy of southern England, which had been important for de Luc's argument. Gohau recalled that 'notre collaboration a été surtout complémentaire, sur le plan scientifique'. However, possibly Ellenberger thought de Luc particularly interesting because of their common Genevan–Calvinist heritage, and Gohau found that Ellenberger's familiarity with the Bible was useful, as well as his knowledge of British stratigraphy. Therefore their study could well have been 'emic' as regards Ellenberger, whereas Gohau would not, I think, have been interested in anything more than a 'historical–etic' account. We can, I suggest, take their joint investigation as one that was potentially intermediate in metaphysical commitment between those of Gillispie and Rudwick.

As such, the Ellenberger & Gohau analysis is interestingly different from the accounts of Gillispie and Rudwick. They did not present a polemical negative representation of de Luc. On the other hand, although it was Ellenberger & Gohau who drew attention to the interesting relationship between de Luc and Cuvier, they did not extend it to Lyell. More importantly for the present purposes, they gave as much attention to de Luc's ideas about pre-Flood geology as to his geochronometry and post-Flood investigations. They noted the 'binary' character of de Luc's history, which allowed emphasis to be placed on one side or the other of his geology (or both).

Ellenberger & Gohau mentioned that de Luc could not read German, so his Wernerism was presumably 'second-hand'. However, that does not mean that he was not deploying the 'Wernerian formation suites'. These were well known in Britain (where de Luc took up residence) from the advocacy of Robert Jameson, and through much of Europe by the dissemination of Werner's students. The more interesting question is the 'biostratigraphical' ideas that were developed by de Luc.

According to Ellenberger & Gohau, de Luc was interested in establishing a history and chronology of the Earth by examining its 'archives' (which could be either rocks or fossils). De Luc could discern a degree of regular order in the lithologies of the superimposed strata of southern England, although the rocks were also severely disturbed in places (such as the Isle of Wight). Thus he envisaged both a sedimentary and a tectonic chronology.

Furthermore, de Luc recognized that strata of characteristic lithologies had characteristic organic assemblages of fossils (at least in Britain), most of the organisms being different from those found in the seas today. This observation was not new, but it was, nevertheless, a precondition for the emergence of biostratigraphy. The second step for the establishment of biostratigraphy, as noted by Ellenberger & Gohau, was the recognition that the different forms of fossils were related to their different ages. This could just be a 'brute fact' (as it was for William Smith, at least in his earlier days) but for the likes of a 'savant' such as de Luc (to use Rudwick's terminology) it was a fact that required explanation.

For de Luc, then, the changes of form were due to the changing chemical environment of the seas in which the organisms lived and from which the sediments in which they were preserved were precipitated. The changes in strata were related to 'mini-catastrophes', which were associated with the emission of different *fluides expansibles* from the Earth's interior:

> Ainsi les changemens qu'éprouvent le *liquide*, et d'où procédoient des changemens successifs dans la nature des *couches*, avoient aussi de l'influence sur la manière d'exister des *êtres organisées marins* (de Luc 1798, pp. 381–382).

However, the changes were apparently abrupt rather than gradual, matching changes in lithology, which could be ascribed to the mini-catastrophes. Thus de Luc was not a transformist in the Lamarckian sense, but he had some of the elements necessary for the establishment of a biostratigraphy. On the other hand, he did not use fossils reciprocally for determining the relative ages of strata.

Ellenberger & Gohau went on to consider the parallels between the system of de Luc and Cuvier. I think they were interested in establishing de Luc as one of the major precursors of Cuvier, a programme that has been followed up or paralleled by Rudwick.

As it appears to me, Gillispie was interested in representing de Luc as a man of limited capacity, bound by his adherence to Wernerism and the Mosaic tradition. Ellenberger & Gohau were interested in the emergence of biostratigraphy and the extent to which de Luc was or was not a precursor of either Lamarck or Cuvier. They wrote respectfully about de Luc and pointed out how his faith had to be accommodated by his geology. And he achieved this successfully (in his own eyes at least). I think also that Ellenberger & Gohau were interested in the emergence of historical geology and biostratigraphy, especially in the Francophone world. They did not emphasize the post-Flood aspect of de Luc's geohistory. Their account seems to me to be objective and one could say that it is a blend of emic and etic historiography, which is perhaps unsurprising considering the known metaphysical positions of the co-authors.

Rudwick shared many of the concerns of Ellenberger & Gohau but, as mentioned, his account was situated in the context of a much larger-scale effort to delineate the steps leading to the emergence of historical geology and biostratigraphy. De Luc received a place of honour in this narrative, but was perhaps also given a favourable gloss by the emphasis given to his post-Flood geochronometers (which, as we have seen, Gillispie tended to denigrate) at the expense of an examination of the archaic physico-theological aspects of de Luc's thinking. De Luc's geochronological work fitted neatly into Rudwick's large-scale historiographic programme, as did his intimations of biostratigraphy for 'pre-Flood' strata. However, that does not give the full story about de Luc (nor need it for Rudwick's historiographic purpose).

De Luc's pre-Flood geology

Now let me say a little more about de Luc's 'pre-Flood' ideas. He invoked collapses of parts of the Earth's crust into subterranean caverns to account for the tectonic changes that he thought were required by the observed distortions of the strata. There was no independent or testable evidence for the former existence of these caverns (although such structures had frequently been suggested in the early literature). They were *ad hoc* explanatory entities.

Beyond that, de Luc's pre-Flood geology was, as mentioned above, chiefly Wernerian. In fact, he said, one had to rely on chemistry for information on the very early period of Earth's existence. In his *Elementary Treatise on Geology* (de Luc 1809), which summed up his life work and his geotheory, he spoke of a 'primordial liquid' somehow produced by light acting on some substance in the atmosphere (which I may here call substance 'X') to give heat, which produced liquidity. Granite was the first precipitate from the primordial fluid. A succession of catastrophes resulted from a succession of collapses, which, with the changing conditions, gave rise to a succession of different precipitates.

Therefore, in thinking about de Luc as a geologist or geotheorist, one cannot leave aside his pre-Flood ideas or his more general metaphysical or theological commitments. We may consider his statement:

> The Deluge is described by MOSES under circumstances so precise, that if they are true, they must be impressed on the whole of our globe as forcibly as its *chronology*: and now, in proving that they are so, I shall not confine the character of MOSES to a *faithful historian*, but shall make it manifest that he must necessarily have *been directed by God himself* (de Luc 1809, p. 389).

That is, for understanding Earth's history, de Luc thought Moses no less important as a source of information than was the study of delta enlargements, for instance. Indeed, it was a major goal of de Luc's work to reconcile empirical results with what was stated in Genesis. Rudwick tended to downplay this, in part by focusing attention on de Luc's actualistic study of post-Flood phenomena. However, de Luc's pre-Flood geohistory certainly did not contribute to the emergence of geoscience, regardless of the methodological soundness of the geochronometers. For Gillispie, that sort of history impeded the progress of geology.

A British view of de Luc by one of his contemporaries

Both Ellenberger & Gohau and Rudwick have seen de Luc as playing an important role in the establishment of geology, with, *inter alia*, intimations of biostratigraphy, an actualistic methodology for the post-Flood period, and the use of 'absolute' geochronometers for that period. It is interesting, then, to notice what a British geologist of de Luc's time thought about him.

Among the William Smith Papers at the Natural History Museum at Oxford University (OUMNH: Box 5, Folder 4) there is an undated and incomplete letter, identified by Hugh Torrens and Stella Brecknell as being in the hand of Smith's friend and patron the Reverend Benjamin Richardson (d. 1832), Rector of Farleigh Hungerford, introduced by 'Dear Sir' but apparently intended for Smith. It contains some extraordinarily strong critical comments on de Luc's geology and stratigraphy. Richardson wrote regarding de Luc's *Letters to Blumenbach* (as published in *British Critic*, **4**, September 1794[4]):

> As I cannot suppose you possess patience to wade through this *6 Days Dream*, I have marked some of its Curiosities by reference to the Pages. This colossus of Facts, of Reading and Knowledge & Science, in honour of French Confidence comes to enlighten the phylosophic World with the whims of a Midnight Dreamer.
>
> It is the only work I ever perused without picking up some kind of useful information— . . .
>
> There is much more Confusion in De Luc than in the Earth itself— His proof that Granite is primaeval because it contains no organic matter; is that a Sea has not covered the Hills above a certain height for the same Reason, their being top[p]ed with *Granite*: is surely an argument of its being formed the last.
>
> This Arg[ument] will prove the Red Ground[5] also to be primaeval.
>
> How is it proved that there is nothing now taking place in the Sea, similar to the production of Strata, which formerly took place?'

Admittedly, this document could be said to come from a 'partial' source, as it expresses antipathy for French ideas, as might well be expected in a period of military conflict between France and Britain, and was penned by a supporter of the stratigraphic ideas that Smith was endeavouring to establish. However, it would seem to indicate that not all contemporary geologists thought of de Luc as favourably as do some modern historians of science. In fact, it would appear that Richardson regarded the ideas of his approximate contemporary, Jean-André de Luc, as an impediment to the development of geology.

Conclusions

Thus we find that, in their respective historiographies, Gillispie emphasized de Luc's pre-Flood ideas, Rudwick gave particular attention to his post-Flood geology and regarded de Luc as 'one of the most prominent geologists of his time' (Rudwick 2001, p. 51), whereas Ellenberger & Gohau held an intermediate position (as it appears to me). This meshes with their known religious positions.[6]

We should note that de Luc's post-Flood work did indeed feed into modern ways of thinking about geohistory, and thus we gain from the accounts of Ellenberger & Gohau and Rudwick, although perhaps they have, for different reasons, exaggerated de Luc's importance in the history of geoscience, if the evidence about Richardson's views given above is taken into account. Whether de Luc himself considered his pre- or post-Flood ideas to be more important I am not able to say, but his 'binary history' was, I suggest, his escape route to get round the problem of reconciling empirically based historical geology and geochronology with Mosaic tradition. It enabled him, so to speak, to have his Moses and eat the cake of geology (or geochronology).

I think historians should be interested in the theological dimensions of the history of geology. It is part of the tapestry of the early phases of the history of the science. The two 'magisteria' were certainly overlapping in the early nineteenth century, and before then too. Does one's theological perspective make any difference to the kind of history that one writes? I think it does; and I have endeavoured to demonstrate that this is so by considering different writings about de Luc's geology. It is probably the case that of the four historians that I have discussed Gillispie's account was the least faithful to his subject; and he is, like me, an atheist. However, Gillispie's book was a pioneering study in the history of geology, written from a perspective that does not agree with modern views on historiography. (But are today's views on historiography necessarily the best?) It was undoubtedly an entertaining book, and almost certainly the most widely read of the three accounts (although it is, of course, older and has had more opportunity to be read). Perhaps the difference in the metaphysical views of Gillispie and de Luc (separated in time and space) made it impossible for Gillispie to adopt an 'emic' attitude towards de Luc so that Gillispie's bold youthful work had 'etic defects' in consequence.

Where does all this leave me as an atheist historian? In practice it means that I am not specifically attracted to the study of geoscientists' religious views and the way they may have had an effect on the development of their thinking, unless they have given rise to significant developments in geoscience. For example, it is interesting to me (and also somewhat perplexing) that Jesuit scholars have given so much attention to geophysical observations. (Presumably Jesuits would not find this fact so strange: I suppose they believe that the Earth is part of God's creation, and so it is appropriate to study its measurable physical 'behaviour'. If I were a Jesuit, I would presumably have no difficulty in understanding why the Jesuit community has given so much attention to geophysics over the years.) So if geoscientists' metaphysical views happen to have been relevant to their geological work, then I may be interested. In the case of de Luc, I think his theism was so misguided that sometimes it is almost laughable (as Gillispie seemed to think); but it is nevertheless important to see how it operated within his geology. I am antagonistic towards creation science and intelligent design arguments today, as I think they are mistaken and are sometimes used for political and social ends that are pernicious. One should 'know thine enemy', so I am interested in books that explain how, when, where, and why creationism has flourished in the USA; itself a significant question for the social historian (of science).

I think, as do most people in the community of historians of science these days, that our work should not have anachronistic or whiggish elements (but see Oldroyd 1989). It should not be harnessed to nationalistic, political or religious ends, although if (for example) it can reveal the origins of the evils of the military–industrial complex I should regard that as a worthwhile accomplishment. These days, I mostly study what used to be called the 'internal' history of science; but looking at the 'external' contributions can certainly be every bit as important, and I have done work of that kind at times. (And, yes, I know that arguments can be developed to suggest that the internal–external dichotomy is a false one.) I value historical objectivity, or 'eticity', although that can sometimes yield a dull product. Also, surely anyone who studied the history of geology in the manner of Latour & Woolgar would produce a curious result. Moreover, as shown, an element of 'emicity' can sometimes lead one in interesting directions and yield useful results, although equally, it may lead one to overvalue the work of someone whose religious or philosophical views are particularly close to one's own.

In this paper, I have sought to show how theological commitments may 'modulate' the work of geohistorians. This can easily happen, and should be kept in mind by both writers and readers of history, although it is not necessarily going to lead to 'bad history'. Whether readers of this paper may think that my position as an atheist and a proponent of a naturalistic metaphysic has impaired my judgement I leave them to decide. I contend that historians do well to have a soundly based philosophical position; and I have stated my own position, but not argued for it here, as such an enterprise is not really appropriate to a book devoted to the history of geology *per se*. It is possible that a historian with a religious viewpoint or a worldview different from mine will come to similar conclusions. In fact, that ought to happen if I have accomplished my task successfully. On the other hand, 'mining' the history of science to support a contemporary theological position (as some creationists do) is not, I suggest, the appropriate thing for a historian to do, although it seems to me that naturalistic science does have things of importance to say that may (or should?) influence one's worldview.

I thank W. J. Kennedy of the Oxford University Natural History Museum for permission to reproduce part of a letter by Benjamin Richardson concerning de Luc, and H. S. Torrens and S. Bracknell for locating and identifying the document. I also thank the referees M. J. S. Rudwick and D. A. Young, along with M. Kölbl-Ebert, for their comments and suggestions, which I have endeavoured to follow as far as possible.

Notes

[1]The terms were introduced by the linguist and cultural anthropologist Kenneth Pike (1967).

[2]There had been some earlier usages of the word, but not in the same sense as it is used today. With de Luc, it acquired its modern meaning. Dean (1979) credited de Luc with being the first person to use the word in its modern sense; although Vai & Cavazza (2003) considered Aldrovandi to be the originator of the term

in the early seventeenth century. Dean reported the use of the word 'geologiam' by Richard de Bury in 1344.

[3]This well-known aphorism or adage was coined much later by Archibald Geikie in his *Founders of Geology* (Geikie 1897, p. 299). The concept, however, goes back well before then, at least to the times of Hutton and Lyell.

[4]De Luc's choice of journal is noteworthy. The *Letters* were published in *British Critic: Quarterly Theological Review and Ecclesiastical Record* between 1793 and 1796.

[5]This was the eighteenth unit (from the top) listed by William Smith in his initial tabulation of strata 'examined and proved prior to 1799' (Sheppard 1917, facing p. 127). Smith stated that no fossils were known in it. The 'Red Ground' rocks are today regarded as Triassic (Keuper Marl); and fossils have still not been found in them. I thank Professor Torrens for drawing my attention to this letter, for his identification of the *British Critic* reference, and information about the 'Red Ground'.

[6]But this is not for one moment to suggest that Rudwick has not done valuable work on the history of geology round 1800. On the contrary, he has enlightened us all by his detailed researches.

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Water and Inca cosmogony: myths, geology and engineering in the Peruvian Andes

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Abstract: Water was a key element in the Inca civilization (*c.* AD 1438–1534), both for their crops and as part of their vision of the cosmos. According to myths on the origin of the Incas, their civilization arose from the sea through one of its main manifestations, Lake Titicaca. Throughout the period of Inca dominance, as in some of the cultures that preceded them, water was a sacred element. This vision of the cosmos can be regarded as a hydrogeological model with similarities to the beliefs in force in Europe from the classical period until the end of the seventeenth century. Because of their excellent intuitive understanding of water, the Incas developed a complex irrigation system to channel water to their agricultural lands. Coinciding with the distribution of water, they organized periodical thanksgiving festivals, when farming communities gathered to celebrate the beginning of a new agricultural cycle with songs, dances and festivities. However, the centralized control of water resources introduced in the twentieth century led to the disappearance of many of these traditions and to the replacement of an irrigation system that had proved acceptable, by one that was alien to the customs and history of the country people. This led to the first conflicts over water control. As a result, the vision of the cosmos based on water and rooted in agricultural communities has been lost.

The origin of the Inca culture has not yet been discovered. It has been shown that, of the small kingdoms formed during the Second Intermediate Period in the Cuzco region, one of them was established by force of arms. What we currently know about the Inca Imperial period is well documented in 16th-century Spanish chronicles but they do not provide sufficient information about how that ethnic group was formed and consolidated its power. The Incas' history is full of legends that have reached us through oral tradition, but archaeological data are very scarce. One such legend concerns the ancestors of the Inca lineage, Manco Capac and his wife Mama Ocllo. From them until the last Inca, Atahualpa, the dynastic list known in the 16th century comprises 13 names. However, only from the ninth, Inca Yupanqui, onwards, can one consider the narrated dates and events to be real. It was around 1400 when the Incas established a 'state', after the defeat of the Chancas, a warlike people from the Pampas river valleys. In subsequent centuries, they expanded by conquering the inhabitants of the nearby valleys: the Lupazas, Collas, Huancas and Chancas (1438). At that time, the governor was Pachacutec ('the Earth's saviour'), who earned the title of Inca and became established in Cuzco. Therefore, the Inca civilization commenced as such in the 12th century, although 1438 is usually chosen as the year that the administrative and political structure of the Inca Empire began, or, alternatively, 1450, the start of the 'Late Horizon' period (named from an archaeological perspective). From 1450 onwards, the Inca Empire continued its military expansion and the cultural assimilation of conquered villages. The Inca Empire's northern border was near today's border between Colombia and Ecuador. In the south it reached central Chile and towards the east it reached NW Argentina (Rostworowski 1988).

The Incas divided their geographical space into four geopolitical quarters (*suyus*) which formed the entire territory (Tahuantinsuyu, land of the four quarters), whose centre was located in the city of Cuzco (Qosco, the centre of the world). The Chinchaysuyu (the coast and mountains of north Peru and Ecuador) was NW of Cuzco. The Antisuyu was NE (south and central Andes and the upper Amazon river basin). The Collasuyu (Bolivia and lake Titicaca, north Chile and NE Argentina) was towards the SE. The Cuntisuyu was south of Cuzco, and comprised the south and central coast of Peru and the Andes (Fig. 1; Urton 2003).

In addition to this quadripartite organization, the Incas had a dual vision that enabled them to

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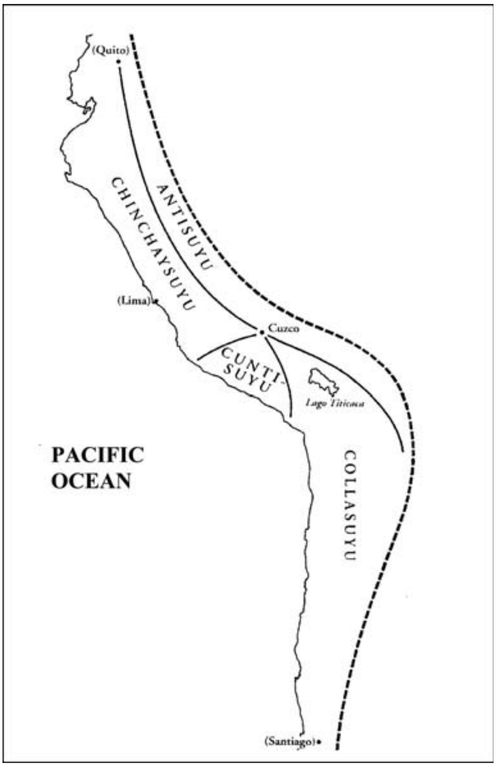

Fig. 1. Inca Empire in South America.

structure commercial exchanges based on reciprocal relations between peoples. That duality was justified symbolically by one of the myths about their origins, in which Cuzco was founded with the participation of two dynasties (Hanan and Hurin); these names were later transferred to the Incas' administrative reality. Each of their cities, starting with Cuzco itself, was divided into two halves: Hanan (the upper half) and Hurin (the lower half). Even the Tahuantinsuyu was divided into two halves: Hanansaya (with the Chinchaysuyu and the Antisuyu) and Hurinsaya (Collasuyu and Cuntisuyu) (Zuidema 1991).

The third component of their view of the world was a tripartite organization. Their world was stratified into three levels: Hanan Pacha (the higher world, inhabited by the main gods in their pantheon: Viracocha, Pachacamac, Mamacocha, etc.), Kay Pacha (the middle world or Earth's surface, inhabited by living beings) and Hurin Pacha (the lower world, inhabited by the dead). The springs (*pukyu* in Quechua), caves and all types of openings in the Earth's crust were considered to be communication routes between Hurin and Hanan Pacha (Sherbondy 1992). That tripartite organization also manifested itself in real life with the existence of three hierarchies: the Collana (Inca chiefs) the Cayao (the defeated non-Inca people) and the Payan (a group formed by the union of Inca and non-Inca people).

In addition to these symbolic and organizational expressions, water was the focal point of the Inca cosmogony (Mazadiego & Puche 2004; Bosch 2005). The Inca civilization considered itself as arising from water, and, it extended its control through water. There was a very close relationship between cosmology, religion, and social and political structure during the Inca Empire (D'Altroy 1987; Williams & D'Altroy 1998). In the Andean cosmos model, the lower part was filled with the original sea ('the cosmic sea'). When the upper surface of these deep waters reached the surface of the land, lakes and rivers emerged. The sea was regarded as the Mother (*Mama Cocha*) and the lakes, rivers and lagoons as daughters (*Cochas*). The deep waters followed a 'centrifugal' movement, from inside to outside the Earth (Sherbondy 1984), creating a flow as if they were underground rivers that emerged in the shape of springs; these springs, in turn, fed the rivers that flowed into the sea. Thus the Incas considered that surface waters and underground waters originated from the sea.

The Andean vision compared with European hydrogeological theories

Until the seventeenth century, in Europe it was generally accepted that the waters in rivers and springs had no connection at all with atmospheric precipitation, which was believed to be insufficient to contribute to the flow of rivers. Furthermore, people believed that the Earth's surface was too impermeable for rainwater to filter through.

The first hydrogeological theories were developed by the Greeks. Thales of Miletus, around 650 BC, held that springs and rivers were fed by water from the ocean that filtered into the land and that, eventually, as a result of high pressure, emerged as springs (Puche 1996). This theory displays many common aspects with the Inca vision of the cosmos: a closed circuit where the rivers are generated by seawater that, once it has filtered through the subsurface, creates underground watercourses that form the rivers on the surface. Plato (427–347 BC) also held this hypothesis, although he asserted the existence of a great cavern, which he called Tartarus, into which all surface waters flowed and from which they emerged (Plato 1985).

During the Roman period, Lucretius and Pliny endorsed the Greek theories; Lucretius, in his book *De Rerum Natura* (Lucretius 2003; Pliny 1995), postulated a hydrological cycle in which water evaporates from the surface of the land and sea and falls back as rain. That idea also appeared in the Inca culture, which personalized this into elements of their cosmogony. The god Huiracocha travelled from lake Titicaca to the ocean, which symbolized the flow of the water along the rivers (*mayu* in Quechua) to the river mouth. The water was then drunk by the Llama constellation (*yacana*), the flow process would begin through the Milky Way (also called *mayu* like the rivers) and the water would finally return to Earth as rain (Zuidema & Urton 1978).

During the European Middle Ages and until the end of the sixteenth century, it was still believed that all water came from the sea. This idea was based on a number of biblical passages, which were taken literally, such as the following: 'All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come, thither they return again' (Ecclesiastes 1: 7–9). These ideas continued to be upheld until the seventeenth century. Scientists such as Kepler (1571–1630), Kircher (1602–1680) and Descartes (1596–1650) held that all water came from the sea (Kircher 1664; Solís 1990). Descartes, for example, stated:

> There are large cavities full of water under the mountains, where the heat from the light of the sun continuously produces vapours, which, being nothing more than tiny droplets of water separated from each other, escape through the pores of the earth and reach the highest plains and mountains where they regroup and form the springs, which flow down the valleys, join, form rivers and eventually flow into the sea. Although this process causes great amounts of water to escape from the said cavities under the mountains, they never empty completely. This is because there are many channels through which seawater reaches the said cavities in the same proportion as water escapes to the springs (Descartes 1644).

Hydrogeology emerged as a science, towards the end of the seventeen century, when scientists such as Palissy or the priest Pierre François rejected the Greek water cycle theories (François 1563; Palissy 1957).

The sacred nature of the Inca hydrogeological theory: the origins of the Inca universe

The Inca hydrogeological model was the basis of the cosmological vision that explained their origins. According to their beliefs, the Inca universe originated in the cosmic sea, although Inca tradition also referred to one of the manifestations of this sea, Lake Titicaca, as the birthplace of the Sun, the Moon and the stars. A vertical movement led to the creation of the rivers and lakes, from which water filtered through the subsurface to feed the underground watercourses. Therefore, in the Andean world, water classification was of prime importance because of its symbolic significance. There was water that flowed along the surface, water that flowed along the subsoil and seawater. Seawater had a major significance in purification and fertility rituals, and, like seashells, played a major role in the worship of hills during the rain ceremonies (Urton 1981).

In most Inca settlements water was considered as feminine; it was regarded as the sacred milk that flows from the hills and mountains (considered as male). In 1571, Polo de Ondegardo stated that the Incas 'offered seashells to the fountains and springs, affirming that the shells were the daughters of the sea, the mother of all waters' and that they also presented shells to the hills to plead for rain (Polo de Ondegardo 1917).

The Incas believed that they had to pray to the hills and mountains to favour the start of the rains. Thus there was an association between the 'forefathers (ancestors)–origin–founding of villages–water (upwellings, lakes)' group and the 'mountain–water–fertility' group. In effect, the mountains were considered as divinities that acted to bring about rain in the places inhabited by the god Wamani and all the other gods who controlled the water circulation through the canals (Reinhard 1983; Farfán 2002). This is the reason for most of the pre-Hispanic settlements being located on hills and oriented towards their *pacarina* or place of origin (a lake or hill).

The Inca origin: Cuzco and water

Of the various versions of the mythical origin of the Incas, the most widespread was compiled by the chroniclers Martín de Murúa and Guaman Poma de Ayala. According to them, the Inca ancestors crossed the subsoil from Lake Titicaca to the Pacaritambo cave, which is around 33 km from Cuzco. The site's ruins are currently called Mauqallaqta ('Old City') (Martín de Murúa 1964; Guamán Poma de Ayala 1980). From that site, the Inca ancestors went to the valley of Cuzco where, after conquering the inhabitants, they established political and administrative structures that gave rise to their Empire. The Incas considered that they were the first people to have been created, so they had the honour of dressing in clothes decorated with gold, the symbol of the Sun, and of wearing large ceremonial ear flaps (*orejeras* or *orejones*) (Cieza de León 1943; de Betanzos 1987). They believed that all the people of the world were created in Lake Titicaca and then moved through the underground watercourses (the 'veins of Mother Earth', *Pacha Mama*), until they came to the surface through springs, upwellings, rivers, lakes and caves. These places were called *pacarinas* ('places where nations dawned') (Earls & Silverblatt 1976).

Rituals of foundational water

When they chose a new governor, the Incas would take water from Lake Titicaca in memory of their origins. Later, given the expansionist nature of their culture, when they settled in a new place, they would take water from the former *ayllu* (village or community), pour it out and give the name of their old upwelling place to the new settlement (Albornoz 1984). It was a way of legitimizing their power through the original water from Lake Titicaca. The most important surface water bodies for the Inca were Lake Titicaca, Lake Choclococha (central Andes) and the sea (for the coastal villages, both the Paracas area and the NW coast of Peru) Water thus became a unifying element for the villages, the Incas (the conquerors) and the new settlements (the conquered). The objective was to ensure complete integration in the new site. For example, Lake Coricocha, around 12 km from Cuzco, was the mythical reference of the Huayllacan people. When the Inca Roca married Mama Micay, the woman-chief of the Huayllacan, a commitment was established between the two peoples, and recorded as follows by local tradition: 'The Inca Roca married a woman named Mama Micay, the chief of the Huayllacan people. . . . Once the festivities were over, the now married woman said that those lands did not have sufficient water for irrigating the corn fields. So the Inca Roca brought the waters and it became a family duty to distribute the water with which the valley was irrigated' (Cobo 1957).

At present, the farmers believe that the water used for irrigating their fields comes from Lake Coricocha and that it reaches them through underground canals built by the Incas to endorse their common origins after the marriage between the Inca and the woman-chief. The idea was to establish a common territorial unit based on water distribution in the area of the old village of Guayllamán, which became part of the Antisuyu, one of the four Inca political divisions.

The cult of water

The cult of water manifested itself in diverse ways in the Inca world. In addition to appearing in the legends of their origins, water also appeared through the *paccas* (i.e. the objects used to adore the liquid element). In the ceremonies that took place in the city squares, *chicha* (an alcoholic beverage made from maize) was poured over the idols and into the irrigation canals. According to the Inca beliefs, water had the power to wash away impurities and, therefore, stave off evils and illnesses. One of these festivities, perhaps the most important one, took place in Cuzco, just before the start of the rainy season. A procession took place with four groups (symbolizing the four divisions of the Inca Empire). One group would go to the river Collasuyu, another to the river Quiquijana, another to the river Apumírac and the other to the river Urubamba. Once they had bathed themselves in the river, they believed that they had staved off their misfortunes. Meanwhile, the inhabitants of Cuzco bathed themselves in the fountains (Zuidema 1991).

Hypothesis on the Inca's geological knowledge

Irrigation water was a very important element in the consolidation and survival of the Inca civilization as it enabled them to grow corn, a vital product for their economy and religion, and maintain pastures for llamas and alpacas. It has been proved that the layout of some cities was based on hydrological criteria. The most obvious case is Cuzco, where administrative districts were organized, inside the metropolitan area, based on irrigation systems (Sherbondy 1987); that is, first the channels that transported the water were installed and later the city was divided into districts.

The Cuzco cosmogony was based on the dual division of Hanan Cuzco (the higher quarters) and Hurin Cuzco (the lower quarters), based on the hydrological features of the Huantanay River, which irrigates the district. Hanan belonged to the hilly and mountainous areas, the source of the life-giving rivers, and Hurin belonged to the valley, the widening of the basin and the flow of the water through the fields. Each of these parts was dedicated to a dynastic ancestor, who was associated with the mythical construction of the hydraulic works and the channelling of the water. The canals built by the Inca predecessors were considered to be sacred and thus were included in the myths about their origins. The Incas worshipped their ancestors, so, to make the history of their people sacred, in their legends they re-created the fact that those predecessors discovered the water sources that they later turned into canals (Sherbondy 1982).

This dual hydrological principle also led to political and social hierarchies. Hanan Cuzco was more important than Hurin Cuzco, simply because it was linked to the source of the waters. Also, considering not only the central area of Cuzco but also its outlying neighbourhoods and satellite villages, one can see that a radial pattern of organization was designed based on a series of lines (*ceque* in Quechua) that could be considered as radii that divided the territory into sectors (Sherbondy 1982, 1984). Each half ('upper' and 'lower' areas) was, in turn, divided by lines that originated from the city centre. The purpose of this layout was to indicate the sources of water for the irrigation channels in a town and connect them symbolically at a central point, and to indicate the borders between areas by radiating lines.

This radial organization has been confirmed in many Andean towns, such as, for example, in present-day San Andrés de Machaca (Bolivia). It is, therefore, not surprising for Polo de Ondegardo, the colonial administrator (magistrate) who investigated the religion, customs and superstitions of the Inca, to have written, in 1571, that 'it is not possible to understand the organisation of the Inca Empire without studying the "*ceque*" system' (Fig. 2). The description of the Cuzco *ceques* commenced in 1653, when Father Bernabé Cobo identified 41 *ceques* that radiated from the temple of Coricancha.

Bauer (2000) studied the 328 *huacas* (sacred sites) described by Cobo, and classified them based on their typology (Table 1). We can see that the Inca chose manifestations directly or indirectly linked to geology (streams, rocks, geological formations and quarries) as their sacred places. However, these conclusions are difficult to extrapolate to the Inca reality. Writing was unknown by the Inca culture. Therefore, everything that we know is based on chronicles that were written years after the end of that empire, especially those written by Europeans. Because we do not have any documented confirmation of the degree of geological knowledge of the Inca people, anything that we might say is only a hypothesis. Nevertheless, according to Menegat & Porto (2007), we can accept that the Inca not only based most of their cosmogony on water but they also based this

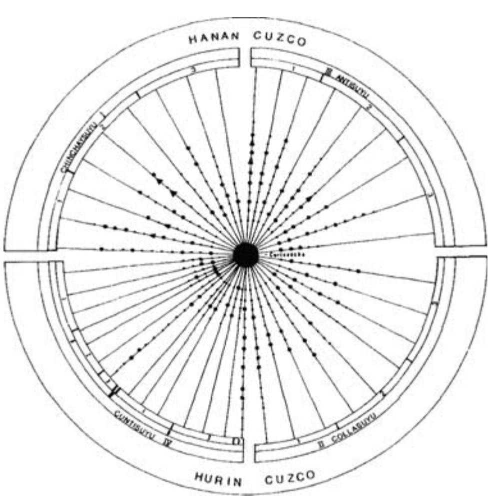

Fig. 2. Imaginary lines (*ceques*) with a group of *huacas* from Coricancha in Cuzco (Sherbondy 1987).

Table 1. Huacas *related to geological elements, according to Bauer (2000)*

Type of *huaca*	Number	%
Water sources	96	29
Rocks and geological formations	95	29
Hills and mountains	32	10
Inca palaces and temples	28	9
Plains	28	9
Tombs	10	3
Gullies	7	2
Caves	3	1
Quarries	3	1
Stone seats	3	1
Sunset signs	3	1
Trees	2	1
Pathways	2	1

intellectually on what those researchers defined as 'landscape geoforms' (Farina & Belgrano 2004). That hypothesis is corroborated by the relatively large number of *huacas* related to geology. Menegat & Porto also suggested that the Inca culture considered geological faults as a landscape unit for their cities, especially around Cuzco. Those researchers considered that the Incas constructed around faults based on their scale and the blocks of rock that they could cut for use as walls. Indeed, in both Machu Picchu and Ollantaytambo, or the Inca's Baths, faults were interpreted as phenomena in which water was replenished and as an ideal location for urban or ceremonial settlements.

Pre-Hispanic irrigation systems

Several methods of channelling water were used by the Incas and other people in the Andes. Sunken fields (*huachaques*) drew water from the subsoil by filtering it, and plants such as reed mace and rush were subsequently sown. Terraces and plots were constructed in the mountains, with the aim of limiting the loss of nutrients in spillway waters to lower levels. Sunken gardens (*chacras* or *mahmaes*), used in coastal areas, were constructed by removing loose sand and earth to obtain a damp basin of subsoil that was favourable for sowing. Sunken basins (*qòchas*) followed a similar procedure to that used for the *chacras*. Canal systems, especially in the valleys, helped to move water from its collection points to the cultivated areas. *Waru Waru*, in the province of Puno, was carried out using raised embankments over the land surface, alternating canals with bands of stones on the basin (Deza 2002).

The only irrigation system that was used was underground aqueducts (Fig. 3), such as the one in Cantayoc (Nazca). They were narrow canals designed to take the water to a number of storage

Fig. 3. Underground aqueduct in Nazca (photograph by Luis F. Mazadiego).

points (*cochas*) from where it was taken to the fields through canals. The walls of the aqueducts were covered with stones fitted together with the help of guarango wood. Throughout the aqueducts, there are wells (*eyes*) that ventilate the system and through which the canals could be cleaned. These constructions are still the object of a ritual in which the farmers give thanks for the water that reaches their lands; this tradition is related to the Inca custom of worshipping the initial waters that arise from the subsoil as the most sacred ones, as a result of having a close contact with *Mama Pacha*.

Irrigation systems today

The dual division or organization (Ossio 1976) has had a significant effect on the spatial, social and political reality of Andean communities since pre-Columbian times. The Hanansaya and Hurinsaya organization was a key element in the geopolitical stability of the Inca Empire. This dual nature inspired a clearly symbolic element that was also linked to fertility. Extensive evidence has been collected that alludes to a number of traditional festivities during which the community was divided into two parts, as a way of representing both sexes and, by means of games, plays and prayers, they invoked the fertility of the land through irrigation or, more generically, rainfall. Even today, Andean agricultural communities elect a so-called 'water mayor', who holds this position for about 50 days, the duration of a complete irrigation water distribution cycle.

In the Inca villages and now in the Andean world, water is the origin of life. Sharing water becomes a kinship relationship, just as in the Inca Empire it was used to seal friendship between villages through a unified cosmogony. The irrigation technology was transmitted from generation to generation as a cultural heritage that was necessary for survival. Water was regarded as sacred and so were the irrigation canals, such as 'Achicaria', located in Ica, south Peru. The legend related to this canal is as follows: 'In 1412, the Inca Pachacutec . . . embarked on the conquest of the Ica valley. In one of his raids, he fell in love with a maiden named Mama Chira, whom he courted and told her to ask him for anything that she needed. She replied that she would be satisfied if he provided water to her community. In the next ten days, 40,000 Inca soldiers opened a riverbed to take the water to that place'. As we have seen, water was used as a unifying element between two groups of people with opposing interests: one wants to conquer new territories whereas the other wants to defend itself from the invaders (Oré 2005).

It must be stressed that this dual distribution of the irrigation system and of other local activities (e.g. grazing, agriculture) continued even after the arrival of the Spanish Conquistadores. These, by means of the so-called *encomiendas* (concessions of native labour) based their organization on the *sayas* (Hurin and Hanan). Later, after independence, this division into two parts continued, for example, in the collection of taxes, which was performed independently in each half.

This dual organization remained the essence of country life until the middle of the twentieth century, when a number of administrative reforms reorganized the districts. However, extensive proof of its existence can still be found, both at folkloric level (festivities, celebrations) and in the use of the land (in the higher regions, farmers still take their animals to graze in the same upper districts or Huaran).

Conclusions

Inca cosmology presents many common points with the hydrogeological beliefs held in Europe from the Greek (Thales of Miletus, Plato) and Roman period (Lucretius, Pliny) until the end of the seventeenth century (Kepler, Kircher, Descartes), when finally the theoretical models that led to the birth of hydrogeology as a science were developed. The Incas held that rivers, springs and lakes stem directly from the sea and that, through underground courses, seawater rises to the surface to create a closed cycle. Furthermore, the Incas identified evaporation and rainfall as additional factors. This hydrogeological theory was given a sacred quality, as it was part of the foundational myth of the Inca Empire, based on water from the sea through one of its most significant manifestations, Lake Titicaca. This understanding of hydrogeology enabled the Inca people to base their entire political, social, economic and religious organization on the channelling of water through sophisticated irrigation systems, which were linked to Andean ethnohistory by religious symbolism.

Some researchers (Alva Plasencia *et al.* 2000; Gelles 2000) have considered that the present water distribution system, centralized by local political agencies, has breached the ancient tradition of sharing irrigation water and has led to a number of social conflicts. Furthermore, one of the major demands presented by the native people has been the preservation of the purity of water that has been polluted by industrial discharges. For native communities located near mines, one of their chief demands harbours a symbolic quality, linked to their religious beliefs. They demand the right, not only to preserve their rivers, which are affected by uncontrolled discharges from mineral treatment plants, but also to maintain their relationship with water by means of communal control over it.

On this subject, the conclusions of the second World Water Forum (2000) stated that: 'having studied the documents presented to the Forum, native populations and their traditional values, knowledge and systems have been ignored during the present process'. In a way, the policies of the countries in the Andean region have led the native peoples to renounce their traditional beliefs and their ethnic identity in exchange for progress. As a result, the new water control strategies have increased social conflict, which had been kept to a minimum by the irrigation structure used during the age of the Incas.

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Explanations of the Earth's features and origin in pre-Meiji Japan

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Abstract: Pre-Meiji Japan was a religiously rich and intellectually varied country, where a large number of theories and beliefs about the origin of the Earth and its features coexisted. The history of science, and the history of geology in particular, lacks an account of this fertile and stimulating socio-cultural system and intellectual environment. The present paper aims to contribute to its understanding, by providing an overview of the most influential religious and scholarly approaches to geological topics in Japan from the eighth century to 1868. The comparison of explanations and beliefs on subjects such as fossils, volcanic eruptions, mountains and the origin of the Earth, and the analysis of geological expertise confirm the heterodox and holistic tendency of the Japanese intellectual and religious environment, which has had positive and negative outcomes for scientific thinking. It also reveals the importance of power structures, and of the social division of labour and knowledge, in the shaping of the Japanese intellectual and religious history.

The Meiji period (1868–1912) represents a great turning point in Japanese history. After more than two centuries of almost total closure to the world, the conquest of power by the Meiji élites in 1868 signalled the beginning of deep and rapid changes in Japanese society. Among the many reforms undertaken, a programme for the large-scale introduction of western sciences and technologies was initiated, compulsory education was organized, and the country rapidly began industrializing and constructing a nation state modelled on the example of the European powers. The last decades of the nineteenth century are also considered to be the time when geology was established as a science in Japan. The first universities were founded in the 1870s, science teachers were hired, and the Geological Society of Japan was founded in 1893. A substantial amount of research, in Japan and in the west, has been devoted to the history of geology after this official introduction as a western science. The works and biographies of the first western scientists in Japan are well documented, and have been comprehensively analysed and described. For example, we may cite a paper by Martin (1995) on the geological research of the US zoologist Edward Sylvester Morse (1838–1925), or the observations of Tanaka (2004) on the activities of John Milne (1850–1913). The first western geologists in Japan wrote about their work, as is the case for the first geological mapping of Hokkaidō in 1877 (Lyman 1877) by Benjamin Smith Lyman (1835–1920). Also, at the end of the nineteenth century the first Japanese geologists appeared and the bibliography of geological writings in Japan, both in English and Japanese, started to grow rapidly.

However, there are very few studies on the approaches to geological features in pre-Meiji Japan. There is no specific study on the historical development of geological knowledge and techniques, and no research on the relationship between religion and natural sciences or geology. The few passages on the contribution of Chinese geological expertise and theories in Japan, included in the book *Chinese Sciences and Japan* by Yabuuchi (1978), or the paper 'Science and Confucianism in Tokugawa Japan' by Craig (1965), are two examples of the potential for a study of pre-Meiji intellectual approaches to nature, and of the little space dedicated to this subject.

This lack of knowledge is disappointing from the point of view of science historians and scholars of Japanese history and anthropology, and is regrettable from the perspective of the history of knowledge and sociology. Understanding the history of geological interpretations, or of mining and mineralogy, and the history of the relationship between religion and geology in Japan before the introduction of western scientific methods, and more generally the approach of pre-Meiji Japanese culture to natural sciences, means achieving a deeper understanding of a number of facts. For example, understanding the changes to Chinese geological knowledge and technologies after their introduction in Japan, and the reasons governing such changes, would give us some insight into the social and historical forces that shaped proto-scientific, technical or rational thinking in Japan, and more generally the issues involved in the interactions between rational thinking, craft knowledge, beliefs, societies and the

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understanding of the Earth. 'Nature' and 'Earth' are not neutral concepts; they are culturally and historically defined and constructed. Geological thinking, too, is a cultural product, and, especially in its proto-scientific, religious or mythological form, cannot be thought of as being independent of socio-cultural and historical contexts.

On the other hand, in the voluminous literature on Japanese religion, there are many references to the ideas about the Earth held by pre-Meiji Japanese. The same can be said about the rich bibliography developed on the intellectual and the general history of the archipelago. Moreover, research on the history of Chinese natural sciences and geology is well developed, especially as a result of the contributions of Joseph Needham and Yabuuchi Kiyoshi. In this context, the present paper is a preliminary step in the direction of a general overview that draws from these literatures, and considers Japanese religious conceptions about the Earth, its history, its phenomena and its characteristics. The present paper is not a history of geology in pre-Meiji Japan. I aim, more simply, to conduct a preliminary discussion on the following three questions about pre-Meiji Japan. Which were the most popular or influential religious and mythological explanations of geological subjects in pre-Meiji Japan? Which were the most popular ideas on the formation of the Earth, the Earth's age, and geological features and phenomena such as fossils or earthquakes? What is the relationship between religious, scholarly and dominant interpretations on geological matters? To answer these three questions it will often be necessary to digress from the analysis of explanations on geological features, and become involved in more general study of myths, and of the religious and intellectual history of Japan. Because interpretations of geological facts, as well as of nature in general, were often of a religious and philosophical nature, and can appear in treatises on disciplines as remote from geology as ethics, the analysis of such 'geological' thinking is often an epistemological study.

Preliminary observations

First, it is necessary to clarify some points related to Japanese intellectual and religious history. In the present paper the term 'Japanese culture' refers to a varied ensemble of beliefs and cultures that are observable throughout the history of the various societies that have inhabited the Japanese archipelago. The use of the singular form does not imply the acceptance of a common definition of 'Japan' as a historically, ethnically and socially homogeneous society, nor the acceptance of the existence of a Japanese spirit (*Nihon no kokoro*) since ancient times until today, such as has been assumed by many Japanese scholars. Projecting such contemporary mythological constructions of a national identity onto the past is a historically inaccurate distortion of reality with no scientific justification.

From prehistoric Japan an ensemble of beliefs and views on the Earth and on nature has survived, although with important changes, until today. Collectively labelled Shintō, these beliefs and socio-religious institutions are an essential constituent of Japanese religious and intellectual history, and are still an integral part of the socio-cultural approach to many geological features, such as mountains or cinnabar ores. The philosophical and religious traditions that came from China and Korea, starting around the sixth century, such as Taoism, Confucianism and neo-Confucianism, and the different schools of Buddhism, became an integrating feature in Japanese culture and influenced, among other things, views on nature, the Earth and geological features. Together with these cultural elements introduced from the continent, were also theories and speculations on the Earth and on geological matters, as well as expertise and knowledge on mining and mineralogy. The 'foreign' religions, technological expertise and philosophies added new views and beliefs to the existing ones, but did not erase them. Moreover, they stimulated a synthesis between different doctrines and concepts, so that a number of philosophical theories and religious beliefs resulted from the interaction of continental and local thinking. From a religious point of view, these theories usually go under the name of *shinbutsu shūgō*: literally 'synthesis between Shintō and Buddhism'. These unifying theories and theologies also involved many elements of Taoism and, to a lesser extent, of Confucianism. When Buddhism was introduced in China, it was interpreted and translated using many Taoist words and concepts. Thus a first synthesis had already happened outside Japan, and the forms of Buddhism that arrived in Japan included many Taoist elements. An idea of the length and complexity of the process labelled *shinbutsu shūgō* is given by the great number of myths and theologies that have been created to explain (or prove) the identity between Shintō Gods and Buddhas, for each of a large number of divinities of the extensive Shintō pantheon. This syncretistic approach was based on the idea that the local Gods were avatars, or manifestations, of the Buddhas. There were also explanations that reasoned the other way around, and saw the Buddhas as extensions, outside Japan, of the local Gods.

Because it is easier (and long established) to think about Buddhism, Shintō, Confucianism and Taoism as separate, independent traditions, scholars of Japan often distinguish these four major schools, and I will follow in this simplification. However, this does not correspond to the reality of pre-Meiji Japan's speculative and religious life, where we can easily count more than a hundred religious and philosophical groups, schools or sects. Virtually all of them had a syncretistic approach, incorporating elements of at least two of the above-mentioned traditions.

The myth of Izanagi and Izanami

If we define the beginning of 'history' as the moment when a society starts writing, Japan's history began with the adoption of the Chinese writing system, by the political and intellectual élites, in around the sixth century AD. However, the first complete documents that have survived are the *Kojiki* (712), usually translated as *Records of Ancient Matters*, and the *Nihonshoki* (720), or *Chronicles of Japan*. These two texts include the mythological and historical patrimony of some of the ancient inhabitants of the Japanese archipelago (who became the dominant culture), ranging from explanations of the origin of the world, to more historically related chronicles of the first kings and emperors. These texts are very important because they give us an insight into prehistoric and early historical Japanese ideas about the Earth, and because their content has been interpreted and used through the centuries (and still is today) by intellectuals, politicians and priests, to explain the contemporary state of being, and sometimes to justify alleged 'original' and 'indigenous' views as opposed to imported and foreign cultures.[1]

The *Kojiki* and the *Nihonshoki* often have the same content, although they were compiled for different purposes. The former was intended for internal use: the rulers ordered its creation to impose an official view on historical and mythological matters, putting together the myths and traditions of different clans. It was 'shaped and tinted by urge to exalt an imperial line running from the Sun Goddess . . . to the emperors and empresses reigning in the seventh century' (Hall 1997, p. 2), as it is clearly stated in the introduction:

> The Heavenly Sovereign commanded, saying: 'I hear that the chronicles of the emperors and likewise the original words in the possession of the various families deviate from exact truth, and are mostly amplified by empty falsehoods. If at the present time these imperfections be not amended, ere many years shall have elapsed, the purport of this, the great basis of the country, the grand foundation of the monarchy, will be destroyed. So now I desire to have the chronicles of the emperors selected and recorded, and the old words examined and ascertained, falsehoods being erased and the truth determined, in order to transmit [the latter] to after ages (Chamberlain 2005, pp. 10–11).

The *Nihonshoki*, on the other hand, was written in Chinese, and was to be presented at the Chinese court, the great power of the time and one of the main sources of political legitimacy. When reading these first two texts we need to remember their political intent, which probably bent some traditions to political interest and excluded others. Both texts followed the pattern of a progressive passage from chaos to order thanks to divine intervention. They both 'divide time into discrete ages: (1) chaotic time, or acosmic time . . . (2) cosmogonic time, or the divine age . . . (3) legendary time, or the heroic age . . . (4) historical time′ (Metevelis 1993, p. 384).

At the beginning, three primeval Gods 'were . . . born alone' (Chamberlain 2005, p. 4), according to the *Kojiki.* It should be noticed that the terms 'God' and 'divinity' are translations of the Japanese word *kami*, which has a wider meaning than its English counterparts and includes a pantheistic and animistic conception of 'divine'. A *kami* can be a God as in the western sense, an anthropomorphic or zoomorphic superior being, or a higher form of intelligence, but it can also be a form of energy, a particular feature of nature, such as a rock, or a mountain, or even a very old tree. It can be benevolent or malevolent, or neither. The ancestors are also *kami*. Although the origin of the Earth was not clearly explained in either text, there is a passage in the introduction of the *Kojiki* about a change from a chaotic universe to an ordered one, thanks to divine action. This explanation is more speculative than the rest of the text, and includes concepts of Taoist origin, such as the distinction between form and force, or the existence of passive and active energies. Moreover, this passage is included in the introduction, written by and for a ruling elite educated in Chinese culture, as a presentation of the following corpus of myths and records. Therefore, its value as a document on pre-Chinese vision about the Earth is disputable:

> when chaos had begun to condense, but force and form were not yet manifest, and there was nought named, nought done . . . Heaven and Earth first parted, and the Three Deities performed the commencement of creation; the Passive and Active Essence then developed, and the two Spirits became the ancestors of all things (Chamberlain 2005, p. 4).

The two spirits, a male and a female *kami*, were Izanagi and Izanami, the two ancestral Gods who created most of the existing divinities, including the islands of Japan. The myth of these two Gods is very useful to understand ancient Shintō ideas about the Earth, its (divine) origin and nature. Izanagi and Izanami were ordered by the other Gods to 'make, consolidate, and give birth to this drifting land', as the Earth was 'young and like unto floating oil', and 'drifted medusa-like' (Chamberlain 2005, pp. 17–18). The divine couple was given a spear, and standing upon the Floating Bridge of Heaven, pushed down the jewelled spear and stirred with it, whereupon, when they had stiffed the brine till it went curdle-curdle, and drew [the spear] up, the brine that dripped down from the end of the spear was piled up and became an island. This is the Island of Onogoro. Having descended from Heaven onto this island, they saw to the erection of a heavenly august pillar, they saw to the erection of a hall of eight fathoms (Chamberlain 2005, pp. 21–22).

Izanami and Izanagi then copulated, and from their sexual intercourses were born 14 islands and 35 deities, all listed in the *Kojiki* with their names and attributes. The first things to be created were the eight major islands of Japan. The other divinities were concerned with order on the Earth: they ruled over (and were) the oceans and the waters (e.g. the deities Great-Ocean-Possessor, Water-Gates, or Earthly-Water-Divider), the atmosphere (e.g. the deity of Wind), and the Earth (e.g. deity of Trees and deity of Mountain).

From this myth we can see that the ancient Japanese had an animistic concept of the Earth as consisting of divine islands in the ocean, a vision of the world of pre-historical (and possibly Malayo-Polynesian) origin, which mirrored the collective experience of the people who conceived it. Logically, in historical times such a view could not remain unchallenged by the confrontation with the existence of China and Korea, or of the many countries and regions cited in the Buddhist and Chinese literature such as India, Central Asia or SE Asia. However, the idea of a sacred and divine genesis of the Japanese islands did not disappear, and has survived until today. Generalizing, we can say that in historical times this myth has often been explained not as the description of the creation of the Earth, but as the account of the birth of the sacred Japanese archipelago and of the sacred Japanese nation. Such ideas were not the prerogative of popular religion: they were discussed by scholars and played an important role whenever differences (often politically motivated) surfaced between partisans of the indigenous and of foreign cultures. The ancient texts were very useful instruments for nativists of all times. Let us consider, for example, Motoori Norinaga (1730–1801), one of the greatest philologists in Japanese history, and one of the most renowned among the nativists of the Tokugawa period (1600–1868). He considered the *Kojiki* as completely and historically authentic. In his *Naobi no mitama* (*The spirit of the deity Naobi*, fourth and final version published in 1790) he made it clear that what was written in the Kojiki is true. He wrote that 'all things in this world are the design of the Gods' (Nishiyama 1991, p. 24) and that 'Japan is where the awesome Sun Goddess, the ancestor of all the Gods, appeared. This is why Japan is superior to all other countries ... She decreed that Japan was the land where her descendants would reign forever' (Nishiyama 1991, p. 27). Norinaga was a member of a group of nativists called *kokugaku* (literally 'national learning'), which, during the Tokugawa period, was in opposition to the dominant and Sino-centric, neo-Confucian schools. Among the 'national scholars' who held similar views, were Kamo no Mabuchi (1697–1796), a poet and philologist who sustained the divine origin of Japan in the essay *Kokuikō* (*Thoughts on the Idea of Nation*, 1765), and Hirata Atsutane (1776–1843). The latter incorporated in his theological philosophy the works on natural sciences by Jesuit missionaries such as Diego de Pantoja (1571–1618), Giulio Aleni (1582–1649) and especially Matteo Ricci (1552–1610). In more recent times, the concept of 'the divine nation' has been reused for propagand a purposes by militarists.

The myth of Izanagi and Izanami also gives us a glimpse of one of the ancient Japanese ideas on the structure of the universe: a heavenly world, residence of the first ancestral Gods, called 'the plain of heaven', existed above the Earth. From the development of the story of Izanami and Izanagi, we also know that there was an underworld or kingdom of the dead. In fact, after giving birth to the God of fire, Izanami died because of the burns she received to her genitals. Izanagi, unable to accept the death of his beloved wife, followed her into the underground kingdom, to bring her back. However, the view of her decomposing body disgusted him, and he fled. Once outside the underworld he blocked its entrance with a rock. The *Kojiki* gives the specific location of this place: the Ifuya pass in the region of Izumo, in Shimane prefecture on the southwestern coast of Honshū. From the actions that followed his separation from his beloved, and from his ablutions in the Tachibana River, a number of new deities were born. Among them, from the washing of his right eye was born the moon, and from that of his left eye the Sun, ancestor of the imperial family, a female deity called Amaterasu.

Buddhism and the metaphysical approach

A major difference between Shintō and the continental philosophical and religious traditions has to do with the concept of time, which influences also the notion of origin. Time in Shintō is linear. The *Kojiki* and the *Nihonshoki* gave specific dates, starting with the first, semi-mythical Emperor Jinmu, who was born, according to the *Kojiki*, in 660 BC. The texts also listed the genealogy of all the descendents and ancestors of Amaterasu. Her great-grandson, Hikohohodemi no Mikoto, was the grandfather of Emperor Jinmu. There were therefore eight generations from the first generation of Gods to the first Emperor. The origins of the universe and of the Earth, according to the mythology of the *Kojiki* and of the *Nihonshoki*, were therefore eight divine generations before 660 BC. Eight was a symbolic number associated with the meaning of great or infinite quantities, as also shown by the famous expressions *yao yorozu no kami*, literally 'the eight myriads of Gods'. To my knowledge, no attempt was made, based on the Kojiki chronology, to calculate the Earth's age.

Markedly opposed to Shintō's linear conception of time is the Buddhist idea of cyclical time, which had a very strong influence in Japan. Furthermore, Buddhist teachings and metaphysics diverge greatly from Shintō's conception of a divine Earth created and made of matter. One of the philosophical foundations of Buddhism is the principle of the illusory nature of the world. In Japan, as in China, this notion has boosted the development of doctrines that we can generalize as idealistic and based on the assumption that reality occurs only in the mind. These theories eventually caused an attitude of disregard towards the empirical observations of nature, a great 'weight . . . on the scale against . . . science' (Ronan 1997, p. 250). Buddhism has been the tradition that contributed the least to theoretical speculation on geological features and phenomena. However, Buddhist monks participated in many activities such as mining, the study of ores, and copying and making commentaries on of Chinese lapidaries, and thus contributed to the development of technologies and expertise.

In Buddhism, time is often conceived as infinite in an infinite space. Buddhist texts usually do not provide explanations of the origin of the Earth or of the universe: that would contradict the foundations of the teaching itself. Ideas of a creation, birth or origin of the universe are generally not contemplated and are rejected. The world is regarded as the continuous and never-ending cycle of *samsāra*: an eternal and causal chain of facts, actions and reincarnations. Besides being infinite, the Buddhist concept of time is also composed of cycles, each of which starts with the arrival of a new Buddha and lasts one *kalpa*. A *kalpa* (a concept borrowed from the Indian tradition) is an aeon, the life span of a universe, which can vary depending on the different interpretations and calculations. In early Buddhist India it was calculated based on observations of the precession of the Equinox, and usually estimated to at 4 320 000 years. In Chinese and Japanese Buddhism the *kalpa* has partially lost its original meaning of 'life span of the universe calculated on astronomical observation' and has became a form of measuring the age and phases of (and to forecast the end of) the universe based on philosophical, religious and theoretical assumptions. Thus *kalpas* may have different religious or philosophical values, and lengths of time that vary between some thousands of years to over a trillion years. For many Buddhist schools, the beginning of a new *kalpa* means the reappearance of the true teaching (i.e. of a new Buddha), but not a physical change in the universe. According to other schools, the end of a *kalpa* means a catastrophic end of the world, characterized by great calamities (e.g. floods, earthquakes, volcanic eruptions), and the spiritual and physical renewal of the Earth or the universe.

Neo-Confucian naturalism and Japan

This latter interpretation of *kalpas* was used in China, especially in the thinking of neo-Confucian naturalists, to explain the existence of fossils, in a manner that vaguely resembles certain western interpretations of fossils as a consequence of the biblical Flood. Let us consider, for example, the writing of Zhu Xi (1130–1200), a Chinese scholar also known in the west as Chu Hsi (in Japanese Shushi). During the Tokugawa period he was one of the most influential neo-Confucian authors in Japan, and gave his name to a school of thought, the *Shushi-gaku*, literally 'Studies of Zhu Xi'. In the *Zhuzi quanshu* (*Collected works of Master Zhu Xi*), after describing the periodical destruction of the world and its regeneration, Zhu Xi explained how fossils are petrified living being that prove the existence of these cycles:

> the frontiers of sea and land are always changing and moving, mountains suddenly arise and rivers are sunk and drowned. Human things become utterly extinguished and ancient traces entirely disappear . . . I have seen on high mountains conchs and shells, often embedded in the rocks. These rocks in ancient time were earth or mud, and . . . lived in water. Subsequently everything that was at the bottom came to be at the top, and what was originally soft became solid and hard. One should meditate deeply on such matters, because these things can be verified (Ronan 1997, p. 290).

Among the Japanese scholars belonging to Zhu Xi school, the philosopher and botanist Kaibara Ekken (1630–1714) distinguished himself as a naturalist and scientific observer.

Confucianism did not present a homogeneous explanation for the origin of the Earth, and often borrowed Taoist terms and concepts. Among neo-Confucian scholars the subject was more debated, although not necessarily in scientific terms. Two concepts were central in the cosmological speculation of neo-Confucians: *li* and *qi* (in Japanese *ri* and *ki*), respectively the 'rational principle' and the 'psycho-physical substance'. In Japan, during the Tokugawa period, neo-Confucianism became a pillar of the Tokugawa state, and Japanese scholars produced original writings and theories on the origin of the universe, the Earth and human beings. These investigations were usually discussions on the forms of the interaction between *ri* and *ki*, and were often related to theories of ethics and political science.

There was, among Chinese neo-Confucian naturalists, a notable interest in rational and speculative analysis of the Earth's features, and the works of these scholars were very familiar to Japanese intellectuals. For example, the achievements of Shen Kuo (1031–1095; Japanese Shin Katsu) related to geological studies were known. After a critical and rational observation of marine fossils (especially bivalve shells), calcareous sediments and different shapes of the rocks on the mountains of Taihang, and also using records on findings of fossils and of petrified bamboo forests, he formulated a theory of geomorphology that included the concepts of weathering and erosion, sedimentation, mountain uplift, climate change, and the ancient Taoist concept of *sang tien*, 'the long periods of centuries during which the sea is turned into dry land' (Ronan 1995, p. 291). Between the second and the eighth century, the concept of *sang tien* had become relatively close to the idea of a 'geological era'. In Chinese literature, which was highly regarded and considerably studied in Japan, the first reference to fossilized vertebrates is the mention of 'stone fishes' by Li Daoyuan (?–527) in his *Shui jing zhu* (*Commentary on the Water Classic*, sixth century). After that, the existence of fossil animals was widely discussed. Fossils were recognized as having once been in the sea by authoritative scholars such as Du Wan, who also compiled the first lapidary that has survived to the present, the *Yun lin shi pu* (*Stone Catalogue of a Cloudy Forest*, *c.* 1126–1133), in which 114 stones were listed and described, and their sources mentioned. In Japan this work was particularly appreciated among experts in gardening and bonsai. Du Wan also disproved experimentally an ancient heliokinetic theory that explained the presence of shells on mountains by their transport there by strong winds. He went to various locations where there were shells, marked them with ink, and checked that they did not move after regular intervals of time and after storms. Moreover, in the Chinese pharmacopoeia, from at least the Sung period (907–1279), pulverized fossils were employed as a remedy against various diseases related to lack of calcium. This use encouraged the composition of taxonomies based on fossils' shapes and pharmaceutical purposes. The Japanese were also aware of many other Chinese achievements and theories, including seismograph project by Zhang Heng (78–139; also known as Chang Heng), and theories by other scholars that explained the formation of rocks, metals and ores by interactions of thunder, mass, pressure and exhalations (see Ronan 1995, pp. 306–307). This rich ensemble of proto-scientific theories, however, was only part of a range of explanations regarding the Earth and its phenomena, and was not the most widely recognized.

Taoism and geology

Taoism is probably the most pertinent school in relation to geology. In Japan Taoism had a virtual monopoly over divination since the Heian period (794–1185). Taoist diviners, called *onmyōji* or *on'yōji*, were among the highest dignitaries of the imperial and shogun courts, and were usually consulted to choose the locations of palaces and even cities: the settings of the capitals of Nara and Heian-kyō (nowadays Kyōto) were decided following the geomantic analysis of the court's *onmyōji*. In the past, Taoist geomancy was widely used also by common people as well as nobles, to choose locations for all kinds of buildings, and to decide the shapes and position of buildings. Today these divination methods are still widely used in Japan to forecast when it is propitious to get married, travel or invest money, but are very rarely employed to decide where to build houses.

Taoism was born as a form of divination, and never emancipated itself from this aspect. However, its century-long empirical and geomantic use brought a great deal of experiential enrichment. Taoist geomancers were not just fortune tellers, but specialists who had the same social function as present-day geologists and engineers in the planning and evaluation of sites and constructions. Although wrapped up in ritual and esoteric notions, their instructions were not without practical consequences, and it was in everybody's best interest to give and receive good guidance. We can also assume that, to be a high ranked *onmyōji*, one needed a sense of diplomacy and understanding of the needs of the commissioners. We can also presume that the esoteric components had the double social role of augmenting the prestige of this specialty and of helping maintain the knowledge in the family and among adepts (handing down job expertise inside a family is a recurrent characteristic of Japanese division of labour since ancient times).

Taoist geomancy included practical and empirical modes of site observation and decision making, although these were mainly expressed with the words of fortune telling. This process started from observations of the geographical and geological reality, which in some ways resembled the procedures of present-day geologists and urban planners. The first operation was the observation, eventually drawn on a map, of the distributions of the five (Chinese) elements in the area where a building (or a city), was to be built, looking for a position of 'equilibrium'. Possible orientations of the project were also considered: Taoist geomancy reserved an important place for the 'five (Chinese) cardinal directions' (north, south, west, east and the centre), associated with favourable or unfavourable conditions. These preliminary observations were sufficient for a location or position to be rejected: too much of an element, a wrong exposure to the north, or a bad rapport between elements and cardinal points, meant that the placement was unsuitable. We should observe that in such an approach there was a combination of religious–divinatory methods based on non-scientific assumptions, but also elements of pragmatic observation. Being too close to a steep mountain slope would be considered a danger, and was called an excess of the earth element; a location too close to a river, or in the wrong position relative to river banks, was explained in religious–geological terms as too much of the water element, and would require protection from potential floods.

Some Taoist theories can also be defined as proto-physics, as they were founded on a concept of the universe that starts from energy and matter. Energy transforms itself in matter, and the combinations and interactions of energy and matter are the basis of the known universe. In Taoism, *yin* and *yang* are the two universal elements, respectively the negative and the positive energies. The combination and interaction between these gives rise to five phases of energy, also called the five elements: wood, fire, earth, water, metal. As the combination of *yin* and *yang* forms the entire universe, the divination method could be used for any kind of matter or situation: the inner human world, the Earth, or society, for example. This idea of a cosmological interconnection permeated many religious and intellectual viewpoints in pre-Meiji Japan.

In Taoism, the universe self-generated according to the universal principle called *Tao*, which is empty and always in motion. One of the most ancient and influential Taoist books, the *Tao Te Ching* (composed, according to tradition, during the sixth century BC), explained the universe as being self-formed following the natural order (the *Tao*):

'There was something formless and perfect, before the universe came into existence. It was serene and empty, solitary, immutable, infinite and eternally existing. It is the mother of the universe. I call it *Tao*, not having a better name . . . Man came after the Earth. The Earth came after the universe. The universe came after the *Tao*. The *Tao* comes after itself (*Tao Te Ching* 25).

Observations on Shintō's approaches to geological features

In pre-Meiji Japan, in addition to the speculative and mythological explanations of time, fossils or the origin of the Earth mentioned above, there was a vast corpus of myths, rites and beliefs, with regional and historical variantions, related to geological features and phenomena. They involve a fundamentally animistic and pantheistic concept of the Earth, very often of Shintō origin, and a mythological explanation of natural phenomena. Many of these explanations survive to this day, sometimes in a secularized form, but often conserving a religious and a social function. We should not, however, assume that all the folk literature on geological or natural topics is or was regarded as truth. In pre-Meiji Japan there was much space for scepticism, and there were different approaches to religious beliefs according to social status. From an overview of the abundant literature by Japanese intellectuals since the eighth century, we find considerable criticism of popular beliefs, sometimes based on forms of Confucianism. Also, there is clear evidence that many legends were treated as amusing oral literature by common people. Many of these stories survive in children tales and folk traditions (oral literature and songs), and are today printed in tourist guides and pamphlets. As an example of such an approach to geological features, we can cite the first Japanese novel that has survived to the present, the *Tale of the Bamboo Cutter* (*Taketori monogatari*, written *c.* AD 920 but probably composed centuries before). At the end of the novel, we find out that Mount Fuji smokes because a king burnt an elixir of life on its peak. There are many local variants of this story, but they all have in common the explanation of smoke coming out of a volcano as the result of actions on, or of, a magical object.

Another example of the richness of Shintō concepts of the Earth and the universe is the cosmogonies. The vertical and tripartite (Gods, humans, and the dead) cosmogony that we deduce from the first pages of the *Kojiki* was not the only one existing in ancient Japan. From anthropological data, as well as from some stories in the *Kojiki*, we can recognize the co-presence, in ancient as well as in contemporary Japan, of at least two other cosmogonies, both 'horizontal': a qualitatively dual, but geographically adjacent space. According to this idea, the Gods and the ancestors do not live in heaven, but close to humans. In particular, the mountains are the residences of the dead, and of a very important divinity, such as *yama no kami* (the 'God of the mountain'), who comes in spring to give fertility to the rice fields, becoming *ta no kami*, the 'rice-field God'. The rituals to welcome this divinity in the spring, and to bid it farewell in autumn, are still an important part of rural life. There was also a diffused variant of this 'horizontal' cosmogony, which today has almost disappeared: the belief in the existence of a world of the Gods and/or of the dead under the ocean, or far away in the ocean, a world that was also cited in the ancient texts. Remains of this belief are still visible in some parts of Japan during the *o-bon* ceremonies. The *o-bon*, which occurs in the middle of August, is one of the two most important annual celebrations in Japanese culture, along with the New Year. It is believed that during the days of the *o-bon* the souls of the deceased return to visit their relatives. The rituals of separation at the end of the *o-bon*, called *shōryō okuri* (literally 'to send away the souls of the dead'), often involve the use of boats entrusted to rivers, lakes or to the sea, to indicate the way and to help the dead return to their land.

In addition to the story of Izanagi and Izanami, there are two other myths in the *Kojiki* that illustrate ancient Japanese ideas on natural features or phenomena. One explains the ocean's tides by the existence of a magical jewel, which commands the level of the oceans. The other is the myth of the heavenly grotto, which tells how the actions against order and purity by the God Susanoo, brother of the Sun Goddess, resulted in the first eclipse. 'Terrified at the sight [of his brother's misdeeds, Amaterasu] closed [behind her] the door of the Heavenly Rock-Dwelling, made it fast, and retired. Then the whole Plain of High Heaven was obscured' (Chamberlain 2005, p. 64). Only a festival, with dances and laughing, could make her come out again. This rapport between feast and the natural order, as well as the use of rites to try to influence nature's processes, was and is central in Shintō. We find it also in the ancient *Chinkon* ceremony, which was performed near the winter solstice to help the waning sun, and its earthly counterpart, the emperor's soul, to reinvigorate and pass to the waxing phase.

Also very important in Shintō, and related to the conception of nature, is the idea that impurity and corruption are causes of imbalance in the natural order, and therefore are sources of negative natural events (including earthquakes, landslides, etc.). Purification is thus a central part of Shintō rites. In Shintō shrines there are always water basins for visitors to clean their hands and mouths and, symbolically, their souls. Before the founding of the city of Nara (seventh century AD), the site of the capital was changed with each Emperor's death, to avoid the impurities associated with this event. Rituals to please or pacify the *kami*, and to purify the Earth, are generally performed before undertaking works that include constructions on unused ground, or digging, by individuals as well as by major corporations. Before building houses, factories, offices, or any other kind of structure, a simple sanctuary may be constructed, or ritual precautions taken, such as marking out sacred spaces (usually rectangular) by means of sacred straw ropes (*shimenawa*). Shintō priests then celebrate the ceremonies of *jichinsai*, 'calming the Earth'. A similar approach is visible in the richness of temples and shrines to calm the local divinities and ask their protection and help, in all the major mine complexes of Japan. The site of the *Iwami Ginzan* silver and copper mines complex (Shimane Prefecture), for example, which was the most exploited at the beginning of the Edo period, and has recently been added to the UNESCO list of World Heritage sites, includes four shrines and 63 religious and ritual sites with different functions: protecting the miners, praying to and ingratiating the local gods, and helping to improve the profits. Ceremonies to appease local Gods, Earth Gods and other kind of divinities who may be disturbed by engineering or mining works are often not perceived as being in contradiction with today's society, or with science. Contemporary Shintō priests, as well as educated people including some academics, have developed various notions to reconcile this religious approach with present-day scientific views. These include ideas stressing the extra-religious value of tradition (e.g. cultural importance of folk culture, social importance of customs, etc.) and various ways of combining religious beliefs with scientific views (e.g. a 'complementary spheres of knowledge' approach).

In ancient as well as contemporary Shintō, a number of geological features are considered sacred. It is not uncommon, for example, when travelling in Japan, to see rocks surrounded with a straw rope (*shimenawa*) or with a strip of cut paper (*gohei*), both of which indicate a sacred space. Festivals involving rituals with sacred rocks are also common. Often, they involve the changing of the (sometimes massive) straw ropes. The sacred rocks seem to have no specific geological characteristics in common. Probably the most famous sacred rocks of Japan, visited by at least two million tourists and pilgrims every year, are the *meoto iwa* (husband and wife rocks), in the village of Futamigaura (Mie Prefecture), a few kilometres from the great shrines of Ise, where the Sun Goddess Amaterasu is worshipped. Other geological features that are personified, deified or venerated include fossils and meteorites. Several hundred shrines in Japan, called *hoshi jinja* (star shrines) or with similar names, are dedicated to meteorites, or to places where meteorites are thought to have fallen.

Mountains are the best known, and by far the most valued or deified geological features in Shintō as well as generally in Japanese religion and history. To this day, virtually every major Japanese mountain hosts rites and religious activities and is the object of cults and worship. Such activities involve no specific social group, but in most cases are regional traditions performed annually by members of a local community. In more than one case, during my field-work in the Kii peninsula, I have met academics who joined in mountain religious activities as a form of self-improvement and/or as a contribution to preserve traditions. Scientific and religious views are not perceived as contrasting, but as pertaining to different spheres of knowledge, and religious activities do not seem to affect geological understanding of mountains: lay people or priests may know very little of geology, and esteem scientists as repositories of specific, scientific knowledge. There are also cases of co-operation between geologists or engineers and priests: when industrial, mining or sampling activities are judged undesirable from a religious point of view, or to avoid intervention on mountains or sacred sites causing a negative or harmful divine reaction, rites to placate the Gods or to ask their permission are performed before work begins. Also, in some cases where ammonites and meteorites that were worshipped in shrines have been moved to museums or universities, rites have been performed to request permission of the Gods, and placate them.

As Japan is a country that is seismically very active, it is not surprising that there are many explanations, beliefs or rituals concerning earthquakes. As Miyata & Takada (1995) have shown, the idea (common among contemporary Japanese) that in ancient times people believed that earthquakes originated by the movements of a giant catfish that held up the Earth has no confirmation in ancient texts or beliefs. However, since ancient times, a giant mythological catfish, called *namazu*, has been associated with natural disaster in general. The *namazu* belongs to the group of monsters and non-human (or partly human) creatures collectively known as *yōkai*, which are very common in Japanese folk religion. It was thought that disasters were due to an imbalance of cosmic forces, which could have been caused by the *namazu* or by other factors, including human disrespect for the Gods or impure actions. According to some scholars, the ancient Japanese identified all natural disasters, including bad weather for agriculture, floods, droughts, typhoons, tsunamis and earthquakes, as a personified force, caused by cosmic imbalance, called the 'stern father'. It is in the urban areas of the late Tokugawa period (1600–1868) that *namazu* were specifically associated with earthquakes. According to this later interpretation, the catfish supported Japan, and earthquakes were caused by its movements.

Shugendō as an example of religious taxonomy of geological features

An example of a syncretistic school that gives an idea of the richness of religious, but also esoteric and nonscientific, approaches to geological features in Japan is the *shugendō*. Probably around the seventh century, the mixing of local cults, especially those related to mountain worship, with Buddhist and Taoist practices and ideas created this very important and influential religious movement, which for many centuries, and especially between the Kamakura (1184–1333) and Muromachi (1333–1568) periods, had a great number of practitioners of all social classes. *Shugendō* produced many schools, practices, rites and myths, mostly related to mountain ascetics, and a complex understanding of nature, of the Earth, and above all of mountains. This tradition is still part of Japanese religious life, although today it is not as popular. The *shugendō* practitioners are called *shugensha* or *yamabushi*. They developed a range of ascetic practices, which they periodically engaged in, including ablutions under waterfalls and long peregrinations from peak to peak. These practices usually included very strict contact with the mountain environments, and often required considerable expertise. They included passing through cracks in the mountain for ritual purposes ('passage through the womb', *tainai kuguri*), spending months cloistered in grottos meditating, or hanging over cliffs, attached by ropes to rocks above. The reliance that the practitioners had on the mountain, and the danger of the practices and their lifestyle, necessitated a pragmatic knowledge of the morphology of their environment, and of certain fundamental geological characteristics of it, such as for example the friability of rocks or the accessibility of some areas. This is evident also in the fact that they classified and named most of the morphological characteristics of their landscape, adding a symbolic and religious interpretation to their pragmatic knowledge of the Earth. They classified rocks according to their shape, ritual functions and religious significance: such typologies include, for example, the ascetic rocks (*gyōdō-iwa*), the peeping rocks (*nozoki-iwa*), the flying rocks (*tobi-iwa*), the fishing-boat rocks (*tsuribune-iwa*), the needle hole (*hari no mimi*), or the rocks to be climbed using chains (*kusari gyōba*). These names have little connection with petrological classification but a strong tie with their religious function. Ascetic paths, grottos and fissures in the mountains also had different names according to their ritual uses, positions, shapes or colours.

Social division of labour and geological expertise

As the great complex of the *Iwami ginzan* mines shows, a good level of mining expertise had been reached by at least the end of the 16th century in Japan. Boosted by favourable prices, and by national and international demand, the production of silver from this site grew steadily and reached, during its peak period (1530s–1640), an annual production between 1000 and 2000 kg, one of the greatest in the world at the time, with a record peak of almost 20 000 kg around 1600–1602 (UNESCO 2007). The archaeological remains show sophisticated extraction and refining techniques: dressing, smelting, refining and cupellation (with advanced techniques introduced from Korea) were conducted on site. However, the expertise related to this industry remained confined to the mines' investors or administrators, and to the miners, who usually lived in villages near the pits and shafts. No particular interest in the extraction or refining activities, or more generally in mineralogy or petrology, was expressed by intellectuals. Neo-Confucians, who tended to study linguistics, philology, ethics, history, literature and political sciences, often expressed a clear disregard of technical research. As an example, during the 18th century, when the production of silver became more difficult and costly as shafts were dug deeper into the ground, and caused great economic loss to the nation, which was already showing signs of a financial crisis, and when economic and engineering research would have been most needed, the best minds were involved in disputes such as the renowned *kokka hachiron* controversy (1742–1746), which touched 'the most compelling issue in quondam intellectual circles, namely, whether the Way (or to use its Chinese equivalent the *Tao*) was a product of Nature . . . or of human invention' (Nosco 1981, p. 77).

Mining expertise is just one example of a tendency toward social compartmentalization of knowledge that can be observed fairly often in Japanese history.

A case that show this compartmentalization from a religious point of view are the shrines dedicated to a Goddess often called *Niutsu hime*, but also known by other names, but always including '*Niu*'. These sanctuaries are found all over Japan in places that are rich in cinnabar (HgS), a crystalline form of mercury sulphide used in European and Asian arts to produce the red pigment vermilion. Beside the wide use as a pigment, it served as a polishing agent for metallic objects such as bronze mirrors or arrowheads. Tradition often ascribes the discovery of mercury to Kōbō Daishi, the posthumous name of Kūkai (774–835), although most historical records contradict this belief. The dates of the foundation of most shrines connected with cinnabar extraction make it impossible for him to have built them. As in the case of most of the merits attributed to him (e.g. the invention of the *hiragana* syllabary or the creation of the famous Shikoku pilgrimage), his figure is an archetype of the actions and progress accumulated over the centuries by the many wandering religious professionals, Buddhist itinerant monks and mountain ascetics who are extremely important figures in Japanese religious history. Some scholars claim that *Niu* was the name of the clan-God (*uji-gami*) of the clan that was in charge of cinnabar mining. The function of the *Niutsu hime* shrines was both practical and religious: they were constructed to thank the Goddess of mercury, to placate her for using such a substance, to invoke her help, and to ensure the abundance of cinnabar. They were mining centres, the laboratories where cinnabar was ground, and the repository of the mining and pigment-making techniques, which were usually transmitted through one family together with the monopoly on extraction.

Conclusions

We can infer the existence of five characteristics of the intellectual and religious history of pre-Meiji Japan that are linked with the development of proto-geological thinking: (1) it was an environment generally inclined towards ideological and religious heterodoxy; (2) speculations there on natural sciences had a holistic approach; (3) a great number of religious and intellectual authorities existed, with no absolute power or prevalence over each other; (4) there was a frequent supremacy of civil or military authorities over the religious ones; (5) there was social compartmentalization of knowledge and expertise. The combination of these five characteristics resulted in a very rich and relatively peaceful cultural and religious environment, but also in the dispersion of valuable knowledge because of its connection with a particular school of thought, or with a class or job, or because of the large number of existing and competing theoretical approaches.

The fertile assortment of philosophical schools, practical knowledge and expertise, and religious doctrines described above drew freely from each other and from a common reservoir of notions, texts, symbols and practices, depending on the circumstances. The lack of supposedly absolute and revealed truths in the traditions that coexisted in pre-Meiji Japan may be related to the absence, in Japanese history, of dogmas or holy wars, and to a different understanding of the concept of heresy (or heterodoxy) and consequently a different attitude toward heretics (or heterodox theories). This feature partially explains how it was possible that very different views on the Earth's origin, such as Shintō parthenogenesis, Taoist proto-physics, neo-Confucian cyclical renewal and Buddhist metaphysical no-beginning, could coexist peacefully and even influence each other. The theoretical and philosophical foundations of Shintō, Taoism and Buddhism helped to avoid the imposition of a unique view on subjects such as the origin of the universe or the Earth and their features. For example, besides the stress on non-violence and compassion included in the teachings of Gautama, among the many concepts of the Buddhist tradition that promoted synthesis instead of tending toward conflict is the idea of *upaya*. Introduced by the Mahāyāna schools, *upaya* (often translated as 'vehicle') can be considered as a relativistic view of religious matters. It implies that there is one ultimate truth, but many ways to reach it.

It is not my intention to portray an idyllic history of religion in Japan. There have been repressions of certain schools, persecution of religious leaders, religious violence and battles between the armies of different monasteries. Christianity was forbidden at the beginning of the seventeenth century for more than two centuries, and Christians were persecuted and crucified. Buddhism too was persecuted, in a less bloody way, at the beginning of the Meiji era, when the ruling elites tried to impose Shintō as a state religion. The main cause of a relatively peaceful and religiously very varied society was power division. Both the structure and the socio-political position of priests and monks in pre-Meiji Japan guaranteed a certain level of harmony, as no religious authority had supremacy. The distinction of roles between religious and political authorities was established fairly early in Japanese history. At the end of the eighth century, the capital was moved from Nara to Heian-kyō to counter the influence that the major temples based in the former capital were gaining over the court. By the ninth century, the pattern of regency by one family had transformed the emperor into a symbolic (and religious) figure with no real power. Since the beginning of the Kamakura period (1185–1333), when power passed completely into the hands of the warriors (*samurai*), the distinction between the emperor (a deified symbol of the country) and the rulers (generals who were given the title of *shogun*) was clear and definitive, and it continued to be so until the Meiji period. The military government that symbolically received power from the emperor ruled over all the religious authorities: over temples and shrines, and especially over the major monasteries, which controlled land and people. Such monasteries sometimes had a considerable amount of power, and participated in political struggles, and even in wars, with their own armies of warrior-monks. However, the religious authorities had a 'polymorphic' structure, with hierarchies clustered around many establishments. All the schools and churches of Japan have a hierarchical organization of their priests and monks, but the large number of churches creates a decentralized system. The birth of new schools, masters or sects was, and still is, a commonplace and socially accepted fact. Moreover, most of the schools usually have no ultimate religious authority and very often have no holy book that is the supposed repository of truth. The coexistence of a number of religious and philosophical schools, each with its own hierarchy, none ever predominant enough to overpower the other, has also favoured a polymorphic intellectual world, with a number of coexisting views over the Earth, its structure, history and features. Moreover, intellectuals, aristocrats and clergy have often been separate social classes, a division that has further increased the pluralism of Japanese religious and intellectual history.

The holistic tendency, on the other hand, has often been a decelerating factor for scientific development, or for the affirmation of purely scientific theories and methods. The lack of a strict division between philosophical and religious speculation, the lack of division between rational logic and mythological or religious thinking, and the lack of subdivision between natural sciences, have slowed down the emergence of most scientific approaches. Geology did not have the status of an independent field, and explanations of the features and the history of the Earth were part of other, broader approaches to nature, which more often than not had a religious or philosophical basis or background.

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Note

[1]This distinction between Shintō as 'indigenous' and opposed to 'foreign' (i.e. Chinese, Buddhist and western) is illogical when applied to historical Japan, which is the result of the merging of pre-existing, indigenous cultures with continental ones. Moreover, at the beginning of our era, the Japanese archipelago was a place where different ethnic groups cohabited, speaking different languages and having different concepts of the Earth. The ancient texts partly show this variety of approaches.

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The providence of mineral generation in the sermons of Johann Mathesius (1504–1565)

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Abstract: Johann Mathesius (1504–1565) was a Protestant minister in the northern Bohemian mining town of Joachimsthal (now Jáchymov in the Czech Republic). His *Sarepta oder Bergpostill* (1562) is a collection of sermons in which he discussed various aspects of metals, minerals and mining. His description of mineral generation emphasized the 'gur theory', which arose within the sixteenth-century mining literature and became highly influential in the seventeenth and eighteenth centuries. The sermons contained numerous biblical references to mining and mineral generation. These did not directly correspond to the generative theories he described, and their purpose seems to have been inspirational rather than didactic. In this way, and by presenting the beauty and utility of metallic minerals as an example of God's providence, Mathesius encouraged his congregation of miners to take an interest in the more wondrous aspects of their labours. His work is significant in its consideration of mineral theories, mineral identities and terminology, and as an early example of a providential perspective that characterized many geological ideas of later centuries.

Johann Mathesius (1504–1565) was a Lutheran pastor in the mining town of St Joachimsthal. He was born and raised in Rochlitz, in the northern foothills of the Erzgebirge. His interest in metals and minerals is first evident in his mining investments and in the treatise entitled *Quaestio de rebus metallicis* that he presented during his theological studies at Wittenberg in 1540. In this, Mathesius noted natural associations between certain metals and minerals. From his remark that the generation of precious metals within the Earth had been diminishing throughout history as God's punishment for increased human decadence (Partington 1969, p. 64), we can see that he believed minerals to be formed through natural causes although subject to the will of God. He discussed this combination of causes in the 'mineralogical sermons' that formed his *Sarepta oder Bergpostill* (Mathesius 1562).

Mining in Joachimsthal

Joachimsthal lies on the Bohemian side of the Erzgebirge in the Czech Republic, and it has the present-day name Jáchymov. The ores there occur as a complex of metallic sulphide vein deposits. They were rich sources of silver and lead, but also involve tin, tungsten, bismuth, cobalt, nickel and uranium mineralizations (Ondruš *et al.* 2003, pp. 13–17). However, the sixteenth-century mining at Joachimsthal was focused on the extraction of silver and lead (Schenk 1970, p. 4), although it proved to be an important site for the gradual recognition of other metallic substances, such as bismuth, cobalt and various zinc compounds, which were mentioned by Mathesius in numerous places in the *Sarepta oder Bergpostill*.

Joachimsthal arose as an important mining town during the first half of the sixteenth century. A previous mining settlement had been founded there under the name Konradsgrün around 1380, but by the middle of the fifteenth century had become abandoned for unknown reasons (Schenk 1970, pp. 4–5). Interest in mining the area was renewed after a member of the local nobility, Pfandherr Stefan Schlick (1487–1526), initiated further prospecting in 1516.

The early assaying results were encouraging, but even richer veins were soon discovered, and a silver rush quickly ensued. An influx of miners came first from the surrounding towns, but gradually people from the Harz Mountains, Switzerland, Salzburg and the Tyrolean region came to live and work in Joachimsthal. During the peak production period of the 1530s there were around 18 000 inhabitants, including several tens of mine-masters, around 300 foremen, about 800 supervisors, and 8000–9000 miners working more than 1300 mines, and producing 6000–7000 kg of silver annually (Majer 2004, pp. 101–104).

Metallogenesis and biblical rhetoric in the *Sarepta oder Bergpostill*

Following the completion of his studies in theology, classical languages and mathematics at the universities of Ingolstadt and Wittenberg, Mathesius began teaching at the Latin school in Joachimsthal in 1530, and witnessed the most rapid period of development in

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the mining activity there. In a turn of events that must have seemed truly providential, his successful speculation in a mining venture provided the funds necessary for pursuing further theological studies at Wittenberg, where he became an associate of Luther and presented the above-mentioned *Quaestio*. He returned to Joachimsthal in the early 1540s as a church deacon, and later became pastor (Kettner 1957, pp. 25–26).

The *Sarepta oder Bergpostill*, first printed in 1562 (the 1571 edition has been used here), contained sermons that he delivered to his congregation, which was composed mainly of people directly involved in mining. In these sermons he considered the generation of metallic ore minerals, the various types of metals and minerals, and terminological questions. Mathesius generously supplemented these discussions with passages from the Bible concerning metals, minerals and mining activity.

Mathesius saw the occurrence of minerals and metals as evidence of God's generosity. In spite of the danger and difficulty of mine work, he emphasized to his congregation that God, through his almighty goodness and wisdom, continues to cause the Earth to become enriched with minerals. As a clear indication of God's munificence, he cited the fact that ores of more than one metal often coexist in single veins. He noted that the beautiful colours and shapes in which many of these minerals occur are worthy of wonder and further reveal the handiwork of a benevolent God. He told his congregation to rejoice that God has his workplace not only in the heavens and upon the surface of the Earth, but within its cold, dark, subterranean depths as well (Mathesius 1571, pp. xxvii, xxxi, xxxii). Despite the gruelling nature of the miners' work, there was abundant cause for them to give praise for the magnificence of these mineral creations that they worked so hard to attain. This profoundly providential attitude venerated the mining profession by glorifying minerals as evidence of God's generosity, and thus offered a positive perspective on the difficult conditions of mining.

A direct familiarity with mineral occurrences is revealed in Mathesius' insightful theoretical considerations. His understanding of metallic ore minerals as diverse impure states of metallic compositions that usually occur intermixed (Mathesius 1571, pp. xxvii, xxix) was consistent with contemporary views. In his discussion, we can see how his knowledge of the diverse contents of ore veins, the various conditions in which metallic minerals can occur, and the processes of ore smelting lent credibility to a number of views on how metals and minerals could be generated.

One of the most significant aspects of Mathesius' writing on mineral generation is that it presented an early example of the 'gur theory', in which a viscous mineral liquid, called gur (or guhr), forms as an intermediate phase in the generation of metallic ores (Mathesius 1571, pp. xxvii, xxx, xxxiiii, xxxv, xxxvii; Göpfert 1902, p. 41). This theory rose to prominence in the sixteenth-century literature in connection with mining activity. Gur, which would be recognized today as clayey or viscous liquid mixtures of metallic sulphides and sulphates, originating from the oxidation of metallic sulphides and the weathering of the surrounding rock, had a recognizable metallic content, an acidic nature and sulphurous stench. The oxidation reaction by which metallic sulphides form sulphates releases sulphuric acid and is exothermic (see Flek 1977, pp. 14–16). This heat was noted, and was generally thought to indicate a type of fermentation. This belief led to the conclusion that a generative process was occurring. It was therefore reasoned that such material was becoming a deposit of solid, metallic minerals. The gur theory had slightly earlier precedents in the works of Georgius Agricola (1494–1555) and Paracelsus (1493–1541) (Norris 2007), although neither author used the term 'gur'. Mathesius was credited with the first use of this term by a later author on mineral generation (Grasseus 1661, p. 306).

On the basis of the polymetallic sulphide deposits of the Joachimsthal mines, Mathesius also found the sulphur–mercury theory of metallic composition to be entirely credible. In this theory, metals were believed to consist of components likened to sulphur and mercury. The degree of purity of each of these components, and their relative proportions, were believed to account for the sulphurous nature of many metallic ores, the fusibility of otherwise solid metals, and even the qualitative differences between the known metals. To Mathesius the sulphur principle that formed the Joachimsthal ores was directly evident from their sulphurous scent, and the mercurial component was seen in the volatile poisons and viscous corrosive liquids that threatened the health of the smelter and the miner (Mathesius 1571, p. xxxi). All the ores with which Mathesius was familiar contained sulphur, and the liquified substances that commonly occur around ore deposits were considered by him as a form of proto-metallic mercury. Indeed, gur seemed to conjoin the stench, acridity and heat of the sulphurous principle with the liquidity of a mercurial principle (Mathesius 1571, pp. xxvii, xxx).

Readers might be aware that the sulphur–mercury theory is associated closely with the alchemical tradition; Mathesius, naturally, also knew this. Mathesius wrote that alchemists were correct in asserting the roles of sulphur and mercury in the generation of metals, but their efforts to transmute metals by art were misguided, for although metals can be transmuted in nature, art is inherently subordinate to nature, and the alchemists would never be able to replicate God's operations inside the Earth. He noted that it had never been proven that alchemists had ever really changed the entity of a metal even if they did change its colour, and claims of successful transmutations were fraudulent (Mathesius 1571, pp. xxx, xxxv). Mathesius' usage of the sulphur–mercury theory is thus an instructive example of its applicability completely outside the alchemical literature.

In common with Paracelsus (Oldroyd 1974, pp. 134–135; Norris 2007, pp. 76–80), Mathesius believed that minerals were engendered through semina (or *samens*) created by God. Unlike the former, Mathesius did not construct an elaborate theory of how this occured and how such seeds worked on a compositional level, but instead supported this view with biblical rhetoric concerning the way God has created plants and animals, and thus all of nature (Mathesius 1571, pp. xxx, xxxiiii).

This openness to a variety of potential mineral-forming processes reveals a degree of looseness in Mathesius theoretical considerations. Only a few years earlier, the sulphur–mercury theory had been carefully criticized by Agricola, himself a former Joachimsthal resident, in favour of a type of gur theory involving what he called mineral juices or slimes (Agricola 1558, pp. 61–62, 64; Norris 2007, pp. 73–76). Mathesius' description of the gur theory reveals his awareness of mineral processes, and the knowledge revealed in his sermons suggests direct experience with mineral veins and their various contents and conditions. However, his willingness to identify gur with the mercurial principle ignored the cogent considerations of mineral generation by Agricola (1558, pp. 65–67; see also Nobis 1998, pp. 47–50).

However, such reference to a diversity of theoretical views was common in the early mining literature that addressed mineral generation. For example, the anonymously published *Bergbüchlein* (*c*. 1505), probably the earliest printed work on mining, discussed the sulphur–mercury theory, related it to an early form of the gur theory (although the term 'gur' was not used), and also cited astral influences in the generation of metals and ores (Sisco & Smith 1949, pp. 19–21; Nobis 1998, pp. 29–31). Similarly, the much later *Speculum metallurgiae Politissimum* (1700) by the Saxon mining officer Balthasar Rössler (1605–1673) gave descriptions of ore-forming processes involving the Paracelsian *tria prima* (salt, sulphur and mercury), gur, mineral semina and astral forces (Rössler 1700, pp. 11–12). In this way, Mathesius' approach was characteristic of the literature both before and after his lifetime, when the influence of Agricola's critical views was rarely seen. Although both Mathesius and Agricola were often cited in subsequent literature, one has the impression that the fame of Agricola's *De re metallica* (1556) overshadowed his theoretical work, whereas the pliable coupling of gur with variants of the sulphur–mercury theory (including the *tria prima*) retained substantial explanatory power.

In addition to the physical processes that Mathesius described, he also insisted on God's benevolence and omnipotence as crucial factors in the generation of minerals (Mathesius 1571, p. xxxiii). Indeed, he seemed to criticize Agricola for not acknowledging the important role of God in mineral generation (Mathesius 1571, p. xxxiiii). Mathesius believed that we can see evidence of the generative processes and of the materials used therein, but that we can go no further into discerning the primary causes of mineral substances. Who, he asked, can see through the mountains into God's subterranean workshop? Mathesius wrote that minerals are primarily the products of God's decree, and no amount of experience can further reveal his methods to us (Mathesius 1571, p. xxxiii).

Mathesius also mined the Bible for references to mineral subjects. He collected many such citations, although they are noticeably vague in comparison with the theories he supported. For example, Mathesius likened the gradual subterranean perfection of earthy metals and minerals to St Paul's words in Corinthians concerning the purification of the human soul through spiritual love (Mathesius 1571, pp. xxvii, xxx); Moses and Job were brought into agreement that God causes metals to form and increase in veins within the Earth, as in the generation of iron from rock and dusty earth; and Job was quoted on the association of ore generation with water, that metallic veins are narrow, and rock difficult to break (Mathesius 1571, p. xxxi).

In comparing such biblical passages with Mathesius' theoretical considerations, it is obvious that the former served inspirational purposes, and that Mathesius did not expect anyone to learn about mineral generation from the Bible. He neither judged the contemporary theories against the biblical citations, nor attempted any critical comparison. These references were mostly meant to edify the work of his congregation in their own minds, by demonstrating that the substances and labours around which their lives were centred had been important even in biblical times.

Conclusion

Johann Mathesius was very interested in minerals and the manner of their generation. He sought to explain these by natural processes within the framework of God's providence. In his experience, several mineralogenic concepts, such as the idea of mineral semina, the sulphur–mercury theory and development from gur, all shared plausibility. The gur theory became highly influential in the seventeenth and eighteenth centuries, and Mathesius has been recognized as being among the earliest authors to discuss it in print.

Although he may have lacked the critical abilities of Agricola, Mathesius' discussion of mineral generation in the *Sarepta* was not motivated by a theoretical interest. He believed that minerals were formed by natural processes, but also that God's benevolence was primarily responsible for and evident in their generation, and he therefore sought to inspire his hard-working congregation with both sides of this issue. His biblical references to minerals and mining may have been of scholarly and historical interest by themselves, but Mathesius' main purpose seems to have been to edify the miner's world with pious thoughts, and to validate their efforts and ideas by grounding them in the Bible. It is clear that he felt his contemporary knowledge on the subject to be better than that of the ancients, and any discrepancies between the two were of no concern. He believed that humans were incapable of discerning the primary causes of mineral generation, as this was the inscrutable handiwork of God, and that the loss of a harmonious and innocent wisdom at the biblical fall of Adam further contributed to this incapacity (Mathesius 1571, pp. xxx, xxxiii). Although one could understandably be surprised by the unconventional content of Mathesius' preaching, his strong emphasis on mineral subjects in his sermons entailed no negligence in caring for the souls of his congregation; for, as the miners toiled deep within the hills of the valley of St Joachim, Mathesius considered that he was shepherding them through a valley of darkness brightened by minerals.

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Earthquakes as God's punishment in 17th- and 18th-century Spain

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Abstract: It is generally believed that before the Enlightenment earthquakes were considered as signs of the wrath of God as punishment for men's sins, and that Earth tremors were not considered as natural occurrences until modern times. However, this is an oversimplification, as we can see in Spanish writings of the 17th and 18th centuries. In these writings we have to distinguish between popular and religious documents and academic studies. In the 17th century Spanish authors held the Aristotelian doctrine about earthquakes and regarded them as natural occurrences. Some regarded them as God's punishment for sinful people. The occurrence of a destructive earthquake in Malaga in 1680 brought this question into the open. At that time no opinions were presented against the religious interpretation. The Lisbon earthquake of 1 November 1755 and the subsequent tsunami caused considerable damage in many Spanish cities, and the earthquake was felt throughout Spain. After that earthquake an abundant literature of popular, religious, philosophical and scientific character was published. A strong controversy arose as to whether the earthquake was of natural or supernatural character, with theologians and philosophers on both sides. An important group defended the natural character of the occurrence and deplored the exaggerated position of their opponents.

It is generally believed that before the Enlightenment earthquakes were considered as signs of the wrath of God as punishment for men's sins. According to this often-repeated opinion, earthquakes were not considered as natural occurrences and the object of a scientific study until modern times. This change in mentality usually is thought to have occurred after the Lisbon earthquake of 1755. As we will see, this is an oversimplification, in that even in the Middle Ages most western authors in academic circles considered earthquakes to be natural occurrences. This paper investigates Spanish authors of the 16th to 18th centuries and their opinions on the cause of earthquakes. In this study we have to distinguish between popular and religious writings and those of academic nature, usually written by university professors. We consider as religious writings sermons by the clergy and documents such as pastoral letters from bishops. They differ from popular writings, usually anonymous, which also included religious considerations. The question about God's intervention comes into the open on the occasion of the occurrence of a destructive earthquake. We will consider here the reactions after two earthquakes that caused major damage in southern Spain: that of 9 October 1680, in Malaga, and the Lisbon earthquake of 1 November 1755. Both events gave rise to a considerable number of publications in which different interpretations were presented.

The Aristotelian doctrine on earthquakes

Up to the late 17th century in the west, ideas about the origin of earthquakes were based on the Aristotelian doctrine. Aristotle (384–322 BC) proposed his doctrine on earthquakes in the *Meteorologicorum Libri IV*. In these books he considered various phenomena, such as rain, clouds, thunder, lighting and winds, now included in the modern science of meteorology, but also comets, the Milky Way and earthquakes. According to Aristotle, earthquakes were produced by the dried exhalations (spirits or winds) trapped in cavities inside the Earth trying to escape toward the outside and making the Earth shake. The winds (*pneuma*) were introduced from outside or generated inside these cavities. For this reason, Aristotle considered that regions with abundant caves or cavities in the Earth were more prone to earthquakes. In his treatment of these phenomena there was no mention of anything mysterious or supernatural in their occurrence. Pliny the Elder and Seneca, two Latin authors of the first century, were very influential in the early Middle Ages, and they presented this Aristotelian doctrine with some minor changes. Early Christian authors, such as St. Isidore of Seville in the seventh century and the Venerable Bede in the eighth century, repeated Pliny's and Seneca's ideas. They also wrote nothing about divine intervention in earthquakes. Between the 12th and the 13th century, Aristotle's works were translated into Latin, first from Arabic and then from the original Greek. University professors from this period wrote commentaries on the treatises of Aristotle including the *Meteorologica.* Two of the most important 13th-century commentators on Aristotle were Albertus Magnus and Thomas Aquinas. Albertus

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wrote a long commentary, divided into 20 chapters, on the subject of earthquakes, but he never mentioned that earthquakes are signs of God's wrath (Albertus Magnus 1890). Aquinas, known especially for his monumental theological work, wrote a more literal commentary, including Aristotle's Greek text and its Latin translation. He also did not include any religious commentaries on earthquakes. Because of his influence on later Catholic authors, it is important to search in his other works for religious considerations of earthquakes. The only place where these are found is in his commentary on Psalm 17, discussing the verse: 'The earth swayed and quaked; the foundations of the mountains trembled and shook when his wrath flared up.' First, he affirmed that the first cause of the motion is divine will. Second, he stated that assignment of earth tremors to divine wrath is only metaphorical (*hanc exprimit metaphorice*) and the intention to move men to penance has to be understood in a mystical sense (*mystice designatur per hoc commotio hominum ad poenitentiam*). In the following paragraph, he explained the origin of earthquakes according to Aristotelian ideas. Thus, his authority cannot be cited to support that earthquakes were thought to be caused by divine wrath (Aquinas 1918).

Aristotle's doctrine was predominant in western universities in the 16th to 18th centuries. Among the Spanish commentators on Aristotle's *Meteorologica* was Alfonso Perez (1576), who dedicated three chapters to the subject of earthquakes. The only reference to God's intervention he made was in respect to the earthquake at the time of Christ's death. Perez considered this earthquake to have been caused directly by God as a sign of the reaction of nature to the death of Christ on the cross. Francisco Murcia de la Llana (1615) wrote a more extended commentary on earthquakes, giving a detailed list of 12 effects produced by them. He stated that the first was the fear and terror they produced, and added: 'God makes everything in order to bring to His service those who live having forgotten it.' This was his only mention of this subject. Francisco Alfonso (1641), a professor in the Jesuit College of Alcalá, published a third commentary. He added to the Aristotelian doctrine the presence inside the Earth of inflammable materials such as sulphur and bitumen as the cause of subterranean fires. Again, there was no mention in his work of God's intervention.

Spanish authors before the Lisbon earthquake

Criticism of Aristotelian ideas on other subjects by the proponents of modern science extended also to the origin of earthquakes. Martin Lister in England in 1648 and Nicolas Lemery in France about 1700 were the first to propose that earthquakes were produced by large explosions of inflammable material formed by a combination of sulphur, coal, nitre and other substances accumulated in the Earth's interior. The explosive theory became very popular, and can be found also in Newton's *Optics* (1718) and Buffon's *Histoire naturelle* (1749–1788) (Taylor 1975). In Spain these ideas were mixed with organicist points of view, in which the Earth was compared with a living organism. In this respect there was an important influence on Spanish authors by Athanasius Kircher (1601–1680), a Jesuit professor at the Collegio Romano, especially in his work *Mundus Subterraneus* (1664) (Glick 1971; Capel 1980). Kircher proposed the existence in the interior of the Earth of three systems of conduits through which fire, water and air circulated. He called these systems *pyrophylacia*, *hydrophylacia* and *aerophylacia*. The first were related to the volcanoes and connected them with a fire in the centre of the Earth. Kircher thought earthquakes were related to these systems of conduits, with fire heating the air, which then expanded, causing the Earth to tremble. He added also the explosion of inflammable materials.

José Zaragoza, a professor of mathematics at the Jesuit Imperial College of Madrid, was considered to be one of the best Spanish mathematicians of his time, and he treated the subject of earthquakes in his work on astronomy and geophysics (Zaragoza 1675). After explaining the Aristotelian theory and Kircher's ideas, he added: 'It seems more according to Christian Philosophy that many times earthquakes are a natural effect and at other times God causes them, or lets the Demon do it, in order to punish men.' This is an explicit mention, in a purely scientific work, of God's intervention in earthquakes, although Zaragoza stated that only on some occasions could they be directly attributed to God as a punishment. It is interesting that Zaragoza considered, as another possibility, that sometimes God may permit the Devil to cause earthquakes. Tomás Vicente Tosca, a priest of the Oratory, in his monumental nine-volume work *Compendio mathematico*, wrote a short chapter on earthquakes (Tosca 1707–1715). He explained that earthquakes were caused by explosions of inflammable materials inside the Earth similar to those in mines; he did not mention God's intervention in them. This is also the case in the physics treatise of Andrés Piquer (Piquer 1745).

Diego Torres de Villarroel, a professor at the University of Salamanca, published the first complete work on earthquakes in Spanish (Torres de Villarroel 1748). In this lengthy treatise, in which Kircher's organicist ideas were mixed with the explosive theory, there was only a short mention of the religious problem. After describing the destructive power of earthquakes, which 'level buildings and mountains and destroy cities and provinces', Torres de Villarroel wrote that these phenomena seem to be preternatural and can be considered as miracles, concluding, 'we can believe that they are God's wrath, punishment and . . . inflicted by His Majesty for our sins and in this way they are described by Catholic physicists'.

Another group of Spanish authors who considered earthquakes are those writing about the newly discovered lands of Central and South America, where large destructive earthquakes are common. They wrote for the learned public, presenting the natural aspects of the new lands. Four of the most important of these authors were José de Acosta (1590) and Bernabé Cobo (1890), both of whom were Jesuit missionaries, and Antonio de Ulloa and Jorge Juan, who were naval officers and scientists participating in the measurement of the meridian at the equator (de Ulloa & Juan 1748). This effort was organized by the French Academy of Sciences. The authors described some of the largest earthquakes in Peru and Chile, which had been followed in some cases by tsunamis. They speculated about the nature of earthquakes in similar terms to other contemporary Spanish authors, but did not make any reference to God's intervention. This is important because some of the earthquakes described caused thousands of casualties, and for de Acosta and Cobo they would have been a suitable occasion for a religious consideration.

The 1680 Malaga earthquake

It is one thing to write about earthquakes from the academic point of view, but a very different thing to do it after first-hand experience of a damaging shock. On 9 October 1680 a destructive earthquake took place with its epicentre near Malaga. It caused 60 deaths and injured 150 people, and caused widespread destruction in the city and nearby towns. Its magnitude has been estimated as $M_s = 6.5$ (Muñoz & Udías 1988). Six days later the bishop of Malaga, Alonso de Tomás, wrote a long pastoral letter in which he made it very clear that the earthquake had been caused by the many sins of the people of Malaga. In the first paragraph he expressed the idea that the cause of so much distress was human sins, and suggested that the calamities and horrors were the effects of our evils, which forced God to make us experience his punishment. In the rest of his commentary he provided many quotations from the Bible and exhorted his readers to change their lives and make penance so as to be reconciled with God. At the end he ordered all the priests of his dioceses to make public penances and atone for their scandals and sins; religious processions were made in all churches the following Sunday (de Tomás 1680). An anonymous popular description of the earthquake, published shortly afterwards, began with a sentence declaring that the cause of the earthquake had been many sins and that the justice of God had laid the harshness of his wrath upon the people. The description then considered that God has used the creatures that benefit men to be instruments of their ruin, terror and fright (Anonymous 1680*a*). In another publication of the same type, which related how the shock was felt in Madrid, the earthquake, together, with other calamities, was considered as a warning from God to make penance and repent of evil customs. It was stated that through these events God desired that men turn to him (Anonymous 1680*b*).

Most other documents of popular character recounting the damage of the 1680 earthquake accepted it as a clear sign of the displeasure of God and a punishment for the sins of the people. There were no dissenting voices and no attempts to refute this idea. Although we have seen that at that time university professors in Spain explained the natural causes of earthquakes using Aristotelian natural philosophy, we have not found any document that applied those ideas to this actual earthquake. The only document with a known author, signed by the Priest Antonio de Cea y Paniagua, concerned how the earthquake was felt in Cordova. The author, an arts graduate, refused to give a natural explanation, and wrote: 'we will omit the philosophical question (fruitless here) about the cause of earthquakes, when for the knowledge of piety in the First Cause against the obvious bitter acts of his justice, the clear testimony of his clemency is enough' (de Cea y Paniagua 1680). He recognized that there were also natural causes of earthquakes, but they were not applicable to this case. He considered pertinent only the religious considerations.

The earthquake occurred during the reign of Charles II, the last king of the Spanish Austrian dynasty; this was a time of cultural and economic decay and of exacerbated religious fervour. This has been often presented as the reason behind referring to the earthquake as a supernatural event (Pereiro Barbero 1986). However, evoking the wrath of God immediately after an earthquake was not an exclusively Spanish phenomenon of the time. Similar ideas were used then by Protestant preachers in England. For example, Thomas Doolittle, the Puritan minister of St. Alphage, London, in his sermons after the London earthquake of 1692, distinguished between earthquakes that were caused indirectly and directly by God. The latter provoked the human response of fear, trembling and immediate contrition. Doolittle called it 'holy fear', that is, an activating fear that produced moral benefits: the greater the fear, the more intense the reforming piety (van Wetering 1982). Thus some earthquakes, including the London 1692 event, were directly attributed to God with a religious purpose. However, this was not a universal attitude of religious considerations of the time. A clear contrary example was the reaction of Gaspar de Villarroel, Bishop of Santiago de Chile, after the catastrophic earthquake of 13 May 1647, which totally destroyed that city. Reflecting on whether the earthquake could be considered as a punishment of God for the sins of the people of Chile, he gave the contrary answer: 'whoever has seen the ruin of Santiago will not proceed with the sincerity that teaches the Gospel if he dares to judge that this earthquake was a punishment of the citizens'. He added: 'This is so in agreement with a good theology and God's law so that it will be a mortal sin to judge that their sins destroyed this city' (Amunátegui 1882).

Although, both Catholic and Protestant clergy in the 17th century, used the occurrence of earthquakes to move people to repentance for their sins, they did not ignore the theories about the natural origin of earthquakes, based on either Aristotelian doctrine or the newer proposals involving inflammable materials inside the Earth. The religious considerations were presented at the same time as natural causes were given. The recourse to God's action was not a substitute for the natural explanations, which were fully understood according to knowledge of the times, but was a recognition of the special action of God in certain cases.

The Lisbon earthquake of 1755

The Lisbon earthquake of 1 November 1755 was felt over the whole Iberian peninsula. It caused heavy damage and about 2000 casualties as a result of both the earthquake and the subsequent tsunami especially in the nearby cities of Huelva, Cadiz and Seville (Martínez Solares & López Arroyo 2004). This extraordinary event produced an abundant literature published in Spain, especially in Seville. Many publications were short popular accounts of how the earthquake was felt in a single locality, and many included religious considerations motivated by the event. Most of these anonymous publications were generally short works of a few pages, and were of a popular character, with exaggerated narratives of damage or curious occurrences supposed to have taken place during the earthquake. Some of the accounts were written in verse. Many were predominantly of religious character, asking for help from God, or giving thanks to God for the deliverance from the effects of the earthquake. We have identified 49 of this type of publication.

Other publications belong to the academic category, and some were extended treatises on the physical, philosophical and theological aspects of the event. They were written by natural philosophers and theologians, many of them university professors. Most of these authors handled two main questions. The first was whether this was a natural event or a supernatural one, that is, one directly attributed to God. The second was about the natural cause of this earthquake and the origin of earthquakes in general. A special point discussed was how it was possible for the earthquake to be felt at the same time in widely separated regions. On this second question, traditional and new ideas about the nature of earthquakes were discussed and debated.

Natural or supernatural event

The occurrence of the Lisbon earthquake generated in Europe an intense debate about what has been called 'eighteenth-century earthquake theology' (Kendrick 1955). At the centre of this debate was the opinion, generally asserted by many of the clergy, both Catholic and Protestant, that the earthquake was a deliberate punishment by God of sinful people. A constant theme in sermons, tracts and moralizing poetry, throughout Europe was that God in his anger had destroyed Lisbon because of the sins of its inhabitants. In Portugal the debate was intense, with, among others, the Jesuit Gabriel Malagrida on one side and Sebastian José de Carvalho e Mello, Marquis of Pombal, the powerful minister of King José, on the other. Malagrida took an extreme position and insisted in his sermons that the earthquake had been caused by the wrath of God for the sins of the people of Lisbon. Pombal, who took a pragmatic attitude to organize the care of the victims and oversee the reconstruction of the city, regretted the sermons of the clergy and especially those of Malagrida. In his opinion such statements only led to passivity in the people. Pombal ordered that Malagrida be sent to prison, 6 years later to be executed by the Portuguese Inquisition.

In France the earthquake caused questions about the generally sensed optimism of the times, which held that the world was a good place in which everything that happened was viewed to be 'for the best'. François Marie Voltaire, in his *Poème sur la désastre de Lisbonne* and his novel *Candide*, wrote a strong attack on this optimistic viewpoint. On the other side, authors such as Jean Jacques Rousseau defended the optimist position, and rejected Voltaire's gloomy picture of man's unhappy fate on Earth. In Germany

Immanuel Kant, adhering to Gottfried Wilhelm Leibniz's optimistic theodicy, which held that this was 'the best of all possible worlds', published three short papers on the Lisbon earthquake in 1756. He was more interested in the scientific aspects of the phenomenon, but touched also on the subject of earthquakes in relation to God's government of the world. The optimist position was heavily wounded by Voltaire's sharp attacks in *Candide*. Voltaire's negative position finally carried the day in the Europe of the Enlightenment (Kendrick 1955).

In Spain the debate was centred on the supernatural or natural character of the earthquake, and the discussion began a few days after its occurrence. Popular anonymous publications were generated and sermons in the churches were given, in which the supernatural character of the disaster was presented. Some of them asked for the help of heavenly patrons, or thanked various saints for their protection, among them of the Virgin Mary, St. Francis of Borgia (by the Jesuits), St. Philip of Neri (by the Oratorians), and St. Justa and St. Rufina, patron saints of Seville (by the non-monastic clergy). Many of the anonymous popular publications had a similar theme and many of them were published in Seville. Most of them took it for granted that the earthquake was God's punishment for the sins of the people. Thus, public religious services were organized in the days immediately following the earthquake (Aguilar Piñal 1973). As we have seen, 75 years before the Lisbon event, the earthquake that destroyed Malaga in 1680 was generally thought to have been a punishment by God, with no dissenting voices.

The two sermons of Francisco Olazaval y Olayzola, the Canon of the cathedral of Seville, of 27 April 1755 and 28 February 1756, are examples of purely religious literature. Olazaval y Olazola insisted that the many sins of the city of Seville were the cause of this punishment, which the mercy of God had not permitted to be even greater (Olazaval y Olayzola 1755). Agustín Sanchez, a Trinitarian theologian and preacher, in a note included in Francisco Mariano Nifo y Cagigal's work, insisted 'God uses the creatures to infuse fear in sinners and move them to repentance' (Nifo y Cagigal 1755). Even three years later, José Martin Guzman's sermons insisted on this interpretation. The firmest defender of the supernatural character of the earthquake was Miguel de San José, the Bishop of Guadix and Baza (Granada), who published a short letter in which he refuted the opinions of those who regarded this as a natural event, especially de Cevallos, and affirmed that: 'only to deny or doubt that earthquakes and other disasters are usually the effect of the wrath of God, can be considered as an error in the faith' (San José 1756). Similarly, a short letter of Thomas del Valle, the Bishop of Cadiz, called attention to the sins of the people of Cadiz, noting that God had punished them and called for their repentance (del Valle 1755). Francisco Javier González, a friar of the Minims Order, confronted this rigid position and wrote, answering the bishop, that God does not need to interfere with nature. González related this kind of disaster with sins only in a very general form, as a consequence of the original sin (González 1757).

In contrast to what happened after the Malaga earthquake, by 1755 there was serious questioning about attributing the earthquake to a direct action by God. José de Cevallos (1726–1776), a theologian from Seville and later the Rector of the University, was the strongest defender of the position that the earthquake was a natural event. He was a founding member of the Real Sociedad de Sevilla and of the Real Academia de Buenas Letras, two learned societies of Seville, where enlightened ideas were discussed. De Cevallos expressed his position in his introductory note (*Censura*) to Benito Jerónimo Feijoo y Montenegro's work, where he concluded; 'the earthquake has been entirely natural, caused by natural and proportioned second causes, in which God partakes as in any other natural effect' (Feijóo y Montenegro 1756). He refuted the opposite opinion as being theologically unsound, and insisted that 'if preachers didn't have their devotion and zeal ruled by wisdom and discretion, they will produce disordered effects and false believes'. De Cevallos also refuted those who considered it a heresy to maintain that God does not cause earthquakes, basing this opinion on the catalogue of heresies by Saint Philaster, an Italian bishop of the fourth century. He noted that most other religious writers did not hold this opinion. Juan Luis Roche, a physician born in Catalonia and established in Seville, defended the same opinion, adding that there was no relation between sins committed and the occurrence of earthquakes. Rhetorically he asked: 'Are Lisbon and Seville worse than other cities?' For him those considerations were only 'pious opinions of theologians'. Roche censured the theologians who attacked the physicists (*physicos*) who explained these phenomena by purely natural principles (Feijóo y Montenegro 1756).

The natural character of the earthquake was defended and discussed in several lectures at the Real Academia Sevillana de Buenas Letras, founded in 1751, which served as a forum for new ideas. Several similar institutions were established in Spain at this time, when most universities in Spain were still attached to traditional views. Roche held the first lecture on the earthquake on 12 November 1755 (*Sobre el terremoto del 1 de Noviembre*). The following year there were lectures by Jerónimo Audixe de la Fuente (*Formación y efectos de los terremotos*, 27 March 1756) and by

Francisco de Céspedes Espinosa (*Relación histórica del terremoto de 1755*, 17 September 1756). These discussed the occurrence of the earthquake from a secular perspective. Although priests took part in these conferences, there were no formal theological discussions at the Academia (Sánchez Blanco 1999).

Both de Cevallos and Roche supported their opinions with the authority of Benito Jerónimo Feijóo y Montenegro (1676–1764), a Benedictine professor of theology of the University of Oviedo and a key figure in the Spanish Enlightenment, who was the author of *Theatro crítico universal* (1726–1740) and *Cartas eruditas y curiosas* (1742–1760), two very influential works in the introduction of scientific ideas in Spain. Feijóo y Montenegro defended the natural character of the earthquake, but, already an old man, did not enter the controversy. He wrote that man should fear sudden death more than earthquakes, since the former is more common.

Another defender of the natural character of earthquakes was Antonio Jacobo del Barco y Gasca (1716–1783), a priest and historian of Huelva, whose main work was dedicated to the history and agriculture of the region. Del Barco wrote that he intended to study 'as a philosopher', the causes, duration, extension and effects of the earthquake. Defending its natural character, he added that natural did not mean 'casual', and this type of occurrence had to be used as an occasion for men to turn to God (del Barco 1756). Isidoro Ortiz Gallardo de Villarroel, the Professor of Mathematics at the University of Salamanca, explained the natural causes of the earthquake and did not want to enter into the theological question of whether or not it was a warning from God (Ortiz Gallardo de Villarroel 1755).

Some authors held a mixed position, commenting that the earthquake was a natural event, but God could have used it to punish or warn sinners. Miguel Cabrera, of the Order of Minims, a theologian of Seville, claimed that the earthquake was 'natural in its causes, in its being and in its consequences', but, a special providence could have ordered it to happen at a particular place and time (Cabrera 1756). Francisco de Buendía y Ponce (1721–1800), a priest from Seville, poet, physician of the Archbishop of Seville, and the author of works on history and medicine, held the same opinion (Feijóo y Montenegro 1756). He stated that earthquakes, although produced by natural causes, could be sometimes a 'punishment by the Divine Hand'. Francisco Martinez Moles, a professor at the University of Alcalá de Henares, who argued that earthquakes could be signs of divine wrath, took a similar position (Martínez Moles 1755). He wrote, 'if this was a natural phenomenon caused naturally, it can be investigated rationally'. However, he went on to suggest that there were reasons for saying that God had ordered the earthquake as punishment for sins. Francisco Mariano Nifo y Cagigal (1719–1803), founder of the first newspaper in Madrid, held a similar view (Nifo y Cagigal 1755). After explaining the natural causes of earthquakes, he added what can be considered their moral causes and effects, noting that God could use these phenomena as warnings to sinners for their repentance. Juan de Zúñiga, in a letter to Feijóo y Montenegro, explained the natural causes of earthquakes and commented on how God used natural causes to show his displeasure of man's sins (Feijóo y Montenegro 1756) by De Zúñiga (1756). Pedro Trebnal, a member of the learned societies of Seville, after giving the details of this debate in his unpublished long manuscript on the subject, gave a twist to the problem by rejecting the supernatural character and defending it as a natural event, but suggesting that it was not entirely so because it had a preternatural character. That is, some evil spirit may have produced the earthquake (Trebnal 1756).

In conclusion, in Spain there were defenders of both opinions about the natural or supernatural character of the earthquake. Authors holding the new ideas of the Enlightenment (called in Spain *ilustrados*, many of them clerics) contended that the earthquake was a purely natural event, and should be studied from the purely natural point of view, staying away from theological considerations. On the other hand, traditionally minded clergymen maintained that the earthquake was a punishment or warning of God to sinners. Even as late as 1784 a Dominican friar, Alvarado, wrote that: 'we prefer to be mistaken with St. Basil and St. Augustine than to be correct with Descartes and Newton' (Aguilar Piñal 1973). An intermediate position was also presented, in which the earthquake was thought to be a natural phenomenon but God's providence used it to warn sinners. Authors taking this position argued that men could infer moral consequences from a natural event. Sanchez Blanco (1999) summarized the debate as one between two philosophical positions, a theistic position in which God intervenes directly in natural phenomena, and a deistic position in which God has given laws to the universe, but does not intervene in its normal working. However, Spanish authors, such as de Cevallos and Roche, who defended the concept of the earthquake as a natural phenomenon, cannot be called deists, as they held to the Christian tradition of divine action in the world. All participants in the debate considered themselves to be faithful to Christian doctrine and did not deny the possibility of divine intervention in the world. Moreover, there was no reference to the philosophical debate in Europe about an optimistic or pessimistic view of the world. Spanish authors never mentioned

Voltaire, Leibniz, Kant or any other participant in this debate.

The authors who held that the earthquake was a natural phenomenon took this occasion to explain the general causes of earthquakes. In their explanation we can see to what extent they knew about the scientific ideas being developed at that time in Europe. At the end of the 17th century and beginning of the 18th century new theories about the origin of earthquakes were proposed that replaced the traditional views founded on Aristotelian doctrine. In the writings of Spanish authors after the Lisbon earthquake we find a variety of theories proposed, ranging from those based on the traditional Aristotelian doctrine to the ideas introduced by recent authors (Ordaz 1983). Cabrera, Nifo y Cagigal and Trebnal presented the most traditional point of view and defended the Aristotelian doctrine, with some modifications, against the attacks of recent authors. In their explanations they introduced ideas in which the Earth is compared with a living organism, thereby showing Kircher's influence. Some authors, such as del Barco y Gasca, Roche and Ortiz Gallardo de Villarroel, adhered to the theory of the explosive nature of earthquakes. Feijóo y Montenegro, in his five letters, presented the most original ideas about the origin of the earthquake. He stated that, in the same way as lightning and thunder are produced in the atmosphere by the electricity of the clouds, earthquakes are caused by the electricity accumulated inside the Earth by vitreous material. This was not a totally original idea, as William Stuckley in England in 1750 and Giovanni Battista Beccaria in Italy in 1753 had already proposed the electrical nature of earthquakes (Taylor 1975).

Conclusion

The interpretation of earthquakes as God's punishment for sins, in Spanish writings of 17th and 18th centuries, has been examined using the occasions of the Malaga earthquake of 1680 and the Lisbon earthquake of 1755. After the 1680 earthquake, this interpretation was generally held with no dissenting voices. After the Lisbon event, however, Spanish writers joined the rest of Europe in debating the natural or supernatural character of the earthquake. Authors took positions on both sides of the controversy. Some, such as del Barco y Gasca, Roche, de Cevallos and Feijóo y Montenegro, defended the natural origin of the earthquake. They stated that this position was not against Christian doctrine, so that their position cannot be called deist. On this occasion authors also tried to explain various theories about the origin of earthquakes, ranging from Aristotelian doctrine to organicist theories, and to explosive and electrical theories.

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The idiom of a six day creation and global depictions in Theories of the Earth

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Abstract: During the 17th century, in a new contested tradition known as Theories of the Earth, conventions for the visual representation of the Earth as a whole developed alongside the expression of biblical idiom. Global depictions carried embedded biblical idiom that shaped the formulation of questions, the development of theories, and the exchange of discoveries and ideas. In several examples I contrast the varying ways in which biblical idiom was expressed within global depictions, particularly hexameral idiom (i.e. the language of the six day creation in Genesis 1). I discuss the Jesuit mathematician Gabriele Beati and meteorological and cosmic sections; the cosmogonic sections and hexameral idiom of Robert Fludd; the geogonic sections and hexameral idiom of René Descartes; the apocalyptic idiom of Thomas Burnet; and the global depictions and hexameral idiom of William Whiston in the controversy over Burnet. Biblical and particularly hexameral idiom proved durable and versatile for more than a century after Fludd, and facilitated the development of a directionalist sense of Earth history. The continuities of visual conventions, the durability of hexameral idiom, and the contrasts of disciplinary perspectives and local contexts observed in the examples considered here conform well to the characterization of Theories of the Earth as a contested print tradition.

This paper explores the relations between biblical idiom and global depictions in 17th-century Theories of the Earth as a sequel to an earlier examination of the development of the global depictions (Magruder 2006). Shared conventions for visual representations provided a common ground for the exchange of novel ideas. In a similar way, shared biblical idiom provided a linguistic common ground for the exchange and comparative assessment of rival theories. This paper and Magruder (2006) show how biblical idiom and global depictions each facilitated the establishment of 17th-century Theories of the Earth as a contested print tradition. The relations between early Theories of the Earth and biblical idiom are rich and complex. However, this paper will focus specifically upon the biblical idiom that was embedded within global depictions with emphasis on the embedded hexameral idiom; that is, the language of the six days of creation as narrated in the first chapter of Genesis.

Georges Cuvier (1769–1832) stated that early Theorists of the Earth tried to explain all of the Earth's history by reference to only two events, the creation and the biblical Flood (Cuvier 1812, p. 4). There was truth in his argument, although there were major Theorists of the Earth, for example, Benoît de Maillet (1656–1738) and James Hutton (1726–1797), who did not seek to relate their writings to traditions of biblical interpretation. For others such as Georges-Louis Leclerc, Comte de Buffon (1707–1788), biblical idiom served more as a rhetorical flourish than a substantive resource. However, for many, the use of biblical idiom did signal the continuing importance of a widespread mode of interdisciplinary communication.

To understand the significance of the biblical Flood for Theories of the Earth we may turn to a variety of insightful studies (Rappaport 1978; Young 1995). Less has been written about the tradition of hexameral commentaries and their significance for thinking about the Earth (Williams 1948). Some writers regard Theorists of the Earth as preoccupied with the Flood, as many were indeed. Yet the prolific hexameral commentary tradition was one of the most important textual traditions for discussing the formation of the Earth before such discussions acquired a more interdisciplinary character in the contested print tradition known as Theories of the Earth. To understand Theories of the Earth, therefore, it is essential to take into account the role of hexameral idiom.

'Idiom' refers to nontechnical language that nevertheless shaped how investigators articulated questions, formulated concepts, and appropriated novel ideas by transposing them into a familiar linguistic context. 'Hexameral idiom' refers to the development, presentation and exchange of ideas using the linguistic resources of Genesis 1. Instances of hexameral idiom ranged from the vocabulary of the biblical text, which offered a source of proto-terminology such as 'the firmament' that carried

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Table 1. *Global visions and hexameral idiom*

	Field or discipline	Natural philosophy	Image character	Image type	Biblical idiom
Beati	Astronomy	Jesuit	Didactic and contemplative	Cosmic section	Hexameral
Fludd	Chymistry	Hermeticism	Emblematic	Cosmogonic sections	Hexameral
Descartes	Meteorology	Mechanical	Didactic abstractions	Geogonic sections	Hexameral
Burnet	Classics	Cambridge Platonism	Evidential representations	Global sections and views	Apocalyptic
Whiston	Physics	Newtonian	Didactic abstractions	Geogonic sections	Hexameral

affiliated conceptual resources, to turns of phrase such as ‘the gathering of the waters’ on the third day, to larger linguistic structures such as the pattern of a gradual cumulation of events over a succession of six days. This range of idiom provided a scaffolding for the development and communication of ideas about the history of the Earth regardless of the specific content of the theories or a writer’s area of technical expertise (Magruder 2008).

The earlier paper (Magruder 2006) compared the global depictions of Johann Kepler (1571–1630), Robert Fludd (1574–1637), René Descartes (1596–1650) and Thomas Burnet (*c*. 1635–1715), examining their varied disciplinary and technical contexts, their diverse natural philosophies, and the different roles played by images in their works (see Table 1). This paper will superimpose upon that analysis a consideration of biblical idiom (see Table 1, rightmost column). Because of the incidental role of images in Kepler’s thinking about the Earth, this paper will adopt a different starting point; namely, a brief look at the precedents provided by meteorological sections and cosmic sections for visually depicting hexameral idiom. The resulting survey portrays Theories of the Earth as a ‘hermeneutical conversation’ (Gadamer 1996, pp. 383–405) in which a shared biblical idiom enabled writers to engage in a common critical debate. In early Theories of the Earth, biblical idiom helped to convey a directionalist sense of Earth history, and facilitated the interaction and exchange of new theories between investigators adhering to diverse natural philosophies, methodologies and technical contexts.

Gabriele Beati: hexameral idiom and cosmic sections

Meteorological sections and views depict the relations of the elements of the Earth. Frequently meteorological sections showing concentric regions of earth, water, air and fire were incorporated into cosmic sections representing the second day of creation, when the waters covered the face of the Earth, as in the *Nuremberg Chronicle* of 1493 (Fig. 1a and b; Schedel 1493). Meteorological

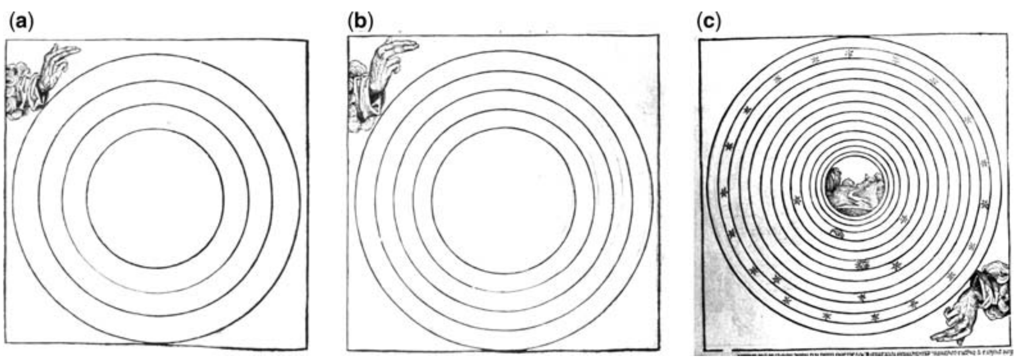

Fig. 1. *Nuremberg Chronicle* (Schedel 1493). (**a**) Meteorological section, second day of creation. (**b**) Meteorological section, third day. (**c**) Meteorological view, fourth day.

views, combining the land and the sea in a single region, depicted the Earth after the third day when the dry land appeared and the waters withdrew into the ocean basins (Fig. 1c). That the meteorological regions, taken together, constituted a coherent body or interrelated functional system is confirmed by the way meteorological depictions could be placed in the heavens, as in Thomas Digges' 'globe of mortality' (Digges & Digges 1576, p. 43).

Gabriele Beati (1607–1673) published a cosmic section in 1662 for contemplation by his mathematics students at the Collegio Romano (Fig. 2; Beati 1662). Far above the meteorological section in the centre, in the higher spheres of the cosmos, lie additional structures inferred from the hexameral account. For mid-17th-century Jesuits such as Beati, three regions were established during the creation week: the meteorological, the celestial and the empyrean. Each of the three regions was composed of a fiery solid that would erupt in conflagration were it not for the cooling effect of fluid waters above.

In the celestial region the solid firmament supported the waters above the heavens just as the solid crust supports the oceans on the Earth. Because the firmament was igneous in nature, the waters above the firmament tempered the heat of the firmament and its fiery stars. The heavens continued to exist only because of this precarious balance between water and fire. In addition, the lower solid part of the empyrean heaven was fiery, supporting a fluid region above. The empyrean thus completed an exact three-way parallel to the Earth's solid but igneous crust underlying the

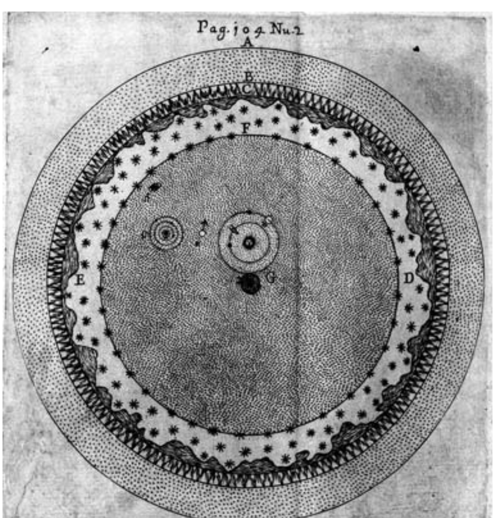

Fig. 2. *Sphaera Triplex* (Beati 1662). Cosmic section. G, meteorological regions; F, firmament; C, empyrean (solid); E, empyrean (fluid).

ocean basins, and to the solid igneous firmament underlying the super-celestial waters. A similar precarious balance between water and fire characterized the well-known global sections of Athanasius Kircher, a Jesuit contemporary of Beati in Rome (Kircher 1665; Waddell 2006). The Jesuit understanding of the Earth manifest in Kircher's global sections, with their dramatic depictions of the balance of fire and water, was made more plausible to readers accustomed to the hexameral idiom embedded within such cosmic sections, including Kircher's own (Kircher 1657).

The didactic, contemplative cosmic section of Beati provides one example of how hexameral idiom became embedded within mid-17th-century cosmic sections. Hexameral idiom pervaded many cosmic sections regardless of religious tradition, disciplinary context or natural philosophy. Both meteorological and cosmic sections, each associated with hexameral idiom, provided important precedents and resources for depictions of the Earth in the 17th century.

Robert Fludd: hexameral idiom and cosmogonic sections

The London physician and chymical philosopher Robert Fludd used images as emblems representing the mysteries of hermeticism that he would interpret for the reader (Fludd 1617; Debus 1966; Godwin 1979; Westman 1984). Fludd's rich use of cosmogonic sections established important visual conventions for subsequent representations of the Earth, including the quarter section and double hemisections explored by Magruder (2006). That paper did not emphasize Fludd's hexameral orientation, however, although it was of central importance to his use of images. For example, Fludd used rotation to suggest the passage of time in the first three days of creation (Fig. 3a).

Fludd's work opened with a sustained cosmogonic series organized explicitly according to the hexameral account, the earliest important series of cosmogonic sections of the 17th century. In this sequence, layers gradually separated as creation proceeded from chaos (Fig. 3). The details of the diagrams do not matter so much as the directional framework of the hexameral idiom. Because of the hexameral context, the diagrams attributed the origin of the Earth to a meaningful sequence of temporal events. That is, Fludd explained the Earth and cosmos by detailed expository references to cosmogonic sections which because of their embedded hexameral idiom attributed a directionalist pattern to the origin of the Earth. (For a careful discussion of directionalism see Rudwick (1971) and Magruder (2000, pp. 6–43).)

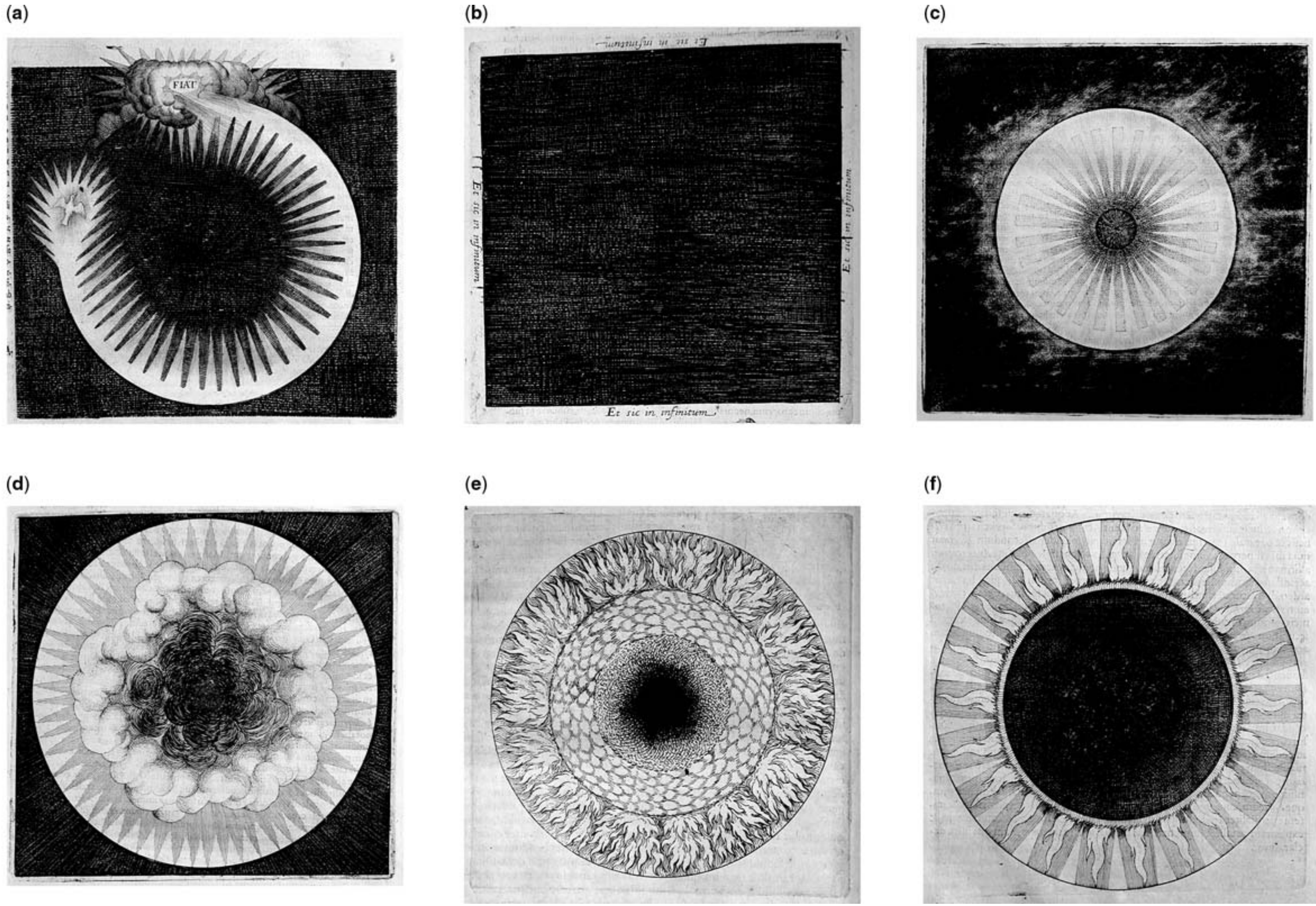

Fig. 3. Cosmogonic sections (Fludd 1617, Vol. 1). (**a**) Rotating figure, p. 49. (**b**) p. 26. (**c**) p. 29. (**d**) p. 37. (**e**) p. 46. (**f**) p. 55.

René Descartes: hexameral idiom and cosmic and geogonic sections

In the *Principia philosophiae* (1644), René Descartes offered a comprehensive mechanical vision of the development of Earth-like planets (Descartes 1644). This mechanical account broke with Fludd and the chymical philosophers in many ways, yet Descartes, too, employed hexameral idiom. While writing the *Principia*, Descartes wrote to Mersenne that he would have no trouble showing the compatibility of his account of the formation of the Earth with Genesis 1 (Descartes 1965, III, pp. 295–296). Compatibility with Genesis 1 was just as important for legitimizing Cartesianism as the often-cited issues of the motion of the Earth and the physics of the eucharist (Nadler 1988). When the *Principia* appeared, however, Descartes trod cautiously, as interpreting the Bible was the prerogative of the theologian rather than the Catholic natural philosopher. Nevertheless, hexameral idiom is present in Question 131 of the *Principia*, for example, where Descartes identified the firmament with the refracting surface of the Sun's vortex. The waters above the firmament were the vortices of other stars, whereas the Sun's fluid planetary heavens comprised the waters below the firmament (Fig. 4a). In this case, hexameral idiom was explicit. The familiar idiom translated novel features of Descartes' cosmology into a familiar and accessible linguistic common ground.

Descartes' idiom was not lost on readers who appreciated the cognitive resources it provided for interpreting the second day of creation. For example, Théodore Barin organized his account of Descartes' natural philosophy in the form of a hexameral narrative, and embedded Cartesian visual representations within that sequential hexameral account (Barin 1686). One cosmic section (Fig. 4b) shows Barin's philosophical interpretation of the second day when the creation of the firmament divided the waters. Barin developed an explicit concordism, drawing highly specific inferences from the hexameral text: neither the stars nor the Sun and planets yet exist, although their vortices are present. The vortices created by the division of the heavens on the second day were then filled with the planets and stars on the fourth day. Barin's second cosmic section (Fig. 4c) depicted the stars and planets as they appeared within their respective vortices on the fourth day. While Descartes drew back from such detailed and highly specific concordism between cosmology and hexameral exegesis, Barin's interpretation did follow the lead of Descartes' hexameral idiom, which explicitly identified the firmament and the super-celestial waters within Cartesian cosmology.

Descartes prepared a singular sequence of geogonic images to show the development of an Earth-like planet over time. In a striking rotating figure, Descartes combined four geogonic sections into one diagram (Fig. 5a; Magruder 2006). Descartes regarded the settling out of the planetary layers to this point as a gradual process, but in Question 39 he asserted that it would not have required a long time. His description allowed readers such as Barin to assign these events to the creation week. In two subsequent geogonic hemisections, a dried solid layer has fractured and tilted, creating

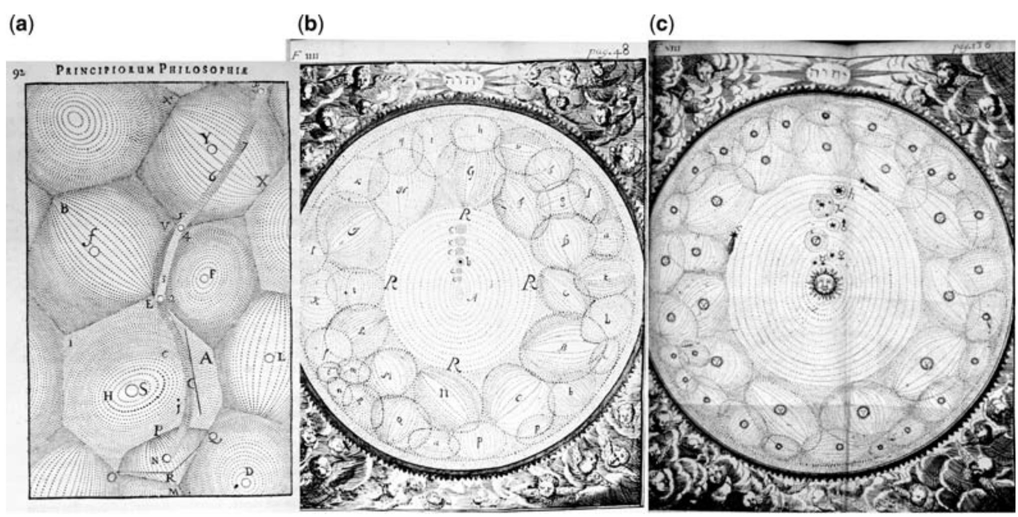

Fig. 4. (**a**) Cosmic section (Descartes 1644, p. 92). (**b**) Théodore Barin, cosmic section, second day (Barin 1686, p. 48). (**c**) Théodore Barin, cosmic section, fourth day (Barin 1686, p. 136).

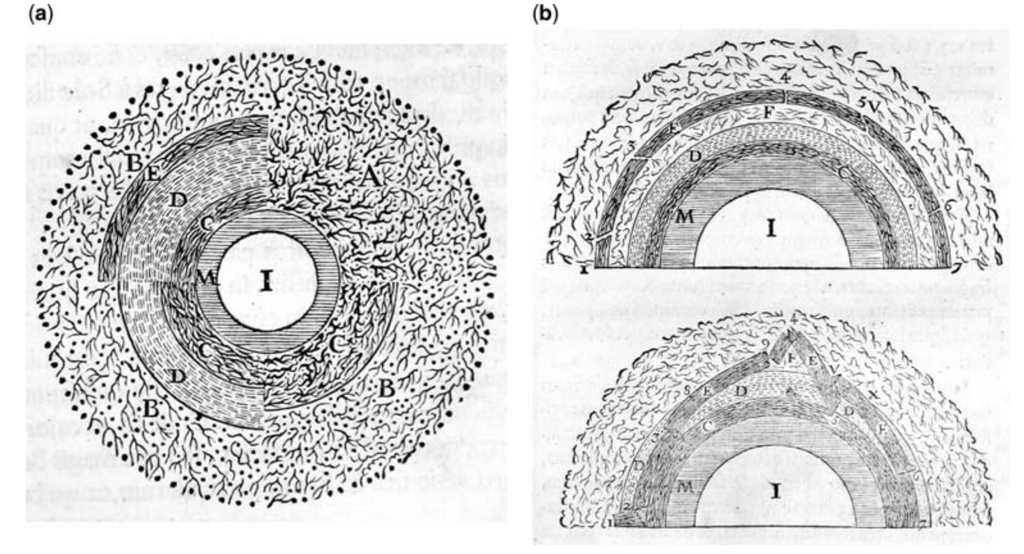

Fig. 5. Geogonic sections (Descartes 1644). (**a**) Geogonic quarter-sections (Descartes 1644, p. 206). (**b**) Geogonic hemisections, (Descartes 1644, p. 215).

mountains and ocean beds (Fig. 5b). In the hexameral tradition, the formation of mountains and ocean beds would have been assigned to the third day, the separation of the dry land and the sea.

Indeed, consistent with hexameral idiom, Barin assigned a Cartesian geogonic section to the beginning of the third day (Fig. 6a) and another to the end of the third day, after the separation of the dry land and the sea (Fig. 6b). Barin saw this as a straightforward reading of Descartes' *Principia.* However, Descartes implied that the crustal collapse would not have been possible in two or three 24 hour days. Barin was willing to interpret the length of the days figuratively, while maintaining the pattern of the six days as a directionalist framework consisting of a temporal sequence of events.

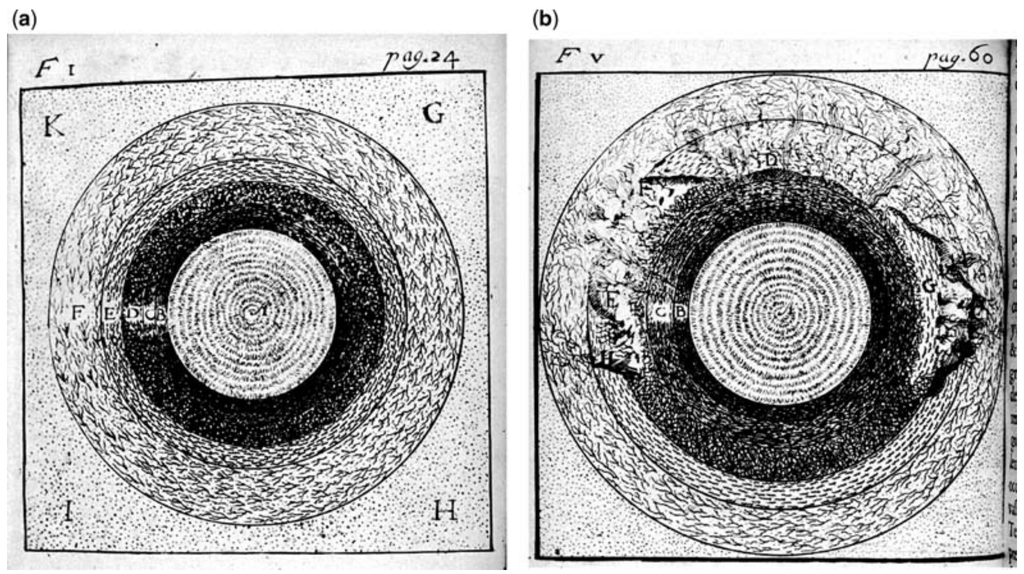

Fig. 6. Geogonic sections (Barin 1686). (**a**) Before the third day (Barin 1686, p. 24). (**b**) After the third day (Barin 1686, p. 60).

Despite the contrasting natural philosophies of Fludd and Descartes, there was a continuity of visual representation, as Fludd provided the visual precedents for Descartes' rotating wheel and hemisections (Magruder 2006). As with visual rhetoric so with biblical idiom: Fludd and Descartes also shared the deployment of hexameral idiom within a directionalist framework of creation. Descartes' cosmic sections and his geogonic sections were presented in terms of the hexameral idiom of the firmament and the waters above and below the firmament, and were consistent with the separation of dry land on the third day. Descartes himself affirmed that he had compatibility with the hexameral account in mind as he was writing the *Principia*. Readers such as Barin who elaborated concordist interpretations regarded this compatibility as legitimizing Cartesian natural philosophy.

Thomas Burnet: biblical idiom and global sections and views

The classical scholar Thomas Burnet substituted apocalyptic idiom for the hexameral tradition. That Burnet's theory owed at least as much to the apostle Peter as to Descartes may be seen in the apocalyptic cycle of Earth history depicted in the frontispiece to his *Theory of the Earth* (Burnet 1684; Fig. 7). Christ's left foot rests upon a ball of chaos under the caption *Apò kataboles kosmou*, 'From the Foundation of the World'. This biblical idiom resonates with apocalyptic overtones, evoking one of the most quoted passages in the New Testament regarding the destiny of the Earth, 2 Peter 3: 3–13, the primary allusion behind Burnet's caption. The epistle of 2 Peter admonished readers that in the last days scoffers would assert nothing but continuities from the beginning of the creation. Believers should rather look for a new Earth by remembering that the former Earth had perished. The epistle spoke of three utterly different worlds: the 'world that then was'; the 'earth that [is] now'; and 'a new earth' that is to come. Burnet described his *Theory of the Earth* as nothing more than a commentary on this text (Burnet 1690, p. 385).

Because Peter established apocalyptic discontinuities between past, present and future Earths, Peter was of greater importance than Moses for deciphering the 'whole Circle of Time and Providence' (Burnet 1684, p. 24). Thus Burnet sought to transplant discussion of the origin and fate of the Earth away from the hexameral tradition, which emphasized continuities of the Earth, into a new apocalyptic discourse that would emphasize discontinuities (for a detailed study of Burnet's apocalyptic idiom, see Magruder 2008). In the controversy that followed the publication of his book, Burnet's argument largely failed because his antediluvian globe, with neither mountains nor oceans, contradicted established hexameral idiom. For Burnet there was no third day of creation, no gathering of the waters into the sea to form the dry land. Wherever one finds mountains in maps of Eden or biblical illustrations of the creation week, the hexameral idiom of the third day implied that mountains were older than Adam (Fig. 8).

Burnet's emphasis on the biblical Flood at the expense of the creation week was reflected not only in his frontispiece but also in his citations of the Bible. In *The Theory of the Earth* (1684), Burnet cited four biblical books nine or more times. It does not take a reference count to suggest that Genesis will be the most quoted biblical book in a work about the natural causes of the Flood and Paradise, and Burnet cited it 40 times. Similarly, nine references to Job and 12 to the Psalms are not surprising, considering the large number of nature passages, often poetical, contained in these books. What would be surprising, were it not for the frontispiece, are the 14 references to the second epistle of Peter, second in frequency only to Genesis. Burnet's references to Genesis also reflect his radical departure from hexameral interpretation. Most importantly, over half (21) of the 40 Genesis references refer to the Flood. Only five references occur to the creation week, and none of these refer to what Burnet's contemporaries would have regarded as the chief hexameral event responsible for the formation of the Earth, the division of dry land and sea on the third day. As Burnet explained, 'Those places of Scripture which we have cited, I think, are all truly appli'd; and I have not mention'd Moses's *Cosmopoeia*, because I thought it deliver'd by him as a Lawgiver, not as a Philosopher; which I intend to show at large in another Treatise, not thinking that discussion proper for the Vulgar Tongue' (Burnet 1684, pp. 288–289). The other treatise would be the *Archaeologiae Philosophicae*, published in Latin rather than the vernacular in a failed attempt to contain the developing controversy (Burnet 1692).

Hexameral idiom and the global depictions of the Burnet controversy

Hexameral idiom played a critical role in the controversy over Burnet's Theory of the Earth. After Descartes and Burnet established visual conventions for depicting the development of the Earth, global depictions became a common currency of debate as critics from a variety of technical contexts proposed arguments to defend the continuities

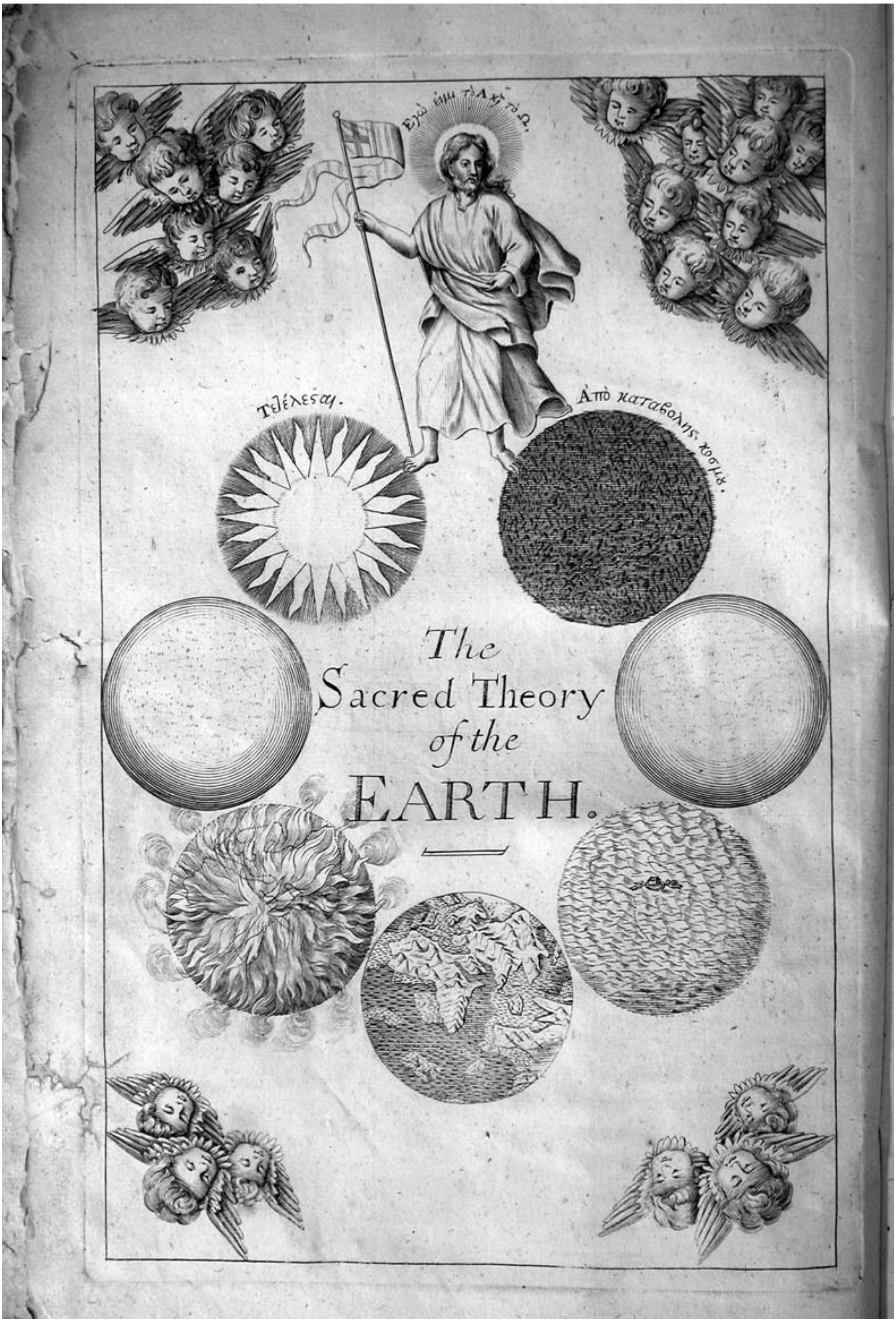

Fig. 7. Frontispiece (Burnet 1684).

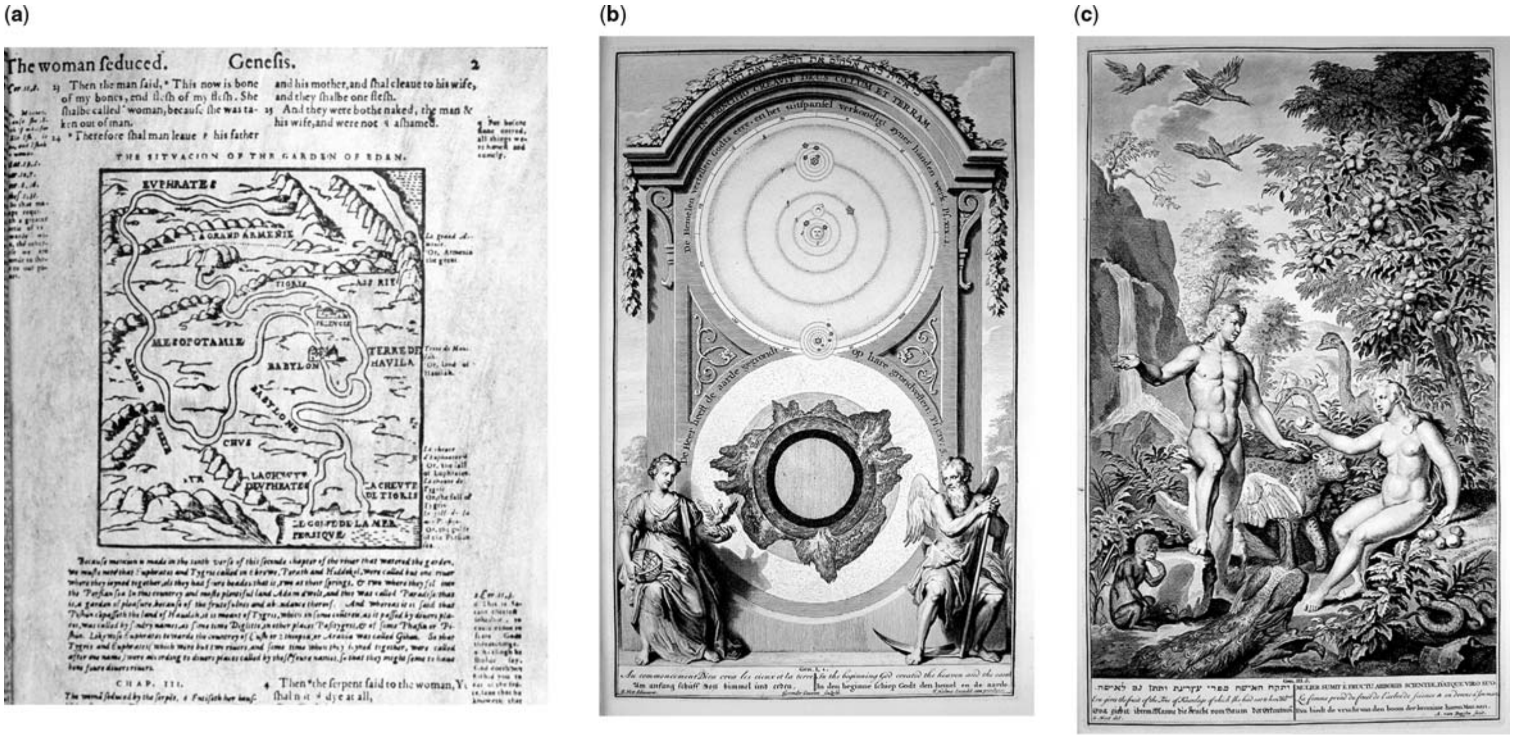

Fig. 8. Hexameral idiom: mountains before Adam. (**a**) Geneva Bible (1560), Genesis 2. (**b**) Gerard Hoet (1728), Genesis 1. (**c**) Gerard Hoet (1728), Genesis 2.

associated with hexameral idiom. The global depictions of three writers (Erasmus Warren, Thomas Beverley and William Whiston) illustrate the significance of hexameral idiom in the Burnet controversy.

The Rector of Worlington, Erasmus Warren, rebutted Burnet in *Geologia*, the first of three critiques Warren published in as many years (Warren 1690). Yet *Geologia* was not an early work of geology, but a discourse rooted in the hexameral commentary tradition. Warren reprinted Burnet's section of the original Earth showing an oceanless globe containing a watery abyss closed to the sky (Fig. 9a). Opposing this diagram on the grounds of biblical interpretation, Warren argued that Adam could not have exercised the dominion over the fish and whales that Genesis attributed to him unless there had been open seas from the time of the creation. Warren explained that Burnet's theory 'presents us with a new notion of the Firmament, and makes it to be quite another thing, than what it has always been said to be' (Warren 1690, p. 226). Warren maintained a traditional interpretation that the firmament or expanse is the air in which the birds fly, and the waters above the firmament are the clouds. This interpretation reflected the views of Calvin and the Geneva Bible, for example, as well as that of Descartes some time after publication of the *Principia*.

In the controversy Burnet's images became a common currency for debate. Not only did Warren attack them as surrogates for Burnet's views, but they could also be appropriated in service of rival conceptions. Thomas Beverley showed how easily Burnet's global depictions could be transposed into hexameral idiom, ironically even by one of Burnet's defenders. By printing two global sections resembling Burnet's, Beverley aimed to offer an eirenic defence of Burnet in response to the abusive wit of John Keill. Yet for Beverley the top scene represented not the Flood, but the first day of creation when waters covered the Earth (Fig. 9c). Beverley omitted Noah's ark and the attending angels, as found in Burnet's deluge depiction (Fig. 9b; Beverley 1699). The biblical idiom carried by global depictions was as adaptable as the global depictions themselves.

Descartes and Burnet established a repertoire of diagrams and a variety of visual conventions for mapping transformations in the Earth over time. Once such conventions were established, similar images were used by various writers to support competing conceptions, as may be seen with the example of William Whiston (1667–1752; Whiston 1696). Whiston attacked Burnet on two fronts: his criticism of Burnet's Cartesian natural philosophy was based on Newtonian mathematical physics and he emphasized the creation at least as much as the Flood. Whiston's Newtonianism is well known and requires little comment other than to note its expression in his visual representations. Whiston's frontispiece and the seven figures prominently displayed at the front of his *New Theory of the Earth* all feature comets in an unmistakably Newtonian perspective. Newtonian comets were incompatible with Cartesian vortices for various reasons, including their periodic orbits, highly variable inclinations, retrograde orbital directions, and rarefied tails of great length. The reduction of cometary motions to the mathematical rule of an elliptical orbit symbolized the triumph of Newtonian mechanics over Cartesian cosmology. As if to emphasize this triumph, in Whiston's *New Theory of the Earth* the favoured Newtonian agent, a comet, arrived in time for almost every purpose under heaven: to provide the material of the chaos at creation, to give the Earth a shock at the fall, to supply the water of the Flood and to ignite the Earth at the final conflagration. And if all this were not enough, Whiston included a Latin dedication of his *New Theory* to Newton.

However, Whiston's presentation was adamantly hexameral as well as Newtonian. In opposition to Burnet, Whiston set out to find a concordism between the creation account and the stages of the formation of the present state of the Earth, beginning his *New Theory* with a 94 page 'Discourse on the Mosaick History of the Creation'. Whiston copied his global sections (Fig. 10, bottom row) almost directly from Burnet (Fig. 10, top row), but for Whiston it was imperative to specify how the geogonic sections, which had now taken on a life of their own, might be fitted into Moses' account of the creation week.

Burnet's first global section represented the chaos. Whiston's first global section was an almost identical redrawing of Burnet's, except for the solid hot core added in the centre region, which identifies the chaos as a cometary body (Fig. 10a). Whiston appropriated Burnet's first four figures in almost identical form to show a gradual division of layers, yet Whiston's global sections served a hexameral chronology.

For Whiston, the first two sections preceded the works of the six days, when darkness covered the face of the deep (the chaotic cometary atmosphere) and the Spirit hovered over the waters. In text accompanying the second section (Fig. 10b), Whiston described a division of the outer atmosphere according to specific gravity (as did Woodward 1695). This separation yielded a dense and heavy abyss that encompassed the central solid body, and an outer, more airy region composed of a mixture of particles. So far, except for the Newtonian comet, Whiston's account and diagram both resembled Burnet's.

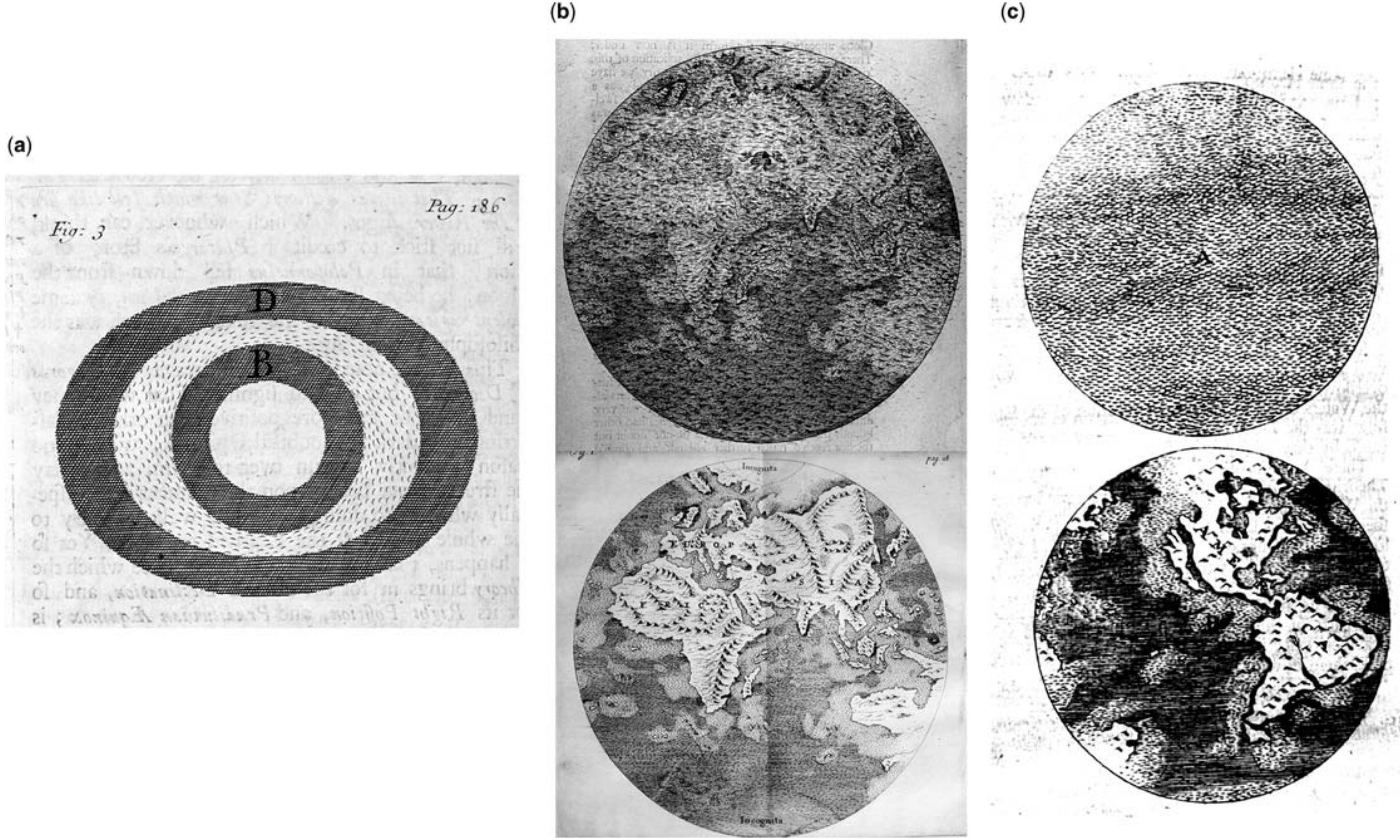

Fig. 9. (**a**) *Geologia* (Warren 1690, p. 186). Firmament (D) and watery abyss (between B and D). (**b**) *The Theory of the Earth* (Burnet 1684), Flood and present world. (**c**) Beverley (1699), creation and present world.

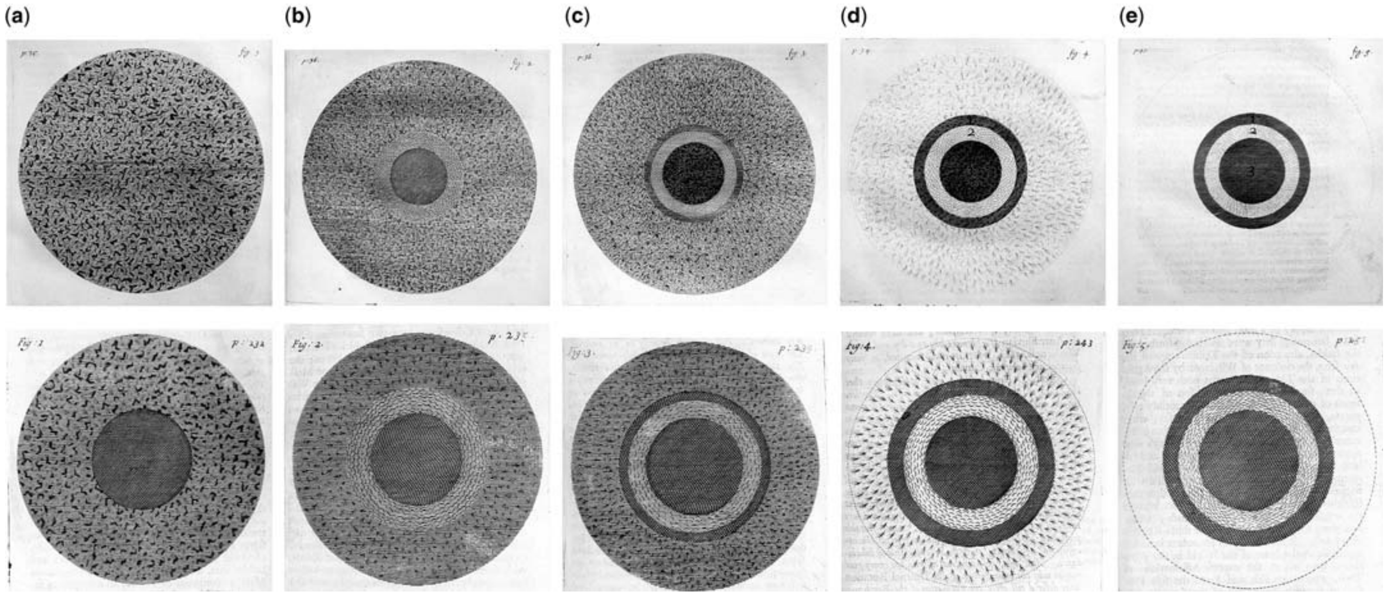

Fig. 10. Geogonic series of Burnet (top row) and Whiston (bottom row). (**a**) Section 1, original chaos. Top: Burnet (1681, p. 35). Bottom: Whiston (1696, p. 232); a comet. (**b**) Section 2, division of layers. Top: Burnet (1681, p. 36). Bottom: Whiston (1696, p. 235); before the first day. (**c**) Section 3, solid orb of the Earth. Top: Burnet (1681, p. 38). Bottom: Whiston (1696, p. 239); Day 1. (**d**) Section 4, air, earth, waters. Top: Burnet (1681, p. 39). Bottom: Whiston (1696, p. 243); Day 2 and Day 3. (**e**) Section 5, atmosphere clearing. Top: Burnet (1681, p. 41). Bottom: Whiston (1696, p. 251); Day 4.

With the third section Whiston described the formation upon the abyss of a 'Solid Orb of Earth', just as did Burnet (Fig. 10c). However, for Whiston this was the first day of creation, on which nonfossiliferous strata were laid down. The thickening outer layer hardened over the enclosed abyss. The outermost atmosphere began to clear, allowing light from the Sun to pass through, which successively illuminated the entire globe. Whiston interpreted 'Let there be light' and similar phrases with respect to what an observer of the visible world would perceive if watching from a standpoint on the surface of the Earth itself; such an approach had been practised by Augustine (e.g. Augustine 1982, Vol. 1, pp. 33, 69–71).

In Whiston's fourth section the outermost airy region surrounded the thick solid layer of the Earth, which in turn contained the subterranean waters, in correlation with Burnet's use of the same diagram (Fig. 10d). However, this durability of visual representation belies the very different contexts, in terms of both cosmology and interpretation, into which Whiston appropriated them. To Whiston, Newton rather than Descartes read the book of God's works correctly, and Moses rather than Peter wrote the relevant passages of God's word, for to Whiston this figure illustrated the work of the second day, the separation of waters above and below the firmament. Like so many others, Whiston identified the firmament as the air and the superior waters as the clouds. These vapours escaped being trapped in the subterranean watery abyss beneath the outer layer of crust.

Whiston used the same figure (Fig. 10d) for his account of the third day, irrevocably parting company with Burnet. For Whiston there must have been a separation of dry land and sea rather than a smooth and uniform paradisiacal globe. Consequently, Whiston argued that the settling of particles out of the chaos did not produce a uniform orb of the Earth, but that it consolidated unevenly and compacted irregularly, 'distinguish'd into Mountains, Plains and Valleys' (Whiston 1696, p. 245). For Whiston the original 'strata,' in contrast to those of Nicolaus Steno (1638–1686) in his *Prodromus* (Steno 1669), were not horizontal or concentric but irregular and inclined. In this conception Whiston followed the views expressed by Isaac Newton (1643–1727) in a 1681 letter to Burnet (Brewster 1855, Vol. 2, p. 450). Whiston justified using the fourth section to illustrate the third day by citing the insensible vertical thickness on such a small scale drawing. Needless to say, Burnet would have found the uneven paradisiacal surface postulated by Whiston as repugnant as Whiston's use of his beautifully smooth diagrams to illustrate it.

Whiston's fifth section again resembled Burnet's depiction of the clearing of the atmosphere, but Whiston appropriated it into the context of the creation week to represent the work of the fourth day (Fig. 10e). As a consequence of accommodating the hexameral account to an earthbound perspective, the Sun and stars, although created before the creation week, were not described until the fourth day, when the atmosphere cleared enough to make them distinctly visible. Thus Whiston wholly transposed Burnet's geogonic series into a narrative organized by the hexameral framework.

Burnet and Whiston invoked biblical idiom in an explicitly theoretical role as part of a concordist rather than a merely compatibilist interpretation. To interpret the book of God's word and the book of God's works, particularly in areas where either one or both were obscure, one might employ biblical idiom to ensure their compatibility. However, if both books were deemed to be unambiguously clear, one might aim to go further and demonstrate specific areas of concordism. Both Burnet and Whiston rejected the compatibilist strategy with its Augustinian principle of allowing for multiple competing literal interpretations. They both emphasized instead the concordist ideal that the Bible cannot be interpreted rightly, or literally, without the aid of a good physical theory.

At some point either prior to or at the beginning of the first day, Whiston argued, the cometary chaos was given an annual motion in a circular orbit around the Sun, either by the direct finger of God or by some other peculiar providence. Thus throughout the creation week, according to Whiston, the Earth had an annual motion but no daily or diurnal motion. Consequently, each day was equivalent to a year; its 'evening and morning' were six months of darkness followed by six months of daylight. This 'literal interpretation' of the length of the days resolved a number of difficulties for Whiston, including the duration required for various natural processes once set in motion by the divine fiat (Whiston 1696, pp. 89ff.). Thus on the third day, during six months of darkness, vapours condensed and fell upon the Earth, filling its depressions to form the seas. During the subsequent six months of daylight, the newly watered and fertile land sprouted the terrestrial plants, as Genesis related. The year-long 'days' assisted Whiston in his explanation of the sixth day as well. The production of the terrestrial animals occurred during the first half of the sixth year. Created in the morning of the sixth day, that is, at the beginning of the second half of the sixth year, Adam enjoyed perhaps six months in Paradise before his fall, which Whiston situated at the beginning of the seventh day. Besides giving Adam time to name the animals before falling into the deep sleep during which Eve would be formed from his rib, a long day allowed for their mutual acquaintance and joint appointment as stewards of the Earth (Whiston 1696, pp. 81–89, 257).

Whiston provided no diagram to illustrate the work of the fifth day (i.e. the production of aquatic and aerial life). We will not consider here additional parallels, such as Burnet's sixth figure that illustrated the ovoid structure of the antediluvian globe, which Whiston adopted as well (Magruder 2008).

The use of hexameral idiom was not exclusive; Whiston, for example, also employed the idiom of the fall, Flood and apocalypse, as well as classical idiom, although hexameral idiom was most prominently embedded in his global depictions. However, on balance, the Burnet controversy saw a rejection of Burnet's Theory of the Earth in favour of traditional hexameral idiom, whether that idiom was couched in terms of Newtonian physics and astronomy by Whiston, or in terms of other technical traditions and natural philosophies by Warren and other critics.

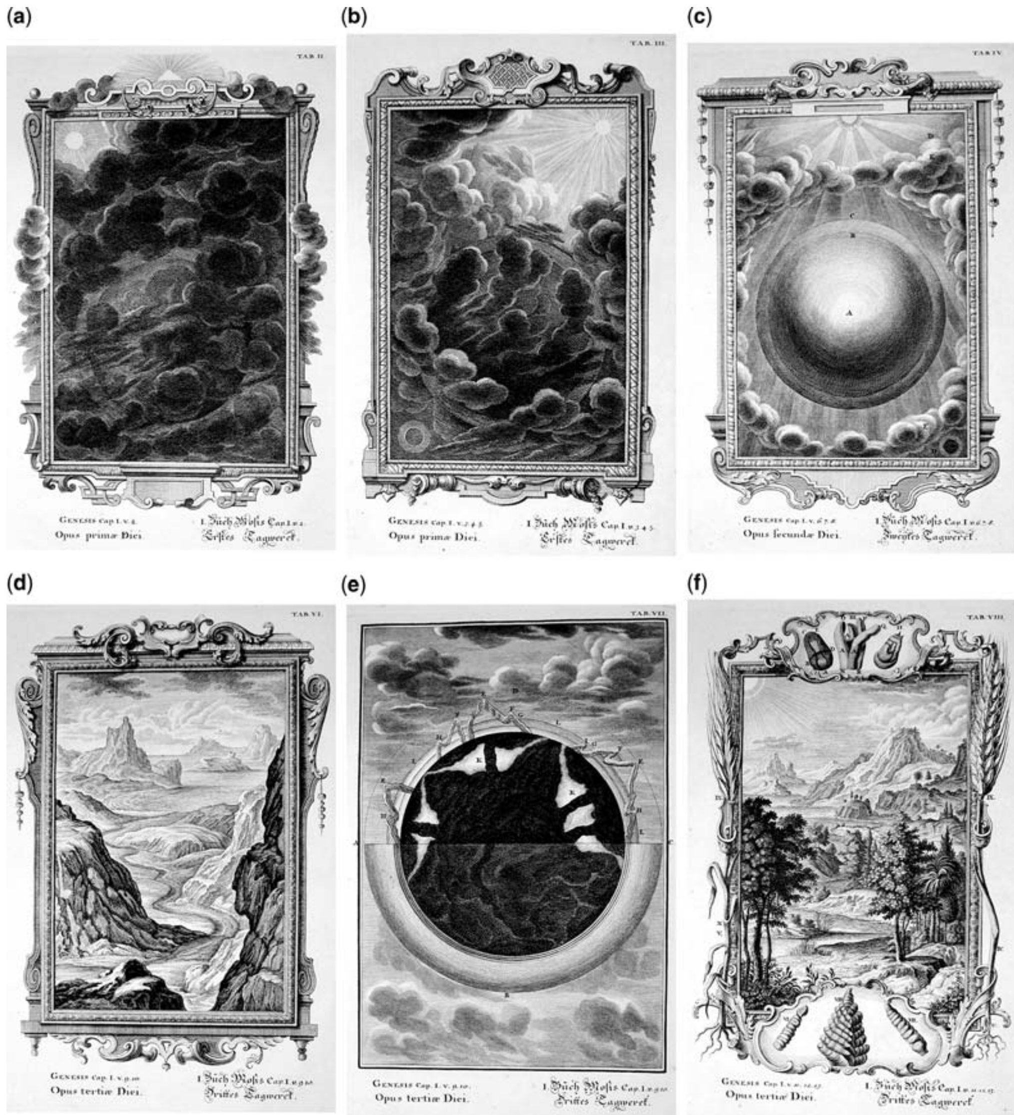

Fig. 11. *Geestelyke Natuurkunde* (Scheuchzer 1728). (**a**–**c**) Global sections for Days 1 and 2. (**d**–**f**) Two global hemisections and two landscape depictions of the beginning and end of Day 3.

Conclusion: hexameral idiom and global depictions in a contested print tradition

Hexameral idiom embedded within global depictions in Theories of the Earth reinforced temporal conceptions of Earth history, and proved durable and versatile. First, hexameral idiom carried a temporal significance for Robert Fludd, Descartes, Warren, Whiston and many others. Concordist schemes were precarious, yet the directionalist tendency of the idiom persisted through various interpretations. A convenient endpoint for this survey is the *Kupfer-Bibel* of Johann Jakob Scheuchzer (1672–1733), published also in Latin and Dutch as *Physica Sacra* and *Geestelyke Natuurkunde*, which served as the starting point of Rudwick's *Scenes from Deep Time* (Scheuchzer 1728; Rudwick 1992). Scheuchzer began this multivolume folio collection of biblical illustrations with a series of global depictions representing the works of the first three days. On the first day, when darkness covered the face of the deep, God said 'let there be light' (Fig. 11a and b). On the second day the firmament divided the waters (Fig. 11c). On the third day, the waters below gathered together to form the sea, separate from dry land (Fig. 11d–f). The lower hemisphere of Figure 11e represents the Earth at the start of the third day; the top hemisphere depicts the Earth at the end of the third day. Scheuchzer accompanied this global section with landscape depictions, again corresponding to the beginning and end of the third day (Fig. 11d and f, respectively). The entire argument to this point about whole-Earth depictions of

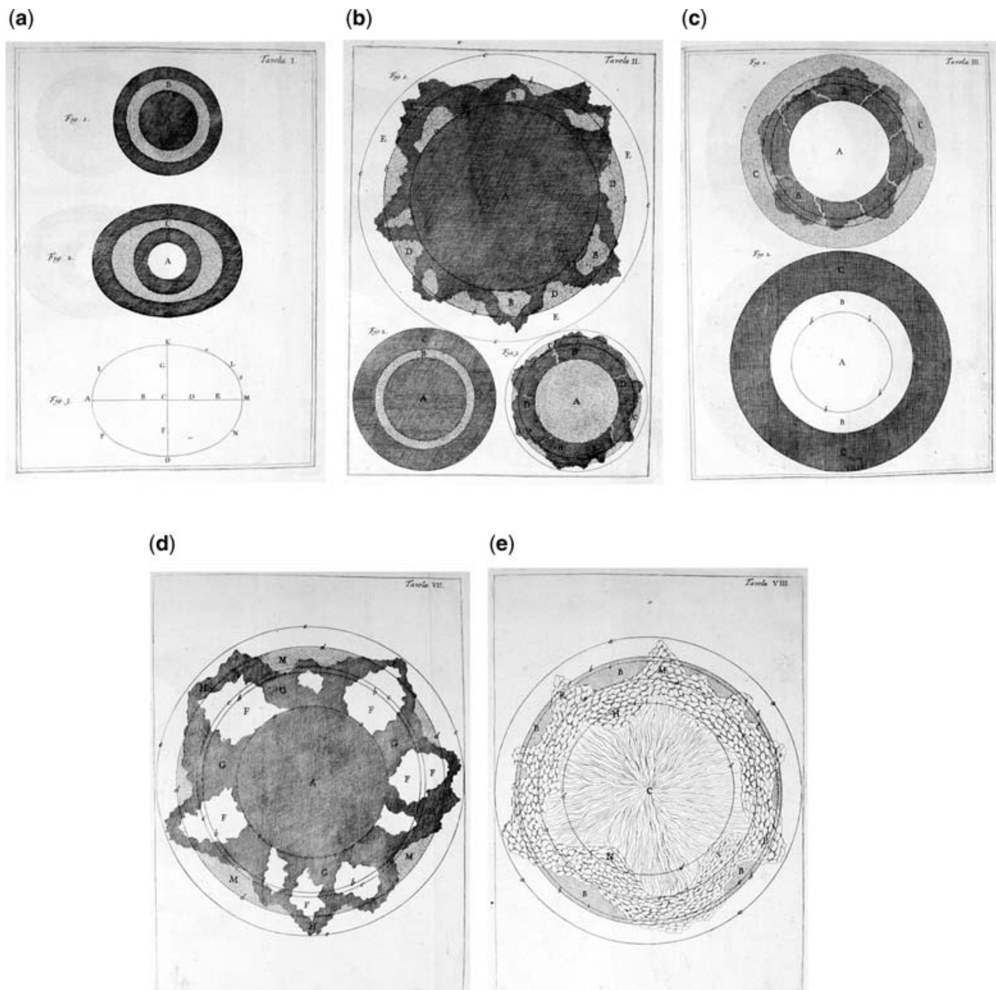

Fig. 12. Global sections Moro (1740). (**a**) Tavola I. (**b**) Tavola II. (**c**) Tavola III. (**d**) Tavola VII. (**e**) Tavola VIII.

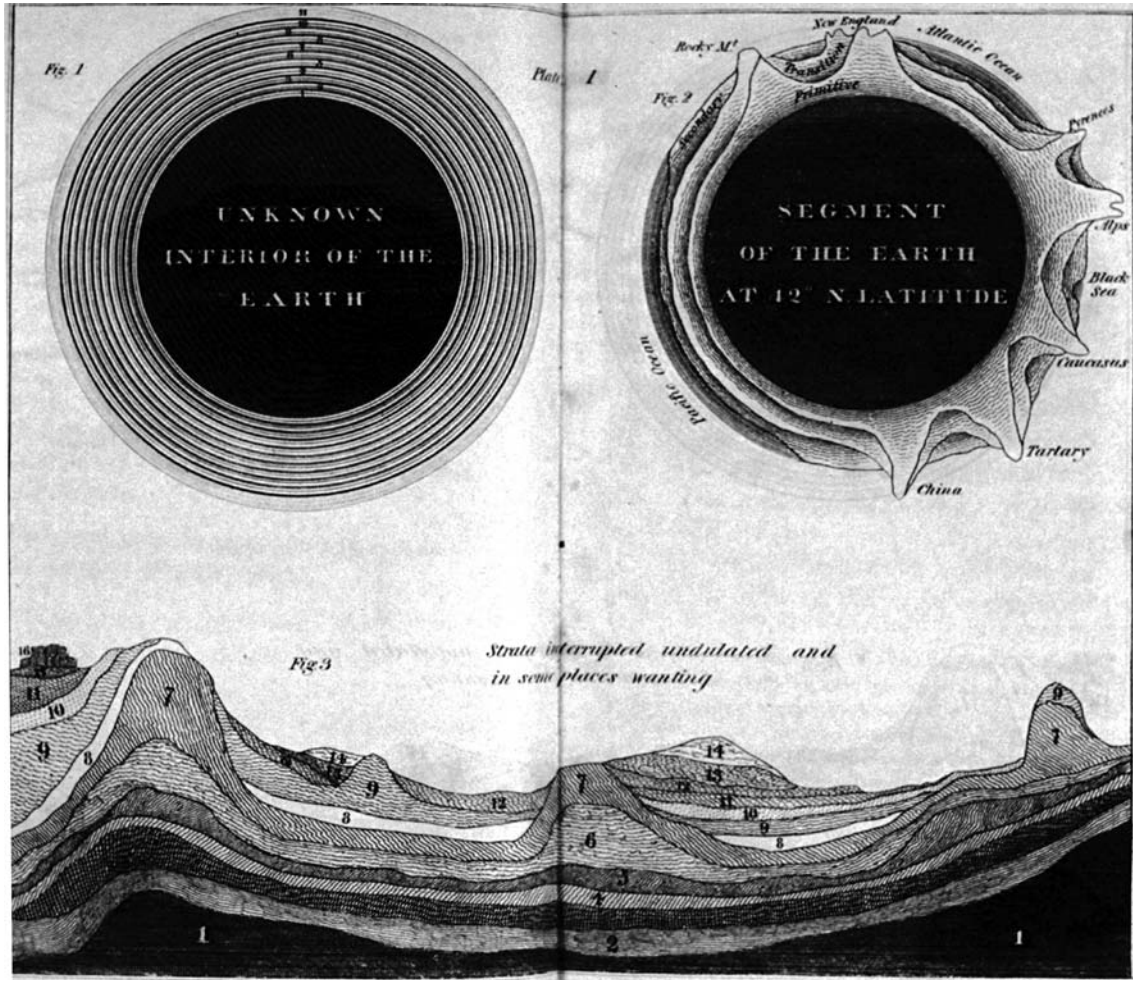

Fig. 13. Eaton (1820), plate 1: Fig. 1, Day 2; Fig. 2, Day 3; Fig. 3.

hexameral idiom in the century prior to Scheuchzer confirms Rudwick's assessment based on the landscape depictions: 'Perhaps the most significant feature of biblical illustrations such as Scheuchzer's was that they depicted a sequence of scenes in a temporal drama that had direction and meaning built into its structure' (Rudwick 1992, p. 26).

In 1740 Antonio Lazzaro Moro (1687–1764) published an account of the globe including a series of striking global sections that began with Burnet-style diagrams (Fig. 12; Moro 1740). Like Whiston, Moro explicitly assigned them to the third day rather than to the Flood. Also unlike Burnet, Moro proposed that dry land on the surface of the Earth was elevated by the action of subterranean fire. Oldroyd has argued that Moro's Theory of the Earth was historical in character: 'As early as 1740 there was in Moro's work something approaching an historical attitude towards a study of the Earth, despite the fact that it was linked with a particular theory, and also attempted a union with the traditional Judaeo-Christian history of Genesis' (Oldroyd 1979, pp. 196–197). Scheuchzer and Moro wrote squarely in the tradition of Theories of the Earth and reflected the temporal, directionalist sensibilities developed in association with hexameral idiom.

Second, hexameral idiom embedded within global depictions proved durable from the 17th century to the emergence of geology as an organized technical discipline. Many writers succumbed to the lure of concordism and produced successive, mutually contradictory schemes. Others, such as Nicolaus Steno, restricted themselves to compatibilist perspectives, employing hexameral idiom with full recognition of the complexity of the act of interpreting the book of God's word and the book of God's works. Although each concordist scheme was precarious at best, the underlying idiom proved resilient and endured. The idiom of Genesis 1 was not exclusive, but it was pervasive over the century from Fludd to Scheuchzer while a tacit consensus was being developed that the Earth possessed an interesting developmental history. Even later, when a geologist wished to persuade readers who might not share the tacit assumptions of directionalist development and an ancient age of the Earth, a continuing association of hexameral idiom with global sections might still facilitate the reception of emerging geological ideas, as in Amos Eaton's global sections representing the second and third days of the creation week (Fig. 13; Eaton 1820).

Finally, hexameral idiom proved versatile and accommodating. As a linguistic common ground, it facilitated critical interaction between a variety of technical and disciplinary contexts. Even when there was no common technical context, disciplinary expertise or natural philosophy, hexameral idiom provided a common point of contact for structuring debate. The use of embedded hexameral idiom cut like a corridor across a variety of disparate technical and philosophical contexts (Table 1, rightmost column), and thus offered a public means of access to a forum that was contested across various disciplinary divides. Whenever a historical figure employed hexameral idiom, historians should ask how that idiom allowed the work to engage a broad readership representing multiple areas of expertise. When geology became sufficiently organized, practitioners no longer needed to use this idiom unless they wished to appeal to a broader audience that did not share their tacit assumptions. In this public and contested character of hexameral idiom lies the most important clue to the character of global depictions and of Theories of the Earth themselves. In my earlier paper (Magruder 2006), I argued that global depictions played a similar role of facilitating interaction across disciplinary divides. This versatility of both hexameral idiom and global depictions in bringing various technical traditions into a common critical debate explains why they were so frequently associated with each other in the emergence of the capacious and contested print tradition of Theories of the Earth.

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The fossil proboscideans of Utica (Tunisia), a key to the 'giant' controversy, from Saint Augustine (424) to Peiresc (1632)

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Abstract: In his book *De Civitate Dei* (published about 424), Saint Augustine reported the discovery, on the shore of Utica (now Tunisia), of an enormous tooth, which he attributed to a giant. In Europe, this finding reinforced the myth of the past existence of giants on Earth, mentioned in the Bible. In 1630, new relicts of a so-called giant were found at Utica. Thomas d'Arcos, who lived in Tunis, described them and sent a tooth to the French scholar Peiresc, who demonstrated that it belonged to an elephant instead. Peiresc knew that he was contradicting Saint Augustine, but, while Galileo was under trial in Rome, he remained silent on this matter. Based on a sketch, the tooth can be attributed to an African elephant close to the present species *Loxodonta africana* or to the Pleistocene *L. africanava*. Peiresc also investigated other similar finds, particularly that of the so-called giant Theutobochus, discovered in 1613 at Montrigaud in France (in reality, a Miocene *Deinotherium giganteum*), and that of 'giants' in Sicily and Puglia (Italy). In each case, Peiresc attributed the relicts to the 'grave of an elephant' instead of a giant. However, his studies did not dispel the myth of giants, which persisted until the 18th century.

In his book *De Civitate Dei* (*The City of God*), written around 412, Saint Augustine recounted the following:

> the large size of the primitive human body is often proved to the incredulous by the exposure of sepulchres ... in which bones of incredible size have been found or have rolled out. I myself, along with some others, saw on the shore at Utica a man's molar tooth of such a size, that if it were cut down into teeth such as we have, a hundred, I fancy, could have been made out of it. But that, I believe, belonged to some giant. For though the bodies of ordinary men were then larger than ours, the giants surpassed all in stature (Schaff 1886, Book XV, Chapter 9).

Saint Augustine referred here to the past existence of a so-called race of giants, who, according to the Bible (e.g. Genesis 6: 4; Deuteronomy 3: 11; Goliath, in 1 Samuel 17: 4) and a few Greek and Roman texts (e.g. Homer, Ovid, Virgil, Herodotus, Pliny), had inhabited the Earth before the biblical Flood, an ancient myth that would survive until the 18th century (e.g. Cuvier 1812, Vol. 2; Murray 1904, Vol. I, pp. 45–50; Céard 1978; Schnapper 1986, 1988; Cohen 2002). When teeth or bones of enormous size were found, they were invariably attributed to a giant. In Europe, Saint Augustine's opinion strongly influenced the belief in giants (Céard 1978; Schnapper 1988; Cohen 2002). It was generally thought that men had decreased in size since the creation. During the Renaissance, however, a controversy arose between those who supported the past existence of giants, mostly for religious reasons (Berose 1545; Lemaire de Belges 1549; Fregoso 1578, Book I, Chapter 6; Fazello 1579; Chassanion 1580), and a few who doubted it (Maggi 1563, Book I; 1603) or even considered it as a tale (van Gorp 1569; see Céard 1978; Schnapper 1986).

The giant of Utica was almost forgotten, when, in 1630, Thomas d'Arcos, who lived near Tunis, informed Aycard from Toulon, in France, that 'the grave of a giant of enormous dimensions' had just been discovered near the ruins of Utica (northern Tunisia), 'in the same place where Saint Augustine says in the book *The city of God*, book 15, chap. 9 ... that he saw another human tooth that could have made a hundred of ours'. The discovery at once interested the Provençal scholar Peiresc, who soon initiated a correspondence with d'Arcos on this matter.

Nicolas-Claude Fabri, Lord of Peiresc (1580–1637; Fig. 1), was *conseiller* in the parliament of Aix-en-Provence (southern France). Although he did not publish any of his studies (he discovered the Orion Nebula, for example), Peiresc is considered one of the great scholars of the early 17th century (e.g. Gassend 1641; Levis 1916; Hellin 1980; Lassalle 1992; Rand 1657; Dhombres & Bresson 2005). Over a 40 year period, he exchanged voluminous correspondence with many intellectuals in Europe, including Aldrovandi, Aleandro, Camdem, Cassiano dal Pozzo, Clusius, Dupuy, Galileo, Gassend, Kircher, Mersenne, Naudé, Rubens, and Urban VIII. Peiresc played a relevant role in the pre-Stenonian geology of his time (Godard, 2005*a*, *b*), studying the origin of fossils, the 1631 eruption of Vesuvius, the stratification of

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Fig. 1. Nicolas-Claude Fabri de Peiresc (1580–1637) (© Bibliothèque Nationale de France).

sedimentary rocks, and many other topics. His theory on the formation of mountains stated that they were oriented east to west, parallel to the Earth's rotation; he was therefore clearly a Copernican.

After having examined one tooth of the so-called giant, Peiresc reached the conclusion that it actually belonged to an elephant. He thus demonstrated that Saint Augustine had misinterpreted the remains found at Utica. At the same time that Galileo was being judged in Rome, Peiresc was questioning the past existence of giants mentioned in the Bible.

We here report on this interesting affair. We also provide a palaeontological and geological description of the Utica elephant find, based on the few available reports. Lastly, we discuss Peiresc's role in putting an end to the myth of giants, through his study of the Utica tooth and of similar finds, such as that of the so-called giant Theutobochus discovered at Montrigaud (France) in 1613.

Peiresc's papers, written in old French, Italian or even Latin, are for the most part preserved in 140 *in-folio* registers at the Carpentras library (e.g. Gravit 1950), and many of them are still unpublished. For convenience, these texts are here quoted in modern English. The sources and biographical information on the various historical figures are given in the endnotes.

The so-called giant of Utica

Thomas d'Arcos, a former secretary of Cardinal de Joyeuse, was captured in 1628 by Barbary pirates in the Mediterranean. He lived in Tunis, where he chose to remain after his liberation. On 10 June 1630, while he was in Cala Numidica (probably Kalaat El Andalous), north of Tunis, d'Arcos wrote a letter to Honoré Aycard in Toulon, informing him of the nearby discovery of 'the grave of a giant of huge dimensions':[1]

> His body, that is to say the bones alone, was of *40 couldées* in length [possibly, a total of 80 minor *palmes* ≈ 5.9 m], his head larger than a wine container of *12 meillerolles* [≈ 0.744 m^3?]. I have seen and weighed one of his teeth & it weighed 2 pounds and a half, that are 40 ounces [≈ 1.2 kg]; the bones of this body are partly decomposed, & partly complete.

On 24 June, he provided further details:

> I have recovered two teeth of this big giant . . . each weighing more than three pounds and a half. The rest of these bones are all fallen to powder. I found them near ancient Utica, and in the same place where Saint Augustine says in his book *The city of God*, book 15, chap. 9 (if I am not mistaken), that he saw another human tooth that could have made a hundred of ours.[2]

At once, Honoré Aycard informed Peiresc, who sent a long letter to d'Arcos on 13 July 1630.[3] Peiresc did not exclude the supposition that the remnants were those of a giant, but he asked for proof:

> one tooth joined to some other piece of bone well preserved, and whose form is truly specific of the human body would satisfy my curiosity.. . . the heel bone that permits motion of the foot would convince me that it is not of a marine monster.

(The heel bone is in fact characteristic of biped man.) To meet the insistent requests of Peiresc,[3,4] d'Arcos gave a detailed account of the discovery in March 1631:[5]

> I moved to the place where this large body was reportedly found, and after having made ten men dig the ground for a day, I did not succeed in recovering anything but a few bones (in reality monstrous), but as soon as we touched them, they suddenly fell to powder, and the same happened to the head, as reported to me by the Moors who found it.

After this, d'Arcos provided details about the occurrence and its location. Most importantly, in the letter he included one of the two recovered teeth. He could not assert 'whether these are the teeth of a human, or of some terrestrial or marine monster, as their form is extraordinary'. Teisseire, a sailor from Marseilles, also gave his own version to Aycard,[6] reporting that the giant skull could hold a *sestier* of corn (*c*. 0.156 m^3).

In several of his letters, d'Arcos echoed the Moors' beliefs about the giant:

> It is thought that this big body is from before the Flood, & a few Moors from here, who have some of their ancient books, pretend to know who he was, & his name, but I think they are dreaming.

However, they consider the discovery of this body as prodigious & say it means that Christians will soon dominate Barbary. God willing.[1]

This last wish is amusing, as d'Arcos soon thereafter converted to Islam, becoming Osman d'Arcos.[7] In another letter[8] he recounted that:

One Moor who is considered a great necromancer assures me that the name of this giant was *Menoiel min el moutideri*. He lived 600 years, & died 4000 years ago. His wife poisoned him. He had 17 children, 7 females & 10 males. You will think (and I also think) that these are reveries.

Peiresc declared disdainfully to Pierre Dupuy that this so-called *Menoiel* was none other than Hercules.[9] D'Arcos continued, indicating that the Moors believed that there had been several Adams and several worlds before this one: 'From this, I think that they were bold enough to claim that this so-called giant was from another world before the last Adam'.[10]

By May 1631, Peiresc had received the tooth sent by d'Arcos, and replied:[11,12]

The big petrified tooth suddenly has rid me of any doubt of what it was about, as I remember having certainly seen the head of a marine monster with a row of teeth of the same form, which fitted the front of his jaws as if they were of one piece. At the moment I do not recollect well whether it was a hippopotamus, a marine horse (or rather a Nile horse) or some sort of whale or even crocodile.[11]

D'Arcos acquiesced in this interpretation[10] and sent Peiresc another smaller tooth and a 'paper in which are bones and powder of a giant [*sic*]'. However, in November 1631, while Peiresc was in his residence at Boysgency (Belgentier, north of Toulon), he had the opportunity to examine an elephant that was exhibited in fairs of northern Italy and southern France (Gandilhon 1956; Bresson 1981; see also Gassend 1641; Lassalle 1992, pp. 205–206; Rand 1657). He sent a detailed account of his investigation to Pierre Dupuy in Paris:[13]

I was curious enough or (rather) mad enough, to introduce my hand in its mouth, and to catch and to feel one of its molar teeth, to better recognize the shape …. It was to verify, as I did, that they were entirely identical in shape, although less in size, to the tooth of the so-called giant of the Tunis coast or of Utica.

Peiresc came to the conclusion that 'several bones of elephants that are buried in various places are often mistaken for the bones of giants'.[13] In similar terms, he recounted this observation to Boniface Borrilly.[14] Although there was a gap in the correspondence with d'Arcos, who had meanwhile 'changed his garment' (i.e. converted to Islam[7]), it started again in March 1633. Peiresc concluded: 'I consider it, with your kind agreement, to be none other than a tooth from the jaws of an elephant'.[15]

It seems that the tooth was not preserved, but a *portraict* sent by Peiresc to Pierre Dupuy[16,17] is still available (Fig. 2). P. Tassy and L. Ginsburg

Fig. 2. 'Dessein de la dent qu'on disoit estre de ce Gean apporté de Thunis semblable a l'une des quatres dents des machoires de l'Elephant' (© Bibliothèque Nationale de France).[17]

from the Muséum national d'Histoire naturelle of Paris kindly examined the picture and identified the upper left molar of an African elephant close to the current species *Loxodonta africana*, or more likely of the Pleistocene species *L. africanava* (or *Mammuthus africanava*).

The relicts were found in a 'structure … made of stones, mixed with lime, harder than the stone itself',[10] which seems to refer to a rock made of blocks cemented together, perhaps by a calcareous cement. We also know that they were found in a ravine 8 feet deep, near Utica:

A small stream, due to the flow of water from the nearby mountains, runs precisely in the middle of the grave of this monster, and having dug the ground some eight feet deep [$\approx$ 2.5 m] it has likely taken away part of the body. This grave is one musquet shot [*mosquetada*] away from the sea that enters Portofarina, from the south, and the location is stony and full of antique ruins, which are hidden, and it is considered certain that this was the site of Utica.[5]

The ruins of Utica are located in an ancient bay, which has been almost completely filled with alluvium over the two last millennia (e.g. Bernard 1911), and is now reduced to the Lake of Ghar-El-Melh (previously, Portofarina) (Fig. 3). The site of the find is at a short distance from Utica. It is a good distance away from

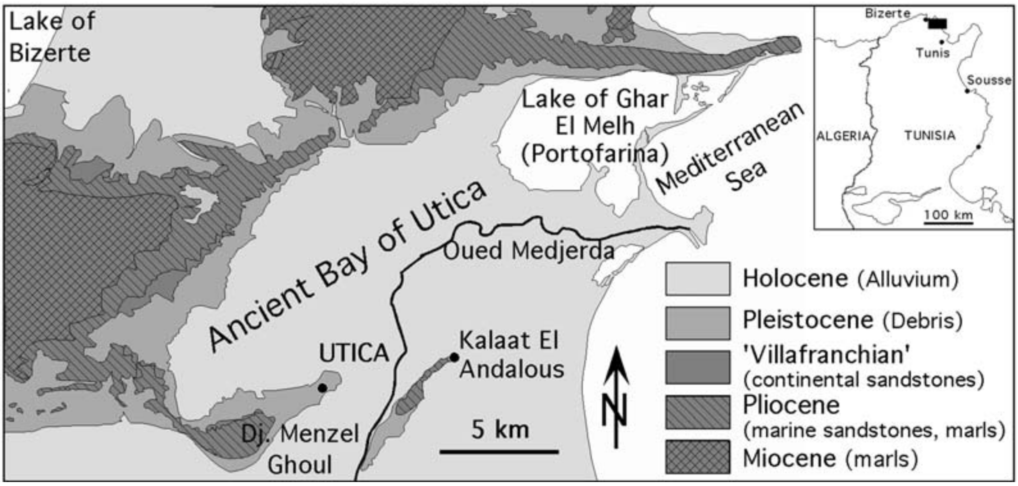

Fig. 3. Geological sketch map of the Utica region (Tunisia), after Burollet (1952).

the present shore, but near the limit of the ancient bay. In any case, it must have been over 2.5 m above sea level, which explains the formation of the ravine. The name of the hill Djebel Menzel Ghoul (which could be translated as 'Mountain of the ogre's home'), some 5 km SW of Utica (Fig. 3), is remarkable and suggests that the remnants of 'giants' may have been found there.

The ancient Bay of Utica is rimmed with Pliocene and Quaternary alluvia (Burollet 1951, 1952; Fig. 3). Although the Pliocene Ghar-El-Melh (or Portofarina) sandstone, which forms the heights of Djebel Menzel Ghoul, can hardly include fossil elephants as it bears marine fossils, it gradually passes to more propitious continental 'Villafranchian' sandstones. More probably, the Quaternary debris that surrounds the same *Djebel*, which is in places cemented and constitutes the bedrock of Utica, could correspond to the block-bearing formation described by d'Arcos.[10] The relicts could also come from alluvia of the Oued Medjerda River, and, lastly, we cannot completely exclude an anthropogenic origin related to the Punic civilization of ancient Utica. Fossil proboscideans are common among the Plio-Quaternary sediments of North Africa (Arambourg 1952). Some were found about 40 km to the west of Utica in 'Villafranchian' sediments of Lake Ichkeul, where systematic excavation led to the discovery of important fossil fauna with proboscideans (*Elephas* cf. *planifrons* Falc., Cautl., *Anancus osiris* Aramb.), Equidae, rhinoceroses and ruminants (Laffitte & Dumon 1948; Arambourg & Arnould 1950). Saint Augustine and Thomas d'Arcos may well have encountered some occurrence similar to the one of Lake Ichkeul.

Theutobochus and some other so-called giants

Peiresc's unravelling of the Utica affair encouraged him to investigate similar cases involving other giants, particularly in France and Sicily.

In 1634, Peiresc initiated an inquiry on the famous giant Theutobochus. On 11 January 1613, a 'tombstone' with the engraving *Theutobochus Rex* was excavated from the sandpit of Langon, near Montrigaud in Bas-Dauphiné (France). Bones of a gigantic size, together with silver coins bearing Marius's effigy, were reportedly found under the stone. It is known that, around 100 BC, the Roman consul Marius defeated the army of the Teutons in southern Gaul. The king of the Teutons was said to be a giant named Theutobochus. A physician called Mazurier exploited these relics, exhibiting them throughout France. They were even shown for some time in the apartments of the Queen Mother, Marie de Medici, at Fontainebleau. The suspicion roused by this extravagant story provoked a controversy that degenerated into a bitter dispute, recounted by Cuvier (1812, Vol. 2, pp. 14–17) and Ginsburg (1984, 1986, 1991), among others (see the bibliographies of Schnapper (1986) and Cohen (2002)). It is now thought that these remnants actually belonged to *Deinotherium giganteum*, a proboscidean of the Late Miocene (Ducrotay de Blainville 1835, 1837; Ginsburg 1984, 1986, 1991).

Twenty-one years after the discovery, Peiresc asked Nivolet, a physician from Saint-Marcellin in Dauphiné, a series of questions. After investigating the site, Nivolet provided Peiresc with details on the circumstances of the find,[18] and sent him one of the coins found in the 'grave', together with bone fragments. In his answer, still unpublished,[19] Peiresc questioned the attribution of the bones to Theutobochus. He wondered about the tombstone, which had strangely disappeared, and why the epitaph was written in Latin although 'neither Theutobochus nor those of his nation spoke Latin'. Most importantly, Peiresc attributed the coin to the Marseille Republic instead of Marius, and assured Nivolet that it was identical to some 500 coins found in Dauphiné a few years before the Theutobochus discovery. A few of these had been given to him by Le Fèvre from Valence. The Theutobochus affair was obviously a hoax. Peiresc concluded with an evasion: 'I am still not quite sure that it be veritably of a giant'.[19] Lastly, the find in 1634 of another so-called giant 2 *lieues* away from Montgiraud[20,21] managed to convince him that such relicts were of elephants, as reported by his biographer and friend Pierre Gassend (1641; see Lassalle 1992; Rand 1657).

Close to Aix-en-Provence, where Peiresc lived, a small hill called *Rocher du dragon* was known to contain 'petrified bones'. A popular legend attributed them to the remains left by a dragon after its meals, and every year during the Rogation Days a procession, preceded by a paper dragon, marched towards a chapel constructed on the *Rocher*. Peiresc identified there 'some human and equine bones, all petrified and mixed together',[11] of which he sent specimens '*par toutz les endroits de l'Europe èz mains des curieux*'. In 1634, he recounted to d'Arcos[22] and Menestrier[20] that a 'horn or a tooth all straight' had been found there some time ago, and that it was supposed 'to be the horn of a unicorn'.[22] A few months later Peiresc interrogated Bernegger about a 'fossil unicorn' found years before near Strasbourg.[23] Although the unicorn myth was still vigorous, he instead attributed these horns to some 'marine monsters' or 'terrestrial animals'.[22] The *Rocher du dragon*, which belongs to the *Bassin d'Aix*, was afterwards studied by Guettard (1760), Lamanon (1780), a geologist who perished in Lapeyrouse's unfortunate expedition, and Saporta (1881) (Godard 2005*b*). It was found to be made of a Miocene continental conglomerate containing a rich mammal fauna.

In 1635, Peiresc also questioned Cassiano dal Pozzo about a so-called giant found with his helmet in bronze at 'Minerbino, in the Kingdom of Naples' (i.e. Minervino, in Puglia, Italy).[21] In reality, the helmet (*celata*), which had been found near the Lake Trasimeno close to Perugia, reportedly in the tomb of one of Hannibal's soldiers, had no relationship to the Minervino find.[24] On the other hand, the past existence of 'giants' in Sicily was widely admitted. Boccaccio (1360, Book IV, Chapter 68) had reported the find in 1342 of a 400 feet tall (*sic*) giant in a cave near Trapani. The Frenchman François Langlois, called Chartres, who had lived in Palermo, assured Peiresc that giant carcasses exhumed near Castelvetrano (Sicily) were exhibited by apothecaries in local fairs.[16] Cassiano dal Pozzo[24] and Claude Menestrier,[25] both Peiresc's correspondents in Rome, confirmed the existence of gigantic bones in Sicily. Menestrier reported to Peiresc that Don Vincenzo Mirabella had sent to Federico Cesi, the founder of the *Accademia dei Lincei*, a few of these bones from Sicily, among which 'a fragment of a jaw with a tooth as large as the fist'.[25] Menestrier apparently had a clear idea of their true nature, as he mentions a mountain containing 'teeth and jaws of elephants that the swindlers sell as unicorn throughout Italy, while it is actually *ebur fossile* [= fossil ivory]'. Some people then considered these remnants as proof of the past occupancy of the island by Homer's Cyclops (Fazello 1579; see Montgitore 1704, pp. 89–100); it is now thought that the nasal cavity of fossil mastodons, mistaken for a single orbit, was the origin of this myth (e.g. Abel 1939; Cohen 2002). Peiresc tried to convince Claude Menestrier, Pierre Bourdelot and Jacques de La Ferrière to visit Sicily[20,26–29] (see also note 30), but the intervention of France in the Thirty Years War against Spain deterred them.[31] In May 1637, Peiresc urged Lucas Holstenius to pass through Sicily on his way to Malta, to have a look at these mountains full of ivory and gigantic skeletons.[32] In his letter, he gives Holstenius precise advice:

> to observe the bones not yet extracted from the exact place from where they were buried in order to judge if they are or not enclosed in any man-made structure for their tomb, or if they are simply set in caverns that could have been immersed in the past, like our mountains [of Provence] full of shells .... And if some of these could not have been marine calves of the big cetacean species.

Evidently, Peiresc did not totally disagree that some of the so-called giants could be 'marine monsters', an idea that he also proposed in a letter to dal Pozzo.[21] He probably had in mind the opinion of van Gorp (1569), who was radically against the giant theory. Peiresc died a few weeks later, on 24 June 1637.

A cautious refutation of the myth of giants

Peiresc, who was sceptical about the legends inherited from the Middle Ages, and paid little heed to the ancient texts (even sacred ones), tried to apply the scientific method to the giant controversy, mainly by comparing the remnants with large animals such as elephants.

He reached the conclusion that these giants were actually buried elephants, but not fossil elephants.

This is apparent in the case of the Utica find: 'The great vicinity of ancient Carthage makes it seem a little less strange that the said elephant was buried, and that a sort of sepulchre was even built'.[13] This is a little surprising as he admits, at a first glance, that the so-called giant could well be a fossilized 'marine monster'.[9,11] We know, moreover, that he believed in the organic origin of fossils and that he even used rudimentary tectonics, limited to vertical movements, to explain the existence in Provence of marine shells above the level of the Mediterranean Sea (Godard 2005*b*).

Most importantly, by demonstrating that the Utica tooth belonged to an elephant, Peiresc contradicted Saint Augustine, who had played a key role in perpetuating the belief in giants. Peiresc knew that the relicts had been found 'in the same place where in his book *The city of God* Saint Augustine says that he saw another human tooth that could have made a hundred of ours',[2] a fact that he regarded as '*grandement remarquable*'.[4] Thus, the Utica tooth was probably of an elephant instead of a giant, an audacious hypothesis that had already been imagined without proof by Maggi (1563, Book I, Chapter 2, p. 77).

Saint Augustine was considered a 'Father of the Church', and his writings were the basis for important dogmas such as Purgatory and the Holy Trinity. It was risky to contradict him, particularly in 1632, when Galileo was under trial by the Holy Office in Rome. Peiresc recounted all the details of the discovery to Pierre Dupuy and Boniface Borrilly, but did not mention the connection with Augustine's observation.[10,13,14] Only after 3 years, on 2 August 1635, did he clearly reveal the link to Cassiano dal Pozzo:[21]

> it was a true elephant that was thought to be a giant, almost in the same place, or not far from where Saint Augustine said to have seen some relicts of it.

However, he remained extremely cautious, adding:

> I by no means want to question the general belief in giants; nevertheless, I strongly doubt that all of the bones discovered in various places are those of giants.

While Galileo was under surveillance at Arcetri after having abjured before the Holy Office, did Peiresc practice a sort of self-restraint? We know that he adopted a prudent and restrained attitude with regard to Galileo. His papers show that he was clearly, although secretly, in favour of the Copernican theory, as he tried to apply the concept of a rotating Earth to the tide theory, the formation of mountains, and the structure of the Earth (Godard 2005*b*; see also Bernhardt 1981, p. 174). However, he did not support this view openly, remaining vague and prudent, even in his private correspondence with Galileo.[33,34] Nevertheless, he had the great courage to defend Galileo in an admirable and prescient letter to Cardinal Francesco Barberini (e.g. Rizza 1961, 1965), the nephew of Urban VIII:[35]

> Certainly [such rigour] will be considered excessive for all, and more by posterity than by the present century .... It will be a blot on the reputation of this pontificate, if Your Eminence does not decide to take him under your patronage and in particular consideration, as I am imploring you and beseeching you humbly and with the strongest ardour.

Peiresc did not publish any of his discoveries. However, his contribution to the giant controversy became known through Gassend's biography of him (Gassend 1641; see also Lassalle 1992; Rand 1657). Pierre Gassend was close to the Church, as he was priest and canon of the Bishopric of Digne (Provence).[36] He retraced without hesitation Peiresc's discoveries, but without mentioning the link with Augustine's observation, which he probably ignored. Later, the *Encyclopédie* by Diderot and d'Alembert briefly recounted Peiresc's studies on the 'giant' of Utica, but did not even mention Saint Augustine (article '*géants*': Jaucourt 1757).

Several historians retold the story of Peiresc's discoveries, but most provided a rather distorted picture, as they did not consult the original unpublished manuscripts. Cornélius de Pauw (1768–1769), for example, recounted a fanciful story:

> The Turk, who knew admirably well the penchant of the Christians of that time for all that came from Palestine under the label of holy relics, each year sent some of these huge bones ... but Mr de Peyresch [*sic*], tired of seeing all these curiosities entering by the route of Marseille, applied himself more than other savants to examining their structure, & he finally succeeded in demonstrating that these bones had belonged to elephants, & advised his compatriots to go and buy ivory in Africa, where the Negroes sold it at a lower cost than the Turk.

A few scholars retrospectively introduced Hannibal's elephants in the story, as did Wright (1926):

> [Peiresc] was also fortunate in having opportunities of examining a quantity of huge fossilized bones excavated from the soil of Provence, and commonly supposed to be those of the elephants of which Hannibal lost so many on his march northward.

Finally, several others, such as Sir Hans Sloane (1727, 1727–1728*a*, *b*), attributed to an elephant the tooth mentioned by Saint Augustine, but did not refer to Peiresc, whose contribution was unknown to them.

However, the giant myth remained popular until the 18th century (e.g. Murray 1904, Vol. I, pp. 45–50; Schnapper 1986). Most clergymen valiantly defended the Bible and Saint Augustine, with the noticeable exceptions of Theodore Rycke (1681) and Kircher (1664–1665), who applied himself to reduce the importance (and the size) of the giants. Whereas Robert Plot (1677, Chapter 5, pp. 131–139) was not convinced of the elephant hypothesis, Tentzel (1696) correctly attributed to an elephant a find at Tonna in Germany. Others continued to believe even in Theutobochus (e.g. Gachet d'Artigny 1749, pp. 130–139). Apart from the religious belief, the non-existence of elephants living in Europe favoured the myth, which was dispelled only with the emergence of modern palaeontology, in the early 19th century. Peiresc's perhaps premature contribution, deplorably unpublished and thus almost ignored, unfortunately did not significantly help to dissipate the myth.

P. Tassy and L. Ginsburg from the Muséum national d'Histoire naturelle of Paris determined the species of the Utica elephant by examining the sketch in Figure 2. M. Smets and J. Dhombres encouraged my research on Peiresc. A. Palladino reviewed the English. Lastly, the manuscript has benefited from constructive reviews by P. Taquet and S. Newcomb, under the supervision of the editor M. Kölbl-Ebert. These are all thanked for their kind assistance.

Notes

[1]Letter from Thomas d'Arcos to Aycard in 'Tollon' [Toulon]. 'De la Cala le 10 juin 1630'. Carpentras (Bibliothèque inguimbertine de Carpentras) 1810, ff. 142r–143r (r indicates recto), copy (this term is used here to indicate a secondary copy by a copyist); Aix (Bibliothèque Méjanes, Aix-en-Provence) 201, pp. 157–159, copy, pp. 190–191, copy; BN Dupuy (Bibliothèque Nationale de France, département des manuscrits, fonds Dupuy) 488, fo. 170r, copy; edited by Tamizey de Larroque (1879–1897, Vol. 2 [Part XV] pp. 192–195). Thomas d'Arcos was born at La Ciotat (Provence, France) in 1568. Captured and sold as a slave in 1628 at Tunis, he was liberated in 1630. He thereafter remained in Tunis, where he probably died. Although he converted to Islam, he maintained a close correspondence with Peiresc and Cardinal Barberini. Honoré Aycard, a merchant at the port of Toulon (Provence, France), was in charge of delivering Peiresc's mail across the Mediterranean Sea.

[2]Letter from Thomas d'Arcos to Aycard. 'De Tunis ce 24 juin de 1630'. Carpentras 1821, fo. 369r–369v (v indicates verso) [369v], copy; Aix 201, pp. 159–160, copy, pp. 194–195, copy; edited by Tamizey de Larroque (1879–1897, Vol. 2 [Part XV], pp. 195–196).

[3]Letter from Peiresc to d'Arcos. 'A Boisgency prez de Tollon ce 13 juillet 1630'. Carpentras 1871, fo. 352r–352v, minute; (this term is used here to indicate an original copy by Peiresc or his secretary) Aix 201, pp. 223–225, copy; edited by Fauris de Saint-Vincens (1815, pp. 93–97), Tamizey de Larroque (1898, pp. 85–88 [86–87]).

[4]Letter from Peiresc to d'Arcos. 'A Boisgency, ce 17 septembre 1630'. Carpentras 1871, fo. 353r, minute; Aix 201, pp. 227–228, copy; edited by Fauris de Saint-Vincens (1815, pp. 97–100), Tamizey de Larroque (1898, pp. 88–90).

[5]Letter from d'Arcos to Peiresc. 'A Tunis ce 15 de mars 1631'. Carpentras 1810, fo. 140r–141r, autograph; Aix 201, pp. 160–163, copy, pp. 195–197, copy.

[6]Letter from Aycard to Peiresc. 'a Thoulon ce 8 nouu[em]bre 1630'. Carpentras 1810, fo. 131r–131v, autograph.

[7]Letter from Osman d'Arcos to Aycard. 'De Tunis ce 15 de mars 1633'. Carpentras, 1810, fo. 144r–144v, copy; Aix 201, pp. 170–171, copy.

[8]Letter from Thomas d'Arcos to Aycard. 'De la Cala ce 10 d'apuril 1631'. Carpentras 1810, ff. 138r–139r, copy; Aix 201, pp. 163–164, copy, pp. 197–198, copy.

[9]Letter from Peiresc to Pierre Dupuy. 'A Boysgency, ce 23 may fort tard, 1631'. BN Dupuy 717, fo. 115, autograph; edited by Tamizey de Larroque (1890, pp. 271–283).

[10]Letter from Thomas d'Arcos to Peiresc. 'Tunis ce 20 d'octobre 1631'. Carpentras 1810, fo. 126bisr–127r, autograph; Aix 201, pp. 164–166, 168–169, 198–202, copies; edited by Fauris de Saint-Vincens (1806, p. 123), partially by Tamizey de Larroque (1879–1897, Vol. 2 [Part XV], pp. 198–199).

[11]Letter from Peiresc to d'Arcos. 'A Beaugencier ce 10 May 1631'. Carpentras 1871, ff. 353v–354v, minute; Aix 201, pp. 231–236, copy; edited by Fauris de Saint-Vincens (1815, pp. 103–112), Tamizey de Larroque (1898, pp. 92–97).

[12]Letter from Peiresc to d'Arcos. 'A Beaugency ce 20 may 1631'. Carpentras 1871, fo. 355r–355v, minute; Aix 201, pp. 239–240, copy; edited par Tamizey de Larroque (1898, pp. 99–101).

[13]Letter from Peiresc to Pierre Dupuy. 'A Boysgency, ce 26 decembre 1631'. BN Dupuy 717, fo. 121; edited by Tamizey de Larroque (1890, pp. 287–295). Pierre Dupuy (1582–1651) was keeper of the Bibliothèque du Roi in Paris. With his brother Jacques, he led a group of Parisian scholars that prefigured the French Academy.

[14]Letter from Peiresc to Borrilly. 'A Beaugentier, ce 14 novembre 1631'. BN f.fr. (Bibliothèque Nationale de France, département des manuscrits, fonds français) 15205, fo. 44, autograph; Aix 202, pp. 391–392, copy; edited by Fauris de Saint-Vincens (1796, p. 374), as extracted from a letter of 10 September 1631, and by Tamizey de Larroque (1893, pp. 36–37). Boniface Borrilly (1564–1648), one of Peiresc's closest friends, was an amateur collector of Egyptian antiquities and a notary in Aix-en-Provence; his collection of antiquities was famous.

[15]Letter from Peiresc to d'Arcos. 'A Aix ce 22 mars 1633'. Carpentras 1871, ff. 358v–360r, minute; Aix 201, pp. 265–271, copy; edited by Fauris de Saint-Vincens (1815, pp. 120–127), Tamizey de Larroque (1898, p. 111).

[16]'Gigantum ossa, Sicilia, Malta'. Carpentras 1821, fo. 140r–140v, autograph from Peiresc.

[17]'Dessein de la dent qu'on disoit estre de ce Gean apporté de Thunis semblable a l'vne des quatres dents des

machoires de l'Elephant'. BN Dupuy 488, fo. 171r; edited by Godard (2005*b*).

[18]Letter from Nivolet to Peiresc, including 'la narration de toute la descouverte de ce geant nommé Theutobochus'. 'A St Marcellin ce 30 aoust 1634'. Carpentras 1821, fo. 171r–172r; Aix 208, pp. 93–95, copy; edited by Tamizey de Larroque (1888, pp. 309–313). Nivolet, a physician from Saint-Marcellin (Dauphiné, France), investigated the Theutobochus affair at Langon, and interrogated Pierre-Antoine Bagarris, who was in charge of the Cabinet des Antiques du Roi in Paris, where some of the so-called Theutobochus' relicts were preserved.

[19]Letter from Peiresc to Nivolet. 'A Aix ce 18 Septembre 1634'. Carpentras 1821, ff. 173r–175v.

[20]Letter from Peiresc to Menestrier. 'A Aix, ce 1 febvrier 1635'. Montpellier (Bibliothèque de la Faculté de Médecine de Montpellier) H271, ff. 165r–166r [165r–166r], autograph; edited by Tamizey de Larroque (1894, pp. 756–759).

[21]Letter from Peiresc to Cassiano dal Pozzo [in Italian]. 'Di Aix alli 2 Agosto 1635'. Montpellier H271 Vol. 2, ff. 164r–168r; edited by Lhote & Joyal (1989, pp. 195–202). See also: Letter from Peiresc to Gassend. 'A Aix, ce 4 aoust 1635'. BN f.fr. 12772, fo. 158, autograph; edited by Tamizey de Larroque (1893, pp. 525–526 [525]).

[22]Letter from Peiresc to d'Arcos. 'a Aix ce 25 Aoust 1634'. Carpentras 1871, ff. 365v–366r, minute; Aix 201, pp. 332–333, copy; edited by Fauris de Saint-Vincens (1815, pp. 355–357), Tamizey de Larroque (1898, p. 139).

[23]Letter from Peiresc to Bernegger, of Strasbourg University. 'A Aix, ce ix juillet 1635'. Carpentras 1876, fo. 110, minute; edited by Tamizey de Larroque (1898, pp. 600–602 [601]). Mathias Bernegger (1582–1640), professor at Strasbourg University, was Kepler's friend and translator of Galileo's works.

[24]Letter from Cassiano dal Pozzo to Peiresc [in Italian]. 'Di Roma, 9 dicembre 1635'. BN f.fr. 9539, ff. 78r–79v.

[25]Letter from Menestrier to Peiresc. 'De Rome ce 19 Decemb. 1634'. Carpentras 1821, fo. 70r–70v, copy; Aix 207, pp. 146–147, copy; BN Dupuy 669, ff. 63–64, copy; edited by Tamizey de Larroque (1894, pp. 738–740). Letter from V. Mirabella 'sulle ossa dei giganti'; Montpellier, MS 1700. Claude Menestrier (1569 or 1580–1639), born at Vauconcourt in Franche-Comté (eastern France), lived in Rome where he was librarian to the Barberini. He completed some geological studies, describing, for example, the fossils of Monte Mario near Rome, which he observed under the microscope (Godard 2005*b*). Vincenzo Mirabella (1570–1624) was an archaeologist and historian from Syracuse (Sicily).

[26]Letter from Peiresc to Cassiano dal Pozzo [in Italian]. 'Di Aix alli 20 marzo 1635'. Montpellier H271 Vol. 2, fo. 151r–151v; edited by Lhote & Joyal (1989, p. 176). The *cavaliere* Cassiano dal Pozzo (1588–1657), a physician, naturalist and alchemist, was secretary to Cardinal Francesco Barberini and member of the Accademia dei Lincei.

[27]Letter from Peiresc to Menestrier. 'A Aix, ce 20 mars 1635'. Montpellier H271, fo. 170r, autograph; edited by Tamizey de Larroque (1894, pp. 767–768).

[28]Letter from Peiresc to Pierre Bourdelot in Rome. 'A Aix ce 22 mars 1635'. Carpentras 1872, ff. 450v–451r, minute; Carpentras 1821, fo. 221r–221v, copy; edited by Tamizey de Larroque (1898, pp. 726–729).

[29]Letter from Peiresc to Menestrier. 'A Aix, ce 30 mars 1635'. Montpellier H271, ff. 171r–172r [172r], autograph; edited by Tamizey de Larroque (1894, pp. 769–773 [771]).

[30]The French Bourdelot, Menestrier and La Ferrière were Peiresc's main correspondents in Rome. Pierre Bourdelot (1610–1685) was mainly interested in antiquities. Claude Menestrier was librarian to the Barberini (see note 25). Jacques de la Ferrière, born near Agen, was physician to Cardinal Alphonse de Richelieu, the Archbishop of Lyon and brother of Louis XIII's minister; he corresponded with Peiresc on matters pertaining to the natural sciences, particularly on the origin of fossils (Godard 2005*b*).

[31]Letter from Peiresc to P. Bourdelot in Rome. 'A Aix ce 31 may 1635'. Carpentras 1872, fo. 462r, minute; edited by Tamizey de Larroque (1898, pp. 729–730).

[32]Letter from Peiresc to Holstenius, in Rome. 'A Aix, ce 7 may 1637'. Barberini 79, piece 64; BN n.a.fr. (Bibliothèque Nationale de France, département des manuscrits, nouvelles acquisitions françaises) 5172, fo. 80, minute; edited by Tamizey de Larroque (1894, pp. 476–482 [477–478]). Lucas Holstenius (1596–1661), from Hamburg, converted to Catholicism and was admitted in 1627 to the household of Cardinal Francesco Barberini.

[33]Letter from Peiresc to Galileo at Arcetri [in Italian]. 'Di Aix alli xvii Aprile 1635, in fretta [*sic*]'. Carpentras 1873, fo. 450, minute; edited by Cibrario (1828, pp. 76–83), Favaro *et al.* (1890–1909, Vol. XVI, pp. 259–262).

[34]Letter from Galileo to Peiresc [in Italian]. 'Dalla Villa d'Arcetri li 12 di Maggio 1635'. Private collection; edited by Drake (1962).

[35]Letter from Peiresc to Cardinal Francesco Barberini, nephew of Urban VIII [in Italian]. Aix, 5 dicembre 1634 (+ 31 gennaio 1635). Barberini (Biblioteca Vaticana, Rome, fondo Barberini) 6503, piece 109 (+ 114, 115), autographs. Edited by Cibrario (1828, pp. 83–87, 87–88), Favaro *et al.* (1890–1909, Vol. XVI, pp. 169–171, 202). Francesco Barberini (1597–1679) was the nephew of Urban VIII, who granted him the rank of Cardinal; a great amateur and patron of the arts, he created the famous Biblioteca Barberiniana.

[36]Pierre Gassend (1592–1655), called Gassendi, was Peiresc's friend and biographer. He greatly admired Copernicus and Galileo, and was priest and canon of Digne. He later taught mathematics at Collège de France in Paris (1645–1648), completed astronomical studies and promoted Epicurean philosophy.

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Flood conceptions in Vallisneri's thought

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Abstract: The scientific studies of the Italian physician and naturalist Antonio Vallisneri (1661–1730) were concerned with the cultural and religious implications of the debate on fossils in the early decades of the eighteenth century. In *De' Corpi Marini* he summarized the main diluvial theories but declined to support them. He explained the presence of fossils in strata in mountainous regions as the result of localized multiple flood and emersion sequences, and restricted the direct action of God to the biblical Deluge. This theory clearly contradicted the biblical interpretation provided by Catholic orthodoxy, which affirmed the existence of a single global Deluge. Vallisneri therefore had to gloss over its real meaning and use a careful self-censorship system, a strategy that he frequently used in his books. The comparison with the work of several Italian and European authors had great relevance to Vallisneri's theories. He continually exchanged correspondence and natural objects with some of the most outstanding of the eighteenth century natural philosophers. This involvement with other scholars deeply influenced his thought, and helped him to reach a pre-eminent status in the Italian scientific community of the time.

In the early decades of the eighteenth century the debate unleashed by the organic interpretation of fossils drew the attention of European 'natural philosophers'. The introduction of a chronological dimension within the developing geological studies necessarily gave scientific subjects a philosophical and metaphysical meaning. The discovery of seashells and other organic remains within many strata in mountainous regions had been interpreted earlier as a clear result of the biblical Deluge, but the hypothesis quickly emerged of a chronological interpretation with a different timescale from that deduced from the Bible. Several European authors tried to explain how the Deluge took place, to reconcile fossil evidence with a biblical perspective. These efforts involved a loose interpretation of the Bible, especially on issues not directly related to doctrinal matters.

The scientific studies of Antonio Vallisneri were deeply concerned with the cultural and religious implications of the debate on fossils. The main lines of his thought on this subject were expressed in his chief natural history text, *De' Corpi marini, che su' Monti si trovano* (*Of marine Bodies that are found on the mountains*) (Vallisneri 1721*a*), which was republished in 1728.

To gain a wider comprehension of the events that led Vallisneri to formulate his theories, consideration must be given to his correspondence, especially letters he wrote to the Swiss naturalists Johann Jakob Scheuchzer and Louis Bourguet some time before and during the composition of the book. Analysis of both *De' Corpi marini* and the letters allows an improved reconstruction of Vallisneri's thought, and facilitates understanding of some of the apparent inconsistencies that can be found in this work.

Vallisneri was, above all, an experimentalist. The establishment of the theories outlined in *De' Corpi marini* was the result of a direct interpretation of the many pieces of information he collected during his journeys in the Apennines, where he obtained a great quantity of experimental data and observations.

Careful analysis of fossil objects and rock layers made the biblical chronology implausible for Vallisneri. Moreover, unlike many European scholars (e.g. Woodward or Scheuchzer), he went so far as to believe the biblical Deluge unable to explain the presence and arrangement of fossils in rock strata. Vallisneri expressed this opinion as early as the first decade of the eighteenth century, in a letter to Luigi Ferdinando Marsili in 1705:

> I send a box containing various objects to Mr Scheuchzer, make sure to watch for them. I will send some *antediluvian* figured stones too. I very much like this word that you have used, *antediluvian.* Therefore they are not *trophaea*, or *sedimenta diluviana*, as everyone writes. They are *antediluvian*, from which I can deduce the theory of the world of your Lordship. That is near to mine, in fact you believe that the sea once naturally covered the mountains. Don't you? (Vallisneri 1991, pp. 296–297).

Acquaintance with the work of several Italian and European authors was of great relevance to

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Vallisneri's theories. He continually exchanged correspondence and natural objects (often fossils and minerals) with some of the most outstanding of the eighteenth century natural philosophers. This involvement with other scholars deeply influenced his thought. Also, he had read Thomas Burnet's *Telluris theoria sacra* (Burnet 1681) and the Latin translation of John Woodward's *Essay* (Woodward 1704), made by Scheuchzer in 1704. However, he did not share their efforts to fit the existence of fossils to the biblical text. Instead, he came to believe that the biblical Deluge was irrelevant to the data collected during his journeys. He expressed his theory in a detailed letter to Bourguet in 1710:

> I suspect that there are no (at least in Italy) sure ... evidences of the Deluge, but that the sea was once there, and later went away, and left uncovered the hills and mountains, that once were as cliffs ... as every day we observe behind the shores of our seas. My main argument is that I have seen in the course of my mountain travels ... the marine bodies to be only up to a certain height, and only on those slopes facing the sea, and this for the mountains facing the Adriatic, and for the Tuscan sea ... and so on: because should they have been left from the Deluge, I see no reason why the marine bodies should not be found on the Alps too, or inside the cavities of the mountains ...
>
> Secondly, I infer from experience that Italian seas in many places, and especially in the front of the sites where marine bodies are found, gradually retreat from the land, on the contrary flooding other countries, opposite to ours.
>
> Third. I infer that ... the bodies, the kind of soil in those hills and mountains are the same found in the present shores of our seas (Vallisneri 1991, p. 583).

The presence of fossils in mountain strata was therefore explained as the result of multiple flood and emersion sequences of various parts of the Earth's crust.

A major role in the formulation of this theory was probably played by the age of the rocks Vallisneri had to deal with. The fossils he studied came from late Cenozoic or Quaternary strata, and therefore resembled present-day organisms more than did the English fossils, found in Mesozoic or Palaeozoic strata. Thus British researchers (such as Woodward, Hooke or Lister) had different problems to solve in developing their theories compared with Italian naturalists.[1] It does not seem accidental that Vallisneri's opinion resembled the ideas expressed by Bernardino Ramazzini in *De fontium Mutinensium admiranda scaturigine* (Ramazzini 1691) and Agostino Scilla in *Vana speculazione disingannata dal senso* (Scilla 1670). Both these authors (whose books Vallisneri read and quoted; Vallisneri 1715, pp. 20, 55, 56; 1721*a*, pp. 58–60) examined the Pliocene and Pleistocene sediments of Italy and found it difficult to adapt the experimental data they collected to the model of a single, global Deluge.[2] Scilla supposed that a sequence of consecutive floods had happened. Ramazzini dimonished the importance of the biblical Deluge with respect to geomorphological processes, arguing that the sediments of the Po valley had been left *in situ* mainly by the protracted action of rivers and streams over many years.

As Ramazzini repeatedly pointed out in his book, his deductions were based on the observation of the Po basin sediments only, and, at least until further verifications, his interpretation had to be considered as limited to this area (or at most to northern Italy). This advice was very close to Vallisneri's thought, when in 1710 he wrote to Bourguet about his theories:

> My system may perhaps be verified in Italy alone, but I speak of what I have seen, not of what I have not seen. (Vallisneri 1991, p. 583).

A careful empiricism in developing his scientific theories characterized Vallisneri's work. Generali has noted how the author made a respect for empirical evidence coexist with the attempt to integrate his scientific thought into a more comprehensive philosophical system (Andrietti & Generali 2002, pp. 70–72). His early years of activity were characterized by adherence to the Cartesian principles that he learned while attending Francesco Malpighi's lessons in Bologna University. In 1698 he read Nicolas Malebranche's *Recherche de la vérité* (Malebranche 1674–1675), and agreed with his refutation of animal insensitivity according to Cartesian theories. From 1713 he was deeply influenced by Leibniz's philosophy, whose theories he learned while corresponding with Louis Bourguet. He especially worked on the doctrines of *scala naturae* and of the recognition of divine providence in nature. He addressed these topics in the *Lezione Accademica intorno all'Origine delle Fontane* (*Academic Lesson on the Origin of Springs*; Vallisneri 1715), and in the 'Lezione Accademica intorno all'ordine della progressione, e della connessione, che hanno insieme tutte le cose create' ('Academic Lesson on the connection and order of progression which all created beings have'), included in Vallisneri (1721*b*).

In the *De' Corpi marini* experimental observation and philosophical interpretation coexisted and interacted to strengthen Vallisneri's theories. As in his other works, the starting point was an account of empirical data, reported by the author himself or by a friend. In this case the argument started from a letter written by Sebastiano Rotari in 1716 concerning the many petrified fish and other marine bodies found on Mount Bolca in northern Italy.

Vallisneri's answer began with a consideration of the real origin of these objects. His first attack was directed against the theories that explained the presence of fossils in rock layers as the result of a *vis lapidifica*, or *spiritus plasticus* (i.e. petrifying and shaping powers) within them, or that believed them to be a product of the development of seeds and eggs carried through the strata with vapour and seawater. Although Vallisneri recognized the biogenic origin of fossils, he firmly denied their growth *in situ*. He disproved the hypothetical passage of seeds and eggs through the rocks in water from the sea. This stance was connected to the ideas expressed in the *Lezione Accademica* (Vallisneri 1715), where he proved the non-existence of Cartesian *alembics* (i.e. filters) in rock layers and, therefore, the non-existence of filtering devices to convert salt water into freshwater.[3]

His second attack was against the *lusus naturae* ('freak of nature') interpretation. According to Vallisneri, experimental observation was enough to challenge these assumptions: the marine petrified bodies were too similar to living sea creatures to be considered as 'jokes of nature'.

Once these 'rancid, and abominable opinions' were removed (Vallisneri 1721*a*, p. 16), he attempted to confront the thorny issue of the Deluge:

> Many people appeal (and it seems to be the most common opinion) to the universal Deluge, but I greatly fear that they have a wrong conception of it, as they suppose the sea to have flooded all the Earth, when rather the common freshwater did it (Vallisneri 1721*a*, p. 19).

Thus he considered that seawater was not responsible for the Deluge. Also, the fossils were not found uniformly in the rocks, but only in some localities. This conflicted with the biblical statement of a Deluge that spread over the entire world. However, Vallisneri also did not consider freshwater to be the cause of fossils in rock strata. The fish and shell fossils in sedimentary layers clearly belonged to marine organisms; moreover, it was almost impossible to understand how rainwater could naturally cover the entire planet in just 8 days. Therefore, all the available water on the Earth was for Vallisneri simply not enough to cover the dry land up to the highest mountains. The Flood consequently had to be considered as a purely supernatural event:

> My Lord, we cannot understand completely what we can daily see and touch with our hands, but we wish to know such a portentous prodigy ... and we try to explain it, despite nature, with the same laws of nature, as some experienced but narrowminded people claim to do? The Deluge occurred, God punished ... the treacherous ingratitude of human beings, but I cannot understand how this took place, if I do not resort to ... his unpredictable will, and to his endless omnipotence. (Vallisneri 1721*a*, p. 24)

With this declaration the author clearly diverged from diluvialism. From this point of view, Burnet's opinion of a Deluge entirely comprehensible by means of natural causes was unacceptable. Also, the Woodwardian fossil-based system was far from Vallisneri's thought, because only the fossils were considered by Woodward as the real proof of the Flood.

The act of faith in a totally supernatural event asserted in *De' Corpi marini* may appear to contradict the earlier claim that Vallisneri was sceptical of a global Deluge. However, as Generali pointed out (Andrietti & Generali 2002, pp. 70–80), this doubt fades if we refer to some of the letters written by Vallisneri before and during the publication of his work. In these, he confessed his real opinion, as we can see in a paper sent to Louis Bourguet in 1718:

> My beloved Mr Louis, the Earth is far older than is believed. We can see how many changes occur on the Earth in just a few centuries: rivers shift, older mountains go down and new ones arise, there are seas and valleys now where dry land once was, or land and fields where once were water and seas. The great plain that surrounds the Po river was once a swamp ... now there are cities and castles ... Earthquakes, volcanoes, the rains sometimes immense, the sea storms, the wind force and other can cause the strangest changes. And what if ... the sea that surrounds Italy would once have been high up to the mountains ...? Unless the faith we owe to the Holy Text ... who assures us of the Deluge? The Chinese question it, and so do a lot of evidences that now ... I have no time to show (Vallisneri 2006, p. 353).

The partial mismatch between published (and public) theories and private communication can offer some insight into the censorship problem that scientific authors had to face in Italy, as well as the kinds of strategies that they used to circumvent it. The position assumed by the Catholic Church on the age of the world and the universality of the Deluge is a controversial issue. As Dal Prete explained, it varied depending on the censor's beliefs and on the tone used by authors when they stated their ideas, as well as on the cultural and social context in which these ideas were expressed. However it has been assumed that censorship became more severe with the Counter-Reformation (Dal Prete 2007). Vallisneri's theory clearly contradicted the biblical interpretation provided by Catholic orthodoxy, which affirmed the existence of a single global Deluge. Vallisneri therefore had to gloss over its real meaning and use a careful self-censorship system.

Vallisneri repeatedly declared the truth of the Deluge in the *De' Corpi marini*. He made these claims to permit its publication, as he confessed in a letter to Bourguet in 1722:

> When we resort to miracles, natural history provides everything. I indeed often use them in my treatise. But do you know why? To make the priests be silent, otherwise I imply that the events I speak of did not happen, as Woodward, and many scholars with him imagine (Vallisneri 2006, p. 738).

Vallisneri used considerable skill to show his real thoughts about the fossil issue. The declaration of orthodoxy occurred often in the book, but almost always a series of experimental data clearly opposite to the diluvial theory was listed afterwards. These data had to be neutralized by a careful and prompt claim to the truth of the Deluge, but Vallisneri's real assumptions were disclosed, as many undeceived readers, often the author's friends, knew well. Moreover, he strongly insisted in his book upon the exceptional and divine origin of the Flood in a call to faith that could paradoxically be read as a call to remove religious interpretation from the study of natural history, and that could be also interpreted as the price that Vallisneri had to pay to explain his theories without the risk of running into clerical censorship.

Vallisneri was not an atheist. Many assertions in his letters suggest that his faith in God was sincere. He none the less believed that religion and science answer different questions: respectively, why and how world was made, a view of Galileo that he probably learned from Malpighi[4] and developed himself, and that he expressed clearly to Bourguet in another of the many letters sent to his Swiss friend:

> I do not understand how the Deluge left the shells on one slope and not on the other ... Your Lordship, like other learned and wise men, consider it as true, above all because the Holy Scriptures state it; but the Holy Scriptures cannot teach anything to the natural philosophers, and fill up the mind with prejudices, while they teach the ways of Heaven, and not the phenomena of the Earth. We need to venerate in silence the Holy Mysteries contained in it, but we cannot claim to understand them (Vallisneri 2006, p. 563).

On the other hand, this stance must not make one think that Vallisneri's thought was free from doubt or problems. In some pages of *De' Corpi marini* he questioned whether the Flood occurred not over the entire planet, but only in the Middle East, which he assumed to be the only populated part of the Earth during the Old Testament time:

> The third (hypothesis is) that the Flood was extended just to Asia, the only populated land in those days, and not to the entire world; so that the term *universal* should be intended just like many words from the Holy Scriptures are, that is, metaphorically, referring to all the world once known, and inhabited. Should this assertion be true, all the reproaches and the difficulties would be brought to an end, since it could explain in a far better way all the mentioned phenomena concerning the animals and plants that were easily transported from one place to another. But I cannot assent to it ... and this due to the Holy Scriptures ... and to the Holy Fathers who agree with it, and to the water equilibrium, that necessarily must be sought (Vallisneri 1721*a*, p. 89).

This cautious supposition (prudently retracted in the next sentence) may perhaps be read as a mild effort to link scientific explanation with religious interpretation. However, the author seems to be less at ease here than in other passages of the book.

Such an assumption was extremely vulnerable to both the sides of religious orthodoxy and scientific verification. Vallisneri was probably well aware of the risk, and preferred to persist in keeping science and religion apart. In fact, the prevailing tendency in *De' Corpi marini* was to claim reciprocal independence between faith and science, a position that Vallisneri sustained throughout the course of his scientific activity.

Notes

[1]As Rudwick and Morello pointed out, Martin Lister denied the organic origin of several English fossils as their shape was too different from that of living organisms. This difficulty was not faced by natural philosophers who studied Italian rocks, where the fossils closely resembled many known life forms (see Rudwick 1972, pp. 62–63; Morello 1979, pp. 19–20).

[2]Noah's Deluge is not the only flood mentioned in the Bible. In Genesis 1: 1–9 God made the waters cover the Earth. That event was not considered, however, as it happened before God created the sea creatures (Genesis, 1: 19–22), and therefore could not have caused the presence of fossils in rock strata.

[3]As Rappaport noted (1997, pp. 166–171), Vallisneri's work on the origin of springs aroused interest in part because it challenged diluvialism: he offered evidence that subterranean waters could not rise to all altitudes, whereas the contrary position had been an essential part of Woodward's treatise.

[4]The role played by Galileo in Vallisneri's work is beyond the scope of this paper. However, his influence is evident here, both in the experimentalism and in the call to keep science and faith apart. Moreover, Vallisneri graduated at Bologna University, where his teacher Malpighi always claimed a Galilean parentage. This academic background probably had a great influence on Vallisneri's thought (see Rappaport 1997, pp. 32–33).

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Discussing the age of the Earth in 1779 in Portugal

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Abstract: In 1779 a paper in Portuguese was published in *Jornal Enciclopedico*, Lisbon, on the age of the Earth. 'Defending the Chronology of the Holy Scripture' was written by A. F. Castrioto, who published in the same issue an essay on philosophy and religion attacking the French Encyclopaedists. The paper was mainly a translation of sections from two books, by Edward Gibbon and Richard Watson, the former supporting the idea of an age of 14 000 years for the Earth and the latter defending an age of some 6000 years. Castrioto possibly published the paper and the essay because in 1778 he had been subject to religious censorship and he wanted to reassure the authorities that he was not impious. The idea of a young Earth prevailed in Portugal in the 1700s. Castrioto's paper presented arguments that are not original; he omitted ideas of naturalists that were not in accordance with his own ideas; and he apparently used his periodical to redeem himself of past 'sins'. However, the paper had merits: it was about a geological subject not commonly discussed in Portugal at the time and was possibly the first on that topic to be published there; the author was aware of the discussion on science and religion that was going on abroad; he defended ideas that were accepted at the time by many naturalists; and he produced a paper of interest for the history of geology in Portugal and for the history of creationism.

In July 1779 a seven-page paper was published in Lisbon on the age of the Earth, in which the author strongly attacked a 'Mr Gibon', who had defended the idea that our planet was much older than could be deduced from the Bible. With the title 'Defeza da Cronologia da Escritura' ('Defending the Chronology of the Holy Scripture') it was published in the first issue of the periodical *Jornal Enciclopedico* (Castrioto 1779*a*).

The article is of special interest because it related geology to religion. In Europe at that time a controversy about such subjects was in progress, involving several *philosophes* and religious authorities. As an echo of this controversy in a country at the periphery of the continent, the article needs to be put in the context of this discussion. To the authors' knowledge it has never been analysed and is the only statement published in Portugal in the eighteenth century that dealt with the Earth-chronology topic using religious and geological arguments. Therefore, if only for such reasons, the paper deserves to be considered in studying the history of geology in Portugal. Also, because it was published in Portuguese in an obscure periodical, in international terms, a discussion of its indirect diffusion may be of interest to historians of geology in general. Finally, in a time when a revival of interest in creationism is seen, a paper on that concept, published more than 200 years ago, is of historical interest.

Castrioto and the *Jornal Enciclopedico*

The author of the paper, Antonio Felix Castrioto (?–1798), was also the periodical's publisher and editor, with help from others, and so he did not sign it. However, he was known for his careless orthography and for his use of too many French words in his articles. There were so many misspelled words in 'Defeza da Cronologia da Escritura' that we can attribute the authorship to him. In the first issue of *Jornal Enciclopedico* there was also an unsigned, long essay (34 pages) on philosophy and religion, in which Castrioto strongly attacked the ideas of the French 'Enciclopedistas', Voltaire in particular (Castrioto 1779*b*). The essay was also full of orthographic errors (e.g. 'Voltere' for Voltaire, 'Pristle' for Priestley, and 'septicos' for cepticos).

Castrioto, although known for his poor cultural level, became a member of the Lisbon Academy of Sciences in 1780 (founded the year before), possibly because he had access to government circles and was acquainted with the Abbé Correia da Serra, secretary of that institution. He prepared several technical memoirs on two or three subjects not related to geology that were not published by the Academy because of their poor quality (Banha da Silva 1966). Not much is known about his background in science or technology.

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He arrived at Lisbon at the end of 1777. He had been in Paris, where, in July and September that year, he addressed several letters to Benjamin Franklin (1706–1790) (American Philosophical Society 2007). From these it can be deduced that they met there and spoke about a 'memorial' (possibly a document for the Portuguese government) to be prepared by Franklin, and that Castrioto had brought from Holland some pamphlets for Franklin. From Lisbon, in December 1777 and in March and June 1778, he addressed more letters to Franklin, stating that: (1) he was ready to deliver the 'memorial' to the Portuguese government; (2) in talking to one of the Portuguese government ministers he had heard about the justice of Franklin's 'cause' and the convenience for Portugal of trading with North America; (3) some misunderstanding with the Portuguese authorities had hindered his chances of getting a job in Lisbon. In writing this, he was probably recalling that in 1778 he had been subject to official censorship by the authorities in Lisbon, who accused him of having brought forbidden books, considered to be impious and obscene, into Portugal from abroad. Thus, his religious feelings and probity had been put in doubt (Banha da Silva 1966). In a letter dated June 1779 he strongly complained about Franklin's lack of reply. Curiously, Castrioto, who greatly admired Franklin, in his essay on philosophy and religion referred to above considered him to be a profound Christian philosopher.

In 1788 and in 1789 Castrioto was again travelling in England and Holland, according to his correspondence with the general-secretary of the Academy of Sciences, Abbé Correia da Serra (1751–1823) (Academia das Ciências de Lisboa 1780–1790).

The *Jornal Enciclopedico* (or *Jornal Encyclopedico*), published irregularly between 1779 and 1793, was founded by Castrioto as a monthly periodical dedicated to Maria I (1734–1816), Queen of Portugal. Intended to spread general knowledge, namely the main scientific achievements and political events in Europe, it was generally well received by the Portuguese elite, as seen in the list of its subscribers. With a title similar to the French *Journal Encyclopédique*, it dealt with such subjects as politics, philosophy, arts, science and medicine. It was, as stated in the editorial of the first issue, aimed at instructing less-educated persons by allowing educated authors to illuminate topics for them. Castrioto was also the editor of the first two issues, published in July 1779 and June 1788. The third issue, published in August 1788, had a different editorial team: Henriques de Paiva (1752–1829), a medical doctor, and Francisco Leal (1740–1820), a teacher. Castrioto became the director of *Gazeta de Lisboa*, a Lisbon newspaper, in August 1788. Therefore, while in Portugal, he was a journalist by profession (Banha da Silva 1966).

The paper

'Defeza da Cronologia da Escritura' was included in the 'Istoria Natural' (Natural History) section of the *Jornal Enciclopedico*, and referred to a 'Mr. Gibon' who, in his 'Istoria da Creação do Mundo' ('History of the Creation of the World'), had given support to the idea, deduced from a description of a journey to Sicily and Malta made by 'Bridonio', that the world was much older than commonly accepted by following Moses' chronological account. It referred also to a 'Dr. Watson' who had given a good reply to 'Mr. Gibon' in writing an 'Apologia' in favour of Christianity. Preceding the article there was an introduction in which Castrioto stated that he did not intend to adopt any particular theoretical system (of natural history) and called attention to the importance of Watson's 'Apologia', which Castrioto believed had put an end to a controversy artfully raised by some non-believers.

'Bridonio' is Patrick Bridone or Brydone (1741–1818), author of *A Tour through Sicily and Malta* (Bridone 1776). This book, possibly read by Castrioto, mentioned the work carried out in the Mount Etna area by the Canon Giuseppe Recupero (1720–1778). The Canon had excavated a pit in the volcanic ground near the settlement of Jaci Reale, which allowed him to observe a pile of seven strata-like lava flows, and he correlated the one on the top to another one considered to be 2000 years old because there was evidence that it had been extruded during the second Punic War. Thus, by analogy, the volcano had been formed at least 14 000 (7×2000) years ago. Recupero had also observed that all the flows, except the one on the top, had been covered by a thick layer of soil; thus more than 2000 years would be necessary for this to be formed, which would add more years to that minimum age. Castrioto in his paper presented a translation of this section of Brydone's book.

'Mr. Gibon' is Edward Gibbon (1737–1794), author of *The History of the Decline and Fall of the Roman Empire*, his *opera magna* (Gibbon 1776–1788). In his first volume, Gibbon, according to Castrioto, had written about how the world had been created ('Istoria da Creação do Mundo') and had reinforced the argument taken from Bridone's book about its age. Castrioto commented that objections to Revelation and to the divinity of the Bible, such as that presented by Gibbon, had little weight, but should be read and known by interested people, along with the reply by 'Dr. Watson'.

'Dr. Watson' is Richard Watson (1737–1816), Regius Professor of Divinity at Cambridge, and Bishop of Llandaff, who responded to Gibbon's attack on Christianity in the first letter of *An Apology for Christianity, in a Series of Letters*

Addressed to Edward Gibbon . . . , first published in 1776 in Cambridge (Watson 1777). This book is the one that Castrioto mentioned as being the 'Apologia' in favour of Christianity. A long section of it, reproducing the arguments against Recupero's conclusions, was extracted and translated into Portuguese by Castrioto and made up most of the text of the paper.

Watson's three main arguments, as presented by Castrioto, against the ideas expressed by the Canon were: (1) there was no definite evidence that the upper lava flow seen at Jaci was the one, or could be correlated to the one, referred to by the historian 'Diadoro' (Diodoro Siculus, a coeval of Julius Caesar, who wrote a history of the world) as being contemporaneous with the second Punic War; (2) solidified lava flows needed different time spans to become covered by soil; (3) in the Vesuvius area seven layers of lava with intercalated soil, as described by Sir William Hamilton in a paper about the nature of the soil in the Naples area, published in the *Philosophical Transactions* in 1771 (Hamilton 1772), could be seen that were on the whole less than 1700 years old. Therefore only some 250 years, not 2000, would be necessary for a solidified flow to develop fertile land. Such concepts could be applied, by analogy, to Etna, proving that the volcano was much less than 14 000 years old.

Watson referred to those philosophers who, having travelled in Europe (and this had been the case for Gibbon), wanted, in his words, 'to rob us of our religion'. He then made a clear statement that he firmly believed that the world had been created approximately 6000 years ago.

Discussion

Except for a couple of short comments by Castrioto, his text was practically a translation of the writings of Patrick Bridone and Richard Watson. Some sections are confusing, in the sense that it is difficult to know whether they were written by Castrioto or by the original authors. Only by comparing the texts is it possible to see who wrote what.

Watson's main arguments were reproduced in the third edition of the *Encyclopaedia Britannica*, published in 1787 (Hughes 1955); that is, 11 years after he had presented them for the first time. This shows the strong influence that his line of thought still exerted on public opinion and it reveals what was commonly accepted about the age of our planet. At the same time, publishing such a paper in the *Britannica* fulfilled a need to combat some sceptical tendencies, observed in certain circles of British society, on the topic of the planet's age. Such 'heresies' were a direct result of recent geological work: in the same edition of the *Encyclopaedia*, Hutton's theory of the Earth was also subject to criticism (Hughes 1955). Interestingly, as we have seen, Castrioto had written that both sides of the question (Gibbon's and Watson's) should be made known to interested people, in his explanation of why he had published 'Defeza da Cronologia da Escritura' in his periodical.

The August 1788 issue of *Jornal Encyclopedico*, with the new editorial team, included a section on 'Historia Natural, Fysica e Quimica' (Natural History, Physics and Chemistry), with no comments except that they were considered 'interessantes' (interesting). A translation of 'Reflections about the relative antiquity of the mountains, and the layers or strata that form the crust of the Earth' was written by an 'M. J. J. Ferber' (1787). Among the ideas expressed in this paper we find: (1) the Earth's history and the great physical events that had affected it could not be known for sure and so could not be fully and truly described; (2) as Moses had not given us, in Genesis, lectures on physical geography, it was worthless to look for that in the Bible; (3) those who dared to discover the way our planet was formed, based on the Moses' account, had to use conjectures to fill in the missing parts; (4) we should not seek any explanation in the Bible for the formation and age of our planet, as the causes and the physical means of the creation were not dealt with in it. 'M. J. J. Ferber' was the Swedish mineralogist (Monsieur) Johann Jacob Ferber (1743–1790), who had published the original paper in three parts in the *Acta* of the Academy of Sciences of St. Petersburg (Ferber 1787). *Jornal Encyclopedico* published a translation of only the first two parts.

It seems that the new editorial team of the *Jornal Encyclopedico* changed its orientation, in the sense that it shifted from defending the biblical interpretation regarding the age of the Earth to citing those who considered that one should not look for chronological evidence in the Bible. Castrioto, it seems, did not bother to contradict such a change nor defend his own ideas (published nine years earlier in a letter written to the journal).

Concluding remarks

Castrioto may be considered a Young-Earth creationist, based on his clear agreement with Watson's statement about the age of the Earth. Without his saying so, he was a believer in the ideas of Bishop James Ussher (1581–1656) on this subject. Second, having in mind that, according to R. Peters, 'theodicic creationists (a category in which young-Earth proponents are included) regard their own interpretation of Christianity as the standard by which modern science should be judged' (Peters 2007, p. 43; see also Peters 2009), Castrioto's comments about the French encyclopaedists, in his essay on philosophy, put him in such a category. Ziggelaar claimed that 'A creationist is someone who in spite of overwhelming evidence from modern science keeps to a literal interpretation of the Bible's time scale', and he stressed the fact that 'Jesuits had found concrete evidence from genealogies in China for a longer stretch of time than that derived from the Bible' (Ziggelaar 2006, p. 99). However, it is doubtful that such information had been made available to the savants in Europe in time for it to be used in arguing against the ideas of Ussher and his followers. Also, relative chronology in geology was then in a very early state of development. Quoting Oldroyd: 'They [Creationists] take it as axiomatic that the Bible delivers the word of God. That being assumed, they are right to suppose that geological evidence will confirm the hypothesis of a Young Earth. This is a hypothesis they may test. To be sure, the test fails, but it is not unreasonable to try it out' (Oldroyd 2007, p. 41). The present authors share this view.

Possibly one of the reasons why Castrioto published the 1779 paper had to do with the problems that he had faced before, related to the books that he had imported from abroad. He wanted to reassure the authorities that he was not an impious man, and he used a scientific topic to do that. Besides, he would not have been allowed to start publishing a periodical dealing with such subjects as politics, philosophy, the arts and science without such reassurance. At the time, Portugal was under strict political and religious control by the government and the Roman Catholic Church. In 1778 the mathematician J. Anastacio Cunha, who taught at the Coimbra University, was imprisoned by the Inquisition. He was accused of being a heretic, an apostate of the Catholic faith, and an advocate of deism and tolerance towards the unfaithful. One of the reasons for the accusations was that he possessed forbidden books (Cunha 1994). Even so, those were the times of the Enlightenment and Portugal lacked a periodical of the kind represented by the *Jornal Enciclopedico*. That lack was regretted both by Portuguese nationals and foreigners, as stated in the editorial of the first issue. Thus, Castrioto was allowed to publish the journal, with the blessing of the Portuguese Crown, but having to be careful about what he wrote. This situation was far from being exclusive to Portugal: 'Au XVIII siècle ... les naturalistes qui étudient la Terre doivent toujours tenir en compte de l'Écriture et du Déluge sous peine d'être vivement attaqués par l'Église' (Furon 1958, p. 658). It is probable that the long essay on philosophy by Castrioto, referred to above, was intended to give the Portuguese authorities extra evidence that he was complying with the established order: he wrote that it was his duty to destroy the false idea that philosophy was incompatible with religion, and that it was reason that guided his beliefs. Curiously, in that essay Buffon (1707–1788) was included in the last place of a long list of philosophers admired by Castrioto because they were able to put together philosophy and religion, not because their conceptions about the age of the Earth. Castrioto had forgotten that in Buffon's work *Époques de la Nature* (Buffon 1778), the great French naturalist had attributed to our planet a minimum age of nearly 75 000 years. Also, Castrioto, had forgotten, or did not know, that in 1772 Jean Louis Giraud-Soulavie (1752–1813) supported the idea that the duration of the geological processes could be of the order of several millions of years (Furon 1958).

Ussher's ideas on the age of the Earth (Fuller 2001, 2005) prevailed in Portugal in the 1800s, at least in some circles, as shown by the example of J. A. Barbosa, a member of the Academy of Sciences of Lisbon and a member of a national board dealing with education in general. Barbosa wrote in 1855 that God's plan for his reign had started to be put in practice 5812 years ago (Barbosa 1855). Others were not so assertive. An anonymous author of a book of elementary lectures on mineralogy, botany and chemistry for the use in schools wrote, in 1803, that he had no shame in confessing his ignorance about the way the world had been formed. He noted that it was a matter of conjecture and that he did not intend to try to guess what had been its origin (see Simões *et al.* 2003). He did, however, accept the vision described by Moses in the first book of the Pentateuch (Anonymous 1803). Also, we may consider the ideas of a man of science such as the Portuguese Abbé Correia da Serra, a catastrophist and a volcanist who knew the work of J. J. Ferber and Buffon. He wrote in 1784 that, in his view, the history of Portugal had started not with the origin of its inhabitants but with the creation of the country itself. Apparently, for Correia da Serra the counting of generations within a territory was not an adequate way of knowing its age. He went on to say that, in discussing such issues as the series of natural events and revolutions that had affected Portugal, he would not make use of any of the hypotheses that great men had presented in the last century. Instead, he preferred to present the results of his own observations and deduce the requisite conclusions (Simões *et al.* 2003). Correia da Serra 'had a rather anti-clerical attitude and discarded religious considerations from his writings on botany, his main field of expertise, and on geology' (Carneiro & Mota 2007, p. 13). It may be speculated that either he believed that we should not seek in the Bible any explanation of the formation and age of our planet, or that he believed that the Earth was older than 6000 years.

In conclusion, Castrioto's works published in the *Jornal Enciclopedico* have several demerits. In 'Defeza da Cronologia da Escritura' the arguments that he presented were not original, and the text was sometimes confusing and full of misspelled words. He conveniently forgot to refer to certain ideas of some naturalists that were not in accordance with his own opinions; for example, he mentioned Buffon in his essay because he considered the French philosopher able to unite religion and philosophy, and not because of his ideas on the age of our planet. Castrioto apparently used his periodical to redeem himself of past 'sins'.

His paper does, however, have several merits. It dealt with a geological subject that was not commonly discussed in Portugal at the time, and was possibly the first paper to be published in the country on interactions of geology and religion. Castrioto was aware of what was going on abroad concerning science and religion, and in publishing the *Jornal Enciclopedico* he was disseminating these scientific ideas (Reis 2007). In discussing Watson's and Gibbon's opposing ideas he adopted an impartial position, even if he was a supporter of Watson and considered Gibbon a non-believer. He was on the line of thought prevailing among many European naturalists at the time. Also, he produced a paper of interest for the history of geology in Portugal and for the history of creationism.

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On the Earth's revolutions: floods and extinct volcanoes in northern Italy at the end of the eighteenth century

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Abstract: During the second half of the eighteenth century, the study of volcanism was related to the question of orogenesis and the controversial lithogenesis of basalt. In the Italian peninsula, the key outcrops occurred mainly along the foothills of the Alps of Veneto. Moreover, the question of the origin of columnar basalts and other rocks (porphyry, granite) involved theories on the age of the Earth and the possible recognition of an evolutionary process of the making of lithosphere. Consequently, following explorations in the Alps and Prealps several scientists began to regard the basaltic formations as evidence of the relationships between mountains and ancient volcanoes. Nevertheless, especially from the 1780s, the spread of Wernerian theory in some Italian States led to criticism of the vulcanists' conclusions. Thus, some naturalists working in Lombardy tried to re-establish the idea of a great flood to explain the morphology of the Central Alps. Discussing this complex situation, the paper analyses the development of regional geology, based on fieldwork, which emphasized the function of volcanic activity in the history of building the Earth's crust and mountains.

In the second half of the eighteenth century, the Italian peninsula was an excellent place for making observations of nature. There were a great variety of endemic botanical species, lithologies and structural features, as well as active volcanoes (Vesuvius, near Naples; Mount Etna, in Sicily; Vulcano and Stromboli in the Aeolian Islands). Additionally, there were many sub-volcanic phenomena that attracted many travelling scientists. Moreover, surveys of Italian volcanic provinces were important in the understanding of extinct volcanism. These analyses were also valuable in formulating a natural history of the Earth and reconstructing the orogenesis of the main mountain chains. Indeed, during this period, several geological studies supposed that magmatism was closely related to the formation of the mountains. It is no wonder that, especially from the 1760s onward, a great movement of scientific explorations of the Alps and volcanoes took place.

Meanwhile, the gradual specialization of the natural sciences led to several types of scientific travels with particular routes and instruments. Also, it should not be forgotten that Italian geologists were strongly involved in the scientific debates of their time, as members of the European network established in the early eighteenth century. The extensive circulation of books, booklets, scholarly journals and scientific correspondence, as well as the exchange of specimens, confirms the existence of this network (Vaccari 1999).

Italian geology 1760–1780

From 1760 to 1780, some naturalists working in the Republic of Venice, such as Giovanni Arduino (1714–1795), Alberto Fortis (1741–1803), the English ambassador John Strange (1732–1799) and Girolamo Festari (1738–1801), had assumed an important role in the discovery and analysis of extinct volcanoes. This study was related to the controversial lithogenesis of the basaltic outcrops found mainly along the flanks of the foothills of the Alps of Veneto; in the Euganean Hills, Berici Mountains, Lessini Mountains and Altopiano dei Sette Comuni (Strange 1775*a*, *b*; Vaccari 1993; Ciancio 1995; Pareto 1995). This group of researchers correctly considered these formations to be the products of the cooling of ancient lava flows, in opposition to Renaissance theories that had regarded basaltic columns and crystalline rocks, especially porphyries and granites, as sedimentary bodies generated by depositional and chemical reactions in a marine environment (Sigurdsson 1999, p. 84). This controversial new argument was involved with theories concerning the age of the Earth and the possible recognition of an evolutionary process in the creation of the lithosphere. Thus, several explorations into the Alps, undertaken by European and Italian scholars, allowed them to consider basalts as evidence of the relationships between mountains and ancient volcanoes.

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Previous and contemporary geological surveys had studied various volcanic regions of Europe, such as the Auvergne, Ireland, the Hebrides and Hassia (De Beer 1962; Den Tex 1996; Sigurdsson 1999; Rudwick 2005), and had led to the development of a theory that volcanism, followed by erosive and sedimentary processes related to water and wind, was responsible for orogenesis. Thus volcanic eruptions were not mere accidents related only to local background, but played an important role in the formation of the Earth's crust. During the eighteenth century, geological travels to the Central Southern Apennines, Phlegraean Fields, Vesuvius, Aeolian Islands and Sicily became more frequent (Rodolico 1965; Leed 1992; Ferrazza 2003; Bossi & Greppi 2005; Brilli 2006). This was a consequence of the great interest in volcanic phenomena, both within and outside academic circles. This is exemplified by the popularity of Vesuvius as a tourist destination in the first half of the nineteenth century.

Wernerian geognosy and the Church

Nevertheless, especially between the eighteenth and nineteenth centuries, the diffusion of the Wernerian geological theory in several Italian States led to criticism of the lithological and theoretical conclusions of the vulcanists (Vaccari 1999). This was in large part because of the Italian scholars of the Bergakademie of Freiberg, such as Spirito Benedetto Nicolis de Robilant (1724–1801), Carlo Antonio Galeani Napione (1757–1835), Matteo Tondi (1762–1835), Giuseppe Melograni (1750–1827) and Vincenzo Ramondini (1762–1811). Moreover, the previous publication of some geological writings of Torbern Olaf Bergman (1735–1784) in the Italian journal *Opuscoli scelti sulle scienze e sulle arti* (Bergman 1779) induced many readers to believe that volcanism was a secondary and local geophysical phenomenon in the evolutionary processes of the Earth. The impact of Wernerian theory was extremely relevant in Italy, despite its being filtered and promoted by neptunists. It should be remembered that Werner's writings were never translated into Italian.

Moreover, during the last two decades of the eighteenth century, the Catholic Church adopted a clear position towards geological questions related to the history of the Earth, because of the need to re-establish the authority of the Bible, above all against Buffon's *Époques de la Nature* (1778) (Buffon 1960). Thus, especially from the 1780s onward, diluvialism was resumed in several states of Italy. For instance, in the Republic of Venice, the Earl Ludovico Barbieri (1719–1791), from Vicenza, published a history of the sea, entitled *Storia del mare, e Confutazione della favola dove scopronsi insigni errori di vari scrittori e specialmente del signor de Buffon* (Barbieri 1782) and, in the same year, Father Filippo Angelico Becchetti (1742–1814) published, in Rome, a general theory of the Earth (Becchetti 1782), based on lectures given at the Academy of Velletri. Both works were strictly related to the history of the creation and the biblical Flood. Some years later, in Lombardy, the abbot Vincenzo Rosa (1750–1819) published, in the *Opuscoli scelti sulle scienze e sulle arti*, an essay dedicated to the drafting of an empirical theory of the biblical Flood, entitled *Sul Diluvio Universale. Riflessioni* (Rosa 1794). He believed that the biblical Flood was caused by a variation in inclination of the Earth's axis. That hypothesis was widely diffused in eighteenth-century Italy. This testifies to the fact that theoretical ideas about diluvialism had not yet been discarded.

Within this historical background, from 1790 to 1807, some naturalists working in Lombardy, such as the Barnabite Ermenegildo Pini (1739–1825), the abbot Carlo Amoretti (1741–1816) and the Piedmontese physician Giuseppe Gautieri (1769–1833), doubtful about the presence of extinct volcanoes along the flanks of the Lombardian Prealps, tried to resume the idea of a great flood to explain the morphology and the geological structure of the Central Southern Alps (Pini 1790*a*; Amoretti 1794; Gautieri 1807).

From the last decade of the eighteenth century, the Lombardy region of the Alps was the subject of various controversies about the presence of an ancient volcano. Thus, between 1788 and 1791, Giovanni Maironi da Ponte (1748–1833), exploring the mountains to the east of the Lake of Como, considered the locally observed porphyritic dykes to be proof of ancient eruptions. His knowledge of the writing of Arduino and Barthélemy Faujas de Saint-Fond's had a strong influence on Maironi da Ponte's interpretation. He was persuaded that the dykes had an igneous nature. At the same time, he did not reject the hypothesis that a great deluge might have flooded the land, eroding the volcanic cones (Maironi da Ponte 1791). Later, approaching the ideas of Pini, he abandoned most of his main theories, and adopted a view that involved a hypothesis of submarine eruptions. In the same period, Pini himself disagreed with the French naturalist Louis Benjamin Fleuriau de Bellevue (1761–1852) about the magmatic origin of the western mountains of Lombardy (Pini 1790*a*). The controversy lasted several years, and involved the well-known Italian geologists Scipione Breislak (1750–1826) and Giambattista Brocchi (1772–1826), and some scientists of international renown, such as Déodat de Dolomieu (1750–1801), who visited the region in 1797, and Leopold von Buch (1774–1853) and

Léonce Élie de Beaumont (1798–1874), both of whom visited the region in 1829 (Brocchi 1809; Breislak 1811, 1838; Malacarne 1829).

Ermenegildo Pini (1739–1825)

After doing detailed fieldwork, Fleuriau considered the porphyritic eastern region of Lake Maggiore to be the result of cooling of ancient lava flows. However, Pini, who visited the same region in 1790, did not collect definitive proof of volcanic activity. Because of the lack of craters and the lithostratigraphical analysis, Pini was not able to prove the presence of an extinct volcano. Moreover, coal seams were visible incorporated into limestone layers. Therefore, on the basis of volcanological theories dating back to the Renaissance and particularly diffused in eighteenth-century Italy, Pini believed that volcanic eruptions were caused by the fermentation of sulphur and pyrite or coal deposits, within the Earth, combined with salt water. Furthermore, his finding of several fossils of sea animals proved to him that the Alps had been flooded by the water of an ancient deluge.

Pini included these observations in a general theory on the Earth's revolutions, published in 1790 and later works (Pini 1790*b*, 1792, 1793), in which he identified two main revolutions. The first was before the creation of living organisms; the second corresponded to the biblical Flood. The second catastrophic event was due to a sudden acceleration of the Earth's rotation. He considered that heavy rainfall caused a rise in the level of the oceans, and the floodwaters gushed out from the bowels of the Earth. He denied that a great flood might have been caused by a comet or a variation of the Earth's axis. The biblical Flood lasted only 40 days, as reported in Genesis, and the seas came back to their original level within a year. Pini distinguished the primary mountains, shaped into a primordial ocean, from the secondary ones, which followed the demolition of the first. This classification doubtless recalled those of Antonio Vallisneri (1661–1730), Luigi Ferdinando Marsili (1658–1730) and Giovanni Targioni Tozzetti (1712–1783), introduced in the first half of the century (Vaccari 2006). Moreover, it is probable that Pini considered the primary mountains as created by God, although he made no clear references to this.

The idea of a great flood was also adopted in some contemporary studies by the Abbot Amoretti, but he resumed the well-known thesis of a comet as the reason of the catastrophe. Nevertheless, he did not reject the hypothesis of extinct volcanism. Indeed, in two works written at the end of the eighteenth century (Amoretti 1796, 1797), he suggested the magmatic origin of the basaltic layers found on the west side of Lake Maggiore, near Intra (Piedmont). Thus, after several melting experiments and detailed fieldwork, he considered porphyries and flood basalts of the Central Southern Alps to be the products of submarine eruptions, as Fleuriau and Maironi da Ponte had done before him.

During the first quarter of the nineteenth century, the neptunist hypothesis of Pini, especially regarding the origin of the Alps in the waters of a primordial ocean, generally lost approval. Nevertheless, in 1807, it found favour with Giuseppe Gautieri, who, after being given the position of Forestry Inspector of the Napoleonic Kingdom of Italy, visited the western mountains of Lombardy. Gautieri, like Pini before him, did not find concrete traces of extinct volcanoes, so he rejected any hypothesis involving the igneous nature of crystalline rocks (Gautieri 1807). Therefore, both Pini and Gautieri thought that the Earth's history had been marked by different 'revolutions', one of which might have corresponded to that of Genesis. However, although Pini had adopted creationist ideas, as stated in his geological essay on the Earth's revolutions (Pini 1792, p. 50), Gautieri, in an essay entitled 'Slancio sulla genealogia della Terra e sulla costruzione dinamica della organizzazione seguito da una ricerca sull'origine dei vermi abitanti le interiora degli animali' (Gautieri 1805) agreed with the thesis of transformism. At that time, the theory of the transmutation of species was spreading in Italy, especially because of the Italian translation of Erasmus Darwin's works (Darwin 1803–1805) by the physician Giovanni Rasori (1766–1837). In his writing, Gautieri's evolutionary theory was also inspired by Schelling's *Naturphilosophie*, de Maillet's theory of the Earth (*Telliamed* 1748), Gall's phrenology, the work of the French physician Pierre Jean-George Cabanis (1757–1808) and the human evolutionary theory of the Lombard physician Pietro Moscati (1739–1824), who in a study on the differences between humans and apes had suggested the primitive four-footed walk of humankind (Moscati 1770; Belloni 1961; Pancaldi 1983, p. 54).

Conclusions

The lively discussions arising from attempts to reconstruct the geohistory of the Alps and the Earth's history on the basis of local and experimental analyses involved a great variety of geomorphological and structural hypotheses. Within this complex outline, briefly described here by the examination of a few Italian naturalists, the distinction between neptunists and vulcanists was not always clear-cut, especially at the end of the eighteenth century, although it is sometimes possible to recognize a correspondence between field-based lithological theories and geological models such as neptunism or volcanism. Pini's works, doubtless influenced by neptunism, is a case in point.

Because of the gradual development of a regional geology based on fieldwork geologists were obliged to face the difficulty of classifying the great variety of terrains observed in the field into single systems very different from neptunism and volcanism, which were both worthless for representing regional 'geo-differences'. Therefore, field-based studies of a local area often yielded complex analyses of geohistory that combined more than one theoretical vision.

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Scheuchzer, von Haller and de Luc: geological world-views and religious backgrounds in opposition or collaboration?

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Abstract: This paper describes the influence exerted by religious belief on the scientific accomplishments of three distinctive naturalists of three successive generations in the era of Enlightenment: Johann Jacob Scheuchzer (1672–1733), Albert von Haller (1708–1777), and Jean-André de Luc (1727–1817). The religious attitudes and their impact on the geological views of these naturalists are compared, with focus on the belief in the biblical Flood and its geological interpretation. In all three cases, a religious belief proved to benefit scientific knowledge; furthermore, the attempt to prove the account in Genesis by scientific means united two contrasting views of the Enlightenment: rationalism and biblical dogma. The Enlightenment thus became the ground on which a new, rational–religious world-view started growing.

If we ask for the reasons why naturalists of all periods have studied of the Earth, the answer is: to find the truth about the structure, the history or the formation of the Earth. On the other hand, if we ask for the motives behind this search for the truth, we discover gradual changes in the course of the history of ideas, which are bound to be other than purely scientific or rational reasons. We find that geology has had some surprisingly diverse partners: first religion, in the 17th and 18th century, then economics, in the 19th century, followed by politics. This paper will focus on the relation between geology and religion, and will try to answer three basic questions. Has religion been capable of fertilizing and enhancing science, and in particular geology? Or has it been indifferent to scientific performance? Or did it delay or impede scientific progress? For comparison, three religious naturalists have been chosen as representatives of the 17th and 18th century, all of them Swiss Protestants: Johann Jacob Scheuchzer (1672–1733), Albrecht von Haller (1708–1777) and Jean André de Luc (1727–1817). They belonged to successive generations, and hence reflect the gradual changes in the relation between geology and religion.

Johann Jacob Scheuchzer

Johann Jacob Scheuchzer was born on 2 August 1672 in Zürich as the son of the city's physician (*Stadtphysicus*) and was educated at the Carolinum, a Protestant school, founded by the reformer Ulrich Zwingli (1484–1531). There, he was trained mainly in the classical languages and theology, although his interests were inclined to the natural sciences, and were strongly encouraged by his father. Having finished school and after further training by the anatomist and surgeon Johannes von Muralt (1645–1733) and by the physician J. J. Wagner (?1641–1695), both in Zürich, he therefore started in 1692 studies in physics and mathematics as well as medicine at the university of Altdorf in Germany. Later, he moved to the University of Utrecht in the Netherlands, where he qualified as a physician in 1694. Journeys in Germany, Bohemia, Bavaria, Franconia and in the Swiss Alps followed, and this last journey first acquainted him with fossils, which would play a predominant part in his religious approach to geology later in his life (see below). In the months to come, however, he returned to Altdorf for further studies in mathematics and physics under his teacher Johann Christophorus Sturm (1635–1703). In 1695, Scheuchzer settled in Zurich as a physician, with the prospect of attaining a professorship at the Carolinum in mathematics. In the same year, his first scientific publication appeared with the title *De genere conchylarum*, in which he considered fossils as merely random products of mechanical forces, of no organic origin, nature's toys (*lusus naturae*). This approach was at the time not exceptional. Many naturalists explained the origin of fossils by magic forces of stars or meteorites, and attributed to them a fateful influence (Rudwick 1976, p. 20 f.), or saw *virtus divinae* as a possible cause of their genesis (Adams 1954, pp. 250–276). Only a few assumed them to be fossilized organic material and called them 'petrifactions'. Many interpreted them, following an Aristotelian–Arabic nature philosophy (Kempe 2003, p. 57), as 'tricks' or 'moods' of nature, as Scheuchzer did at the time. As long as nature was able to perform such 'tricks' on its material, nature had to be seen as a self-creating system (*natura naturans*). However, by introducing the view of fossils

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as organic remains, nature became deprived of its self-generating competence; it was generated by extra-natural forces (*natura naturata*). Kempe noted, that fossils were often assigned to nature's moods because of the lack of plausible scientific explanations of their genesis, which eventually produced a grey area between the two terms *natura naturans* and *natura naturata* (Kempe 2003, p. 57 f.).

From 1695 Scheuchzer established a rich collection of natural objects and became increasingly involved with meteorology, astronomy and geognosy. As well as these scientific endeavours, he studied the geography and history of Switzerland and gave private lectures to young students, to extend their pool of information on these subjects. Based on the published scientific literature in Switzerland and abroad, Scheuchzer planned to edit a natural history and geography of Switzerland. To this end, he published in 1700 the *Historiae Helveticae naturalis prolegomena* (Scheuchzer 1700*a*), listing all Swiss scientists and those elsewhere and introducing his plan to the public, followed by the *Stoichoilogia ad Helvetiam applicata* (Scheuchzer 1700*b*), which gave an overview of natural elements and their phenomena. Encouraged by the *Physica eclectica* of his teacher Sturm (1697), he edited a comprehensive overview of current scientific knowledge in a collection of short theorems in two volumes, under the title *Physica oder Natur-Wissenschaft* (Scheuchzer 1743). Also, in 1702, Scheuchzer became editor of the *Nova litteraria Helvetica*, a journal that reported all new scientific findings in Switzerland. It appeared until 1714. Travel reports of Scheuchzer's numerous journeys in the Swiss Alps rounded off his versatile activities (Scheuchzer 1702*a*). His first meteorological observations and his altitude measurements in the mountains by the use of a barometer occurred in this period, and he untiringly expanded his collections of petrifactions and minerals. He published an essay on dendrites (1700) and a list of Swiss minerals and petrifactions (Scheuchzer 1702*b*).

Up to this point, there was no tangible symptom in Scheuchzer's scientific career that would link his endeavours as a naturalist to any religious belief. However, after he read the *Sacred Theory of the Earth* (Burnet 1722), published in several editions in the 1690s by the Anglican theologian Thomas Burnet (1635–1715), Scheuchzer started a correspondence with him, in the course of which he developed his own religiously linked palaeontological position. Burnet defended his diluvian hypothesis, based on Cartesian mechanics, in which he followed the Cambridge Platonists (Nicolson 1929), and claimed fossils to be of organic origin and not *lusus naturae*. René Descartes' *Principiae philosophiae* (1644) served as the basis for Burnet's claim. He considered organic fossils as the victims of the biblical Flood, which were gradually incorporated into the still soft soil as the floodwaters retreated. Taking into account that he was the chaplain at the court of William III (1650–1702), a student at Christ's College in Cambridge, and had never been involved with natural sciences other than corresponding with Isaac Newton (1643–1727) (Kempe 2003, p. 35), the speculative character of his approach cannot be denied. Although Burnet had been led to this biblical position not by observations in the field, but rather by his religious views of the theoretical interpretation of nature, and especially Descartes' principles, his hypothesis became the core of 18th century diluvian views in geology, which extended into the 19th century with William Buckland (1784–1856) as their defender. Kempe has explained the controversy that Burnet's *Theory of the Earth* evoked, which lasted throughout the 18th century, by the contradictory theological world-views since the 16th and 17th century that the work reassessed (Kempe 2003, p. 34). These mainly concerned God's intention behind the biblical Flood. Pessimistic views that supported *natura lapsa* stood against positive interpretations favouring an *oeconomia naturae*. Martin Luther (1783–1546) and also later theologians strongly believed in *natura lapsa* as the consequence of the fall of humans; he saw in the biblical Flood the beginning of a successive decay not only of humans, but of nature as a whole. On the other hand, the British theologian George Hakewill (1578–1649) regarded the biblical Flood as the onset of nature's clearance, a catharsis so to speak, and he essentially based his assumption of an *oeconomia naturae* on God's own approval of the genesis.

Based on Burnet's hypothesis that the existence of organic fossils could prove the biblical Flood by rational means, Scheuchzer was the first to develop a stratigraphical concept, rejecting his former views in favour of the organic nature of fossils. In this context, he also maintained a correspondence with John Woodward (1665–1728), whose *Essay toward a Natural History of the Earth* (Woodward 1695) he translated into Latin in 1704. Scheuchzer agreed with Woodward on the proofs of the biblical Flood by scientific means; that is, unlike Burnet's view, the perspective of Woodward and Scheuchzer originated in scientific facts and attempted to prove by these facts the real existence of biblical events. From this viewpoint, the cosmos would be manifested in both the Bible and in nature as the symbol of God. Against Aristotle's assumption of a world without beginning or end, Burnet strongly defended the view of the world's beginning by the divine *creatio ex nihilo* and its end by the fight between good and evil (Kempe 2003, p. 38 ff.), followed by the dissolution of the Earth and the Last Judgement. Within this sequence of events, Earth history appeared, according to Burnet, as a process limited in time, linking the creation to the Last Judgement, but occurring in reiterated time cycles (Kempe 2003, p. 39). The biblical Flood marked the centre of Burnet's theory of the formation of the Earth. He explained the Flood by the disruption of the Earth's crust, which set free water and damp masses that had been stored below it and partly evaporated and returned to the Earth by major thunderstorms. This caused the whole of the Earth's crust to collapse, leaving remnants wedged up on end. Hills and mountains formed, and oceans filled huge holes. In conformity with the view of *natura lapsa* by the Flood, the antediluvian world, according to Burnet, was a paradise as compared with the post-diluvian remains. However, this is the crucial point where Burnet's *natura lapsa* converts into an *oeconomia naturae*, encouraged by the views of the Enlightenment; he assigned the 'salvage' of the world to the positive will to progress by rationality and experiment.

It was Burnet's philosophical, rational linkage of facts observable in reality to biblical events that inspired Scheuchzer to accept religious belief personally and regard it as being underpinned by scientific proofs. What distinguished Woodward's approach from Scheuchzer's, however, was Woodward's assessment of the biblical Flood as the tangible expression of *natura lapsa*. As in Burnet's hypothesis, he considered the Earth to be filled with water, which burst through a firm crust. In his *Naturalis historia telluris*, he regarded the present world as a ruin after the Flood, which was the 'most horrible and portentous Catastrophe that Nature ever saw: an elegant, orderly and habitable Earth quite unhinged, shattered all to pieces, and turned into an heap of ruins: Convulsions so exorbitant and unruly: a Change so exceedingly great and violent, that the very Representation alone is enough to startle and shock a Man' (Woodward 1714).

Scheuchzer, on the other hand, and in the tradition of Gottfried Wilhelm Leibniz (1646–1716), believed in the benignity of the post-diluvian world. He regarded the biblical Flood as a catharsis rather than a destructive punishment. The belief in progress that accompanied the Enlightenment throughout the 18th century might have also markedly influenced his position, favouring the *oeconomia naturae.* In addition, the Flood provided humans with a tool to decode the word of God by scientific, Cartesian means. This idea resulted in Scheuchzer's outstanding *Physica sacra* (Scheuchzer 1728–1735), a four-volume work trying to explain the Bible in terms of scientific proofs. In Scheuchzer's view, nature appeared as the direct proof of the Bible's consistency. His idea was to absolve the Bible of its putative irrationality, and to prove its consistency by rational means. Such a proof was considered a proof of God, in other words a theodicy. Thus, his approach to nature was physico-theological, with nature, in conformity with Burnet's approach, appearing as the symbol of God. In the years to follow, Scheuchzer also studied glaciology, amongst many other subjects, and saw in glaciers the proof of the biblical Flood. He discovered that there had not been a continuous, but a discontinuous ice cover over the Alps and subsequently the Alpine valleys. He explained the convolutions of sediments in the Alps of Urnen, in the central part of Switzerland, as consequences of the Flood, having formed by the gradually retreating floodwaters. The first catalogues of his fossil collection appeared as *Herbarium diluvianum* (Scheuchzer 1709) and *Museum diluvianum* (Scheuchzer 1716). It should be noted that Scheuchzer was far from assuming the possibility of the extinction of species. He was convinced of a constant number of species and fossil species still being extant, according to the view that God had created a certain natural order, which was unvariable, with humans at the top of a *scala naturae* that linked living nature on one side to God and the angels on the other (Lovejoy 1993). Scheuchzer tried to find this hierarchical order also in the classification of fossils; that is, he concluded from the fact that still extant species could be ranked in a hierarchical order the possibility of arranging fossil species along such a scale. Scheuchzer's attempt was ineffective, because, as Georges Cuvier was able to prove in 1795 using the example of extinct elephants (Coleman 1964, p. 112), many species from previous epochs of Earth history had died out. Endeavouring to arrange his fossil collection in a *scala naturae* leaving no gaps, Scheuchzer made a great effort to find a specimen of antediluvian humans, and eventually, in 1725, considered the skeletons of two *Cryptobranchus alleganiensis* found in a quarry near Öhningen (Bodensee) to be direct evidence of antediluvian humans, who had reputedly drowned in the Flood (Kempe 2003, p. 129). He informed Sloane in London of the find, then published a preliminary flyer with the title *Homo diluvii testis* and later a Latin description of the specimen. Only after Scheuchzer's death did naturalists start to doubt the human nature of the specimens, and after several misidentifications as fishes and reptiles, the Swiss naturalist Johann Jacob Tschudi (1818–1889) correctly identified the animal as a hellbender (salamander) and named it after its founder *Andrias scheuchzeri* (Kempe 2003, p. 131 ff.).

Scheuchzer's scientific achievements, resulting from his theological–scientific discourse on the biblical Flood, may be summarized as: (1) influential arguments for the organic origin of fossils; (2) contributions to the interpretation of sequential rock layers, leading to the eventual emergence of a biostratigraphic approach in the late 18th century; (3) glaciological findings that half a century later were confirmed and developed by a series of other Swiss scientists: Ignatz Venetz (1691–1750) (Venetz 1861), Horace-Bénédict de Saussure (1740–1799) (de Saussure 1786–1803), Jean de Charpentier (1786–1855) (de Charpentier 1841) and Louis Agassiz (1807–1873) (Agassiz 1840). On the other hand, his palaeontological endeavours, resulting in the false identification of a salamander as *Homo diluvii*, were driven by his determination to underpin religious belief by natural facts. Thus religion had only in part positively motivated science, but in return science had stabilized religious belief by Scheuchzer's approach to nature as an interpreter of the word of God. John Woodward had introduced Scheuchzer to the Royal Society of London. Hitherto, Scheuchzer had promoted many young scientists from the Swiss scientific community and had extended its network well beyond the national borders. In 1727, Scheuchzer presented the young Swiss physiologist and anatomist Albrecht von Haller to Hans Sloane (1660–1753), founder of the British Museum and at the time the president of the Royal Society.

Albrecht von Haller

Albrecht von Haller was born in 1708 in Bern. In the course of his education, he developed predominant interests in the sciences and started his medical studies in Germany at the University of Tübingen. Here, he studied botany, and was especially interested in human anatomy. His continued medical studies led him to the Dutch physician Herman Boerhaave (1668–1738) in Leiden, where he acquired detailed knowledge of physiology and qualified in medicine. Travelling to London in 1727 he met Hans Sloane, the surgeon William Cheselden (1688–1752) and the physician John Pringle (1707–1782). In Paris, he contacted the brothers Antoine de Jussieu (1686–1758) and Bernard de Jussieu (1699–1757), as well as the surgeon Henri François Le Dran (1685–1770). The contacts he established on these journeys were predominantly scientific and medical. In Basel, at the only Swiss university at the time, he started lecturing in anatomy and studied higher mathematics, encouraged by the Swiss mathematician Johann Bernoulli (1667–1748). His interests in the Swiss alpine scene were enhanced when he made his first extended journey with his friend the naturalist Johannes Gessner (1709–1790), a former student of Scheuchzer. These excursions, however, did not immediately result in geological studies, as we might expect, but in an epic poem, 'Die Alpen' (von Haller 1795), which will be outlined below. At this time, von Haller earned his living as a librarian and continued his botanical studies in his own time. He held public lectures in anatomy in Bern. From 1736, von Haller's life was torn between his professorship in anatomy, medicine, surgery and botany at the University of Göttingen and his affection for his native city of Bern. Several attempts to settle in Bern failed. He turned down distinguished positions in Berlin and London, as he wished to have his children educated in his native city. He eventually returned to Switzerland in 1748, when he accepted the position as the director of salt works at Aelen in the canton of Bern. This gave him the first occasion to become involved with geognostic and mineralogical questions, which he combined with technical inventions to improve salt recovery. He summarized his accomplishments in a report (von Haller 1765). In this period, he also focused on general agricultural improvements of the area and carried out comparative anatomical studies on fishes and birds. During his last decade, von Haller edited all the scientific excerpts made during his life as a compilation of the total literature published by others in the various scientific fields he was involved with (*Bibliotheca botanica* (von Haller 1771–1772), *Bibliotheca anatomica* (von Haller 1774–1777), *Bibliotheca chirurgica* (von Haller 1774–1775) and *Bibliotheca medicinae practicae* (von Haller 1776–1778)). In summary, we may regard him as a physician, scientist, poet and land economist.

The gap within von Haller's life, which separated his successful career in Göttingen from his affection for his native area, is reflected in his strictly scientifically determined intellect on the one hand, strongly promoted by the progress-oriented credo of the Enlightenment, and his Protestant religious belief on the other, mirrored in his moral didactic poetry (von Haller 1768), in his religious essays (von Haller 1779), in public lectures, and in the congregation that he established in Göttingen. Toellner has pointed out that various attempts to assign to von Haller a specific position in the history of ideas necessarily failed because of the disparate nature of his personality (Toellner 1971, pp. 21 ff.). Von Haller did not base his views on a specific philosophical line, nor could the development of his religious inclinations be accurately traced back in his life, although the contact in his early years to Scheuchzer through his friend Johannes Gessner might have been influential.

In his poem 'Die Alpen', von Haller depicted the alpine life and idyll, and highlighted the ethical impact of the inhabitants' dependence on natural, God-given imponderabilities in a hazardous world, contrasting it with the vices of dwellers living in the plain. Von Haller regarded this poem, composed of 490 hexameters, as his stylistically most demanding one. What particularly distinguished it from earlier poetry about mountains was its positive ethical call to a life determined by nature itself, whereas earlier poets had considered mountains as monstrosities that their inhabitants were condemned to cope with. His other poems were 'Über die Ewigkeit' ('On Eternity'), 'Über den Ursprung des Übels' ('On the Origin of Evil') and 'Über die Falschheit menschlicher Tugenden' ('On the Deceit of Human Virtues'). These religious and ethical didactic poems reflected his Protestant background, although he himself regarded them as philosophical poetry without the need to deduce philosophical truths rationally and set them in rhymes. He intended rather to warm human spirits by adding the appropriate colour to philosophical truths by the medium of language (Toellner 1971, pp. 41 f.). Von Haller regarded both science and philosophy as tools to find the truth through human reason, but his awareness that reason did not appeal to the human heart prevented him from following the belief of his time in progress by means of the sciences and philosophy. All his poems concern the relation between humans, nature and God (Toellner 1971, pp. 52–81). With his friend Johannes Gessner he followed Scheuchzer's physico-theological approach to nature. To any distrustful response from the church's side to scientific ideas or views of his time, he simply asked: 'Is this fear justified? And should faith really decrease, when the building forces are empirically assigned to nature?' And his answer was: 'We may quietly await, whether the experiments of the savants will confirm these theories or disprove them. They will in any case lead us towards the truth and therefore to God!' (von Haller 1752). This passage makes it obvious that von Haller identified the truth with God; however, in contrast to Scheuchzer, he did not seek the truth to prove God's word, but to encounter God. The term 'nature' did not appear in von Haller's poems and other writings other than in the sense of 'creation'. The only reality above nature was accordingly God. Thus God was not considered identical with nature, but nature was rather the symbol of God. Von Haller made a distinction between the 'exterior' and 'interior' nature, the former being limited to the reality perceptible by the senses, and the latter to nature's spirit, born by God's thoughts and immaterial in contrast to the material exterior nature. Thus, von Haller believed that nature formed an entity by combining substance and spirit, both created by God. This philosophical entity bridged the gap in his disparate life work. He applied sciences to search for the truth (i.e. God) in material nature, and he made the immaterial tangible in the relation between humans, nature and God, as expressed in his poetry.

The centre of von Haller's life work is hence to be seen in his religious belief. This gave the impulse to his spiritual and intellectual activity. Von Haller's and Scheuchzer's approach shared the physico-theological aspect in their scientific research. However, whereas Scheuchzer adopted his research in the field to prove the reality of biblical events, von Haller's scientific approach focused on humans as part of nature and at the same time called to subordinate nature. Hence he regarded humans partly as an object to be scientifically investigated, partly as a poetical subject in the encounter with God and nature. According to von Haller, the Bible's contents did not call for any proof, because its creator, God, was not to be questioned. Nature, however, as the symbol of God, was a subject for investigation, to obtain insight in the mechanisms governing its substance, which was part of the truth, and therefore part of God.

Von Haller's geognostic and mineralogical work is of limited significance in proportion to his life work as a whole. He included his observations in travel descriptions, in the introductions to his botanical works and in some essays in the *Göttinger Gelehrten Anzeigen*. These observations, however, were not innovative in mineralogical or geognostic terms. Only four of his travels in Switzerland were described in detail (in the Emmenthal, the Jura, and those into the Alps), although predominantly in terms of his botanical observations. Passages in his poem 'Die Alpen' described aspects of the landscape in a subjective manner. His travel reports of 1738 were limited to botanical observations. In his introduction to the history of Swiss plants, von Haller claimed, like Scheuchzer before him, that the glaciers were not cohesive. In addition, his mineralogical notes were only descriptive. Von Haller's report on the salt works near Aelen, however, proved his power of observation. He described the works predominantly from the mineralogical point of view and added technical suggestions to improve the exploitation possibilities of its resources. By these improvements, von Haller followed the biblical imperative that humans should subordinate nature in a positive, religious sense.

Jean André de Luc

How did Jean André de Luc as a scientist with religious motivations differ from Scheuchzer and von Haller? He was born in 1727 in Geneva, and his father François de Luc, a clockmaker, inspired in him both a preference for the sciences and his religious inclinations. Like his father, he became involved in politics alongside his scientific endeavours; however, his political enterprises are ignored in this account, which focuses on his religiously underpinned scientific work. In 1773 he moved to England, to the court of George III (1738–1820) and his scientifically interested wife, Queen Charlotte, née Princess Charlotte of Mecklenburg-Strelitz (1744–1818), and, with a high reputation particularly as a meteorologist, became a member of the Royal Society. Rudwick has noted de Luc's self-assessment as a 'philosophe Chrétien' (Rudwick 2005, p. 151); in contrast to other naturalists, he put special emphasis on his religious belief. In his *Lettres physiques et morales* (de Luc 1778), edited from 1778 in seven volumes of fictive formal letters addressed to Queen Charlotte, he set down his geological observations made while travelling in the Alps, the Low Countries and Germany. His innovation was the introduction of a historical dimension into Genesis, by his awareness that human history must have been significantly shorter than the pre-human history of unknown length that had preceded the biblical Flood. This conclusion was based on the assumption that post-diluvian humans must have developed in the lower lands that had formed by gradual sedimentation at the level of lakes and seas. In the heathland around Hannover and in the Rhine delta de Luc saw a model to represent this process. Thereby, the depth of silt that developed after the decomposition of organic material gave him a chronometric tool to estimate the age of these areas. De Luc also included the deposition of organic fossils in these investigations. Rudwick, moreover, has referred to the fact that de Luc did not feel the need to explain the origin of mountains; he was merely aiming at making the account of the biblical Flood plausible by analogy to natural facts. This approach is strongly reminiscent of Scheuchzer's in his *Physica sacra*, regardless of the lack of historicity in his theory. Interestingly, the title de Luc gave to his discursive letters to Queen Charlotte, *Lettres physiques et morales*, indicates the author's intention to overcome the gap between the physical and the moral in describing the Bible's analogue in nature. He later revised his thoughts on his geotheory in his *Letters to Johann Friedrich Blumenbach* (de Luc 1798). Rudwick has noted that de Luc had no fundamentalist belief in the Bible, and thus introduced a new historicity into the question of Earth genesis. This was de Luc's main achievement in his geological studies, and it was motivated by the intention to reconcile the sceptic with the Bible, making its plausibility evident by scientific explanations.

Conclusions

The Enlightenment gave rise to two major philosophical orientations in the history of ideas. On the one hand, the belief in progress and felicity by rational investigation of the real world was enhanced. The mental tools at hand to fulfil this demand were the natural sciences, partly applied to economic projects such as the gaining of mineral resources and agricultural developments. On the other hand, religious affiliations and orientations counteracted these rational trends, with the intention of recalling human subordination to God. Pietism and deism were two contrasting, characteristic religious movements forming at the end of the 17th and in the 18th century. Pietism as a Protestant movement, first propagated by the Alsatian Philipp Jacob Spener (1635–1705), urged men to return to the Bible and dogmatic belief. Deism, in contrast, with François Marie Voltaire (1694–1778) as its advocate, supported the belief in God, but denied any biblically recorded revelation. According to this movement, God gave the impulse to creation, but would not interfere once nature had been created. Thus deism appeared as the appropriate religious background to the rationalism of the Enlightenment.

Scheuchzer, von Haller and de Luc were three Enlightenment naturalists who tried to bridge the gap between rationalism and biblical religious belief. Scheuchzer and de Luc tried to deprive the biblical dogma of its irrational attribute by proving Genesis by scientific facts. De Luc thereby introduced historicity into the Earth's development and disclosed the symbolism of Genesis. Scheuchzer's scientific aim was to unite rationalism and religion into a new, coherent world-view. Von Haller too was well aware of the dualism that split the rational from the irrational world. His scientific research was based on Scheuchzer's physico-theological approach, which provided a synthesis between science and religion. For the sake of humans, as the summit of God's creation, he carried out valuable physiological and anatomical investigations, and he tried to disseminate his religious belief in his poetry and essays. In summary, in all three cases presented here, religion served as a motivation for scientific research and for the dissemination of its results. Regarding particularly Scheuchzer's and de Luc's scientific approach, science appeared as the motivation for disseminating religious belief amongst rationalists.

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Biblical Flood and geological deluge: the amicable dissociation of geology and Genesis

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Abstract: This paper summarizes debates, among European geologists in the early nineteenth century, about the possible equivalence (or non-equivalence) between the biblical account of Noah's Flood, and new and cumulative evidence for an exceptional watery catastrophe or 'geological deluge' in very recent Earth history. The 'diluvial theory' deserves to be taken seriously as an attempted explanation of some extremely puzzling physical features (many of them reinterpreted later as traces of a glacial 'catastrophe' or Ice Age). The 'geological deluge' was eventually recognized as having been far earlier in Earth history than any event recorded by literate human societies. Among geologists, although not always among the wider public, this gradual dissociation between biblical Flood and geological deluge was generally amicable, not acrimonious. It was facilitated by the concurrent development of biblical scholarship, which showed that earlier literalistic interpretations were no longer tenable (and were also destructive of religious meaning). What was transposed into geology in the course of these debates was the strong Judaeo-Christian sense that the world has had a directional and contingent history, which might have been punctuated by occasional catastrophic events.

Historical work on the relations between any of the natural sciences and any of the world's religions should always specify clearly the period, the place and the persons that are under discussion, and also define which social groups were involved. Historians of the sciences now rightly reject attempts to impose any single or simple pattern of, for example, either endemic conflict or perennial harmony, because these are incompatible with the variety and complexity of the historical evidence (see, e.g. Brooke 1991).

This paper is about the 'when' of the late eighteenth and early nineteenth centuries; the 'where' of the whole of Europe (including its offshore islands of Britain and Ireland); and the 'who' of the naturalists who at that time were beginning to call themselves 'geologists'. These are the parameters that Karl von Zittel (1839–1904) used when, over a century ago, he famously defined the decades around 1800 as 'das heroische Zeitalter der Geologie' (von Zittel 1899, p. 76). He too focused on research by Europeans, because during geology's 'heroic period' North America and the rest of the world were still marginal to high-level scientific debate (although treated as valuable sources of new observations and specimens). And he too concentrated on the social group of the leading scientific figures, and on what they were doing and discussing among themselves, rather than on the dissemination and reception of their ideas among the wider public (the latter is a very different story: for the British case, see O'Connor 2007*b*). Within these parameters, this paper focuses on one celebrated (or notorious) case of the relation between geology and religion, namely the attempts to interpret certain physical features as traces of the Flood recorded in the book of Genesis, and conversely the attempts to reject any such correlation.

Earth's history, and its timescale

In late eighteenth- and early nineteenth-century Europe, during what political historians often call the Age of Revolution and the subsequent Age of Reform, the Earth sciences were radically transformed by becoming deeply historical in their outlook and practice. Those who pursued these sciences came to recognize not only that the Earth as a whole has had its own history, but also that its features (particular mountains, volcanoes, rocks, fossils and so on) likewise have specific histories built into them, and cannot be understood solely in terms of unchanging ahistorical 'laws of nature'. This radically new outlook on the natural world was the result of a deliberate transposition of methods and concepts from the writing of human history into the study of the Earth, to reconstruct the Earth's own history (in modern terms, geohistory) in all its complex particularity (Rudwick 2005, 2008).

This geohistorical research strategy was so successful and productive that most modern geologists are unaware of it. They use it routinely and take it

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completely for granted; they ignore the fact that it was achieved at a specific time and place in human history. But it was not achieved against resistance from a reified entity called 'religion' or from a monolithic entity called 'the Church'. On the contrary, it was positively facilitated by the strongly historical orientation of the Christian religion: the strong sense of an unrepeated directional movement in human history, not deterministic or predictable but always contingent. In traditional terms, this history, both terrestrial and cosmic, stretched from creation through the incarnation of Christ towards the end of the world (hence the traditional timescale of years BC and AD, now globalized as years BCE and CE). This fundamental concept of contingent directional change could be, and in the event was, extended from recorded human history back into what turned out to be the depths of prehuman geohistory.

Contrary to the assertions of some modern crusading atheists, the possibility of a greatly extended timescale for geohistory was not a religious problem among naturalists (it sometimes was among the wider public, particularly in Britain: O'Connor 2007*a*). In fact, the idea of an inconceivably lengthy past was, in itself, far from novel. The traditional short timescale of a few millennia for the whole of cosmic history (James Ussher's notorious 4004 BC date for creation was just one of many competing alternatives) had for centuries been juxtaposed to the equally traditional alternative of eternalism, according to which the timescale of the universe was unimaginably vast because it was infinite (Rudwick 1986). It was only during the eighteenth century that a third alternative, transcending this ancient polarity between two equally un-modern options, began to emerge. This was the possibility that the timescale of the Earth's history, and that of the universe as a whole, might be unimaginably lengthy yet not infinite. For the first time, this made it possible to conceive that the Earth might indeed have had a history that was reliably knowable, even though most of it apparently predated any human beings who might have recorded it, rather than just the endless recycling of similar events from and to eternity (Rudwick 2005, pp. 115–130).

By the 1780s at the latest, all knowledgeable naturalists with interests in the Earth sciences had in effect adopted this third (and modern) concept of the Earth's timescale. Although they had no way of quantifying it, they were tacitly agreed that it must be inconceivably vast in relation to human lives or even to the totality of recorded human history. At the same time, however, most of them claimed that through these vast spans of time the Earth had developed directionally towards its present state, that humans were relatively recent newcomers, and that the Earth had therefore not been the same kind of place from all eternity. To put it another way, they firmly rejected any suggestion that the whole of geohistory was confined to a few millennia; but at the same time most of them also rejected any suggestion that humans had always been around, let alone that the timescale might be infinite because the Earth was eternal. In effect, they rejected anything analogous either to the 'young-Earth' beliefs of modern creationists or to the 'steady-state' theorizing (albeit currently out of favour) of some modern cosmologists.

What eighteenth-century naturalists found most persuasive, as evidence for a lengthy but not eternal geohistory, was a product of their fieldwork in many parts of Europe. This was the discovery that the pile of stratified 'secondary' rock formations, the *monti secondari* or *Flötzgebirge*, was immensely thick, at least in some regions. Furthermore, it seemed almost incontrovertible that many of these strata must have accumulated extremely slowly and in very tranquil conditions. An outstanding example was the Plattenkalk or 'lithographic stone' of Solnhofen in Bavaria, with its exceptionally well-preserved fossils. Even if the underlying 'primary' or basement rocks, the *monti primari* or *Urgebirge*, were attributed to the very origin of the planet, it became clear that the total timescale of subsequent geohistory must be unimaginably vast in relation to the whole of recorded human history (Rudwick 2005, pp. 84–98, 115–130).

This inference was surprising and unexpected, but it was no problem for the many leading naturalists who regarded themselves as religious believers. They saw no conflict between a lengthy geohistory and the two creation stories in Genesis (Chapters 1–3), because they were aware that biblical scholars, since the earliest history of the Church, had drawn attention to the limitations of biblical literalism. For example, it had often been pointed out that the seven 'days' of the first creation story could hardly denote periods of 24 hours (the first three were described as preceding the origin of the Sun itself). Each 'day' was better regarded as a time of special divine significance, rather like the 'day of the Lord' in prophetic discourse. The theological significance of the story, and hence its practical religious meaning, lay not in any quantified chronology but rather in its reiterated claim that the world was not self-generated or eternal, but the product of divine intention directed towards what was good ('And God said, let there be . . . and it was so; and God saw that it was good').

The biblical Flood in geohistory

However, the story of Noah's Flood, later in the Genesis text (Chapters 6–8), posed very different problems. Unlike the creation stories, the biblical Flood story claimed to record events within human history, not before it. Therefore it was reasonable to suppose that it would be possible to locate it on the human-historical timescale of years BC, by searching all known textual records, both biblical and non-biblical, using the scholarly methods of the well-established historical science of 'chronology' (Grafton 1991). Also, because the Flood was recorded as having been drastic in its physical effects, as well as catastrophic for humankind, it was also reasonable to expect to find natural evidence for its historical reality, in addition to textual evidence. Naturalists in a much earlier period, in the time of Niels Stensen [Steno] (1638–1686) and John Woodward (1665–1728), had in effect attributed the whole pile of 'secondary' formations to the Flood, although in consequence they had had to interpret the putative event in far from literalistic ways. However, more extensive fieldwork over the next hundred years, leading to the discovery of the sheer thickness of the pile, had made this interpretation less and less plausible. By the late eighteenth century, the only materials still attributed to the biblical Flood, and therefore sometimes termed 'diluvial', were the so-called 'superficial' deposits such as boulder clay (till) and coarse gravels, the *ausgeschwemmte* materials or *terrains d'aterrissement*, overlying all the 'regular' or clearly stratified secondary formations.

It followed that the physical event that had formed the superficial deposits must have taken place (relatively) very late in geohistory. Thus it was reasonable to conclude that it might be recent enough to be the trace of the biblical Flood itself. If so, the diluvial event formed a unique boundary between the (relatively) very brief span of human history and the vast spans of prehuman geohistory; or rather, a unique zone of overlap between the two. Naturalists, including those who were religious, tried hard to explain the diluvial event in purely natural terms, by enlarging the scale of what the Anglo-Genevan savant Jean-André de Luc (1727–1817) termed 'causes actuelles' (actual causes); that is, processes visibly operating now ('actually' in the older sense of the word) in the present world. De Luc himself, for example, conjectured in 1779 that the 'diluvial' features were due to the sudden collapse of major segments of continental crust (an idea that goes back to Descartes), somewhat analogous to modern landslips but on a far larger scale (Rudwick 2001, 2005, pp. 150–158). On the other hand, in 1791 the French naturalist Déodat de Dolomieu (1750–1801) attributed them instead to what would now be called a mega-tsunami, analogous to the devastating tsunami that had followed the notorious Lisbon earthquake of 1755, but again on a far larger scale (Rudwick 2005, pp. 317–324).

After the turn of the century, the great Parisian naturalist Georges Cuvier (1769–1832) wavered between these two alternative explanations. However, he was most concerned simply to demonstrate that the event was real, very widespread and probably even global; and that it was capable of having wiped out the megafauna of apparently extinct mammals, such as mammoths and mastodons, that he was reconstructing from their fossil bones (Rudwick 1997). This would prove that extinction itself was a natural process and not just due to human agency. Far from privileging the biblical story of Noah's Flood, Cuvier treated it as just one of several accounts, all of them more or less obscure, from various ancient cultures ranging as far away as China. And far from being a biblical literalist, Cuvier cited Johann Eichhorn (1752–1827), the great Göttingen orientalist and biblical scholar, to help put a reliable date on the Flood; he used the biblical story simply as a surrogate for the contemporary records of ancient Egypt, which could not yet be deciphered. Only in the Anglophone world was Cuvier misrepresented, when the editions of his work published by the Edinburgh geologist Robert Jameson (1774–1854) asserted that the Frenchman's primary objective was to bolster the authority of the Bible (Rudwick 2005, pp. 557–571, 585–598).

Biblical Flood and 'geological deluge'

Most geologists accepted the plausibility of this idea of a sudden catastrophic event in recent geohistory. However, many of them disagreed with de Luc, Dolomieu and Cuvier on its date. They argued that it was too ancient to be equated with the biblical event, or they simply ignored the question of its date in relation to human history. In effect, the 'geological deluge' (as it came to be called) was distinguished more and more sharply from the biblical Flood: the question of the (geo)historical reality of the physical event was increasingly separated from the question of its chronological date. (This analytical distinction between biblical 'Flood' and geological 'deluge' is not difficult to detect from the contexts in which the terms were used, although the writers themselves did not use the terms consistently in this way, and of course they were referring to the putative event in several different languages.)

For example, towards the end of the Napoleonic wars in 1815, the great Prussian geologist Leopold von Buch (1774–1853) tackled the most puzzling of all the 'diluvial' problems, namely the huge erratic blocks scattered erratically around the Alps

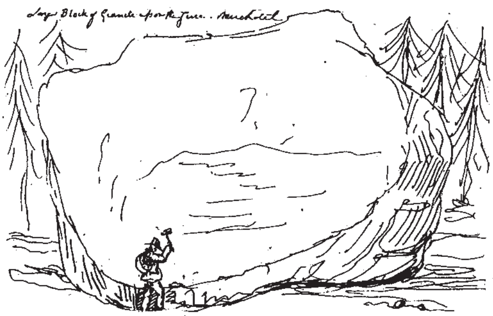

Fig. 1. The Pierre à Bot, a huge granite erratic block stranded on the forested slopes of the Jura range above Neuchâtel, about 100 km from its bedrock source near Mont Blanc, as sketched in 1820 by Henry De la Beche (1796–1855). In 1815 Leopold von Buch had used this erratic as his prime example of evidence for the geohistorical reality of an exceptional aqueous catastrophe, subsequently termed the ‘geological deluge’, in the geohistorically recent past (reproduced with permission of the National Museum of Wales).

and across northern Europe, far from where the relevant rocks cropped out *in situ*. Von Buch’s prime example was the Pierre à Bot high above Neuchâtel (Fig. 1). How had this block of granite the size of a small house been moved over 100 km from its unquestioned source in the Mont Blanc massif, down the upper Rhône valley, across Lac Léman (the Lake of Geneva), over the low hills of the Pays de Vaud, and right up onto the slopes of the Jura range? Von Buch was utterly perplexed; but in 1818 a terrible disaster in the Val de Bagnes (coincidentally, not far from the source area of the granite of the Pierre à Bot) gave him a possible *cause actuelle* for it. At some point in the unrecorded distant past there might have been a similar but far larger and more catastrophic mudslide or subaerial turbidity current, flowing all the way from the high Alps to the Jura. Around the same time as von Buch’s work, James Hall (1761–1832), the younger friend of the deceased James Hutton (1726–1797), described surfaces of scratched bedrock and other strange linear features around Edinburgh. He scaled up the *cause actuelle* of known tsunamis, and followed Dolomieu in suggesting, in a highly un-Huttonian manner, that the enigmatic features were due to a mega-tsunami. Neither von Buch nor Hall referred to the likely dates of these catastrophic events: the reality of the putative geological deluge was dissociated from any explicit reference to the biblical Flood (Rudwick 2005, pp. 573–584).

However, other geologists did follow de Luc, Dolomieu and Cuvier in equating these two events, and in the Anglophone world this coincidence was used by some of them to support the trustworthiness of the Bible as a whole. For example, the Oxford geologist William Buckland (1784–1856) mapped ‘diluvial’ gravels across the English Midlands, which contained distinctive erratic pebbles that had been carried southwards right over a watershed, in a way that seemed inexplicable in relation to the present rivers. He therefore inferred that the gravels were due to some kind of exceptionally violent ‘diluvial current’ or mega-tsunami. Soon afterwards fossil bones were discovered in Kirkdale Cave in northern England. In a careful analysis of this site, Buckland reconstructed the small cave as a former den of extinct ‘antediluvial’ hyaenas. His friend and colleague William Conybeare (1787–1857) caricatured this by showing Buckland time-travelling back into antediluvial geohistory, ‘bursting the limits of time’ in just the way that Cuvier had famously advocated for geology as a whole (Fig. 2). Buckland then turned his attention to many other caves, in Britain, France and Bavaria, that were already known to contain fossil bones; and he used them all as further evidence for the reality and very wide impact of the ‘geological deluge’ (Rudwick 2005, pp. 600–620).

The dissociation of Flood and deluge

In the religiously conservative environment of the University of Oxford, the intellectual centre of the Church of England, Buckland the Anglican cleric argued that the geological deluge was none other than the biblical Flood, although he, like de Luc and other earlier writers, had to interpret the story of Noah in a far from literalistic manner. However, this was not a battle between ‘science’ and ‘religion’. One of Buckland’s most forceful critics in Britain was the Scottish naturalist and Presbyterian (Calvinist) cleric John Fleming (1785–1857), who rejected the reality of the geological deluge altogether, and doubted if the biblical event had left any physical traces, at least in his own part of the world (Burns 2007; Rudwick 2008, 82–86). Fleming denounced Buckland’s diluvial theory, calling it (quoting Francis Bacon) ‘Philosophia phantastica, religio haeretica’. On the other hand, many other critics of Buckland, such as the London geologist William Fitton (1780–1861) and others elsewhere in Europe, accepted the reality of the geological deluge but inferred that it was much too ancient to be equated with the biblical Flood.

During the 1820s and 1830s this dissociation between geological deluge and biblical Flood became more marked among geologists of all European nations. In England a decisive shift in expert opinion came when Adam Sedgwick

Fig. 2. William Buckland crawling into Kirkdale Cave in 1821 with the light of science in hand, and finding that the extinct cave hyaenas, whose habits he had reconstructed from their fossil bones, were alive and well: a caricature by his friend William Conybeare. This putative 'antediluvial' hyaena den was an important part of Buckland's evidence for the reality of a 'geological deluge', which he, unlike many other geologists, equated with the biblical Flood (reproduced from the author's collection).

(1785–1873), Buckland's counterpart at Cambridge and like him an Anglican cleric, defected from Buckland's side to Fitton's. Sedgwick concluded that the diluvial deposits dated from more than one period in geohistory, and that all of them were probably too ancient to be identified with the biblical Flood. He found the extensive fieldwork of Léonce Élie de Beaumont (1798–1874), a Parisian geologist of a younger generation than Cuvier's, particularly persuasive. Élie de Beaumont distinguished older from newer diluvial deposits, and attributed them to distinct and successive 'époques de soulèvement'. According to his tectonic theory, which he had developed from von Buch's earlier ideas, these putative episodes of relatively sudden crustal buckling had elevated new mountain ranges and generated mega-tsunamis at distant intervals throughout geohistory (Rudwick 2008, 113–114, 129–133, 333–336). Whether the most recent upheaval had been recent enough for its mega-tsunami to have been recorded by early human societies was left unresolved; but it seemed certain that few of the 'diluvial' deposits, and perhaps none of them, had anything to do with the biblical event.

During these same decades, fieldwork by many other geologists showed that the diluvial effects were astonishingly widespread across northern Europe and all round the Alps (Fig. 3). In St. Petersburg, for example, Gregor Kirilovitch, count Razumovsky (d. 1837; the brother of the Razumovsky who was Beethoven's patron in Vienna), described erratics that had crossed the Gulf of Finland onto the plains of northern Russia. Cuvier's Parisian colleague Alexandre Brongniart (1770–1847), while visiting Scandinavia primarily in search of trilobites, mapped eskers and erratics trending southwards across southern Sweden. Johann Hausmann (1782–1859) of Göttingen described other erratics of Scandinavian origin that had crossed the Baltic onto the north German plain, some of them even reaching the Netherlands.

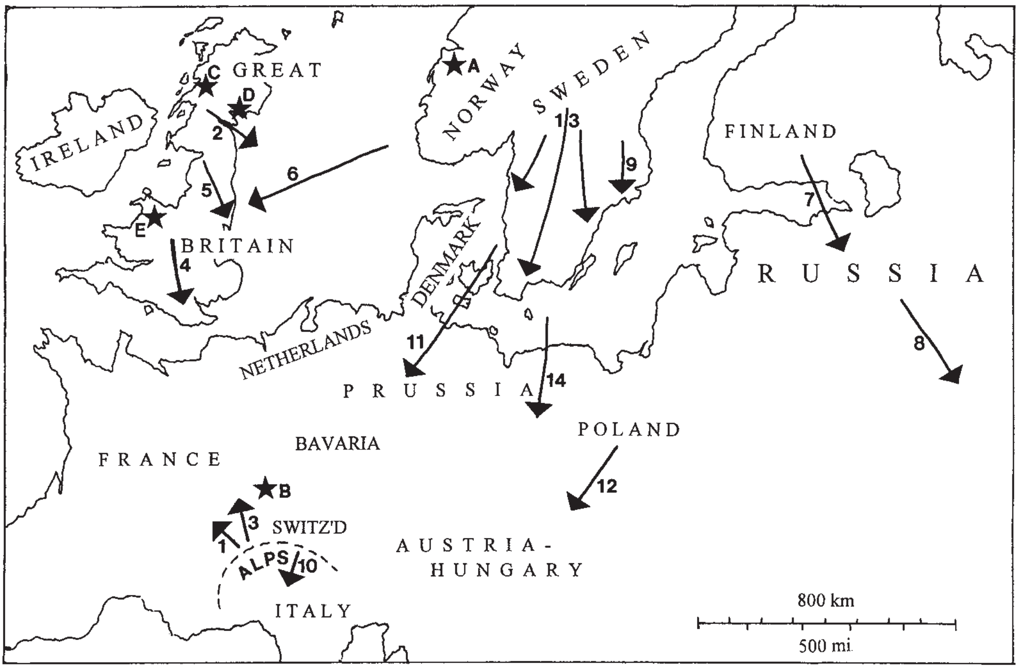

Fig. 3. A map of Europe, showing the inferred tracks of various 'diluvial currents' that had carried erratic blocks and other debris far from their source areas, as reported mostly in the 1820s and 1830s. They include those described by Brongniart (**9**), von Buch (**3**, **10**), Buckland (**4–6**), Hall (**2**), Hausmann (**11**), Pusch (**12**), Razumovsky (**7**) and Sefström (**13**). Many were later reinterpreted as the result of glacial action in a geohistorically recent but prehistoric Ice Age; the asterisks **A–E** denote areas in which the traces of former valley glaciers were detected, which were important in this transformation of the diluvial into the glacial theory.

Buckland noted that yet others had crossed the North Sea onto the east coast of England. Further south, von Buch found trails of erratics on the southern flanks of the Alps to match those he had already traced on the north. The mining geologist Georg Pusch (1790–1846) of Warsaw mapped diluvial deposits and erratics extending from his home city southwards towards Krakow, and attributed them to 'a colossal flood penetrating with immense velocity [mit ungeheurer Geschwindigkeit]'. And another mining geologist, Nils Sefström (1787–1845) of Falun, mapped in detail the scratched bedrock surfaces all across southern Sweden, and attributed them similarly to a huge and violent south-trending 'petridelauniska floden' or flood of little stones, apparently long before any humans were around.

Meanwhile, similar reports from beyond Europe suggested that the diluvial currents were even more widespread and possibly worldwide. For example, John Bigsby (1792–1881), a British physician attached to the commission surveying the disputed frontier between the USA and Canada, reported vast spreads of erratics around the shores of Lake Huron. Also, Buckland, profiting from British expeditions to Burma and Alaska, argued that the megafauna of extinct mammals that Cuvier had first reconstructed had flourished in antediluvial times in all latitudes from the tropics to the Arctic (Rudwick 2008, 185–189, 196–198, 501–505). Apart from Buckland, however, most of the geologists mentioned above inferred, explicitly or at least implicitly, that the enigmatic diluvial event was too far in the deep past of geohistory to have left any record in human history. The consequent dissociation between geological deluge and biblical Flood was generally amicable. To repeat the point: it was not an argument between 'science' and 'religion' or between religious believers and sceptics.

The transcendence of literalism

The role of biblical studies in the nineteenth-century debates about the relation between religion and the natural sciences has been woefully neglected. In fact, scholarly methods of biblical interpretation, based on greatly improved knowledge of the relevant ancient languages and cultures, were already flourishing, particularly in some of the German universities, where such work built on earlier research by scholars such as Eichhorn and the great Johann Michaelis (1717–1791) at Göttingen (Löwenbrück 1986; Sheehan 2005). By the early nineteenth century, educated people in most European countries, including those who would now be called 'scientists', were coming to recognize that biblical literalism was no longer tenable, and that it had not been characteristic of Christian thinking in the earlier history of the Church (Frei 1974; Rogerson 1984; Harrison 1998). In the case of geology, the recorded comments of geologists show that even in Britain at least some of them were aware of this. Conybeare, for example, who did distinguished work in both geology and theology, deplored his compatriots' ignorance of the work of German biblical critics such as Eichhorn, and insisted that 'the Bible is exclusively the history of the dealings of God with men', and that it should not be misused as a quarry for scientific data (Rudwick 2008, 423–427).

This newly historical understanding of all ancient texts, including but not only biblical texts, allowed the putative universality of the biblical Flood, for example, to be reinterpreted in terms of the likely perceptions of ancient cultures. The biblical scholars concluded that the Flood story probably referred to a catastrophic event confined to some limited area (perhaps Mesopotamia, the traditional site of Noah's embarkation in his Ark) that had already been settled by people of an early literate culture: it might indeed have been 'universal', but only in terms of the world as they experienced it. Any physical traces of the historical reality of the Flood would therefore have to be sought in that part of the world, not in Europe. The assimilation of scholarly textual criticism therefore led to the geological marginalization of the biblical Flood, which was now assumed to have been confined to the limited region then settled by the earliest human societies. Even Buckland retracted his earlier emphatic claim that the diluvial features in northern Europe had been due to the effects of the biblical Flood. In effect, the biblical Flood was demythologized (to use Bultmann's classic term) into a localized inundation in early human history.

In contrast, the much earlier and apparently prehuman 'geological deluge', attributed to some kind of massive tsunami-like event, was taken to have spread diluvial gravel and erratic blocks around Europe and North America, and perhaps even globally, while also causing the mass extinction of Cuvier's fossil megafauna (most of it, in present-day terms, of Pleistocene age). However, this natural explanation was soon transcended, and in part superseded, by the concept of a geohistorically recent *Eiszeit* or Ice Age. The glacial theory was proposed most sensationally in 1837 by the palaeontologist Louis Agassiz (1807–1873) of Neuchâtel, but more soundly by other Swiss geologists such as Ignace Venetz (1788–1859), Jean de Charpentier (1786–1855) and Bernhard Studer (1794–1887). It eventually provided a far more satisfactory explanation for most of the diluvial features, and particularly for erratic blocks. Buckland was an early and enthusiastic convert to glacialism, and during the 1840s most other geologists came to agree that the putative geological deluge had in reality been some kind of Ice Age, though few of them adopted Agassiz's extreme 'Snowball Earth' version of it (Rudwick 2008, 508–539).

In retrospect, it is arguable that the relation between the Flood story in Genesis and the findings of the new science of geology would never have become such a focus of debate had it not been for the deeply human-historical character of Judaeo-Christian religion and the newly geohistorical orientation of geology. The novelty of the latter deserves some emphasis. Traditionally, the Earth sciences had not been historical in outlook: in earlier periods they had emulated either the ahistorical classificatory goals of other branches of natural history, or the ahistorical causal goals of other branches of natural philosophy. As mentioned above, it was only in the late eighteenth century that the Earth sciences took a historicizing turn, when methods, models and metaphors from the study of human history were knowingly transposed into the natural world. Half a century later, this geohistorical practice had become so firmly embedded in the science of geology that in 1837 the Cambridge polymath William Whewell (1794–1866), then acting as president of the Geological Society, coined a new name to denote this new kind of natural science. In Whewell's mapping of all the sciences, geology was 'palaetiological' because it combined 'palaeontology', literally the study of past entities of all kinds (not only fossils), with 'aetiology', the study of their causal origins. This was the kind of historicized natural science that the young Charles Darwin (1809–1882) ('I, the geologist', as he then called himself) imbibed at that time, and soon set about extending from the inorganic world into the world of organisms (Rudwick 2008, 489–493, 546–548).

Scientific and religious meanings

The story of biblical Flood and geological deluge, summarized here very briefly, is all too readily turned into grist for any number of anti-religious mills and tendentious 'conflict' narratives. However, there are other interpretations available. The gradual and generally peaceable dissociation between biblical

Flood and geological deluge is a good example of the general human learning process by which the appropriate fields of application of diverse claims to reliable knowledge come to be recognized and differentiated.

The immediate source for the historicizing of nature in the new science of geology was the archaeological work that, for example, reconstructed Pompeii and Herculaneum from their excavated ruins (Rudwick 2005, pp. 181–194). However, a more profound inspiration, as mentioned above, was the overarching Judaeo-Christian sense of human history as complex, unrepeated and, above all, contingent. Transposed from culture into nature, this basic religious sense, far from 'retarding the progress of science' as crusading atheistic fundamentalists often claim, lies at the very roots of the modern Earth sciences. However, it remains an open question whether a modern historicized and demythologized interpretation of the ancient story of Noah's Flood is capable of carrying the imaginative religious meaning that it embodied for earlier ages. This we can at least dimly re-experience, for example in Britten's powerful musical reworking of the mediaeval play *Noyes Fludde* (1958), just as Haydn's *Die Schöpfung* (1798) can allow us to re-experience the earlier imaginative impact of the creation story. Perhaps the whole effort to match the Genesis stories with the science of geology was radically misconceived, in that the newer historically informed biblical interpretation, no less than the literalistic one it sought to replace, failed to put the question of religious meaning centre stage.

Meanwhile, however, and as a properly separate project, glaciologists and Quaternary geologists now find ever richer scientific meaning in the physical features that for a time were fruitfully interpreted as the traces of some kind of 'geological deluge'. In conclusion, therefore, historians of the relation between geology and religion should not be content either with a conflict model or with a harmony model, either with overlap or with non-overlap between 'science' and 'religion'. In the case summarized here, the diverse human learning processes that in German are rightly called Wissenschaften ('sciences' in the plural, both natural and human) led in the course of time to the differentiation of properly distinct spheres of enduring meaning, both scientific and religious.

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‘Our favourite science’: Lord Bute and James Parkinson searching for a Theory of the Earth

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Abstract: John Stuart, the third earl of Bute and the British Prime Minister from 1762 to 1763, and the apothecary surgeon James Parkinson both amassed large and important geological collections; both believed in the biblical Deluge; both admired the work of Jean André de Luc; and both were fascinated by the study of geology. Each sought a theory that would explain the geological phenomena they observed but which also allowed them to maintain their religious integrity. They were men of their time, struggling to come to terms with a new science that challenged their strongly held religious beliefs. Bute’s *Observations on the Natural History of the Earth*, never published, provides us with a snapshot of his thinking about prevailing theories of the Earth. He dismissed all except those that fitted the geological facts as understood at the time, but was nevertheless unable to progress from a rigid belief in the biblical Flood having been a miracle. Parkinson’s *Organic Remains of a Former World* reveals a man fully conversant with contemporary geological ideas being propounded elsewhere in Europe. Also highly religious, Parkinson oscillated between his deeply held beliefs and the contradictory evidence provided by the fossils he held in his hand.

In 1738, Prince George (1738–1820) became the first Prince of Wales to be born in England for more than a hundred years. He was the second child and eldest son of Frederick, Prince of Wales (1707–1751), and the first grandson of King George II, then on the throne. Born prematurely, the young prince was baptized by the Bishop of Oxford on the day of his birth, as there were doubts as to whether he would live. He did live, although as a child he appears to have been of average, if not below-average, ability. Later in life he spoke both French and German, was keenly interested in astronomy and clocks, drew and painted well, was fond of chess and was a great collector of books. He was also devoted to music, playing both the flute and the harpsichord (Cannon 2004). As king, he was probably the most cultured man ever to sit on Britain’s throne. It seems unquestionable that these latent talents were discovered and nurtured by his tutor, John Stuart, the third earl of Bute (1713–1792).

The British Prime Minister

Bute (Fig. 1) was an intelligent and highly educated Scottish nobleman who had succeeded his father to the earldom of Bute in 1723, aged only 10. Bute not only directed the young prince’s formal education but also gained his respect and confidence, becoming, in George’s own words, ‘his dearest friend’ (Schweizer 2004). When George became king (George III) in 1760, Bute rose rapidly through the political ranks, becoming Prime Minister in 1762. During his premiership he managed to negotiate the treaty that ended the Seven Years’ War (1756–1763). Although undoubtedly glorious, for Britain, the Seven Years’ War had also been exorbitantly expensive. To help pay off the national debt, Bute introduced an excise tax on cider. It was intensely unpopular and was to be his undoing. He was publicly maligned and insulted, even physically manhandled in the street. Eventually it all became too much and Bute decided to resign: ‘I would retire on bread and water’, he wrote to the king, ‘and think it luxury, compared with what I suffer’ (Cannon 2004). However, having become the richest man in Britain on the death of his father-in-law two years earlier, Bute was certainly not going to retire on bread and water.

Bute’s wealth enabled him to play a leading role in promoting the intellectual life of his day and he devoted himself to the patronage of science and the arts, amassing his own large collections in both these fields. His first love was botany, and together with the king’s mother, the Princess Dowager, Bute was instrumental in the development of the Royal Botanic Gardens at Kew. In 1785 he published, at the cost of some £12 000 to himself, 12 copies of a splendid nine-volume work, *Botanical Tables Containing the Families of British Plants*, which contained 654 hand-coloured plates. His remarkable library included a huge collection of works on botany and natural

From: KÖLBL-EBERT, M. (ed.) *Geology and Religion: A History of Harmony and Hostility*.
The Geological Society, London, Special Publications, **310**, 111–126.
DOI: 10.1144/SP310.14 0305-8719/09/$15.00

Fig. 1. John Stuart, third earl of Bute (1713–1792). Stipple engraving by C. Watson, 1805, after A. Ramsey. Courtesy Wellcome Library, London.

history (so large that when he leased a house on Kew Green, he had to extend it to accommodate his library), as well as a fine collection of prints that included 'works from the Italian, German, Flemish, Dutch, French and English Schools, In fine Condition, and of the best Impressions, More particularly in the Works of Rubens, van Dyck, Foussin, Visseher, Drevet, Edelinek, And Rembrant' (Turner 1967, p. 215).

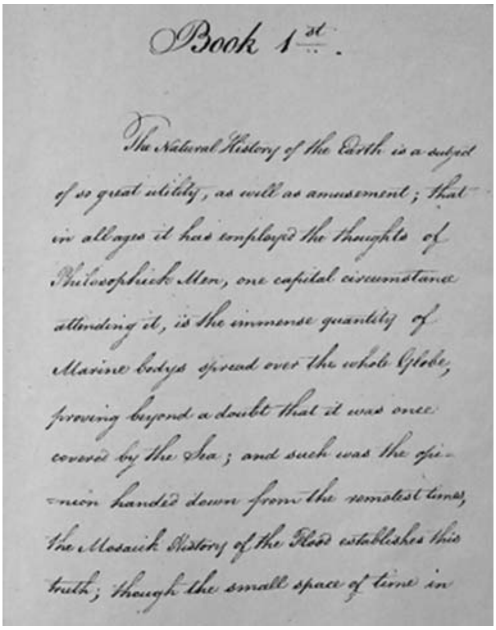
Bute had his own scientific laboratory at Luton Hoo, his house in Bedfordshire, equipped with the most up-to-date apparatus money could buy. His extensive collection of 'Optical, Mathematical and Philosophical Instruments and Machines' (including a large number of microscopes) was sold at auction after his death in June 1793. Furthermore, Bute amassed what was arguably the most important private collection of minerals and fossils in the world at that time. He is reputed to have had over 100 000 specimens (Wilson 1994). The 1600 lots that these specimens amounted to were also sold at auction, in March and May 1793, and in March 1794. They took 14 days to be disposed of and fetched more than £1225 (Turner 1967, p. 213).

'My favourite studdys'

Many Scottish landowners were interested in mineralogy and chemistry because of their close links to mining and land improvement (Eddy 2002, p. 431), thus Bute patronized mineral dealers such as John Walker (1731–1803), who collected a wide variety of 'fossils', seeking to compare their ores, minerals and metals with those from overseas (Eddy 2002, p. 435), and Peter Woulfe (1727?–1803), who carried out chemical experiments on minerals in Bute's laboratory at Luton Hoo (Campbell 2004). However, Bute's interest in mineralogy and natural history went far beyond a desire for land improvement; indeed, he termed them 'My favourite studdys' (Miller 1988). It is thought Bute started seriously collecting around the late 1760s and he is known to have had a sustained correspondence with John Strange (1732–1799), who was elected to the Royal Society in 1766 for his contributions to geology (Sharp 2004). Strange, based in Venice, procured books for Bute on all aspects of natural history and apprised him of mineral and fossil collections for sale. Their correspondence reveals Bute encouraging Strange to communicate his ideas to others, agreeing for the most part with his 'theory of the Earth' and commenting intelligently on the works of other geologists (Miller 1988, p. 224). It would therefore be a mistake to regard Bute simply as a collector.

Hundreds of works in search of a Theory of the Earth were published for the general reader during the seventeenth and eighteenth centuries in the major European countries and languages. As more geological discoveries were made and more evidence became available, various writers attempted to construct an integrated and comprehensive vision of the Earth's past (and sometimes of its future), bringing together evidence drawn from diverse intellectual fields, including, of course, a study of the Bible.

Bute followed the literature closely and read many of these theories of the Earth as they became available in their original languages. Around 1781 (the fair copy is dated February 1782) he began writing a summary and critique of all the main theories that had been put forward over the past 100 years. It is divided into two Books, the first being a critical review of the existing literature, and the second putting forward Bute's own theory. The work is an attempt to establish in his own mind which theory best fitted the geological facts and, equally importantly, accommodated his religious beliefs. The essay was never published, and probably was never intended to be, and in 1992 the draft and fair copy of the manuscript (Fig. 2), entitled *Observations on the Natural History of*


Book 1st.

The Natural History of the Earth is a subject of so great utility, as well as amusement; that in all ages it has employed the thoughts of Philosophick Men, one capital circumstance attending it, is the immense quantity of Marine bodys spread over the whole Globe, proving beyond a doubt that it was once covered by the Sea; and such was the opi-nion handed down from the remotest times, the Mosaick History of the Flood establishes this truth; though the small space of time in

Fig. 2. First page of the fair copy of Bute's manuscript: *Observations on the natural history of the Earth, 1782.* Courtesy University of Bristol Library Special Collections.

the Earth (Bute 1782),[1] were purchased for the Eyles Collection at the University of Bristol, which houses one of the most important collections of historical geology books in the country.

The introduction to Bute's *Observations on the Natural History of the Earth* captures the excitement that the young science of geology engendered in him, and poses the questions that were vexing many savants and amateurs alike as the eighteenth century drew to a close:[2]

The Natural History of the Earth is a subject of so great utility, as well as amusement, that in all ages it has employed the thoughts of Philosophick men. One capital circumstance attending it, is the immense quantity of Marine bodyes spread over the whole Globe, proving beyond a doubt that it was once covered by the Sea; and such was the opinion handed down from the remotest times. The Mosaick History of the Flood establishes this truth; though the small space of time in which that miraculous event happened, will by no means account for the various Phenomena hereafter specified; the Earth we now inhabit, will appear, not only to have been once under water but to have existed for many ages at the bottom of the Ocean. How therefore this astonishing change was effected; how the Sea came to retire, and at what period that happened, are matters of the greatest difficulty. [...] many different Hypothesis and Systems, have succeeded each other, the last generally condemning all that went before; tho' most of these are the Children of Fancy, the mere sport of heated imaginations, yet some observations in all of them will be found useful (Bute 1782, p. 1).

This passage relays to us across more than 200 years the intellectual difficulties that Bute, and many like him, were facing. On the one hand he accepted that the world had indeed once been entirely covered by the sea, both because the Bible told him so and because the geological evidence seemed to concur with this, yet on the other hand he had the 'greatest difficulty' in imagining how this 'astonishing change' and the subsequent withdrawal of the waters, had occurred. Having set the scene, Bute went on to review nine of the prevailing theories of the Earth. This is no great intellectual work, but the thoughts, musings perhaps, of a highly educated, widely read and intelligent man. It provides us with a snapshot of how he, and probably others, viewed these theories at the end of the eighteenth century. Several of them were, by then, almost 100 years old, so it is not surprising that it is these early theories he was dismissive of and the later ones that he preferred.

The first theory addressed by Bute is Thomas Burnet's (*c.* 1635–1715) *Sacred Theory of the Earth* (1681–1689), considered by Stephen J. Gould to be the most popular geology book of the seventeenth century (Gould 1977, p. 141). A hundred years later, Bute summarized Burnet's theory and unorthodox interpretation of the Flood in a paragraph, and dismissed it in a sentence:

Dr Burnet's Theory of the Earth publish'd in 1681 begins the Romance of Natural History. He describes the Mosaick Chaos as a fluid heterogeneous mass, the heaviest parts of this, sunk towards the Center, forming in the middle of the Globe a solid hard Kernel, surrounded by Water while oily unctious substances impregnated with terrestial particles first floating in the air, then by degrees precipitating, formed a coat over the Water, of oil and Mud mixed, this was the Primeval Earth (Bute 1782, p. 4).

In summary, Burnet conjectured that the antediluvian Earth had formed as a smooth, regular sphere upon which the relatively thin crust of the Earth rested like an eggshell upon a vast watery abyss. Thus the pre-diluvian Earth was without faults and wrinkles. The Flood itself, he argued, had not been caused by 40 days and nights of rain, but had occurred when 'by Divine Providence ... the frame of the Earth broke and fell down into the Great Abysse'. He regarded the post-diluvian Earth as a 'broken globe', a 'great Ruine', a 'little dirty Planet', 'a World lying in its Rubbish'. Bute, however, was dismissive of such flights of fancy:

Every part of this is so extremely absurd, it is scarce worth observing that neither Plants not Animals could exist without moisture, and as the Waters were entir'ly shut up within the Earth, Fish and other marine bodys were not in being, which is directly contrary to the present condition of the Globe. And whether we suppose the Author to have been serious or in jest, He does not appear to have had the least acquaintance with the Natural History of the Earth (Bute 1782, p. 6).

He moved rapidly on: 'The next System we owe to Woodward'. *An Essay Toward A Natural Theory of the Earth* (Woodward 1695) by John Woodward (1665–1728), argued that the biblical Flood had caused a general dissolution of Earth's material, which then settled out by weight into the various geological layers he observed in England. Bute commented that

> this author was a diligent observer of Nature, and formed his Hypotheses on his own observations, but as these were confined to this Island they often lead Him into Error (Bute 1782, p. 7).

Apart from 3 years in Italy (1769–1771), Bute himself was not very well travelled, but he nevertheless appreciated that geological features were very different in other countries. He continued:

> Woodward was conversant with Nature, which Burnet was not, and as He often found Marine bodys over this whole country at great depths and had heard that the like existed in all parts of the Globe, even on the tops of the highest mountains, He naturally supposed the whole Earth must have been under the Sea (Bute 1782, p. 11).

> He seems so thoroughly convinc'd of the truth of His Hypothesis, that He often neglects giving reasons for many of his assertions, it is however surprising, that a man of his learning, and great experience in Natural History should advance so many things contrary to notorious facts, such for example, is that of all bodys being found buried in the Earth according to their specifick Gravity, a fact on which His whole Hypothesis depends... and I much doubt if He is right in affirming that Marine productions are found on the highest Mountains of this Country. That they are not on the primitive mountains of the Alps will appear hereafter from undoubted authority. We have in this authors System a proof of the dangerous tendency of all Hypotheses composed on a narrow base, and on a few favourite circumstances; the author sees every thing in one light, and shuts His Eyes to all Phenomena that make against this darling child of his own production (Bute 1782, p. 12).

Next in line for Bute's attention was the 'eminent but warm Astronomer' William Whiston (1667–1752), whose *New Theory of the Earth* (Whiston 1737) proposed that the ancient Earth had been formed from a comet that subsequently came very close to a second comet. Water in the second comet's tail rained down on the Earth, resulting in the biblical Flood:

> Whiston having formed the ancient Earth by a comet, He has recourse to another [comet] to explain the Deluge; this dreadful catastrophe being occasioned by the approach of one [comet], whose tale consisting of watry vapours pour'd down cattaracts upon the Earth, agitating in the same time a great abyss so violently, that the crust was split and raised up in many parts, while torrents of water rushed out, the Deluge ended by the waters gradually withdrawing to their first abode or sinking into caverns formed during the convulsion, & dry land once more appeared, but very different from the former Earth, for in place of gentle risings, great chains of mountains & broken precipices arose (Bute 1782, p. 15).

From here Bute considered Whiston's theory to be much like the previous two in terms of explaining the presence of marine fossils in the rocks, with one important difference: Whiston attempted to integrate his theory with Moses's account of the Creation as given in the Bible. However, although Bute approved of this, he still could not accept what was obviously a physical impossibility:

> His [Whiston's] plan is adapted to the Mosaick History, which our modern Theorists affect to treat with great contempt, we must own however that some things here are liable to great objections; thus, the body of Earth which inclosed the Waters being a concave arch, could neither rest upon them nor sink into them; this error in Mechanics overlooked by so eminent a mathematician shows the dangers of these ideal systems (Bute 1782, p. 17).

Bute continued:

> Hooks Theory [Robert Hooke (1635–1702); *Lectures and Discourses of Earthquakes and Subterraneous eruptions*, written in 1668 but published posthumously in 1705 (Hooke 1978)] comes next in order, it is comprised in his discourses given in the Royal Society on Earthquakes. He ventures to describe the manner in which the Earth arose from the Chaos of the Mosaick History, but as all He says on that subject is mere Hypothesis & conjecture, I shall pass it over and proceed to his ideas of the present Globe. These may be given in a few lines. He supposes that immediately after its formation, it underwent great changes from Earthquakes, that to these are owing Mountains, Hills, Valleys; which at the Deluge changed again their situation by the same means, so that no part of the present Earth remains, which was not Sea either before or after the Deluge (Bute 1782, p. 18).

Bute passed rapidly on to Benoît de Maillet's (1656–1738) *Telliamed* or *Conversations Between an Indian Philosopher and a French Missionary on the Diminution of the Sea* (de Maillet 1748):

> Mr Maillet in his romantick Treatise of Telliamed, not satisfied with bringing the Earth from the Sea, makes that Element [the sea] the origin and primeval abode of Men and Animals; this is so very absurd, that altho' there are excellent observations on the various substances found in the Earth interspersed, the Treatise as a System is too ludicrous to dwell upon (Bute 1782, p. 21).

Lazaro Moro (1687–1764) fared little better, but Bute's comments on Moro are worth quoting at length, as his work *De' Crostacei e degli altri corpi marini ebi*[3] (Moro 1740) may be less well known than the other works Bute discussed:

> The next writer on this subject is Lazaro Moro an Italian, his Hypothesis is entirely confined to the operation of fire, he supposes the Earth at first a stoney crust perfectly round, covered by fresh water to the height of 175 fathom; on the third day of the Creation in which the dry land appear'd, subterraneous fires broke open the crust, and raise'd it in many places to the height of our loftiest mountains; these still composed of Stone at their first erection, were quickly split by various fissures thro' which they began to vomit forth Lava, Cinders, Pumice and such volcanick matters, which rolling down in immense torrents into the Sea, formed by degrees the Secondary mountains in layers, and Sulphurs, Salts etc. issuing from the fissures occasioned the saltness of the waters whence it became a proper element for Fish and Marine Plants; the volcanick eruptions continuing in layers of various mixtures, soon formed a soil proper for animals & Vegetables, and when these eruptions thus raised the bottom of the Sea, they produced new layers covering the former, and burying under

them, Fish, Shells, Plants and all other matters that had been on the antient surface and to account for these bodys sometimes found at great depths, he has recourse to fresh volcanos and frequent eruptions, like those of Etna, Vesuvious, the Lippari Islands etc, which still continue burning and throwing out Lava, these he thinks are sufficient to give us some idea of that dreadful Period, when the whole Earth we inhabit, was in perpetual convulsions.

It is on our present volcanos that Moro has founded his whole Hypothesis. That there have been many of these burning mountains is certain, and that they have produced dreadful effects and alterations in particular places cannot be denied, but to affirm, that the Alps, the Andes, Pyrannees, Caucasus etc, are all the offspring of fire, because Vesuvious & Etna seem formed by it, is a most chimerical idea (Bute 1782, pp. 22–26).

The penultimate theory to be addressed was that of the ‘amiable author’ Comte de Buffon (1707–1788). Of his 36 volumes of *Histoire naturelle, générale et particulière* (Buffon 1749–1778), the final one was just available to Bute, who, at that time, would not have seen the eight additional volumes published after Buffon’s death. Buffon was probably the person most responsible for the rise of European interest in natural history during the eighteenth century. His massive *Histoire naturelle* set out to organize all that was then known about the natural world. He was the source of important ideas about the distribution of plants and animals around the world, relationships between species, the age of the Earth, the sources of biological variation, and the possibility of evolution. We are not told whether Bute read all 36 volumes but his assessment of Buffon’s work is the most comprehensive of all the theories he examined, suggesting that he had studied it at length. Bute’s comments, however, primarily addressed Buffon’s assessment of how the Earth was formed, and we are left wondering what he thought of the many other theories put forward by this erudite man:

We now come to the first Theory of Buffon. In this, water is the great efficient cause of all the Phenomena attending our Globe tho’ operating in a great variety of ways, this amiable author joins to an extensive knowledge and great erudition, so beautiful a style and elegant composition, that the reader must be constantly on his guard, or He will be carried away by a torrent of eloquence, into every Hypothesis a warm and fertile fancy can suggest. This happened at first to myself, I greedily entered into His ideas and preferr’d His system to all others, but doubts gradually arose, the charm ceas’d, and I was able to examine His Theory unbias’d by his style (Bute 1782, p. 26).

Buffon was famously skilled with words, which earned him the nickname from the mathematician Jean le Rond d’Alembert of ‘the great phrasemonger’.

He begins with informing us, that our Globe with the rest of our Planetary System, were fragments struck off by a comet from the Sun composed of boyling vitreous matter, a kind of Glass which cooling by degrees, the burning atmosphere consisting of water, and volatile mixed substances, combined with the united actions of the Sun, the Winds, the Ebb and Flow of the Tide, by degrees borrowed the surface of the victory as matter, made steep excavations, sunk valleys, raised Hills and Mountains, and thus formed the first irregularitys of the Globe. Amazing operations for water to perform, but what will not time do, and as a hundred thousand years are trifling with this Gentleman, it follows that wind and water have had the principal share in the present form of the Earth; the Hills and Mountains thus produced, lye all in layers, and Marine bodys are met with on the loftiest Summits (Bute 1782, p. 27).

His general hypothesis of the planetary system is very ingenious, but requires no observation [comment]. There is one circumstance attending it however which I cant help taking notice of. In talking of the Deluge our Theorist blames in the strongest terms those who attempt to account for that dreadful catastrophe by natural means, as it was in every part miraculous, and no data left for us to reason upon; this is indeed the truth, but was the formation of the Globe [any] less a miracle which He [Buffon] however describes as minutely as if he has been present at the great work of the Creation (Bute 1782, p. 35).

In the course of this eulogy to Buffon, Bute briefly referred to von Leibniz’s (1646–1716) *Protaginea* [*sic*] (von Leibniz 1859): ‘the whole of this Hypothesis is so entirely the work of fancy that there is no occasion to make any remarks upon it’ (Bute 1782, p. 37).

In the last of Buffon’s 36 volumes, *Les époques de la nature* (published in 1778), he again discussed the origins of the Solar System, and speculated that the planets had been created by comets colliding with the Sun. He also calculated that the Earth was very old. Based on the cooling rate of iron, he estimated the age to be 75 000 years. Bute seems to have taken all this with a pinch of salt:

The Epochs De La Nature ... in this last work Buffon has given way to all the exuberancy of fancy without the least constraint and however it may disagree with many Phenomena of our present Earth, it is a most elegant performance, wrote in a beautiful style, and seems the master piece of this excellent Author (Bute 1782, p. 40).

Nevertheless, Bute went on to give a long and detailed summary of this last volume, although he left the reader to decide for themselves how much to believe, once they had assessed the work of de Luc, which followed:

How far this bold Theory [Buffon’s] agrees with the actual state of things any more than it does with the Mosaik History, will appear when we come to examine the best and most recent observations (Bute 1782, p. 53).

The history of the Earth

Bute’s favourite theory of the Earth was that put forward by Jean André de Luc (1727–1817). De Luc had moved to England in 1773, following the collapse of his family business in Geneva and bringing with him his reputation as a European savant (Rudwick 1997, 2002). His well-known work on meteorology had merited his immediate election as a fellow of the Royal Society and soon afterwards he was appointed Reader, or intellectual mentor, to Queen Charlotte, wife of George III, a post he held for 44 years until his death in 1817. The queen quickly formed a liking for de Luc and found him 'a proper philosopher for ... all his works are full of admiration for the Supreme Being' (Tunbridge 1971, p. 18). De Luc too was delighted, for the position afforded him a comfortable income with the opportunity to devote himself almost entirely to scientific research.

At the time Bute was writing his *Observations* in 1781, de Luc had just published (de Luc 1779) a series of letters addressed to Queen Charlotte in which he expounded his theory on the history of the Earth and humans. Over the years de Luc refined his theory considerably, but it would have been the 1779 version, which Bute would have read in French, then the language of science in the way that English is today, and to which Bute referred:

> The last and in many respects the best system I have seen is by Mr De Luc, just published under the Title of the *History of the Earth*. This excellent naturalist carefully avoids all Hypothesis relative to the first formation of the Globe, of that He finds no data to proceed upon, nor does He touch on the Antedeluvian Earth further than he thinks necessary to account for the present situation and Phenomena of the one we inhabit ...
>
> The whole of the system [de Luc's theory] is comprehended in the following short sentence: the Antedeluvian Earth and Sea have changed their position, the present Earth was the antient Ocean, the Antedeluvian Earth sinking beneath the level of the former Sea, became the bed of the present one (Bute 1782, p. 54).

De Luc's argument was that the Earth had undergone a radical 'revolution' in the recent past, during which the sea floor had become land and the land had sunk beneath the waves. He considered this had probably been caused by a collapse of the Earth's crust, but exactly how it had occurred was of far less consequence to de Luc than the fact that it had occurred (Rudwick 2002, p. 55). His theory divided geohistory into two periods: the familiar world we see today populated by humans, and the ancient or 'antediluvian' pre-human world that existed before the 'revolution' and that was of immense duration in time.

Like several other naturalists before him, de Luc did not feel constrained by a literal interpretation of the biblical chronology, which stated that the world had been created in six days; instead, he interpreted geohistory as a sequence of seven vast periods, each corresponding to one of the seven days of creation, the seventh metaphorical day representing not a day of rest, but the period of human dominance of the Earth. Compared with the vast tracts of time represented by the other six 'days', the present world of the seventh day was only a few thousand years old and the 'revolution' that separated it from the others was identified by de Luc as being the biblical Flood. However, it was de Luc's 'loose' interpretation of the 'Mosaick History' that disappointed Bute, and it was the only thing in the theory with which he found fault:

> With the utmost respect for the Mosaick History, He [de Luc] endeavours to confirm and strengthen it by his observations, and makes it the basis of His Theory. Had this important point been strictly adhered to, I should with the utmost pleasure have given my assent to every page, and if I feel myself under a necessity of differing from this worthy Man, I do it with real sorrow and concern (Bute 1782, p. 56).

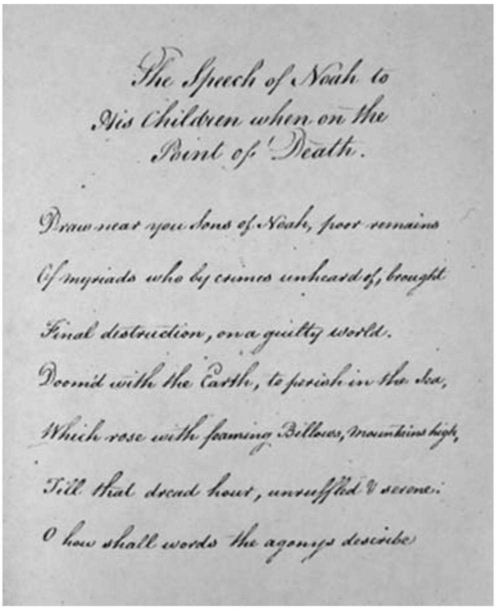
Despite this difficulty, Bute felt that de Luc's theory was so 'founded on a careful observation of the present Earth, with which it so exactly corresponds in a multitude of important Phenomena, that I shall adopt it without hesitation', with one exception:

> I propose to fix my Theory, differing in one part only from this excellent Author; He judges it necessary to account for this great revolution by Natural causes, and fixes on those, which are most agreeable to the Mosaick account. I who look on the Deluge to be in all lights as real a miracle as the first Creation, rest satisfied with what it has pleased the Almighty to relate, relative to that memorable Catastrophe (Bute 1792, p. 67).

It was the cause of the Flood on which Bute disagreed with de Luc; he considered it to have been a miracle and caused entirely by the hand of God, whereas de Luc considered it the result of natural events. This difference was crucial to Bute, who believed implicitly in the miracle of the Creation and the miracle of the biblical Flood. This belief was not just based on a reading of the Bible; it was backed up by Bute's extremely wide knowledge of the historical literature. A passage expounding Moses's description of the formation of the Earth indicates his familiarity with these works: 'These are no new ideas ... all this with much more of the same nature, abounds in Ancient writers, in the works of the oldest Lawgivers, Philosophers, Historians and Poets' (Bute 1782, p. 151), and throughout Book 2 there are references to the contents of these works.

Furthermore, there is a section in Book 2 entitled 'The Speech of Noah to his Children when on the Point of Death' (p. 136) (Fig. 3), which, Bute claimed, is from a 'fragment' that had recently fallen into his hands, of the kind of material found in the Sacred Book of the Gentoos.[4] Although Bute doubted it actually was a verbatim account of what Noah said on his death-bed, 'the whole has the air of great antiquity and perfectly corresponds with the Eastern Traditions' (Bute 1782, p. 133). He thus translated the speech from the French in which his fragment was written, first summarizing what Noah said:

> Noah begins with the destruction of the former world, and in the manner of a Prophetick vision, describes the guilty scenes which are to pass in this [world] we now inhabit, then touches on the



The Speech of Noah to
His Children when on the
Point of Death.

Draw near you Sons of Noah, poor remains
Of myriads who by crimes unheard of, brought
Final destruction, on a guilty world.
Doom'd with the Earth, to perish in the Sea,
Which rose with foaming Billows, mountains high,
Till that dread hour, unruffled & serene:
O how shall words the agonys describe

Fig. 3. First page of Noah's speech to his children in: *Observations on the natural history of the Earth* (Bute 1782). Courtesy University of Bristol Library Special Collections.

dangerous situation Man will be in for many ages, and lastly in order to convince his Children that the greatest blessings may be lost by disobedience to the will of Heaven, the good old man [Noah] gives them a beautiful description of the Earth in which He first drew breath (Bute 1782, pp. 133–413).

The fragment comes to an abrupt end 'in a most interesting Passage, when the Good Old Man, seem'd in the highest raptures with the vision, which had suddenly broke in upon him' (Bute 1782, p. 159). Presumably Noah died at that moment.

At the beginning of Book 2, Bute summarized the findings of Book 1 and complained that none of the authors whose works he had reviewed provided an account of what happened after men and animals came into existence, despite appearing not only 'to have been present at the great work of Creation, but emply'd ever since in minuting down the various changes which have happened … so that we know now to a year, how long the Earth continued in fusion, how long it was under water, and how many Centurys elapsed before it acquired a temperature proper for Animal life' (Bute 1782, p. 119). There follows a section in which Bute attempted to redress this omission by discussing the achievements of the 'Antedeluvians', a remarkable race of men who, like Noah, lived for 900 years.

The final section of *Observations* is taken up with the Earth's physical evolution once the sea retired after Noah's Flood. Immediately after the event Bute considered the world to have looked like the bottom of the ocean as it is today, although he made no attempt to explain where the sea went: 'the soundings [of mariners] prove the existence of Mountains, Hills, Valleys, and where the Line can no longer reach the bottom; I incline to think that there lye vast extended Plains' (Bute 1782, p. 175). Subsequently, the ocean bed, now the Earth's surface, was modified into the world we see around us by 'Deluges of Snow and Rain, separating into many ridges the long extended Chains [of mountains], by a multitude of steep and narrow Channels; called by the French Ravines, many of these where the soil was soft and the slope gentle were by the violence of the Torrents form'd into valleys of all dimensions' (Bute 1782, p. 177). He went on: 'Gigantick Mountains, … which on their first appearance, astonish the beholder, they seem a mass of Ruins, where nothing remains but rugged Peaks and forked summits, wearing away by slow degrees' (Bute 1782, p. 190). These mountains were probably the Alps, as Bute was unlikely to have seen any others. His reaction to them was echoed by John Playfair (1748–1819), writing 20 years later, also about being in the Alps: 'as soon as he has recovered from the impression made by the novelty and magnificence of the spectacle before him, he begins to discover the footsteps of time …. He sees himself in the midst of a vast ruin' (Playfair 1802, p. 110; O'Connor 2007, p. 82). This final section of *Observations* shows Bute to have a good understanding of geography and basic geological processes, and 'wearing away by slow degrees' even hints at the vast timescales implied by such landscapes.

Nearly at the end of his life, and deeply embedded in traditional beliefs, Bute's theological position remained fixed on Noah having rescued his family and 'a chosen few' animals in the Ark, despite Bute's considerable scientific knowledge. The remainder of all antediluvian life perished in the Flood, which covered the mountain tops, and from these few survivors of the Antediluvian world was born all future life on Earth. Nevertheless, his scientific knowledge and his esteem for de Luc's geological interpretations led Bute to believe that all that remains is to 'methodise these proofs and observations and then to judge upon the strictest examination, whether they don't all unite to prove the certainty of the great revolution recorded by Moses.' It is particularly interesting to note his use of the term 'revolution' in its geological sense, in the context of what Moses observed.

In volume two of de Luc's *Geological Travels* (de Luc 1811, p. 122), he recalled having stayed with Bute when examining the cliffs between Christchurch and Lymington on the south coast of England. 'these cliffs will renew the proof which I gave in my former works, that our continents were produced by a single revolution, at an era not very remote in comparison with that supposed in some histories of the earth . . . I had already observed these cliffs, many years before the journey which I am now relating, with one of my nephews . . . we then passed together some days with the late Lord BUTE, at High Cliff, a very pleasant house about three miles from Christchurch, which he had built at a little distance from the edge of these cliffs for the enjoyment of the sea air in summer.' Unfortunately, de Luc did not report on their conversations.

The apothecary surgeon

James Parkinson (1755–1824) also admired de Luc's work and, like Bute, Parkinson struggled to unite his religious beliefs with the geological evidence he held in his hands. 'Believe me, my dear Sir,' he wrote to de Luc in 1812,[5] 'as a student in Geology, when I declare that I feel myself under high obligations to you for your life of laborious exertion, employed . . . in the inquiries immediately respecting those great and important objects, the formation of the earth and of man'. In particular, Parkinson also respected de Luc for the way in which his geological theory dovetailed with Moses's account of creation. Parkinson continued:

No circumstance, my dear Sir, has given me more pleasure than to find the accordance of the position of different fossils which the Mosaic account of the Creation and the consideration of the well known fact—the absence of any fossil remains of man, almost decidedly proving his late Creation. It shows us the Almighty not as having set the universe once in motion as it were, and then leaving it to exist and proceed according to certain laws of Nature without any farther interference with, like the God of the Epicureans, but we discover the God of the Universe superintending and carrying on the work of creation, down to yesterday, for so may we comparatively term the period at which man was formed.

Like de Luc, Parkinson's contribution to geology has often been overlooked because of his somewhat convoluted style of writing and the consequent difficulty in reading some of his works. At the end of a 20 page review of the third volume of *Organic Remains of a Former World* (Parkinson 1811*a*), the reviewer rather harshly commented on his style:

To Mr Parkinson's labours, we cheerfully accord the praise which is due to ingenuity, diligence, and perseverance, and we may be permitted to express a reasonable expectation that, in virtue of his substantial services [to geology], the mere geologist will generously overlook a numerous list of literal errors, much clumsiness of style, and a frequent contempt of the rules of grammar (Muir 1813, p. 20).

It may be that his style and approach seem 'old fashioned' when compared with those savants working elsewhere in Europe (Rudwick 2005, p. 432), but this is an inequitable comparison for two reasons. First, the development of geology and other sciences in Britain was generally behind that elsewhere, because of Britain's isolatation for 15 years as a result of the Napoleonic wars. Second, Parkinson was very much the 'amateur' in that he was not paid for carrying out scientific research like Georges Cuvier (1769–1832), he was not wealthy like Bute, neither did he benefit from patronage as did de Luc, all three of whom had all the time in the world to follow their chosen science. On the contrary, Parkinson was typical of the 'middling sort' of Georgian London; ambitious to 'improve' himself, but having to fit in his studies around the demands of an incredibly busy medical practice. Despite this, he was one of the most enlightened geologists working in Britain at that time. His knowledge of the geological literature available to him is impressive: in the historical chapter of *Organic Remains* (Parkinson 1804) he made at least 54 references to books and papers (Thackray 1975), and many more were referred to throughout the three volumes. In addition, he acknowledged the names of more than 60 collectors across the three volumes (H. S. Torrens, pers. comm.).

James Parkinson was baptized, married and buried in St Leonard's church, Shoreditch, a typical Anglican church that has a history dating back to the thirteenth century. He lived and worked his whole life in Hoxton (Fig. 4), a small village that lay just outside the city gates of London, in the borough of Shoreditch (Morris 1989; Roberts 1997). Today, Hoxton is part of central London. At the age of 16, James was apprenticed to his father, John Parkinson, then an apothecary surgeon in Hoxton, to learn the art and mystery of being an apothecary. Apothecaries were at the bottom of the medical hierarchy that placed physicians with degrees from Oxford and Cambridge at the top (Lawrence 1996, p. 77). Despite this fairly inauspicious start, Parkinson became a highly competent practitioner, writing many popular medical works for the general public and pioneering important new ideas such as smallpox vaccination and the use of fever wards in workhouses. He wrote a medical paper that for the first time identified the shaking palsy as a specific medical condition (Parkinson 1817). His accurate descriptions of this disease meant that 50 years later, when people recognized the importance of this paper, the condition became known as Parkinson's disease. His highly developed social conscience led him to campaign for universal suffrage during the Age of Revolution[6] (before 1832 only 2% of the population were eligible to vote), as well as helping to get the laws changed on child labour and the lunacy act (Roberts 1997).

(a)

(b)

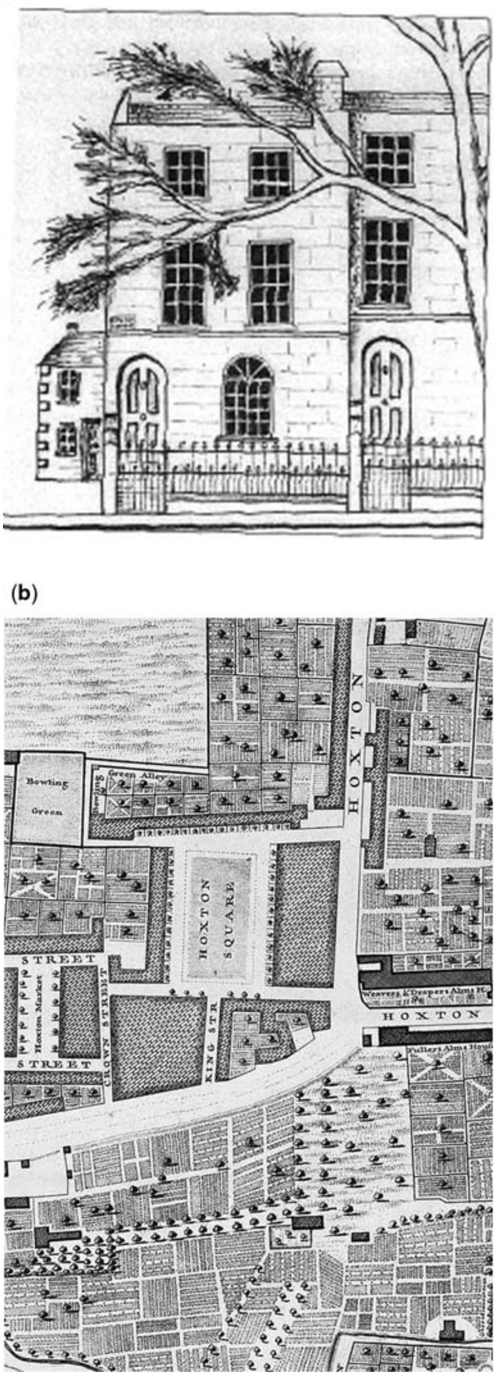


Fig. 4. (**a**) A sketch of No. 1 Hoxton Square, as it looked in the 1780s. Parkinson lived there for all but the last two years of his life. (**b**) A 1746 map of Hoxton Square, made just before Parkinson was born, shows a small village surrounded by fields and market gardens.

Parkinson passed the oral examination for entry as a member to the Company of Surgeons 10 days before his twenty-ninth birthday. Later that year he appeared on a list of surgeons approved by the London Medical College. Sadly, his father had died just three months earlier, in January 1784, and did not live long enough to see his son officially become a practising surgeon. His death left James to cope with the practice on his own in an area that was soon to become the most densely populated in the whole of London.

'My favourite science'

Exactly when Parkinson became interested in 'my favourite science'[7] is not certain but, as he said of himself, 'I have, therefore, always allotted a small portion of my time to such pursuits as have, at least excited a disposition to scientific research and an enthusiastic admiration for the beauties of nature' (Parkinson 1804, p. 2). Like many medical men of his time, James Parkinson's particular scientific interest was in geology. The expansion of the middle classes during the eighteenth century and the search for upward mobility meant that 'doing science' became a gentlemanly pastime. Studying the natural world placed them within the polite ranks of cultivated men and gave them intellectual respectability. In Georgian times doctors typically visited their patients, rather than have them call on him. James would have done his rounds on horseback and probably covered considerable distances, during which time he would have ample opportunity to examine the countryside. He evidently used to visit Sewardstone, a small village in the Lea Valley some 15 miles from Hoxton, where John Keys, his friend and eventual brother-in-law, lived, and where together they looked for fossils in the gravel pits.

It is not until 1804 that Parkinson appears, to us at least, to burst on to the geological scene with the publication of his first volume of *Organic Remains of a Former World: An examination of the mineralized remains of the vegetables and animals of the Antediluvian world; generally termed extraneous fossils* (Parkinson 1804, 1808, 1811*a*) (Fig. 5). Like Bute, Parkinson introduced the work with a tremendous enthusiasm for this science:

> IMPELLED by that eager curiosity, which a view of the remains of a former world must excite, in every inquisitive mind, the writer of the following sheets, long and earnestly, sought for information, respecting these wonderful substances, from every source to which he could obtain access (Parkinson 1804, p. v)

He went on to relate how, having become interested in fossils, he had tried to find publications in English that would help him understand what he was seeing. As little was available he had to

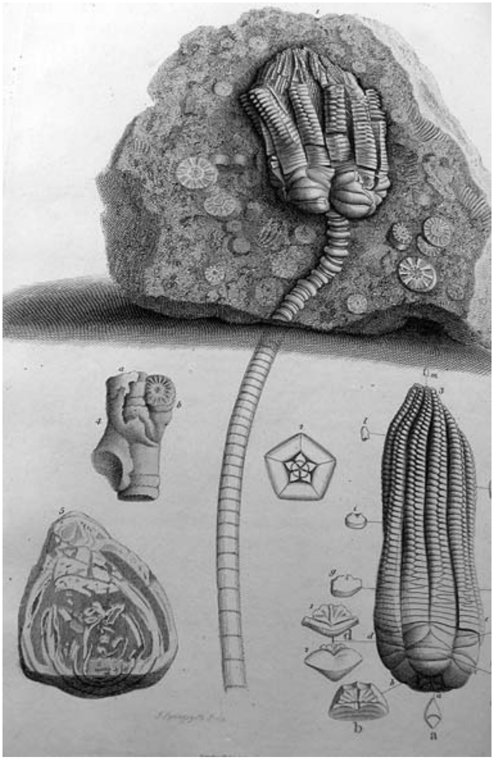


Fig. 5. Plate XIV from the second volume of *Organic Remains of a Former World.* Courtesy University of Bristol Library Special Collections.

'recourse to the more general observations, which are to be found in the writings of the learned of Italy, France, and Germany; the valuable collection of which, in the British Museum, he was happy in being enabled to consult, with all the advantages which the kindness of the officers of that noble institution could yield' (Parkinson 1804, p. v). Assuming that others must be having similar difficulties, Parkinson decided to write the definitive book on fossils 'for the general reader'. The first problem he encountered was the lack of a precise terminology with which to describe this new science.

According to geological myth, it was de Luc who, in 1779, first coined the term 'geology' to mean the study of the Earth (Rudwick 1997, p. 4; 2002, p. 51).[8] The myth appears to originate from the Reverend Henry de la Fite's 1831 translation of de Luc's *Letters on the Physical History of the Earth addressed to Professor Blumenbach* (de Luc 1831). Here, de la Fite wrote in a footnote to his Introductory Remarks:

> It may perhaps be worth stating, that the name by which this science [geology] is now universally known, was invented by De Luc. Having in the 'Lettres physiques et morales sur l Histoire de la Terre et de l'Homme,' employed the word Cosmology, he [de Luc] adds in a note: 'By cosmology, I mean here the knowledge of the earth only, and not that of the universe. *Geology* would, in this sense, have been the proper word; but I am afraid to employ it, because it is not in use.'

Perhaps what de Luc should have said is that the word geology was not in common use, for the word was certainly available at the time. More than 40 years earlier Benjamin Martin's *The philosophical grammar* (1735) defined 'geology' as that 'which treats of the Nature, Make, Parts and Productions of the Globe of Earth on which we live', and Samuel Johnson's (1755) *A dictionary of the English language*, described the term 'geology' as 'the doctrine of the earth; the knowledge of the state and nature of the earth'. What could be clearer than that? Thus the term was definitely not 'invented' by de Luc, as suggested by de la Fite.[9] It is true, however, that the term was not in common use until after 1800; thus Parkinson, in 1804, complained: 'I have to ... treat of a science which has not yet acquired a peculiar name' (Parkinson 1804, p. 30).

Parkinson went on to describe how he believed the difficulty regarding geological terminology had arisen:

> the philosopher ... found himself engaged in the contemplation of objects almost unknown; and in the study of a science, entirely new. This occurring at so late a period, when language was fully established, and when every word had its peculiar [particular] office allotted to it; necessity drove him to the alternative of either coining new words, or of selecting from those already in use ... The latter mode was preferred.
>
> The word FOSSIL appears to be the only word our language can supply, which is capable of being employed as the term denoting these substances [organic fossils] in general (Parkinson 1804, p. 34)

However, although Parkinson had no problem using the term 'fossil' when holding one in his hand, as the beholder could see that he referred to something previously organic, he considered there was difficulty in using the term when written down, as it would not always be apparent to the reader which kind of 'dug up' object was being referred to, a mineral or a once organic substance. To make the distinction, two adjectives were commonly applied to organic fossils: 'extraneous' which Parkinson stated meant 'foreign to the region in which it is found', and 'adventitious' which 'not only conveys the same idea as the foregoing word [extraneous] but also denotes that the present situation of these substances is the result of chance or accident'. Although choosing to use 'extraneous' as the less 'objectionable' of the two 'epithets', Parkinson was unhappy with either term, as they 'convey opinions respecting these substances, which a close examination will show are ill founded' (Parkinson 1804, p. 34).

Aware of the potentially small size of his readership, Parkinson feared that 'a dry, strictly scientific work might not meet with a sale, proportioned to the expence of the undertaking; he therefore considered it to be necessary to adapt it, as much as possible, to readers in general' (Parkinson 1804, p vii). Those general readers, however, would have been fairly wealthy individuals who could afford to purchase the volume at £3 13s 6d; more than a month's wages for a residential apothecary employed in one of the London hospitals, for example (Lawrence 1996, p. 57). Parkinson's aim was to lead his readers into a study of Nature's works that they may not be familiar with. To this end, like several of his medical works, *Organic Remains* was written in epistolary form as a series of letters between a naive but intelligent and curious gentleman interested in geology, and an 'expert' who had 'long made this branch of natural history your particular study' (Parkinson 1804, p. 4). Both of whom were, of course, Parkinson.

At the start of volume one, our gentleman is accompanied by his daughter Emma[10] and a companion, Wilton, as they travel around the countryside in a chaise looking at rocks. Wilton's 'resolute scepticism, with respect to the more rational; and his submissive credulity, as to the more popular explanations of such natural phenomena' (Parkinson 1804, p. 2), provides our gentleman with the opportunity to show his readers the absurdity of maintaining a belief in the folklore surrounding fossils, and at the same time Wilton's remarks 'so full of quaintness and of humour' greatly amuse the companions and, thereby, entertain the reader.[11]

Because Parkinson could never resist an opportunity to finger-wag, the first letter from the layman to the expert started with a remonstration to those of us who waste our leisure hours 'not seeking intellectual endeavors', which results either in 'lapses into the dreadful torpor of hypochondriacism' or causes us to seek 'temporary gratification from pursuits, unworthy, from their vicious tendencies, to be adopted by a being endowed with reason' (Parkinson 1804, p. 1). This was also a constant theme throughout his popular medical works. He went on dramatically: 'I have lived long enough to have repeatedly witnessed similar terminations of the dreams of happiness, which have deluded those men of the world who, intent only on the acquisition of money, have supplied their minds with so little information that they possessed not the means of using, as a blessing, the hardly earned wages of a life of care.' Eventually, having made sure our objectives are of the highest standards, the companions set out from London in a chaise to 'visit the most interesting parts of this island'.

Parkinson had a good understanding of the fundamental facts of geology as they were understood at that time, and seems to have accepted the generally held view espoused by de Luc, James Hutton and others, that the Earth had been subject to several 'revolutions', the last of which was the Flood that separated the ante- from the post-diluvian world of today. He knew, for example, that rocks changed their composition as they became buried; that long periods of time were required for that to happen; and that animals existed in the past for which there are no living counterparts today:

> By these medals of creation [fossils] we are taught that innumerable beings have lived, of which not one of the same kind does any longer exist—that immense beds, composed of the spoils of these animals extend for many miles under ground, and . . . enormous chains of mountains . . . in which these remains of former ages are entombed . . . are hourly suffering those changes, by which, after thousands of years, they become the chief constituent parts of gems; the limestone which forms the humble cottage of the peasant; or the marble which adorns the splendid palace of the prince. Surrounded, as we are, by the remains of a former world, it is truly surprising, that, in general, so little curiosity and attention are excited by them. Wherever civilized society exists, these wrecks of the earliest ages may be found, yielding to man, the most important benefits (Parkinson 1804, p. 8).

It is this last sentence that reveals Parkinson's belief as to why the world is as it is.

Parkinson's religious beliefs

By the second half of volume one of *Organic Remains*, although the epistolary style was maintained, the information contained in the letters was now a much more perfunctory account of geology as Parkinson described the formation of coal, bitumen, petroleum and the fossilization of wood, fruit and vegetable matter. None of these are exactly the everyday fossils that a day out in the countryside might reveal to the amateur for whom this volume was originally intended. It soon becomes apparent that Parkinson chose these subjects not because they were likely to be encountered by the collector in the field, but because they illustrated the fact that everything that has happened to the world since the Flood has been for the benefit of mankind.

Wood, for example, became so deeply buried after the biblical Flood that it could no longer fulfil a useful function for man, either as timber or soil. However, there was good reason for that: it subsequently underwent certain changes 'peculiarly fitted for supporting combustion in the various modes necessary for promoting the comforts of mankind' (Parkinson 1804, p. 465). 'Thus we perceive that a state of permanency is yielded to the substances thus formed [coal, bitumen, petroleum], which . . . appears to be intended for the use of man for a period of time, not only beyond our knowledge, but even beyond the reach of conjecture.'

While contemplating the difference between the ante- and post-diluvian worlds, Parkinson acknowledged that however well-adapted the antediluvian world might have been for the purposes for which it was designed, the present world 'has undergone such a change, as has rendered it much better fitted to supply the necessaries, and even the comforts and luxuries of civilized man, than it could in its former state' (Parkinson 1804, p. 465). Thus, in disposing of the antediluvian world in the Flood, God's

> one grand object appears to have been attained—an arrangement and modification of the seeming ruin, as produced the regeneration of a world, stored, in its deepest recesses, with substances calculated to promote the comfort of man; to tempt him to the exercise of his innate powers; to furnish him with the means of supporting his dominion of the animals around him; and even to urge him to a change from the savage to a civilized state (Parkinson 1804, p. 467).

However, such perfection in the present world implied a criticism of the old, and that 'its first formation was deficient in design' (Parkinson 1804, p. 467). This in turn implied a 'narrow limitation of the power of the Creator'. However, all was easily explained by using an analogy, a literary device still successfully used today by all good science writers to explain difficult concepts. Acknowledging that the world may have undergone 'several revolutions and reformations; and that, in common language, several worlds had existed before the present', Parkinson compared these cycles to the natural history of the silk-worm. He pointed out that when taken in isolation, each stage of that insect's development might seem incomplete, but when viewed as a whole, we see the complete cycle from egg to moth, which enlightens our understanding. As such, we should view these revolutions of the Earth as being only part of a bigger picture that only God can see. However, there were future consequences for this continuous cycling of the Earth. Parkinson asked: 'may not this [Earth] also be preparing to undergo, at some distant era, a new recomposition, by which it may be made to exceed this [one], in a similar proportion in the possession of every excellence? May it not thus become fitted for the reception of beings of [even] higher susceptibilities and powers?' Parkinson shied away from answering this question, preferring not to 'indulge in vain, and perhaps dangerous conjecture' but to 'return to inquiries rather more within the reach of reason' (Parkinson 1804, p. 468).

Parkinson then addressed the difficult issue of extinction. Having compared fossils from the former and the present worlds, he found such dissimilarity between them 'as to warrant the conclusion that ... many genera and species of vegetables, which existed before the Flood, are now entirely lost or remain secreted from us in some remote ... part of the world' (Parkinson 1804, p. 469). However, extinction posed a theological problem, as the loss of a single link in the chain of creation implied such a deviation from the first plan of creation 'as might be attributed to a failure in the original design' (Parkinson 1804, p. 469). Undaunted, Parkinson explained this as a great display of the wisdom and power of God, who was able to create a world in which it did not matter if one species failed. Finally, he confronted the biggest problem of all: did humans exist before the Flood, as told in the Bible? He pointed out that 'not a single antediluvian piece of art has ever been found' (Parkinson 1804, p. 470) and argued that had humans existed for the same length of time as the antediluvian world 'the number of human beings which would have existed at the time of the deluge, would have been so great ... that their weapons, the various utensils, and articles of furniture, must necessarily have been frequently discovered among the antediluvian remains'. As none had ever been found, he concluded, like de Luc, that 'man had not been created, at that period' (Parkinson 1804, p. 470), thus contradicting Moses's account of the Flood in which sinful humans had perished.

In these passages, Parkinson showed that at this time he was prepared to adapt his religious views to accommodate geological evidence, seeking instead, a different way to view the ever-present munificence of God. What is most surprising is that he ended the first volume by questioning why the Flood had to have occurred at all:

> Why the earth was at first so constituted that the deluge should be necessary—why the earth could not have been at first stored with all those substances, and endued with all those properties, which seem to have proceeded from the deluge—why so many beings were created, as it appears, for the purpose of being destroyed—are questions which I presume not to answer, trusting, however, that what has already been said must render their solution less difficult (Parkinson 1804, p. 471).

Later, however, Parkinson appeared to oscillate between accepting and questioning Moses's account of the Flood. For example, when writing to William Buckland (1784–1856) in 1821, although he was still quite clear that no remains of man have ever been found, 'either in the deposits of the earlier ages or in the alluvium of the deluge itself', it remained a problem that tormented him. On the one hand, ignoring the scientific evidence 'may interrupt the progress, and misdirect the exertions of science', whereas, on the other hand, an admission that humans did not exist before the Flood was to question the 'sacred cause which we are all anxious to uphold'.[12]

In the third volume of *Organic Remains*, he appeared to retract some of his earlier statements:

> Coal, as I have already endeavoured to show, appears to be the product of vegetable matter, buried under particular circumstances.... If this opinion be correct, coal may then have been formed at any

period since the creation of vegetables; and of course, it would be improper to confine its origin, as is done in the first of these volumes, to that period at which the deluge occurred which is spoken of by Moses. The observations of Werner support this opinion, he having ascertained the formation of coal to have taken place at different periods (Parkinson 1811*a*, p. 443).

However, in summarizing his conclusions at the end of this volume, he went through the stratigraphic column, providing evidence from each stratum that he considered illustrated that these layers were laid down according to the order stipulated in Genesis. At the end of his great work, he appears almost more 'fundamental' in his way of thinking than he did in volume one.

Through *Organic Remains*, James Parkinson put palaeontology in England on a sound scientific footing at a time when the study, as opposed to the collection, of fossils had hardly begun, and when few works on fossils were available in English. His prodigious reading on the subject, in many languages, enabled him to synthesize the latest developments in the science and to reproduce them in a format that most could access. He was not a particularly original thinker, but quickly picked up the ideas of others. For example, he foresaw the impact Cuvier was to make on geology:

Cuvier, in a paper given into *La Societé d'Histoire Naturelle*, at Paris, has published some important remarks on the fossil remains of various unknown animals: and has likewise announced his intention of publishing his enquiries on this subject, on a very extended scale. From this work so much information is to be expected, that, I doubt not, its publication will prove an important epoch in the history of this science (Parkinson 1804, p. 28).

Indeed, Parkinson's third volume of *Organic Remains* (Parkinson 1811*a*) almost exclusively concentrated on Cuvier's work, bringing Cuvier's science to English readers several years before its official translation into that language.

Parkinson acquired a large collection of fossils for which he was justly famous, and he became one of the country's foremost experts on the subject, often being consulted when something new or unusual was found. He was the only founder member of the Geological Society (1807) with a real interest in fossils (all the others were interested in mineralogy) and in a remarkable paper on the strata around London, published in the new Society's first *Transactions* (Parkinson 1811*b*), he extolled the work of William Smith, insisting that a study of fossils and the strata in which they were found could provide information about former worlds in a way that nothing else could. He complained: 'The study of fossil organized remains has hitherto been ... considered ... as an appendix to botany and zoology, [rather] than as (what it really is) a very important branch of geological inquiry'. In this paper he concluded that there was a 'continuity of the stratification' between England and France (Parkinson 1811*b*); a remarkable deduction for its time. In that respect his geological ideas were ahead of those savants in France, Cuvier and Brongniart, who had themselves only just completed a similar study of the Paris Basin (Cuvier & Brongniart 1811) but had not extrapolated their ideas so far as to cross the English Channel.

Underpinning Parkinson's detailed work on fossils, his exquisite drawings and his boundless enthusiasm for his science, was a belief that everything on the Earth had been put there for the benefit of mankind, out of the kindness of God's heart. I would argue that one of the reasons *Organic Remains* became so immensely popular with the general public (his wife still benefited from sales after his death) was partly because he did manage to integrate the geological facts with prevailing religious beliefs. Parkinson bridged the gap between the savant and the collector, and although he revealed rather frightening images of 'mutilated wrecks of former ages' (Parkinson 1804, p. 10), it was within a religious context with which the general public reading his books were familiar and felt comfortable.

For example, we see his legacy in books such as *Geological sketches and glimpses of an ancient world* (Hack 1832), written for children almost 10 years after Parkinson's death (Fig. 6). In this book, Maria Hack reported examples of Parkinson's work on almost every page and followed his lead in using the formation of coal as an example of how God's sole purpose was to benefit mankind. As a greater understanding about the Earth and its early inhabitants emerged, James

Fig. 6. 'Medals of Creation.' Maria Hack copied this sketch from a small part of the frontispiece of Parkinson's *Organic Remains* and reproduced it as the frontispiece in her book for children, *Geological Sketches and Glimpses of the ancient Earth* (Hack 1832) Courtesy University of Bristol Library Special Collections.

Parkinson's Theory of the Earth provided a way for the average collector to start making sense of it all. *Organic Remains* undoubtedly contributed to geology winning such an enormous middle- and upper-class following by the late 1830s.

Conclusion

[Geology] is always like this, very slow moving. When a new geological discovery or suggestion is made it is quite quick if it is noticed in 20 years, and may take 50 to 100 or more. Then dogmas form obstructions. (Doris Reynolds cited by Lewis 2000, p. 157).

Schweizer (2004) noted that once Bute moved in to Highcliffe in 1771 he conducted his studies in 'melancholy grandeur', happiest when in 'scholarly seclusion'. Indeed, in 1774 Bute wrote to Strange, assuring him he could be trusted with Strange's scientific ideas because he saw so few people to impart them to. A year later he illustrated the point:

I have now lived with my door lockd these 8 years past . . . I see no body, I no longer know those I was once intimate with nor they me . . . I keep no measure, but spend the poor remains in my own way, & the greater part of it, in the inexhaustible researches into the works of nature (Miller 1988, p. 230).

Thus it seems most likely that Bute wrote his *Observations* in splendid isolation, not discussing his ideas with anyone, but summarizing a philosophy developed over at least two decades of studying geology, and a lifetime of extensive reading.

Parkinson, on the other hand, had a large number of contacts, both in his medical and scientific circles, and ample opportunity to discuss his ideas on religion and geology. But did he? So few letters to or from Parkinson have been found that it is difficult to know how much others' views might have influenced him. Most of the letters in existence deal exclusively with matters concerning fossils and it seems likely that his communications with the 60 collectors mentioned in *Organic Remains*, and his colleagues at the Geological Society, were also of that nature. There are two letters, however, that discussed more philosophical matters, and these serve to amplify Parkinson's intellectual struggle.

In his 1812 letter to de Luc, Parkinson claimed he had tried not to be too concerned about the 'how' of geology but, as he explained, it was not easy: 'Hypothesis I have ever endeavoured to keep as clear of as I could; but observation of facts will be accompanied by conjecture, oftentimes the foundation of hypothesis.' In other words, it was difficult to observe and not to think about what he saw. The second letter, written in 1821, just 3 years before his death, appears to be thanking William Buckland for having invited him to attend one of Buckland's lectures. In it we see Parkinson still agonizing over the same issues regarding evidence for human existence prior to the Flood that had concerned him for two decades, and to which he never really found an answer. He then asked Buckland rhetorically:

it is not too much to suppose that you have yourself experienced the unpleasantness of beholding incontrovertible facts, apparently contradicting those statements which, until viewed in another light, the dictates of conscience allowed you not to doubt?

We do not know Buckland's reply, but Parkinson's 'dictates of conscience' guided all aspects of his life.

Apart from a shared interest in geology, James Parkinson and the third earl of Bute also upheld a profound belief in a benevolent God, and extolled his beneficence in the works discussed here. Within the context of their time, this was nothing unusual. In the eighteenth century, religion indoctrinated people for life, much as it can still do today, and although many people did not go to church, practically everyone had faith and a belief in God and the Bible, as well as convictions regarding heaven and hell, good and evil, reward and punishment (Porter 1982, p. 184). Beneath all the rationalism and worldliness of the Enlightenment, religion remained ingrained. Although the emergence of the new 'science' of geology may have made some question their faith, others, such as the geologists William Buckland and Adam Sedgwick (1785–1873), who were both at least a generation younger than Parkinson and some 70 years younger than Bute, still adhered to a biblical account of creation and the biblical Flood, well into the middle of the nineteenth century. As Doris Reynolds noted, talking about the slow acceptance of evidence for continental drift: old ideas take a long time to die. Indeed, many, even today, still adhere to creationist beliefs (see Roberts 2009). What is interesting about Bute's and Parkinson's religious beliefs is not that they had them, but the way in which their slightly different philosophies facilitated, or obstructed, their interpretation of geology.

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Notes

[1]Restricted Eyles Collection QE506 BUT, University of Bristol Library Special Collections.

[2]I have adjusted the punctuation where necessary to make Bute's passages more accessible to the present-day reader

but otherwise the text is as Bute wrote it. The main difference is that he rarely used full stops; preferring commas and semicolons in their place.

[3]The origin of marine fossils.

[4]'The Indian book called 'Bagavadem', one of the eighteen Pouranem, or sacred books of the Gentoos, translated [into French] by Meridas Poullė, a learned man, of Indian origin, ... claims an antiquity exceeding *five thousand years*' (Hartley 1847, p. 289).

[5]A transcription of this letter, dated 11 December 1812, is held in the University of Bristol Library Special Collections, DM1186, in a folder purporting to represent letters to James Sowerby. Photographs of the original letter are held in the archives of the Wellcome Library amongst uncatalogued material from A. D. Morris, PP/ADM, Box 1, and bear the class mark: 8(or 3).h.B. 63-314, which I am so far unable to associate with any collection. The letter is addressed to 'Dear Sir', but history does not record why anyone thought that might be Sowerby. The letter's contents clearly indicate it was to de Luc. In particular, when considering evidence that suggested sea levels are higher today than they have been in the past, Parkinson wrote in this letter: 'The shells of the Craggs of Suffolk noticed by Prof. Playfair, whose remarks have properly been commented on by you'. In de Luc's *Geological Travels* (de Luc 1811), which Parkinson had probably just read, he wrote (p. 16): 'If Mr Playfair had given any attention to my work above mentioned, he would have seen, ... that I had placed the phenomenon of the Crags of Suffolk among those concurring to demonstrate, by the nature of some of the shells', and went on to refute Playfair's claims that the area had been elevated, following subsidence. (If anyone knows the whereabouts of the original letter, which may have the addressee's name on the back, could they please contact the author.)

[6]Parkinson wrote many political pamphlets using the pseudonym 'Old Hubert' (see, e.g. Parkinson 1792).

[7]Letter to William Cunnington from James Parkinson, 21 February 1809. Cunnington Letters, Devizes Museum Library.

[8]According to Rudwick, de Luc used the term to mean a study of theories of the Earth, rather than the Earth itself.

[9]For more on this debate, see Dean (1979).

[10]Parkinson had a real daughter called Emma who coloured the plates in *Organic Remains*. She, and her daughter Emma, were left the remains of Parkinson's fossil collection when Parkinson's wife died. It seems that of all his six children, Emma was the most interested in fossils and was therefore the most likely to accompany him on such a trip.

[11]For a more detailed analysis of this first letter, see O'Connor (2007, pp. 83–85).

[12]Letter to William Buckland from James Parkinson, 28 January 1821. Oxford University Museum of Natural History. Buckland Letters, Box 2/P3.

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Cuvier's attitude toward creation and the biblical Flood

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Abstract: Georges Cuvier was born in Montbeliard in eastern France, which at that time was part of the dukedom of Württemberg. He received a Lutheran religious education and was deeply anchored to his Protestant faith until the death of his daughter Clementine in 1827. This faith, along with his writings, and especially his well-known *Discours sur les Révolutions de la surface du globe*, gave him the reputation of being convinced of the existence of the biblical Flood, the last catastrophe to have swept the surface of the Earth. However, Cuvier's ideas on creation and the Flood, borrowed and distorted by some British followers of natural theology, are not so clear-cut. A thorough reading of Cuvier's works and an analysis of his (unpublished) written exchange with Henry de la Fite, the translator of de Luc's *Elementary Treatise on Geology*, show that the French naturalist always took great care to separate all that referred to facts linked to natural history, palaeontology and geology from references to geotheories, metaphysical ideas and theological interpretations.

Cuvier was born in 1769 in Montbeliard in eastern France, which was at that time part of the dukedom of Württemberg. The *pays de Montbeliard* was a Lutheran country. Cuvier born into a Lutheran family was baptized inside the Saint Martin temple in Montbeliard one day after he was born. At school, he learnt to read French in the small catechism of Luther and in the bible of Royaumont, or in the psalms and poems of the Huguenot theologian Drelincourt. At the completion of his studies in the *Gymnasium* (secondary school), Cuvier took an examination that selected the best students, who were sent to Tübingen, where they were educated in theology to become ministers of religion. However, Cuvier, who was too self-assured, was not chosen. This was fortunate for his future career in natural history.

Cuvier went to Stuttgart in 1784 to study at the Caroline Universität. Well educated in the Lutheran religion, he had a typically Huguenot approach to life and had a tendency to be introspective: Cuvier wrote that in his faith everything is submitted to argumentation, as opposed to the Roman Catholic faith, where 'authority is the only reference' (Cuvier 1861). When he returned to Montbeliard in 1788, he got a job with a Lutheran family living in Normandy. Cuvier went then to Paris in March 1795. In 1803, he was elected to the body appointing the Consistory of Paris. Cuvier was closely involved with the establishment of the first Parisian Lutheran parish, of which he was one of the founders.

He married a widow, a Roman Catholic, who had three children; their marriage ceremony was Lutheran and was held in the chapel of the Swedish embassy in Paris, the only place in Paris in 1804 where Lutherans were allowed to practise. Cuvier's children were baptized and educated in the Lutheran faith there.

Cuvier was also very active as a founder of the Parisian Biblical Society in 1818 (the aim of the Society was to print and distribute Bibles). From 1822 until his death in 1832, Cuvier was Grand Master of the Protestant Faculties of Theology of the French University. From 1827 to 1832, he was director of the non-Catholic religion at the Home Office.

As Grand Master of the University and as member of the *Conseil d'Etat* (an institution that discussed the law), Cuvier was involved with the organization of schools, of the university, and of the curriculum. He tried to introduce some reforms to adapt teaching to the schemes used in Germany or in the Dutch states during the Restoration, but the Roman Catholic church was strongly opposed to such reform.

His beloved daughter Clementine was involved with charitable organizations together with the Huguenot banker Hottinguer. She created an orphanage in Boissy Saint Léger near Paris for young girls, to give them a good education. Cuvier's life was affected by the tragic death of all of his four children. Following the death in 1812 of Anne when she was 4 years old, and in the next year of his son Georges who was 6 years old, Cuvier became less active in his religious practice. The most tragic event happened in 1827, when his daughter Clementine, who was 22 years old, died from consumption just before her wedding. Cuvier

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was completely distraught. Later, the Huguenot community published a booklet devoted to the depth of the faith of Clementine (Wilks 1828). In the tradition of Huguenot families, verses from the Bible were engraved on the tombstones of the Cuvier family (except for Cuvier's own). On Clementine's tomb was put a verse from the Bible (book of Wisdom IV: 13–14): 'she lived a short time on the Earth, she became very quickly perfect, so God called her in order to leave a perverse world'. The funerals of Cuvier's children and of Cuvier himself were celebrated at the Temple des Billettes in the centre of Paris.

Did the deep faith of Cuvier in the Lutheran tradition influence his scientific approach to the study of nature? As did nearly all the naturalists of the beginning of the nineteenth century, Cuvier believed clearly in the existence of a Creator: 'we conceive the Nature simply as a production of the *Toute Puissance* [the Power above], ruled by a wisdom from whom we are discovering the laws by observation. But we think that these laws ascribed only to the conservation and to the harmony of the whole. So there is no necessity for a scale of beings, no necessity for a unity of plan; and we don't believe the possibility of a succession in the appearance of the diverse forms' (Cuvier 1825).

Cuvier's attitude toward creation and the biblical Flood

Cuvier was very careful to separate in his works the metaphysic from the physic; he was a follower of the work of Kant the philosopher, whose *Critique de la raison pure* was published in 1781 (Taquet 2006, p. 146). Cuvier did not like the German *Naturphilosophie* and systems, which were for him poetic approaches to the study of Nature, that did not first analyse the facts. In November 1788, when he was only 19 years old, he wrote to his friend Christoph Heinrich Pfaff, and outlined that he wanted to devise a new plan for a study of a general natural history. He wished to look carefully at all the relationships between all existing beings, and he explained to Pfaff that systems were not very interesting to elaborate, and that it was not a very useful task, because there were already a hundred such systems in existence. Cuvier is well known for stressing the primacy of fact over theory, and he used his *Eloges* of other scientists to denigrate the speculative activity (Taquet 2006, pp. 180–181); for him, the principle of the conditions of existence was the fundamental guide for working on natural history (McClellan 2001). Although Cuvier appears to have believed in supernatural design, he was also familiar with Kant's critique of the design argument, as well as the critique of philosophers such as Buffon or d'Holbach.

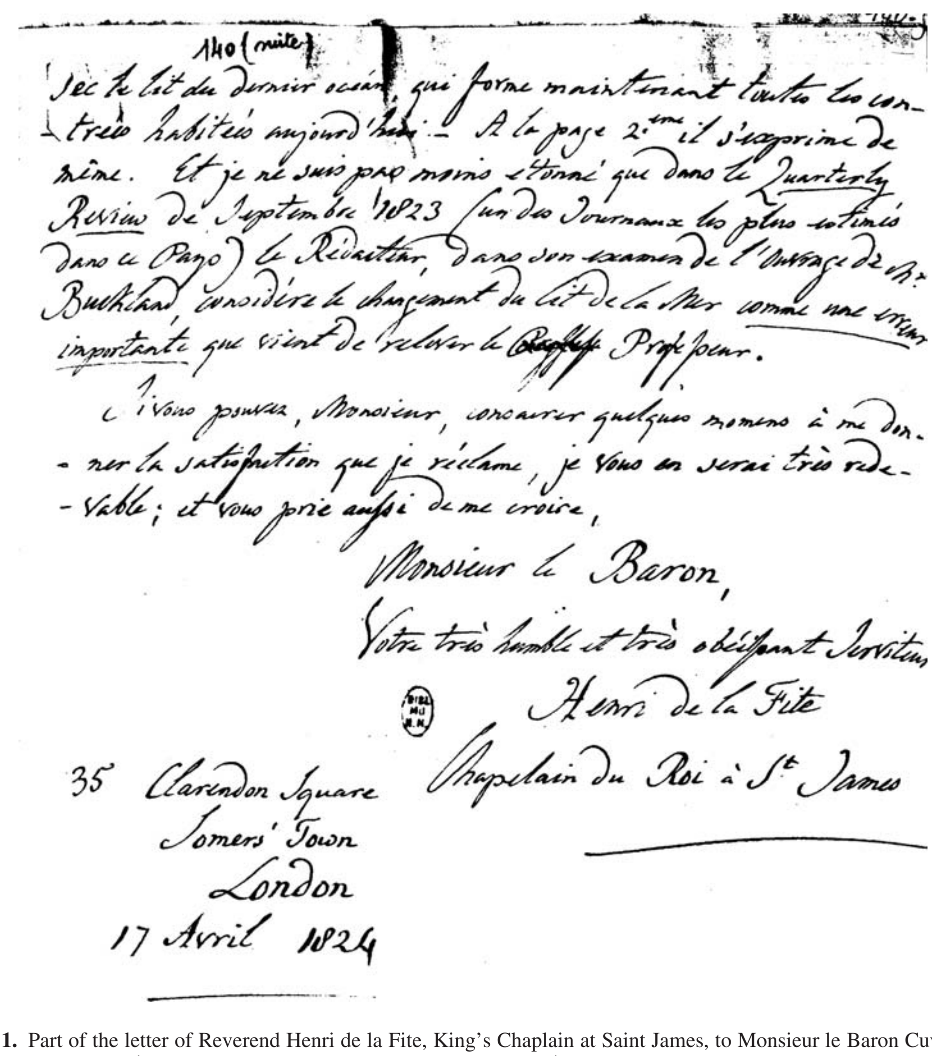
Regarding geology, Cuvier, as Rudwick (2005) has demonstrated in *Bursting the Limits of Time*, introduced a detailed study of the 'medals of the past', and he built a geohistory to replace the geotheories he disliked strongly.

During my studies on Cuvier's life and work, I was fortunate enough to find an exchange of letters between Cuvier and Henri de la Fite, a teacher at Trinity College in Oxford, who was then Chaplain of the Saint James Royal Chapel in London, on the important question of the biblical Flood. Henri de la Fite was the translator into English, in 1809, of Jean André de Luc's elementary *Treatise of Geology* (de Luc 1809). Some of the ideas expressed by de Luc were first published in French in the *Lettres physiques et morales sur l'histoire de la terre et de l'homme adressées à la Reine de la Grande Bretagne* in 1779 (de Luc 1779). De Luc was a Christian philosopher (Rudwick 2005, p. 150); his geotheory was an integral part of a Christian cosmology. For de Luc, the recent catastrophe of the biblical Flood was supported by extensive physical evidence. For example, in letter CXII, de Luc described the Schartzfeld cave (also named the *Einhornloch* or the *Unicorne* cave, from where Leibniz had described this legendary animal (Leibniz 1749)). For de Luc there were many hypotheses to explain why so many bones were deposited in this cave. The origin of these bones was only a natural history phenomenon. They were terrestrial bodies deposited when the biblical Flood covered the continents (de Luc 1779, p. 580).

In 1800 Cuvier sent many of his colleagues in Europe a prospectus, a programme of research untitled *Extrait d'un ouvrage sur les espèces de quadrupèdes dont on a trouvé les ossemens dans l'intérieur de la Terre* (Cuvier 1800). In this document, he explained that the world shows traces of great revolutions; that these traces have from a long time impressed the spirit of the men; and that the tradition of the deluges (the floods) originated from the marine bodies deposited all around the Earth. For Cuvier, however, these were only popular ideas: some scientists had tried to explain these phenomena with theories, but now there was a new generation of scientists using only facts. All the fossils of quadrupeds were different from the modern animals, so the question was to know which was the last catastrophe which preceded our actual continents, and how were these antique animals destroyed. Cuvier ended his paper with this question: to explain all this, isn't the metaphysics more confused than the physics?

In 1807 Cuvier wrote a report on a paper by M. André entitled '*Théorie de la surface actuelle de la Terre*' (Cuvier 1807). In this report, Cuvier underlined that the last catastrophe on the Earth was explained in Genesis, and by the traditions of pagan people, as the Flood. However, André had forgotten that the Flood was described in Genesis as a miracle, or as an act of the Creator, and that it is unnecessary to seek any secondary causes for it. Cuvier clearly distinguished a natural history approach, from a metaphysical approach, and he recommended the geological part of M. André's work to be published by the Academy of Sciences, but asked that the speculative part of that work should not be published.

In 1812 Cuvier published his *Discours préliminaire* (Cuvier 1812), in which he outlined the proofs for revolutions of the Earth that had occurred in the past. He explained that these had been numerous and sudden, that they had occurred before organisms existed, and that no human bones were found fossilized. Cuvier regarded these revolutions as physical proof of the young age of the continents in their present state, and he noted that all known traditions made the renewal of society reach back to a major catastrophe. He wrote that one previous revolution, at least, had submerged animals, and, judging by the different kinds of animals whose remains were found, Cuvier thought they had been affected by perhaps two or three invasions by the sea. Thus, for Cuvier, the last revolution could be the one existing in the human tradition as the biblical Flood, although there were other revolutions in the past. Cuvier noted implicitly there were no humans on the



140 (suite)

sec le lit du dernier océan, qui forme maintenant toutes les contrées habitées aujourd'hui. — A la page 2.ème il s'exprime de même. Et je ne suis pas moins étonné que dans le Quarterly Review de Septembre 1823 (un des Journaux les plus estimés dans ce Pays) le Rédacteur, dans son examen de l'Ouvrage de Mr. Buckland, considère le changement du lit de la Mer comme une vérité importante que vient de relever le ~~Profess~~ Professeur.

Si vous pouvez, Monsieur, consacrer quelques momens à me donner la satisfaction que je réclame, je vous en serai très redevable; et vous prie aussi de me croire,

Monsieur le Baron,

Votre très humble et très obéissant Serviteur,

Henri de la Fite

Chapelain du Roi à St. James

35 Clarendon Square
Somers' Town
London
17 Avril 1824

Fig. 1. Part of the letter of Reverend Henri de la Fite, King's Chaplain at Saint James, to Monsieur le Baron Cuvier, 17 April 1824. Muséum national d'Histoire naturelle, Paris, Bibliothèque, Fonds Cuvier, manuscrit 627–140.

Earth when the last revolution occurred because no fossilized human bones had been discovered.

In 1813 Cuvier's *Discours préliminaire* was translated into English by Robert Kerr and edited by Robert Jameson under the title *Essay on the Theory of the Earth* (Cuvier 1813). As Rudwick has shown, the editorial work by Jameson gave Cuvier's *Essay* a distinctive slant that was deeply misleading, as he transformed it from a geohistory book into a geotheory book.

In 1823, William Buckland published in his *Reliquiae diluvianae* (Buckland 1823) observations on the organic remains contained in caves, fissures and diluvial gravel, which together with other geological phenomena attested to the action of a universal deluge. Buckland wanted to demonstrate that this event was the biblical Flood, and he used the 1813 translation of Cuvier's *Discours préliminaire* and an 1821 version of it to support his ideas. However, for Cuvier and for other geologists such as Leopold von Buch in Germany, a geological deluge might have been distinct from the biblical one.

A very interesting analysis of the work of Buckland was published in the *Quarterly Review* in September 1823 (Anonymous 1823).[1] I was lucky enough to find in the library of the Muséum National d'Histoire Naturelle a rare reprint of this article, which is annotated with some corrections

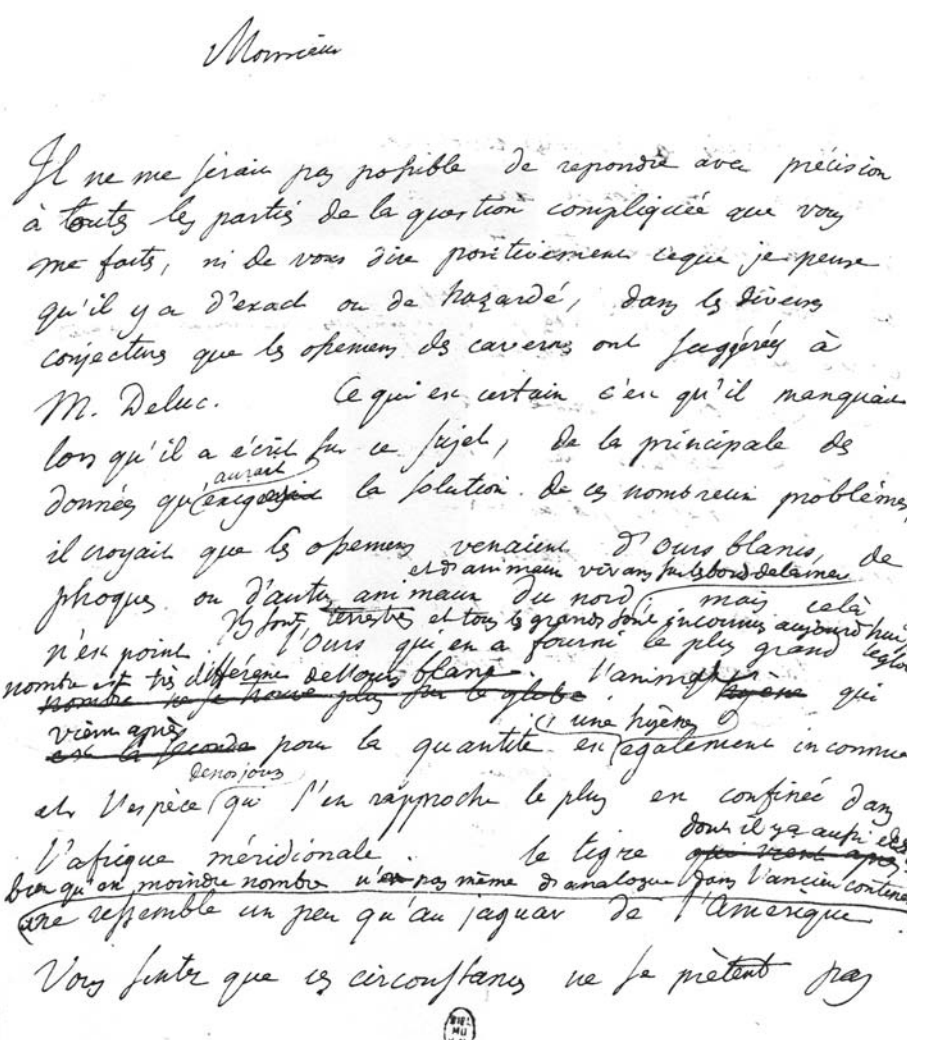


Fig. 2. Part of the draft of a letter from Georges Cuvier to Henri de la Fite, undated. Muséum national d'Histoire naturelle, Paris, Bibliothèque, Fonds Cuvier, manuscrit 627–141.

possibly by the author himself. The author of this paper explained that the creation and the Deluge have long been the stumbling blocks of geologists, but now Buckland's work provided a geological explanation of this event.

Soon after the publication of these two papers (Buckland 1823; Anonymous 1823), de la Fite wrote a letter to Cuvier on 17 April 1824.[2] A translation is given in the Appendix. As a friend of de Luc and translator into English of his *Treatise of Geology*, de la Fite submitted to Cuvier the following point of discussion (Fig. 1).

In his letters to Johann Friedrich Blumenbach (1752–1840), de Luc wrote of the Schartzfeld cave, and explained in accordance with Cuvier that the ancient bed of the sea is today the surface of the continents. He questioned how one might explain the mud found in these caves and also in the caves described by Buckland. How, wrote de la Fite to Cuvier, does one explain the presence of polar bears inside the caves described by de Luc? With the valleys described by Buckland formed as the result of the biblical Flood, in agreement with de Luc, he argued that Cuvier explained that this was due to the changing level of the sea, and this disagreed with Buckland's idea. Buckland in his book ascribed to Cuvier the idea that the Earth was submerged by a transient deluge, although that expression was not in Cuvier's book. Again, in a review of Buckland's book, the reviewer stated that the idea of the changing of the bed of the sea was an error that Buckland had corrected.

Cuvier sent an answer to de la Fite (Fig. 2), which he prepared most carefully. The draft of his letter is today in the archives of the Paris Museum.[3] A translation of this draft is given in the Appendix. Cuvier explained to de la Fite that it was impossible for him to answer in detail all his complicated questions. He noted that when de Luc wrote his book he did not have all the elements that would have allowed a solution of the problem. The bones were not from polar bears but from species extinct today. Cuvier asked the following questions. How did the mud come to be inside the caves? Was it produced through the decay of the bodies or did it settle by infiltration? Cuvier wrote: 'I must confess that I ignore it.' He believed, like Buckland, that this catastrophe was the last one or probably the one before the last one that affected the whole Earth, and that the memory of this had been preserved by people as the biblical Flood. However, it was not possible to explain its causes, or to explain the how and the why of each small fact. It would be going farther than possible in the present state of knowledge. It was also impossible to know the duration of this catastrophe, or if the inundation reached great elevations. Cuvier was not sure also if the actual surfaces of the Earth were, as Buckland believed, the same as the regions the sea had invaded, or if there had been other great changes. He confessed that, if he was obliged to make a choice, which was fortunately not the case, he would accept the last option. Cuvier apologized to de la Fite for his caution, but noted that throughout his scientific career, his main guiding principle had been to never go beyond the facts.

Conclusion

The prudence and the determination of Cuvier not to be involved with religious debate, as we can see in the draft of his letter to de la Fite, is characteristic of his approach to the study of natural history. This stance was also a typical attitude of members of the Huguenot community in France, who wanted during the Napoleonic period to be integrated into the social and political life of the country, which was a Catholic one.

Having been given a Lutheran education, Cuvier was naturally strongly involved in the activities and the religious life of this portion of French Protestantism, but his scientific attitude was to never go beyond the facts. For Cuvier, there had been several natural and catastrophic events during the history of the Earth, there had been probably several geological deluges, and the memory of the last of these could have been preserved among the humans as the biblical Flood. However, Cuvier remained far from the ideas of Buckland, who identified the last geological deluge with the biblical Flood.

Appendix

Letter from Reverend Henri de la Fite, Chaplain of the King at St James to Mister Baron Cuvier (Muséum national d'Histoire naturelle, Paris, Bibliothèque, Fonds Cuvier, manuscrit 627–140). Translation by the present author.

33 Clarendon square. Somer's Town. London. April 17th 1824

Monsieur le Baron,

As an old friend of the late Mr De Luc, and translator in English of his elementary treatise of geology, I dare to take the liberty to submit to you a point of discussion on a topic in which your works have shed so much lights. I would be very much obliged to you if you could tell me if the explanation given by this famous geologist of the phenomena of the bones found in the *caves* in Germany is in accordance in all points with his theory and yours that the ancient sea bed forms our present continents. This is what he says in his *lettres au Prof. Blumenbach*, sect. 38; 14th letter: 'we must not mistake this phenomenon (that of remains of terrestrial animals deposited in the light layers, exposed sect. 35) with those of the bones we find in such great quantities in some *caves*. I had made this mistake in my *Lettres sur l'histoire de la Terre et de l'Homme*, in describing the *Schartzfeld* cave, but I rectified it in the 14th of my letters in *Journal de Physique*. This last phenomenon essentially differs from the former, in that the bones concerned are buried in accumulations of *stalactite*; which proves that they had been deposited at a time when those caves were already under the level of the *sea*. I reported in the same letter, the reasons that lead me to believe that these caves belonged to *islands*, originated from the top of our hills and mountains, and that they served as den for *quadrupeds*, specially amphibious; I gave an example of that for some coasts of Europe where the same thing now happens: the sea-calves above all come to retire when they are sick, and die there. So these ancient caves were also like *cemeteries* for the animals that lived in them or visited the *isles* which they belonged to; this only can explain the prodigious quantity of animal bones unknown in the country that have been found piled up and covered or surrounded by *stalactite*; and we have proofs that they have not been here since centuries; because those who are not so covered are very well preserved and in several of these caves the progress of stalactite can be observed generation after generation'. It is necessary to explain first how *mud* and *sand* are deposited, which Prof. Buckland mentioned in his observations on the Yorkshire cave, and on the German one. Mr De Luc in this respect in his *Voyages en Angleterre*, Vol. II, sect. 909, observes that in general in several caves there must be deep reservoirs in which are deposited earthy sediments washed from the surface through the crevices of the layers. And in his *Voyages en Allemagne*, Vol. II, sect. 661, he develops on this question from the observations he relates, in which we can see that a crevice inside a cave in *Bayreuth*, in which he went down, had at one time been almost closed by stalactite. Is not this explanation enough to indicate the formation of the *muds*; and would not its confirmation be found in the *position* of these muds placed below the stalactites of the vaults? It is true that Pr. Buckland deduces that because the walls and the vault of some caves do not have traces of mud sediments, they can't come from the crevices. But filtering rain waters could have washed these different passages since. On his side Prof. Buckland is of the opinion that the Pickering valley where the concerned cave is, used to be a lake, which could have given the aquatics, found among the bones, and he explains the sandy mud by the result of the Flood. Concerning the caves of Bayreuth (*Voyage en Allemagne*, Vol. III, sect. 657), there was a fact that impressed greatly Mr De Luc: it is at some depths in these caves that *sand from the sea* is found under the stalactites. This led him to conjecture that while the sea still occupied its old bed, and that its level lowered progressively because of the infiltration of its liquid inside the globe, there was a certain period when the level of these caves having been in connection with that of the sea, they had been used as retreat for *white bears* during a sickness or their old age. He then learned that from ten caves which had been discovered, in only two, bones were enclosed; that these two caves were the most elevated ones; but that in all of them, there were stalactites, under which, in some parts, a *marine sand* was found. It is this circumstance which confirmed the conjecture of Mr De Luc, showing at the same time what was the last level of the sea on its old bed, before its sudden retreat on the bed it occupies today; this level corresponds with those of the highest of these caves, they have been used by *white bears* as useful retreat. The lower caves existed also at that time, having been formed by the same catastrophes; but being under the level of the sea, these animals could not retire in them to benefit of the air and when the sea lowered suddenly to its actual level, the caves were left in the centre of a new continent and the white bears that find their prey on the coast, and even look for them on the floating ice masses on the sea, followed its retreat to the North. *Carnivorous animals* were also found in caves, at upper level, a fact says Mr De Luc which is not in contradiction to the idea he expressed; because they could have entered the caves subsequently to the great revolution which gave birth to our present continents; while the bears followed the sea during its sudden retreat to the North, consequently to its collapse to its present level. (The observation of Mr De Luc that bones have been found uncovered by stalactites, proves that Prof. Buckland's opinion, that the bones have been preserved due to this incrustation, cannot be generally applied). Moreover, there is no reason why the *carnivorous* could not have lived in the *upper caves*, *before* the retreat of the sea water from its old bed, as Mr De Luc presumes concerning the bears which lived in the lower caves; this would be closer to what you observed, Monsieur, 'that it is sufficiently proved, that these different animals have lived together in the same countries, and have belonged to the same epoch'.

As to the valleys Mr Buckland believes that they have been produced by the action of the waters of the Flood. Without doubt, Monsieur, your opinion, similar to that of Mr De Luc concerning the changing of the bed of the sea, is in contradiction to your acknowledgment of the idea of the Professor. I am surprised to see, page 225, of his *Reliquiae Diluvianae*, that quoting you concerning his opinion regarding the short antiquity of the present state of the surface of the Earth, he makes you say that it was *submerged* at a recent time by the waters of a *temporary* Flood (transient), an expression that we see nowhere in your work, *Theory of the Earth*, sect. 14, from where he seems to have taken them; and this would be in contradiction to what you say yourself, that a huge and sudden revolution has left dried the bed of the last ocean, which now forms all the countries inhabited today. On Page 2, he expresses the same thing. And I am no less surprised that in the *Quarterly Review* of September 1823 (one of the most valued journal in this country) the Editor in the review of Mr Buckland's work, considers the changing of the bed of the sea *as an important mistake* that was noticed by the Professor.

If you could, Monsieur, spend some of your time to give me the satisfaction I claim I would be very indebted; and I also beg you to believe me,

Mister Baron

Your very humble and obedient servant

Henri de la Fite

Chaplain of the King at Saint James

Draft of a letter of Georges Cuvier as answer to the letter of Henri de la Fite (Muséum national d'Histoire naturelle. Paris, Bibliothèque, Fonds Cuvier, manuscrit 627–141). Translation by the present author.

Sir,

It would not be possible for me to answer precisely to all the parts of the complicated question you ask me, nor to positively say what I think, be it exact or guesswork, in the different conjectures that the bones of the caves have suggested to Mr De Luc. What is certain is that the main data, which were required to solve these numerous problems were missing, when he wrote on the subject; he thought that the bones came from white bears, from seals, or other animals from the North and from animals living on the seashore; but this is not. They are terrestrials and all the big ones are known on the globe; the bear, which has given the greatest number [of bones], is very different from the white bear. The animal, which comes after by quantity, is a hyena equally unknown and the species, which is the closest today, is confined to meridional Africa. The tiger, which is also represented by bones, but in less quantity has no analogous in the old continent, it looks a little like the jaguar of America. You feel that these circumstances do not allow the idea that this deposit of bones could have been accumulated since the last revolution of the globe. It is true that we also find in these caves carnivores closer to ours, such as wolves, foxes, gluttons, but the identity of their species is not yet demonstrated and it is not impossible that they have come more recently than the others. Lastly, M. M. Buckland, Gibson etc. etc. have found in the caves of England bones of elephants, Rhinoceros, and Hippopotamus, which the carnivores seem to have dragged in, which proves that they lived at the same time as these large quadrupeds; now the last revolution of this globe has certainly destroyed all these large species; it is thus posterior to the accumulation of the bones in the caves.

Besides I think like Mr De Luc that the carnivores lived in the caves and died there; even, maybe, the catastrophe which has destroyed their species has led them in some places to seek refuge in greater number in these caves and has surprised them, but certainly they were already there when it produced its destructive effects.

What Mr De Luc says that some of these bones are in the dried mud and others in the stalactite and that this stalactite is formed everyday is true, and even there are places where stalactites penetrate the mud, and harden it; in other places it is covered by a floor or by a vault; there are others where it envelops immediately the bones, which the mud has not covered. These are accidents that do not belong to the primitive fact of accumulation of the bones and of their burying in the mud. In fact how did this mud come here; did it result from the decay of bodies; has it filtered in; has it been brought by the catastrophe that has destroyed these species? I confess that I ignore it.

I nevertheless think like M. Buckland that this catastrophe is the last or rather the one before last of those that have affected the whole or most part of the globe, and whose souvenir has been kept among the people under the name of Flood; I also think that it was sudden, as some of those that preceded it; and if I was to explain myself on the physical causes I would say that the most probable conjecture is that it was due to some breaks in the crust of the globe, which changed the level and the position of the seas, as they have already changed at other epochs and by other catastrophes. But I must keep to these general terms and even I give them only for what they are, for the expression of a simple conjecture. To want more precision, to pretend to explain far away causes, and specially to explain the how and the why of each and every little fact, would to my opinion go much farther than it is possible in the actual state of our knowledge. I could not ... *thus neither affirming nor contesting the question to know if all the parts where the sea rushed during this catastrophe were kept covered by it or abandoned and left uncovered to more or less extent; all that I gain for sure is that the catastrophe has been sudden and has consisted of an invasion of the sea* ...

Thus nothing establishing apart from physical facts neither regarding the length of the invasion produced by this catastrophe nor about the question of knowing if it has reached great heights. I would neither affirm that the lands uncovered today are on all points as Mr. Buckland wants them to be, the same as the sea has invaded, or if great mutations occurred. I must even admit that it is this last opinion I would prefer if I had to take one which is luckily not the case; (*my proof would just be today's animals and even men*). I beg you to excuse me if I expressed some reserve but in my entire scientific career, I had for principal rule to never go beyond the facts.

I am grateful to P.N. Wyse Jackson (Dublin) and M.J.S. Rudwick (Cambridge) for a critical review of this paper and for improving my English.

Notes

[1]The author of this anonymous paper, attributed to Fitton (1780–1861), was Edward Copleston (1776–1849). The reprint of this paper was perhaps the property of the son of Alexandre Brongiart's wife; then it became the property of Victor Joseph de Lisle Thiollière (1801–1859), a specialist in fossil fishes who worked in Lyon, and then of Léonard Ginsburg, a palaeomammalogist

working at the Museum in Paris. It is deposited today at the library of the palaeontology laboratory of the Museum.

[2]Lettre du révérend Henri de la Fite à Monsieur le Baron Cuvier. Muséum national d'Histoire naturelle, Paris, Bibliothèque, Fonds Cuvier, manuscrit 627–140.

[3]Lettre de Georges Cuvier au révérend Henri de la Fite. Brouillon sans date. Muséum national d'Histoire naturelle, Paris, Bibliothèque, Fonds Cuvier, manuscrit 627–141.

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Jesuits' studies of earthquakes and seismological stations

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Abstract: The Jesuits' dedication to seismology forms one of their most important scientific contributions. Its history can be divided into two periods. In the first, from the 16th to the 18th century, they studied single earthquakes, some in the newly discovered lands of America, and speculated on the causes of these phenomena. In the second period, beginning in the 19th century, Jesuits established a large number of seismographic stations throughout the world. In North America they founded in 1909 the Jesuit Seismological Association, which ran the first seismographic network of continental scale with uniform instrumentation. Jesuit seismographic stations in Africa, Asia and South America were, in many instances, the first installed and, in some cases, were for years the only ones there. Jesuit seismologists have made important contributions to a variety of aspects of this science. Among them J. B. Macelwane is widely recognized as an important figure in the history of seismology.

The study of earthquakes and the scientific contribution to seismology by the Society of Jesus as an institution, through its colleges and universities, and by its members as individual scientists forms an important chapter of the history of this science, especially in the early years of its development. Jesuits' recent work in seismology has been described in several short papers (Macelwane 1926; Sánchez Navarro-Neumann 1928*a*, 1937; Heck 1944; Linehan 1970, 1984). A more comprehensive study covering the recent period has been made by Udías & Stauder (1996). Since 1970 most Jesuit seismographic stations have been closed, and practically speaking there are no Jesuits actively working in seismology today. It can thus be said that this is a chapter of Jesuit history that has come to an end. Jesuits' interests have moved in other directions and it is not likely that the study of earthquakes will become again an important aspect of their work.

Jesuit spirituality and science

It may be puzzling to some why a religious order should dedicate so much effort to a science such as seismology. This must be seen as part of Jesuits' general involvement in the natural sciences. From its foundation in 1540 by Ignatius of Loyola, the Society of Jesus dedicated itself primarily to educational work through its many colleges and universities, of which there were at the end of the 18th century some 850 in Europe alone. From the establishment of these colleges, which coincided with the beginning of the development of modern science, mathematics and experimental sciences were important subjects in their curricula. The *Ratio Studiorum*, the regulating rule for Jesuit colleges published in 1599, recommended establishing chairs of mathematics in all major colleges where there were philosophical studies. It was recognized that there was a growing importance given to mathematical sciences and a social demand for this type of studies and Jesuit colleges tried to fulfil this. This demand was recognized by the Jesuit astronomer Christopher Scheiner, the first with Galileo to observe sunspots, who stated: 'It is evident that mathematics is the net with which one can catch the magnates and nobles and bring them to God's service'. Teaching mathematics had for Jesuits a clear apostolic character. A key figure in this early development was Christopher Clavius (1537–1612), the professor of mathematics in the Collegio Romano (Rome), who established a serious programme of mathematics, astronomy and natural sciences not only in his college, but in all Jesuit colleges and universities. Descartes recognized that in no other place was mathematics taught as in Jesuit colleges. The early work of Jesuits in science has recently received considerable attention (Baldini 1992; Giard 1995; Romano 1999; Feingold 2003; Hellyer 2005). In the 17th and 18th centuries Jesuit colleges established about 30 astronomical observatories where meteorological observations were also made. In China from 1645 to 1773 Jesuit missionaries were appointed directors of the Imperial Astronomical Observatory of Beijing. This tradition forms the background of modern Jesuit scientific work. Since the middle of the 19th century Jesuits established some 40 geophysical observatories around the world, many of them with seismological stations (Udías 2003).

Harris (1989) explicitly linked Jesuits' involvement in the natural sciences with their 'apostolic

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spirituality', and he regarded the main elements of this as the emphasis placed on Christian service, which leads to activities not usually associated with religion, an active engagement with the world and what he called the 'sanctification of learning'. These elements led to the Jesuits' enormous effort in the field of education, where the natural sciences are an important subject. This can be recognized in the establishment of the early colleges in the 16th century and the present colleges and universities. However, some of Harris's elements of the 'apostolic spirituality' can also be found in other religious orders and congregations founded after the 16th century and active in educational work that have not developed a comparable scientific tradition. We can find some reasons for this involvement in science in the specific Jesuit spirituality that stresses the idea of finding God in all things and of the union of contemplation and work. Jesuits are called to be 'contemplative in action', as defined by Jerónimo Nadal, a collaborator of St. Ignatius. For Jesuits there is no activity so profane that it cannot be turned into prayer. This explains how, from the very beginning, Jesuits became involved in activities that other religious groups found incompatible with religious life. Moreover, some Jesuit scientists found ways to explicitly integrate science into their spirituality. Pierre Teilhard de Chardin (1962), a Jesuit geologist, recognized in science a profound meaning of sanctity and communion, and considered scientific research as a priestly operation. For him it formed a contribution to the progress of a world that is finally oriented towards God.

Jesuit scientific studies from the 16th to the 19th century

In the Jesuit colleges and universities in the 16th to 18th centuries, Jesuit involvement in science was mainly concerned with the mathematical sciences, which then included astronomy and aspects of physics such as optics, mechanics, electricity and magnetism. Teaching of astronomy led soon to the founding of observatories. Missionary work, an important part of Jesuit effort from the beginning, led to the presence of Jesuit astronomers in China and India. Because of their interest in astronomy, Chinese and Indian rulers welcomed Jesuit astronomers to their courts, where their influence was great. They were for some time the only western astronomers available and they introduced western astronomy into these countries. The suppression of the Jesuit Order in 1773 cut short all these developments. At that time, Jesuit interest in earthquakes was limited to the description of their effects and some speculation on their origin.

Seismology is a new science and can be said to have begun with the development of seismographs in the 19th century, which provide quantitative measurements of the motion produced by earthquakes (Davison 1927). The Jesuit Order was restored in 1814 and began again to establish new observatories with a sense of continuity with its past scientific tradition. Astronomy was at first the main subject in these observatories, but meteorology, geomagnetism and seismology were also studied. Seismology became increasingly important in the observatories, and Jesuits began to establish seismographic stations and became active in work to mitigate the destructive effects of earthquakes. Especially in undeveloped countries, Jesuits were in many instances the first to install these stations and to carry out seismicity and seismic risk studies.

In the 19th century, modern science was firmly established and a rationalistic mentality was spreading that led in some instances to the staging of opposition between science and religion. A belief in such opposition was clearly expressed, for example, in the influential book by Draper (1874), in which he stated: 'Then has it in truth come to this, that Roman Christianity and Science are recognized by their respective adherents as being absolutely incompatible; they cannot exist together; one must yield to the other; mankind must make its choice —it cannot have both'. The existence of this belief was also felt inside the Catholic Church. In 1891, Pope Leo XIII refuted such ideas: 'Those borne of darkness are accustomed to calumniate her [the Church] to unlearned people and they call her the friend of obscurantism, one who nurtures ignorance, an enemy of science and of progress, all these accusations being completely contrary to what in word and deed is essentially the case' (Maffeo 1991, p. 207). Apologias were common at that time defending Christianity against accusations of being against science.

Against this background Jesuit scientific work in the observatories was a practical way to show that opposition between science and religion does not exist and furthermore that harmony between them is possible. Aloysius Cortie (1923), the Director of the Stonyhurst Observatory in England, affirmed: 'The enemies of the Holy Church have made such an unwarranted use of science as a weapon of attack against her most fundamental truths, that an impression has sometimes being produced among many of her children that the pursuit of science is damaging and dangerous to faith'. He presented Angelo Secchi, the Director of the Observatory of the Collegio Romano (Rome) as a striking example of one who knew how to unite religion and science. Thus the presence of Jesuits in science, through their own scientific institutions, was considered a clear argument against such accusations and was presented as an example of the compatibility between Christian faith and science. Particular cases were the observatories (most with seismographic stations) installed in countries where there were Jesuit missions, where their scientific prestige afforded an important help to missionary work. Bonaventure Berloty (1912), the founder of the Ksara Observatory in Lebanon, wrote: 'Missionaries (working in the observatories), helping scientific development, perform work useful to the countries where they work and show, once more, that the Catholic religion, working mainly for the salvation of the souls, has never neglected true science which adorns the human spirit'.

Early studies of earthquakes

Natural philosophy was an important subject in Jesuit colleges and universities in the 16th to 18th centuries. The basis of these studies was formed by commentaries on Aristotle's works, especially the *Meteorologicorum Libri IV* (see Udías 2009). The best known Jesuit commentaries on Aristotle's books on natural philosophy were those of the professors of the University of Coimbra (Portugal) published under the name of *Conimbricensis* (Anonymous 1602). In these commentaries on the *Meteorologica* books, we find what we may call the official Jesuit doctrine on the nature of earthquakes (in Liber II, Tractatus XI, De Terraemotu). For Aristotle, earthquakes were caused by dried exhalations (spirits or winds) trapped in cavities inside the Earth, which, trying to escape, make the Earth shake. Little was added to this doctrine by the professors of Coimbra. Regarding the types of the motion they quoted the opinions of Poseidon, Agricola and Albert the Great, and they mainly used earthquakes from antiquity as examples, except for one earthquake of 1531 that affected Lisbon and other cities in the region.

This doctrine was further explained by Athanasius Kircher (1601–1680) in his influential book on the interior of the Earth, *Mundus Subterraneus*. In Chapter X of that book, Kircher added to the Aristotelian doctrine the explosive effect of inflammable material accumulated in the interior of the Earth, and compared earthquakes with explosions in mines (Kircher 1665). The explosive nature of earthquakes had been proposed by Martin Lister in England in 1648. In the 18th century several Jesuits wrote about the nature and causes of earthquakes; among these writers was the Sicilian Michele del Bono, who proposed some variations on the Aristotelian views (Bono 1750). On 1 November 1755 a major earthquake occurred, followed by a tsunami, which caused the destruction of Lisbon with about 12 000 victims, and severe damage and casualties in south Portugal and Spain and NW Morocco. This event caused in Europe a renewed interest in the study of these phenomena. Several works were published by Jesuits, such as those in Prague by the professors of mathematics Gaspar Sagner (1720–1781) and Joseph Stepling (1716–1778); the latter was also director of the observatory. Stepling observed that the Lisbon earthquake caused changes in the thermal fountains in Tepliz, near Prague (Sagner 1756; Schwab 1784; Stepling 1784). Other Jesuits writing about the Lisbon earthquake were Johan Schwab (1731–1795), a professor at Heidelberg, Aimé H. Paulian (1722–1800), the professor of mathematics in the colleges of Aix and Avignon, and Antonio Pereyra (1693–1770).

Outside Greece and Italy, major earthquakes are not common in Europe. In the 18th century, Jesuits such as Giuseppe D. Giulio (1747–1831) and Francisco Gusta, provided descriptions of earthquakes in Sicily and Calabria in 1783 as did Francis Zeno (1734–1781) in Bohemia in 1770. Missionaries in South America also experienced the occurrence of large earthquakes. The first work by a Jesuit in which descriptions of earthquakes in South America appear is *Historia Natural y moral de la Indias* (1590) by José de Acosta (1540–1600). He described the effects of a major earthquake in Chile (no year was given, but it was probably 1575), which affected a large area along the coast, and of two earthquakes in Peru (Arequipa in 1582 and Lima in 1586). The Lima earthquake caused much destruction affecting a wide area. It was followed by a tsunami with the water travelling 10 km inland and the sea level rising 20 m. De Acosta concluded that there was a relation between water and earthquakes, as he considered that earthquakes usually happen near the coast and water closes the cavities of the Earth and impedes the exit of the winds (de Acosta 1590). Juan Conzález Chaparro (1581–1651) described in detail the earthquake that destroyed Santiago de Chile on 13 May 1647. Pedro Lozano (1697–1759) and Joseph Pfriem (*1711) wrote descriptions of the major Lima earthquake of 28 October 1746.

Jesuit seismographic stations

Two trends may be distinguished in Jesuit involvement in seismology from the nineteenth century to the present. In the USA emphasis was on the co-operation of Jesuit institutions in the establishment of a network of seismographic stations directed by the Jesuit Seismological Association. In other countries, especially in countries where there were Jesuit missions, the movement developed out of the activity of single institutions in establishing seismological observatories. Table 1 lists seismographic stations installed and maintained by

Table 1. *Jesuit seismographic stations, in chronological order of establishment*

Manila, Philippines, 1868–present
Puebla, Mexico, 1877–1914
Tusculano, Frascati, Italy, 1888–1920
Tananarive, Madagascar, 1899–1967
John Carroll, Cleveland, OH, USA (JSA), 1900–1992
Cartuja, Granada, Spain, 1902–1971
Ebro, Tarragona, Spain, 1904–present
Zikawei, Shanghai, China, 1904–1949
Belen, Havana, Cuba, 1907–1920
Santa Clara, CA, USA, 1907–1958
Mungret, Limerick, Ireland, 1908–1915
Stonyhurst, Lancashire, UK, 1908–1947
Gonzaga, Spokane, WA, USA (JSA), 1909–1930
Holy Cross, Worcester, MA, USA, 1909–1934
Marquette, Milwaukee, WA, USA (JSA), 1909–1951
Regis, Denver, Co, USA (JSA), 1909–1988
Riverview, New South Wales, Australia, 1909–1985
Georgetown, Washington, DC, USA (JSA), 1910–1972
Canisius, Buffalo, NY, USA (JSA), 1910–present
Fordham, New York, NY, USA (JSA), 1910–1977
Ksara, Bekka, Lebanon, 1910–1979
Loyola, New Orleans, LA, USA (JSA), 1910–1960
Spring Hill, Mobile, AL, USA (JSA), 1910–1989
St. Boniface, Manitoba, Canada, 1910–1922
St. Louis, MO, USA (JSA), 1910–present
Ambulong, Philippines, 1912
Baguio, Philippines, 1911
Guam y Butuam, Philippines, 1912
Loyola, Chicago, IL, USA (JSA), 1912–1990
San Calixto, La Paz, Bolivia, 1913–present
Sucre, Bolivia, 1915–1948
Rathfarnham Castle, Ireland, 1916–1961
San Bartolomé, Bogota, Colombia, 1923–1940
Xavier, Cincinnati, OH, USA (JSA), 1927–1986
Florissant, MO, USA, 1928–1974
Mt. St. Michel's, WA, USA (JSA) 1930–1970
Little Rock, AK, USA, 1930–1958
Weston, Boston, MA, USA (JSA), 1930–present
Saint Louis, Jersey, 1936–1979
Cape Girardeau, MO, USA, 1938
Tagaytay, Philippines, 1939
Saint George's, Kingston, Jamaica, 1940–1975
Instituto Geofísico, Bogota, Colombia, 1941–present
Chinchin, Colombia, 1949
Galerazamba, Colombia, 1949
San Luis, Antofagasta, Chile, 1949–1965
San Francisco, CA, USA, 1950–1964
Baguio, Philippines, 1951
S. Jean de Brebeuf, Montreal, Canada, 1952–present
Addis Ababa, Ethiopia, 1957–1978
Baguio y Davao, Philippines, 1962
French Village, MO, USA, 1974
Cathedral Cave, MO, USA, 1991

JSA, stations directed by the Jesuit seismological Association.

Jesuits with dates of their installation and closing, and Figure 1 shows the location of the main stations. Distribution by continents is as follows: six in Europe, eleven in Asia, two in Africa, 24 in North America, and ten in Central and South America. Most of these stations were created before 1920 and many ceased operation in the 1960s and 1970s. At present, there are only eight stations working regularly, most run by non-Jesuits. Initially, the preferred instruments were Wiechert and Mainka mechanical seismographs; from about 1930, Galitzin–Wilip electromagnetic seismographs; and more recently, from about 1950, Sprengnether and Geotech short- and long-period instruments were used. In 1962, 11 stations became part of the 125 global World Wide Standard Seismographic Network (WWSSN) stations installed and maintained by the US Government. Of these, two stations in Colombia and Bolivia were later upgraded to become SRO (Seismological Research Observatory) and HGLP–ASRO (High-Gain Long-Period–Adapted Seismological Research Observatory) stations. This was a clear recognition of the reliability of the seismological work done by Jesuits at these stations. North American stations will be discussed below, together with the Jesuit Seismological Association (JSA).

The first seismograph installed by Jesuits in Europe was a seismoscope made by Giovanni Egidi (1835–1897) and installed in the Tuscolano meteorological observatory, at Frascati, Italy, founded in 1868. Two stations were installed in Spain, one in 1902 in the Cartuja Observatory in Granada, the most seismically active region of Spain, and the other in 1904 in the Ebro Observatory, Tarragona. In Granada most seismographs were made under the direction of Manuel Sanchez Navarro–Neumann (1867–1941), and they reproduced with some improvements the Omori, Wiechert and Galitzin seismographs (Sánchez Navarro-Neumann 1928*b*). The Ebro station has functioned uninterrupted to the present with continual improvement of its instrumentation. Also of Jesuit design was the first seismograph installed in Ireland, an inverted pendulum suspended by steel wires with a mass of 600 kg, with smoked paper recording, by the Jesuit William J. O'Leary. This was installed in 1908 in Mungret College and later (1916) in Rathfarnham Castle, where it was in operation until 1961. In the Stonyhurst observatory, England, the station operated from 1908 to 1947. A seismographic station was also run by Jesuits on Jersey from 1936 to 1979.

Of great interest are the seismographic stations installed by Jesuits in various countries in Africa and Asia. In many instances they were the first seismographic stations installed there. The first seismographs were installed by Jesuits about 1868 in the

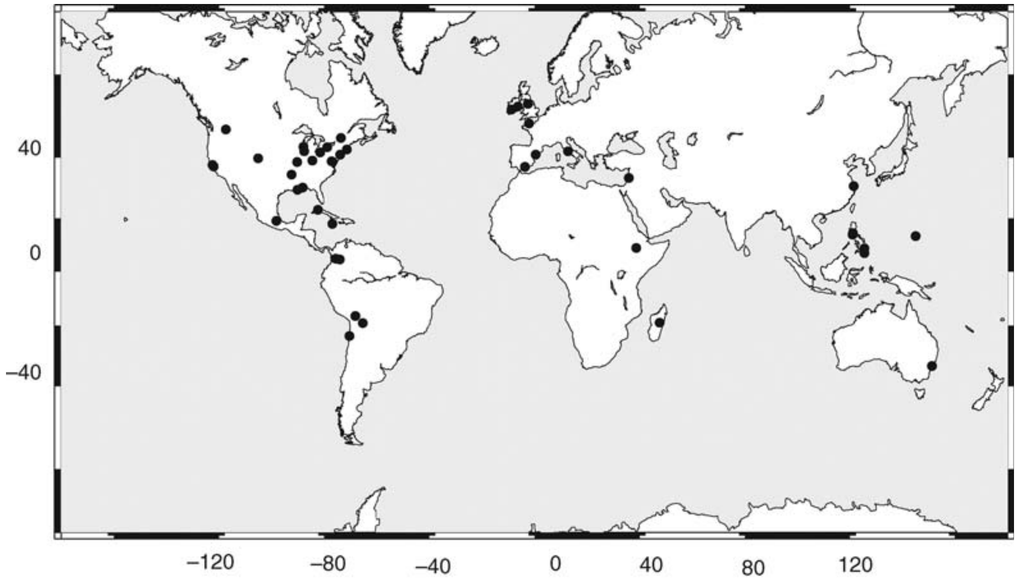

Fig. 1. Location of Jesuit seismographic stations.

Observatory of Manila, Philippines. They functioned intermittently until 1877, when regular uninterrupted seismographic recordings began. After the Manila earthquakes of 1880, Federico Faura (1847–1897), director of the observatory, installed new Cecchi, Bertelli and Rossi seismographs made in Italy. The station was later upgraded and new instruments were installed. Seismographic stations were also installed at other places in the Philippines: Baguio, Ambulong, Butuam, Tagaytay and the island of Guam (Saderra-Masó 1915). Unfortunately, all seismographic records were lost in the destruction of the Manila Observatory in World War II. After the war, new seismographs were installed in Manila, Baguio and Davao. The last two sites became WWSSN stations in 1962. In 1899, Jesuits installed a seismographic station in Madagascar, the first in Africa, with Italian instruments. In 1927, Mainka seismographs were installed and the station worked under Jesuit supervision until 1967. In 1904, Jesuits installed an Omori seismograph donated by the Japanese government in the observatory of Zikawei, Shanghai, which may be the first in China. Improved with Wiechert and Galitzin–Wilip instruments in 1909 and 1932, Zikawei was a first-class station until the Jesuits were expelled from China in 1949 (Gherzi 1950). In Ksara, Lebanon, seismographs were installed in 1910 and operated uninterrupted till 1979. This was an important station because of the lack of stations in the Middle East. Although not a Jesuit station in the strict sense, in 1955 a seismographic station was installed in the newly created observatory of Addis Ababa, Ethiopia, directed by the Canadian Jesuit Pierre Gouin (1917–2005), which became a WWSSN station in 1962. In Australia, the seismographic station of Riverview was initiated in 1909 with Wiechert mechanical instruments. In 1962 it became a WWSSN station and operated until 1985. For many years this was the best known and best equipped station in Australia.

In Central and South America major earthquakes are a common occurrence, with very high risk of casualties and damage. The first seismographic station was installed in the Observatory of the Colegio Sagrado Corazón in Puebla, Mexico, in 1877. The observatory was closed, together with the college, in the Mexican revolution in 1914. In the 2nd General Assembly of the International Seismological Association, Manchester, England, in 1911, a resolution was passed recommending that the Jesuits install a seismic station in the central part of South America. This recommendation shows the confidence of the scientific community in the seismological work done by Jesuits. In response to this recommendation a seismological station was installed in 1913 in La Paz, Bolivia with the name of Observatorio de S. Calixto, by Pierre M. Descotes (1877–1964). In 1930, the station was upgraded with Galitzin–Wilip seismographs. From 1964 to 1993 the station was directed by Ramón Cabré (1922–1997). For many years the observatory of S. Calixto has been one of the most reliable stations in South America (Coenrads 1993). The first seismograph in Colombia was installed by Jesuits in 1923 in Bogota. In 1941, the Instituto Geofísico de los Andes Colombianos (today Instituto Geofísico, Universidad Javeriana) was founded by Jesús E. Ramirez (1904–1983) and this soon became one of the best seismological research institutes in South America (Ramirez 1977). In 1962 the stations of La Paz and Bogota became WWSSN stations. Later La Paz became an HGLP–ASRO station (1972) and Bogota an SRO station (1973). This is a clear recognition of the work done by Jesuits at these two stations. Other Jesuit seismographic stations, in Cuba and Chile, functioned for only a few years. In 1940 a seismographic station was installed by Weston Observatory in St. George's College, Kingston, Jamaica. In Montreal, Canada a seismographic station was installed in 1952, the last seismographic station installed by Jesuits. For 31 years this station was directed by Maurice Buist (1902–1986).

The Jesuit Seismological Association

The history of Jesuits' work in seismology in the USA is linked to the Jesuit Seismological Association (Macelwane 1950). The first Jesuit to install a seismograph in the USA was Frederik L. Odenbach (1857–1933) in 1900, in John Carroll University, Cleveland, Ohio, with two seismoscopes of his own design. In 1908, Odenbach conceived the notion that the system of Jesuit colleges and universities scattered throughout the USA offered an excellent opportunity to establish a network of seismographic stations. He thought that such a network stations could contribute significant data to the International Seismological Centre established in Strasbourg, France, in 1896 to process data from seismographic stations at a global basis. Odenbach told the presidents of the colleges and the US Jesuit provincials about the idea. The network, named the Jesuit Seismological Service, was inaugurated in 1909. It was formed by 16 stations (15 in colleges in the USA and one in Canada), all equipped with the same instrumentation, horizontal Wiechert seismographs of 80 kg mass. The stations processed their seismograms and sent the data to the Central Station in Cleveland, which forwarded them to the International Seismological Centre in Strasbourg. This was in effect the first seismological network of continental scale with uniform instrumentation. However, the intended plan did not work well for long and the co-operation of all stations was never fully established. In 1925, James B. Macelwane (1883–1956), the Jesuit professor of geophysics at Saint Louis University, made an effort to revitalize the Jesuit seismographic network. The impetus for this came not only from his own interest, but also from the urging of scientists of the National Research Council and the Carnegie Institution of Washington, and from the further encouragement of another Jesuit seismologist, Sánchez Navarro-Neumann of the Cartuja Observatory in Spain. Thus in the summer of 1925 the stations were reorganized into the Jesuit Seismological Association (the 13 member stations are marked JSA in Table 1).

The Central Station was now established in Saint Louis University, which also assumed the responsibility, on behalf of the JSA, of collecting data from member stations and from around the world, of locating earthquake epicentres, and publishing and distributing them to the worldwide seismological community. The Central Station continued this service until the early 1960s, when it was discontinued to avoid duplicating the work of the US Geological Survey and other international agencies.

Most of the JSA seismographic stations continued regular operation until relatively recent time. Florissant (St. Louis), Weston, Georgetown and Spring Hill became WWSSN stations in 1962. At present only Saint Louis and Weston continue as seismological research institutes. For many years the Jesuit Seismological Association met jointly with the Eastern Section of the Seismological Society of America, the most prestigious society of this science. This society established in 1991 an annual award named the Jesuit Seismological Association Medal, as a tribute to the work done by the US Jesuit seismologists.

Jesuit seismologists

It is not possible here to do more than mention some of the most important of the Jesuit seismologists. Among these is Federico Faura, the first director of the Manila Observatory, who wrote a study about the destructive Manila earthquakes of 1880, in which he published the first graphics obtained by the instruments there. Faura later improved the seismological instrumentation of the observatory and published a seismological bulletin. Another early Jesuit seismologist was Giovanni Egidi, director of the Tuscolano Observatory in Italy, who collaborated since 1877 with M. S. de Rossi in seismological observations.

Two Spanish Jesuits contributed to the early study of the seismicity and seismotectonics of the Philippines and Spain. Manuel Saderra-Masó studied seismicity of the Philippines, and he interpreted it in terms of seismotectonic lines and related it to the geological structure in the archipelago in a very early paper of this type (Saderra-Masó & Smith 1913). M. Sánchez Navarro-Neumann, director of the Cartuja Observatory, Spain, compiled the first modern earthquake catalogue of Spain, and published numerous studies on Spanish seismicity and the first book on seismology in Spain (Sánchez Navarro-Neumann 1917). He composed in 1924 a special formula for blessing seismographs approved by Pius XI (Sánchez Navarro-Neumann 1924).

The most renowned Jesuit seismologist was, without doubt, James B. Macelwane (Byerly & Stauder 1958). Macelwane obtained his doctorate at the University of California, Berkeley, in 1925, with the first thesis on seismology in the USA. In 1925 he became the first director of the Department of Geophysics of Saint Louis University and reorganized the Jesuit Seismological Association. Travel times of seismic waves, the constitution of the interior of the Earth, and the nature of microseisms and their relation to atmospheric storms were a few of the topics of his research papers. He was an outstanding educator, and from his time Saint Louis University became one of the best known and most prestigious centres of seismology. In 1936 he published the first textbook in seismology in the USA (Macelwane 1936). In 1928–1929 he was President of the Seismological Society of America and in 1953–1956 of the American Geophysical Union. In 1944, he was elected to the National Academy of Sciences. In 1962, the American Geophysical Union created a medal in his honour for the recognition of a significant contribution to the geophysical sciences by a young scientist of outstanding ability.

Among Macelwane's many students was William C. Repetti (1884–1966), who studied the interior of the Earth from travel times of body waves and established the existence of several discontinuities in the Earth's interior. In 1928 he went to Manila Observatory, where he was in charge of the seismological section and compiled a catalogue of earthquakes of the Philippines. The Colombian Jesús E. Ramírez (1904–1983) worked on the problem of microseisms and storms, and designed a tripartite station system to track the centre of tropical hurricanes. In 1941 he founded in Bogota the Instituto Geofísico de los Andes Colombianos and published a large number of studies on Colombian seismicity. He was a leading figure in the seismology of South America. The seismological research in Saint Louis University was continued by William Stauder (1922–2002), who developed new methods for the study of the mechanism of earthquakes and applied them to the tectonics of several regions, thus contributing to the beginning of the plate-tectonic theory.

J. Joseph Lynch (1894–1987) became director of the seismographic station of Fordham University in 1920. This was the beginning of a long career as a seismologist in which he carried out a variety of seismological studies, including field studies of the Dominican Republic earthquake of 1946. Daniel Linehan (1904–1987) was professor of geophysics and director of Weston Observatory for 32 years. A prolific writer on many aspects of seismology, he was especially interested in seismic exploration. In 1950, accompanied by Lynch, he carried out a shallow seismic exploration survey in the Vatican for archaeological purposes. He participated in three expeditions to the Antarctic, one to the Arctic and several UNESCO seismological missions in Africa, Asia and South America. Two other Jesuit seismologists participated in separate expeditions to the Antarctic during the International Geophysical Year: Edward Bradley of Xavier University, Cincinnati, and Henry Birkenhauer of John Carroll University, Cleveland. Of European Jesuit seismologists, Richard E. Ingram (1916–1967), director of Rathfarmham Castle, Ireland, should be mentioned for his theoretical papers.

Of the various aspects of seismology, the study of microseisms attracted the special interest of Jesuit seismologists. We have already mentioned the work of Macelwane and Ramírez; the latter produced his first paper on the subject in 1940. Probably the first suggestion of the relation of microseisms and storms was made by José Algué (1859–1930), Director of the Manila Observatory, as early as 1894 in his study of Philippines typhoons. Ernesto Gherzi (1886–1976), director of Zikawei Observatory, China, carried out an early investigation and published several papers on the relation between microseisms and atmospheric conditions. In 1952 a seminar was organized by the Pontifical Academy of Sciences in the Vatican on the problem of microseisms, in which Gherzi, Macelwane and Antonio Due-Rojo (Cartuja) participated among a selected group of specialists.

Jesuits participated in the early stages of the organization of seismological associations. R. Cirera (1864–1932), first director of the Ebro Observatory, represented Spain as one of the 20 delegates at the second meeting of the International Seismological Conference in 1903 in Strasbourg. Bonaventure Berloty (Ksara Observatory, Lebanon), Sanchez Navarro-Neumann (Cartuja, Spain) and Johan Stein (Vatican Observatory) were present at the first General Assembly of the International Association of Seismology in The Hague in 1907. Jesuits have participated actively in the International Association of Seismology and Physics of the Earth Interior (IASPEI) since its establishment in 1922, as part of the International Union of Geodesy and Geophysics (IUGG). Jesuits have had a special relation with the Seismological Society of America. One of the 13 assistants to the meeting on its founding in 1906 was Jerome S. Ricard (1850–1930), Director of Santa Clara Observatory, who was elected member of the first board of directors. Macelwane served on the board from 1925 to 1956, and was elected

President of the Society in 1928. Several Jesuits have been chairmen of the Eastern Section of the Seismological Society of America: J. B. Macelwane, 1926 (first chairman); J. J. Lynch, 1930; V. C. Stechschulte, 1933; D. Linehan, 1954; W. Stauder, 1963.

Conclusion

Jesuits contributed to organizational, experimental and theoretical aspects of seismology as part of their involvement in science, and regarded such work as part of their Christian service. The history of these studies has two periods. In the first, from 1540 to 1773, science was part of the educational programme in Jesuit colleges and universities. Teaching mathematical sciences, which included astronomy, optics and mechanics, was an innovative element of their educational work, which attracted students interested in the new sciences being developed at that time. In the second period, from 1812 to the present, and especially during its early years, Jesuit scientific work aimed to show that science and Christian faith should not be considered as hostile or opposed to each other. Jesuit scientists showed that the pursuit of science should not be considered as damaging and dangerous to faith.

Seismology was a subject that caught the interest of Jesuits because of its social consequences of mitigating the damaging effects of earthquakes. The principal contribution of Jesuits has been in establishing seismographic stations to provide seismological data for the assessment of earthquake risk and in research on the constitution of the Earth and the processes of earthquake generation. To accomplish this more effectively, Jesuit stations regularly endeavoured to update the quality of their instrumentation. Between 1910 and 1960, the number and quality of seismological stations world-wide was very limited. Jesuit stations in South America, Africa and Asia were particularly important at that time. In some instances, they were the only reliable stations for many years. Although, more recently, the establishment of national seismological networks has made their work no longer necessary and explains the closing of many Jesuit stations, those still active, although with very small Jesuit presence, maintain this tradition. Jesuits have played an important part in the earthquake hazard reduction programmes of various regions, in co-operative international initiatives, in the development of the theory of plate tectonics, and in the study of the nature of earthquake sources and the deep structure of the Earth. Such work has been founded on the tradition of the early Jesuit pioneers of seismology.

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'Red and expert': Chinese glaciology during the Mao Tse-tung period (1958–1976)

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Abstract: This paper gives a brief account of some of the political and social events that occurred in China during the period of the 'Great Leap Forward', when the slogan of 'red and expert' was first enunciated, and the subsequent 'Cultural Revolution'. These two movements exerted considerable influence on Chinese science and technology. As an example, we consider the establishment of glaciology in China and the (largely unsuccessful) attempts to increase water supplies in arid regions by means of melting glaciers. The question is then raised as to whether the 'Maoism' that motivated the Great Leap Forward and the Cultural Revolution had features in common with organized religions in other countries. The conclusion is reached that it did in some respects, although it was more in the nature of a civil and nationalistic form of religion than a spiritual movement and was atheistic.

The concept of 'both red and expert' (*you hong you zhuan*) emerged in the 1950s, when Mao Tse-tung[1] (Mao Zedong) (1893–1976) first used this slogan at the third session of the eighth National Congress of the Communist Party of China (1957) (Mao 1977). Mao required scientists and technologists to follow 'correct' political standards (i.e. those of the Communist Party of China and those defined in his speeches and writings by Mao himself) and maintain a capacity for research appropriate to the needs of the new China and particularly those of the proletariat. Subsequently, Mao mentioned the notion of 'red and expert' at several important meetings (Yang Fengcheng 1997). The phrase gradually became widely used and eventually turned into a slogan, or even an idiom in the Chinese language.[2]

At the time that Mao brought this relationship between 'redness' and 'expertise' into discussion, Chinese scientists were indeed concerned about the relationship between their social responsibilities and obligations and their own research work. They began to use the word 'red' to refer to 'political stance' and 'expert' to stand for their professional work. The concept of 'red and expert' soon became a required fundamental principle for scientists. The meaning and interpretation of the concept changed over time, but essentially it had to do with the perceived need for the 'cadres' who worked for the Government to have the appropriate technological knowledge and skills to assist the development of the nation; and for intellectuals it involved changing their attitudes from bourgeois to proletarian and undertaking their scientific or technological work with practical knowledge relevant to national construction as a prime goal. Thus they were to dedicate their lives to the advancement of socialism.

In 1957, the slogan 'red and expert' became a significant factor in what was called the 'Struggle against Rightist Deviations'. At that time, intellectuals had a lower status than members of the proletariat because scientists (intellectuals) were educated before the People's Republic of China was established in 1949. They were therefore thought not to have the appropriate political stance or to have assimilated Marxist ideas, and, in consequence, they needed to remould their ideology by learning from the proletariat. They were not required merely to sympathize with the situation of the proletariat, but were expected to learn from workers and peasants and change themselves so as to become proletarian. When the Government announced that intellectuals were to become part of the workers, Chinese scholars were, in fact, delighted as this implied an elevation of their status at that time.

Glaciology began in China at a time when the 'red and expert' ethos was prominent or even dominant. Taking this branch of geoscience in China as an example, this paper examines the influence of the notion of 'red and expert' in relation to geoscientific research, and then considers whether Maoist beliefs and practices, and the behaviour patterns of the Chinese people in the Maoist period, had features in common with those associated with religions. We can distinguish several stages in the unfolding of events.

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The 'Great Leap Forward' in China (1958–1960)

The 'Great Leap Forward' was the name given to what was attempted and what occurred during the first 3 years of China's Second Five-Year Plan (1958–1962). It called for the rapid development of China's agriculture and industry, with massive increases in agricultural production and iron and steel manufacture. Collectivization was accelerated, and large 'peoples' communes' were established, which were intended to be largely self-sufficient. They were to develop some light industry and undertake construction projects, such as those concerned with irrigation. Steel and grain were seen as necessities; so small but inefficient 'backyard' smelters were constructed in many parts of the country (see Fig. 1). These often used wood as fuel and this had serious adverse effects on China's forests. The steel produced was of low quality and the vision of catching up with the industrial production of the UK in 5 years was not realized. Moreover, in 1958 so many peasants were diverted to iron or steel production that the harvest was not brought in and grain production fell. However, the local agricultural areas had been encouraged to announce exaggerated grain production levels. These claims were taken at face value and assumed to be accurate, so grain was taken from rural areas to feed the cities. In consequence, there was widespread rural famine. The Great Leap Forward was an un-natural disaster.

Glaciological research at the time of the Great Leap Forward

There are many glaciers among the mountains of NW China, and in 1956 a Soviet expert suggested that Chinese scientists should give attention to glaciology, which, he pointed out, was a significant gap in Chinese scientific research (Chu Coching (Zhu Kezhen) 1989, p. 651).

Water is *the* great problem for agriculture in NW China, and it became one of the principal tasks for Chinese scientists to seek to solve the water shortage. At a meeting of the Chinese Academy of Sciences in 1958, during the Great Leap Forward, the alleviation of drought in that region by utilizing glacial melt-water was discussed and it was determined that the 'poldering' of water from glaciers, and an increase of the quantity of glacial melt-water, were key tasks or objectives. At that time it was assumed that the large glaciers would provide a permanent source of water. The possible adverse environmental effects of drawing off additional water from the mountains were not considered and, of course, global warming was not an issue at that time.

Therefore, glaciological research not only filled a gap in China's geoscience but also it appeared potentially useful for agricultural development and production, and therefore, it was thought, it could meet the requirements of 'redness and expertise'. Hence, the Chinese Academy of Sciences organized a research team for 'Utilization of Glacier Melt-water in Alpine Areas' (see Fig. 2). The team investigated the distribution of glaciers in western China and conducted research on the possibility of accelerating glacial melting to increase water supplies in the country's arid regions.

Thus a research programme intended to deal with the very practical problem of water shortages promoted the establishment of a new subject in Chinese science: glaciology. It took 3 months for the research team to examine the distribution, melt-water production, formation, and types of glaciers in the Qilian Mountains, where the investigations

Fig. 1. Peasant iron foundries. Source: http://courseware.dec.ecnu.edu.cn/zsb/zls/zls15/zls154/zls15405/zls154059.htm.

Fig. 2. Glaciology Group in the mountains of NW China. Photograph provided by Shi Yafeng, taken in 1957 by L. D. Dolgushin.

were focused.[3] The research team also observed glacier accumulation and melting patterns, and discussed the possibility of melting snow artificially. After finishing the fieldwork, the team took only about 2 months to finish the 430 000-word *Report on the Glaciers in the Region of the Qilian Mountains*, which was published in January 1959 (Team for the Utilization of Glacial Melt-water in Alpine Areas 1959). It was the first major glaciological text written by Chinese scientists and filled a large gap in glaciological research in China, even thought the report was only provisional.

However, a so-called 'Struggle against Rightist Deviations' (another political movement, initiated in 1959) started at a time when the glaciological research appeared to be running smoothly, and the research team was criticized for its neglect of practical results, although one of the seven sub-teams was specifically charged with investigating the melting of ice and snow. This illustrates the fact that science in China at that period had to function under abnormal political circumstances: the notion of 'pure science' was politically unacceptable. On the other hand, it might be said that China was then facing severe political and economic problems, so the idea that the Government should support any scientific research programme that might happen to interest scientists was perhaps unreasonable.

The 'red and expert' ethos also inhibited or stifled scientific controversy. One of the most prominent (and politically well-connected) geologists of the time was Lee Siguang (or J. S. Lee[4]), sometimes referred to as the 'red flag' of Chinese scientists. He wrote on Quaternary geology, among many other topics, and was a man of considerable prestige, influence and power. Having scientific ideas that differed from Lee's was unacceptable at that period. For example, Lee thought that there were many glacial features in eastern China. If someone disagreed with him, this was regarded as a political, not an academic, question, and the dissenting scientific opinion was suppressed (Jing 1998; Zhang & Wu 1998).

The 'red and expert' campaign therefore had a significant effect on the ideas of the glaciology researchers. The team members were classified according to their supposed 'redness'. Table 1 gives the 'ranking' of the professors and associate professors of the glaciological research institute in the 1950s and 1960s according to this criterion.[5] We can readily see how and why researchers' political views had to 'bend with the wind'. In the case of the glaciological research team, any scientist who spent time on pure research instead of directing efforts towards agriculture (for example) would be placed in the 'rightist' column. This categorization was a serious matter at that time and people naturally tried to avoid it.

However, with the expansion of the political campaign, people's perception of 'red and expert' changed. Some leaders in the Chinese Academy of Sciences considered that the idea was a contradiction in terms, as educated scientists or technologists were evidently different from the poorly educated bulk of the population who at best would only know about traditional craft techniques or farming practices. The term 'white and expert' was therefore suggested. However, this notion led people into thinking that a professional focus on scientific theory to the exclusion of practical considerations implied sympathy for capitalism and was a 'rightist deviation'. A 'white' scientist was one who conducted their research without consideration of any practical effects or practical value to the nation. This was politically imprudent, or unacceptable, at that time. As noted above, in the early 1950s, because most of the scientists had been educated before the People's Republic of China was established, or had even been educated abroad, they were presumed to have an incorrect political stance. From the late 1950s, scientists were educated in the 'New China', but were still thought to have (potential) capitalist tendencies and needed to remould their ideology.

Thus amidst the confusion about the relationship between 'redness' and 'expertise', the glaciological research shifted its focus or emphasis from

Table 1. *Political leanings of members of the Glaciology Group*

	Left	Centre–left	Centre	Centre–right	Right
1950s		3	3	4	0
1960s	1	4	3	2	0

From the archives of the Chinese Academy of Sciences: Z358-110.

academic work to the practical problem of making glacial melt-water available for agricultural use. The research team was required to put all its effort into work on trying to increase glacier melting, in collaboration with governments at the local level.

In 1959–1960 the local governments organized thousands of local people to work for 3–4 months to put 'carbon black' (the ashes of burnt horse, cow or sheep dung, or burnt grass) on the surface of ice or snow. More than 1 million RMB (yuan) was spent on this kind of activity, at a time when a professor's salary was only about 100–300 RMB a month.

It is hard to know whether such activities were of any practical use. According to the team leader's recollection, the team reported to the local government that they had melted 100 million cubic metres of water, although there was not as much as that (Shi Yafeng, pers. comm.). The number was an exaggerated estimate and the actual volume is unknown.

Glaciological research in the 'adjustment period' (1961–1965)

The Great Leap Forward caused significant waste and soon led to a national financial crisis. Some provinces in northwestern China had a high death rate caused by famine and some 20 million people died of starvation in 1960 (Yao Kaijian 2003, p. 90). The effects of the economic policies are reflected in Table 2.

The financial crisis generated by the technical failures of the 'Leap' adversely affected the research team's funding for its supplies; and, with the emphasis on practical results, the scientific quality of the investigation deteriorated, as there were few opportunities for team members to undertake genuine scientific research and some researchers left the team. Admittedly, the glaciological research team was able to do its work with little financial regulation during the 'Leap' but this did not enhance its organization or its theoretical, empirical or practical achievements. The financial problems caused by the 'Leap' and the lack of experienced scientists adversely affected the work (Shi Yafeng 1999).

Table 2. *Death rate of the Chinese population (1956–1961)*

Year	Nationwide deaths caused by starvation (%)
1956	1.140
1957	1.080
1958	1.198
1959	1.459
1960	2.543
1961	1.424

Source: Bureau of statistics (1983). See also Yao (2003).

Scholarly life was also greatly affected. At times, the glaciologists had to try to collect their own food or 'live off the land'. Poignantly, one morning in 1960 all members of the team were asked to go out to gather leaves as a substitute for food, but they found that the leaves on the trees had already been taken by the local people. Such was the tragic situation in the countryside at that time. By 1961, the Central Government eventually realized that there were serious problems with the Great Leap Forward (although it was still presented as a success), and a new policy was announced. This was stated in eight Chinese words and is thus called the 'eight-word policy'. It can be stated in English in four words: 'adjustment', 'consolidation', 'enrichment' and 'enhancement'. The political environment was by then somewhat less intense and 'red' was no longer emphasized in such an extravagant way.

However, at the beginning of the 'adjustment', the research work on glaciers could not be sustained because of financial difficulties. As a result, the team leaders instructed their members to study at home, so that no external fieldwork was undertaken. Subsequently (about 1962–1964), when the economic situation improved somewhat, the glacier research groups took action to expand their glaciological research. Well-qualified staff members were recruited, including graduates from within China and those who had studied overseas. Two journals were published on a regular basis: *Research Materials for the Study of Glaciers and Permafrost* and *Translated Publications on Glaciers and Permafrost*. Laboratories for the study of terrestrial photogrammetry and permafrost mechanics were established, and also for the investigation of thermal physics. The living conditions for the field teams were improved with the help of support from the Provincial Government of Gansu.

However, this improved situation did not last long and the political environment soon swung to the left once again, even before the Cultural Revolution in the late 1960s. Shi Yafeng, a member of the programme, has recalled that research work had to be halted during periods of political campaigning; and regardless of whether or not the researchers had scientific work to do they were required to hold meetings (on political issues) every night (Shi Yafeng, pers. comm.).

To meet the continuing requirement of 'redness', scientists and researchers were required to spend large amounts of time studying Mao's thoughts.

As a result, many of them had little time to do any research during this period. The Central Government and the Chinese Academy of Sciences designed policies to solve this problem many times. However, the suggestions were not implemented properly because of frequent interruptions by political campaigns or activities. For example, at the end of 1960, an investigation by the Chinese Academy of Sciences on working time in three research institutes in Beijing showed that on average each researcher devoted only 3 days per week to academic research from January to October (Lu Zhenchao & Wang Yangzong 2004). The working time for glaciological research was even more restricted, but was just as arduous, because most of the work was concentrated in the harsh and remote areas of NW China.

Glaciology in the 'Cultural Revolution' (1966–1976)

Soon after the implementation of the 'eight-word policy', the political environment leaned yet further to the left. A major shift in the understanding and implementing of the idea of 'red and expert' emerged after 1966 and peaked during the so-called 'Cultural Revolution'.[6] The causes of this 'Revolution' are not agreed upon by Chinese historians, as most of the archives of the period are still not available. At least 10 reasons have been suggested, the most popular of which are: (1) there was a struggle for power and profit in the highest levels of the Government and Party; (2) Mao initially wanted to establish a 'utopia' by means of the Cultural Revolution (implementing the idea of 'continuous revolution'), but the process got out of control. Whatever the causes, the effects on scientific work (and education in general) were profound.

In the early stages of the Cultural Revolution, glaciological research again virtually came to a halt. In fact, there was no significant glaciological research programme during the Cultural Revolution. All the researchers were employed with the workers or peasants and studied Mao's works. Table 3 shows the changes that the Institute of Glaciology underwent during the 20 years from 1958 to 1978; however, no amount of name changing or bureaucratic reorganization could put things right while the country was in such a state of turmoil.

Political campaigning dominated scientists' time; and the leaders of the glaciology team were 'put in the cowshed' (the punishment of being required to do manual work in factories or in the countryside). Later, in the early 1970s, the situation was relaxed somewhat, but scientists could still only spend a limited time on their professional work, as all weekday afternoons and evenings were allocated to political activities.[7]

Table 3. *'Evolution' of the Chinese Academy of Science's Glaciological Institute during the period 1958–1978*

Date	Title of the Glaciological Institute of the Chinese Academy of Sciences	Number of researchers
1958	Team for Utilization of Glacial Melt-water in Alpine Areas	>100
1960	Institute of Glaciology, Snow, and Permafrost	Tens
1961	Coalition with the 'Earth Physics' Institute	>200
1962	Separation from 'Earth Physics', becoming a research group of the 'Geographical Institute'	78
1965	Coalition with the 'Desert Research Group', becoming the 'Institute of Glaciology, Permafrost, and Deserts'	>100
1975	Separation from desert research, becoming the 'Institute of Glaciology and Permafrost'	>100

The structure and mode of management in research organizations also changed greatly during the Cultural Revolution. Research institutes adopted a military style of management, with each research group being changed to something like a military unit (*lian*). The group directors became the 'team leaders', and a Communist Party member held a role as political instructor in charge of the political thoughts of each group. This military management system was fairly soon abandoned (in 1972). Nevertheless, political offices (and officials) were retained in every research organization.

Besides being criticized and denounced (or criticizing and denouncing), scientists had to study Mao's thoughts intensively and were asked to review their ideas to find any divergences from the orthodox views and modify them accordingly. In 1968, so-called '7 May Cadre Schools'[8] were set up throughout the country to inculcate a better understanding of Mao's ideas. Scientists were transferred to the countryside to do manual work and receive 'guidance' on rural matters from the peasants (see Fig. 3). In the cadre schools, often located in remote and undeveloped areas, scientists not only had to do arduous manual work but were also required to study politics and military matters, and attend criticism and denunciation meetings directed against capitalism.

Fig. 3. An intellectual (identified by glasses) working amicably with a peasant, who is holding a copy of Mao's *Little Red Book* (http://hi.baidu.com).

Religion or politics? The influence of Mao's thought

We may now consider whether the events in China in the period from the Great Leap Forward to the Cultural Revolution amounted to a form of religion. The answer to this question will, of course, depend on what one understands by the term 'religion'. There are many dictionary definitions of the word; for example, 'belief in a superhuman controlling power, especially in a personal God or gods entitled to obedience or worship', or 'a particular system of faith and worship'. 'Faith' means 'firm belief not based on proof'. 'Creed' means a 'set of principles or beliefs, especially as a philosophy of life' or 'a statement of a set of religious belief(s)', which is formalized in the case of Christianity, for example (although the doctrines of that religion have changed over the centuries).

Did Maoism amount to, or have some of the characteristics of, a religion? During the decade between the Great Leap Forward and the Cultural Revolution, Mao's prestige gradually reached a peak. His ideas dominated Chinese society and were treated as if they were almost infallible. Was this adulation of the leader a form of religion or was it just politics?

When modern science and technology were introduced in China early in the twentieth century, the Chinese scientific world was to a considerable extent dominated by both anti-traditional and anti-religious feelings. Most westernized intellectuals in China considered that science and religion were incompatible; and after the establishment of the People's Republic of China the new social and institutional structures restricted the 'space' for traditional forms of religion. In this situation, the westernized intellectuals had some reason to welcome Maoism. Moreover, the Chinese people almost worshipped Mao, because he had a utopian vision for the country that was attractive to much of the population, who had undergone great hardship during the partial colonization in the nineteenth century, the Second World War, with the partial occupation of the country, and in the Korean War. Mao's strong personality, backed up by his military successes, filled a spiritual vacuum in China as a patriarchal figure, which made the world more understandable for the uneducated. He also held out a utopian vision for the educated part of the populace (or it was presented to them as such). It seemed that his visionary ideas offered a guide to truth. However, with the lack of success in the economic sphere, Mao was not deified, at least until the Cultural Revolution, when the political pressure reached its greatest intensity. He was regarded as a great leader who had successfully driven out the Japanese invaders and the Kuo Min Tang, and had repelled the Americans in Korea. From that perspective, belief in Maoism was a geopolitical matter, not a religion.

However, from the beginning of the Great Leap Forward, and especially during the Cultural Revolution, devotion to Mao reached an unreasonable level and manifested itself in what now appear as irrational forms of behaviour and beliefs. He was not, of course, regarded as a transcendent or 'magical' figure, but in many ways there were analogies between Maoism and aspects of more traditional Chinese religious thoughts and practices. His power was exercised and his ideas were promulgated through the country by groups of (often very) young men and women known as Red Guards, who acted as 'enforcers', and who had themselves been indoctrinated.

Mao worship or veneration had, we suggest, something in common with religion in the following respects.

(1) Mao's ideas became the unquestioned and only principles for social and economic life, and they formed a kind of dogma. They also offered a distinctive blend of the political and the moral. His famous *Little Red Book*,[9] seen being brandished by thousands of hands in Figure 4, opens with a chapter on the Communist Party. For a revolution, it stated, there must be a revolutionary party; and 'the Chinese Communist Party is the core of leadership of the whole Chinese people' (Mao 1966, p. 2; speech delivered on 25 May 1957). The Party's policy was what was right for people to follow; and it had to be taught (inculcated), studied, and followed. One should have 'faith' in the Party (Mao 1966, p. 3; speech delivered on 31 July 1955). The world was divided (in Manichaean fashion) between socialism–proletariat (good) and capitalism–bourgeoisie (evil), locked in struggle (Mao 1966, p. 18, speech delivered on 27 February

Fig. 4. 'Group frenzy' in Tienanmen Square, saluting Mao (the 'Red Sea'). *Source*: Institute of Curriculum & Textbooks (2006). (This picture is so 'popular' that it can also be found at: http://blog.mop.com/weianran8/2007/05/22/3375692.html.)

1957). As Mao ruled the Party, the Chinese people were being enjoined to have faith in his ideas and social policies, and his moral principles.

The *Little Red Book* stated that Communists should know how to behave in the new China:

> At no time and in no circumstances should a Communist place his personal interests first; he [*sic*] should subordinate them to the interests of the nation, and of the masses. Hence, selfishness, slacking, corruption, seeking the limelight, and so on, are most contemptible, while selflessness, working with all one's energy, whole-hearted devotion to public duty, and quiet hard work will command respect (Mao 1966, p. 269; speech delivered in October 1938).

Thus, 'The Party' had some positive analogies with a Church.

(2) Studying Mao's thought became a routinized ritual, which involved such practices as reciting quotations (see Fig. 5), seeking instructions in the morning, reporting at night, studying, mass dancing or 'fealty dances' (z*hong zi wu*) and exchanging learning experiences. These regulated routines and complicated rituals were, we suggest, analogous to religious activities or systems of traditional religious education. During the Cultural Revolution, all students in their early teens were required to learn the text of the *Little Red Book* by heart, as a kind of equivalent to the Bible and the catechism in older Christian schools. As in the days of pre-Industrial Europe, for most people there was little else to read. China was a closed world, and students knew little other than what they learned in their 'Bible'.[10] They were unaware of alternative political or religious notions. In some times and places, the actions took on the form not only of mass hysteria akin to Fascist meetings, but also of religious devotion and zealotry (see Fig. 4).

The glaciologists were included in all this. A set of notebooks compiled by Shi Yafeng from this time (the Cultural Revolution) (see Fig. 6) shows Mao's ideas having been copied and presumably learnt by heart. The text below the photograph reads tellingly:

> The Great Leader waving his hand to us. The thunder of the Revolution is heard everywhere. Follow the Leader's direction. Strive as if against wind and waves. The Great Leader waves and unlimited energy fills our hearts. Hold the Red Flag high! Don't stop until we have won the battle.[11]

The other notes consist of summaries or extracts of Mao's writings, as if the glaciologist were trying to master his thoughts. He did not work on glaciology at all at that time. It may be mentioned that, according to Professor Shi's recollection (Shi Yafeng, pers. comm.), during the Cultural Revolution he was expected to 'ask for instruction from Mao every morning' and 'report to Mao every evening'. One day in 1968, he was reminded that he had forgotten to 'report to Mao' and said: 'Oh!

Fig. 5. Studying or reciting the works of Mao. *Source*: http://101098.yi.org/tp40htm.

Fig. 6. Notebooks on Mao's work, compiled by Shi Yafeng during the Cultural Revolution. Photograph by Zhang Jiuchen.

I forgot to pray'. Because of this, he met with much trouble and inhumane treatment, to the extent that he attempted to commit suicide by jumping into the Yellow River. In the event he was saved, but the experience is telling.

(3) People who rejected or opposed Mao's ideas were banished, an action analogous to excommunication in Roman Catholicism. Many intellectuals had to endure 'public criticism meetings' (see Fig. 7) and were beaten by the 'Red Guards'. A number of them committed suicide.

(4) Mao's influence and reputation and his military successes helped him win the trust and respect of the Chinese people. Such prestige made him powerful in attracting support, and this played an important role in instilling in the Chinese academic world the idea that 'science must serve production'. This concept was unlike any other kind of religion that we know (except perhaps the belief system of the early Soviet era). However, priests in many religions have performed rituals to beg for good harvests or sufficient rain; that is, they were concerned with practical as well as spiritual matters. On the other hand, they relied on supernatural influence rather than down-to-earth science. Mao's red and expert science was clearly naturalistic.

Fig. 7. A 'disgrace meeting'. *Source*: http://www.miancheng.com/Article_Print.asp?ArticleID=1980). (This site shows photographs of a number of other unpleasant events that occurred during the Cultural Revolution.) It is interesting that the long pointed hats of those being disgraced were similar in shape to those that people were forced to wear during the time of the Spanish Inquisition; and also, of course, dunces' hats. However, we have no means of telling whether the similarity was more than coincidental. The names of the disgraced people have been crossed out on the placards, making them 'non-persons'. The characters at the top of each placard read: 'Anti-Communist'.

Discussion

In an era that was officially one of atheism and non-religion, the 'worship' of Mao produced a common belief system and gave cohesion to Chinese society. The power of Mao (political, military and psychological) and his thoughts also induced many Chinese scientists to accept his ideas and the principles of 'redness'. Also, as has been shown, this vague principle had a profound impact on scientific research at that time, even in an out-of-the-way field such as glaciology.

However, we suggest, it is better to regard Maoism as a 'civil religion' rather than a 'revealed religion'. In writings on the sociology of religion, a civil religion is the folk religion of a nation or a political culture; for example, Shintoism in Japan (which has animist roots), according to which the Emperor was regarded as a deity until the end of the Second World War. In China before Mao's period (i.e. before 1949), many people were Buddhists, although there were also some Christians and Muslims, but for the most part, the Chinese people did not follow such organized religions. Ancestor worship prevailed, especially in the rural regions. Students had to study and follow the ethical teachings of the philosopher Confucius (who was reviled during the Mao period). There were also traditional Taoist beliefs, with animist–shamanist–polytheistic roots and belief in mythical entities such as dragons, which proferred a 'way of living' and practice, without formal worship. Thus religious beliefs and practices were multiform up to the time of Mao, and lacked the notion of a singular transcendental being found in the monotheistic religions. During Mao's period, however, most forms of worship ceased, to be replaced by the dominance of 'the Party' and Mao's ideas (as expressed, for example, in the *Little Red Book*). Subsequently, the older forms of religion have revived, as has Confucianism.

Besides animist forms of civil religion, such as Shintoism or Taoism, there is also a political kind, which may involve such activities as crowds singing the national anthem at public gatherings, parades or displays of the national flag on patriotic holidays, oaths of allegiance to a country, retelling of mythologized tales of founding fathers or great leaders or events, monuments commemorating great leaders of the past or historical events, monuments to dead soldiers or annual ceremonies to remember them, expressions of reverence for a country or its leader, and public display of the coffin of a deceased political leader.

The US version of civil religion, which has been described by Bellah (1967) as an institutionalized collection of sacred beliefs about the USA, involves, among many other things, a veneration of the nation, its constitution, its founding fathers and its flag. For example, the flag is routinely saluted in US schools. With the founding of the USA, 'under God', such a form of religion emerged at a time after a constitutional separation of Church and State had been made, as had occurred in Republican France (although the US founding fathers wanted to give expression to their theism.) US politicians routinely use the expression 'God bless America'.

It would appear, then, that Maoist China was a country with a 'civil religion'; although it was not one that invoked a transcendent God, as is done in the USA today. Given time, and the successful implementation of his policies, Mao might eventually have been deified, but in the event this did not happen. His economic system proved to be unviable and Maoist doctrine rapidly declined after his death,[12] so it seems unlikely that he will ever be the basis of any permanent kind of religion (although Maoist groups have been politically active in Nepal in recent years). He was never regarded as an incarnation of a transcendent being (although he was remote from the majority of the population). After his death, China moved fairly rapidly towards a more popular 'religion': 'consumerism'. Also, Buddhism and other religions (Christianity, Islam, etc.) have revived. Therefore we do not anticipate that Mao will become a spiritual guide, lasting through the ages, like the Buddha. Chinese people no longer read the *Little Red Book*, and when they did so there was a substantial element of coercion.

It is possible that Mao would like to have had the lasting influence of a religious figure. In any case, his influence on world history has been immense. A few people in remote areas of China continue to worship Mao at their family altars, pray to him for peace, prosperity and safety, burn incense, and kowtow to images of him. However, today this is rare. A few years ago, taxi drivers in Beijing had portraits of him in their taxis, perhaps in the hope that they would not have an accident; but more likely it was just a passing fashion and this phenomenon has now largely disappeared. Mao himself probably approved of his being an object of the 'cult of personality'. However, his influence was more in the direction of nationalism than spirituality, despite the moral content of his political ideas and the manner in which they were transmitted to people, which had some analogy with the transmission of religious beliefs. In conclusion, we may say that Maoism involved a form of politics that had religious overtones. But that is nothing new in human history.

We are indebted to Shi Yafeng (academician of the Chinese Academy of Sciences) for sharing his memories of his career as a glaciologist with us and for allowing some of his old notebooks to be photographed. Comments by M. Kölbl-Ebert, P. Barbaro and G. Vai have been gratefully received and we have endeavoured to implement their suggestions.

Notes

[1]In this paper, the family names of Chinese people are given first.

[2]Some dictionaries give 'red and expert' (*you hong you zhuan*) as a new (single) idiomatic word.

[3]The Qilian Mountains extend along the northeastern fringe of the Qinghai–Tibet Plateau, with an average elevation of 4000 m. The main peak, Qilianshan, rises to 5547 m above sea level.

[4]Before World War II, his *Geology of China* (Lee 1939) had made him a well-known figure in the west. He was also called James S. Lee or Jonquei Su-Kwang Lee.

[5]At the time, each institute of the Chinese Academy of Sciences had a Communist Party branch secretary who had a great power in the institute and decided the ranking. They were mostly ex-army men, not scientists, and had more power than the scientists.

[6]It was called a 'cultural revolution' (*wen hua da ge ming*) to distinguish it from the economic revolutions envisaged in Marxist theory. It was intended that the whole of Chinese society, or 'culture', was to be radically changed by the Cultural Revolution.

[7]Archives of the Chinese Academy of Sciences: Z386-71.

[8]These were not real schools. Academics had to go to the countryside to eat, live, and work with the peasants.

[9]In China at that time, it was called *Hong Bao Shu*, which literally means Red Precious Book. There were many editions of Mao's works, but in this paper references are made to the English translation (Mao 1966). We are informed that the work is called the *Mao Bible* in Germany (M. Kölbl-Ebert, pers. comm.), which indicates that others have seen a parallelism between Maoism and a form of religion.

[10]The earlier part of the curriculum did, of course, encompass reading and writing, and also mathematics, but people who were at school during that period have told us that they learned virtually nothing other than Mao's thoughts, and mathematics, during their early teens.

[11]One is vividly reminded of the popular British 19th-century hymn of 'muscular Christianity', Onward Christian Soldiers! (words by S. Baring-Gould (1864); music by Sullivan (1871)), which clearly linked Christianity and nationalism.

[12]However, his embalmed body has been preserved and can be visited today in his memorial at Tiananmen Square in Beijing (like Ho Chi Minh's body in Hanoi). This suggests a desire to preserve a semi-sacred object that still commands respect.

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Adam Sedgwick (1785–1873): geologist and evangelical

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Abstract: Adam Sedgwick (1785–1873) was one of the leading British geologists, who did much work on the Lower Palaeozoic stratigraphy. He was professor of geology at Cambridge and was an Anglican clergyman, later becoming Prebendary (Canon) of Peterborough. This paper considers his religious beliefs in relation to his geology, which, as he was an evangelical, centres on his and other people's interpretations of Genesis. Although he did not publish anything on Genesis, his understanding becomes clear from three interactions with fellow Anglican clergy. Two were acrimonious, one being with Henry Cole after the publication of *The Discourse* in 1833, and the other his controversy with Dean Cockburn of York at the British Association meeting in York in 1844. The third was his friendly correspondence with the evangelical Dean of Carlisle, Francis Close. This letter gave the longest statement of his 'reconciliation' of geology and Genesis.

Adam Sedgwick (1785–1873) (Fig. 1) was one of the leading early 19th century geologists in Britain. For nearly half a century after becoming Woodwardian Professor of Geology at Cambridge in 1818, he was at the forefront of geological research and made some of the greatest contributions to elucidating the Lower Palaeozoic stratigraphy. There has not been a recent full-scale study of his work as a geologist, although Secord (1985) and Rudwick (1985) have considered his and other geologists' work on the Welsh Palaeozoic and Devonian strata, respectively. However, my present concern is not so much Sedgwick as a geologist *per se*, but Sedgwick as a geologist and evangelical Anglican clergyman, and how his faith impinged on his science and vice versa.[1]

Sedgwick was born in Dent in the Yorkshire Dales near Sedbergh. His father was vicar of Dent and the living passed from father to son from 1768 to 1885. He was schooled first in Dent, then at Sedbergh School, and went to Trinity College, Cambridge in 1804, graduating as a Senior Wrangler in mathematics. He remained at Trinity for the rest of his life, initially tutoring mathematics and becoming a Fellow in mathematics in 1810. After he was ordained in 1817, his future seemed settled; unless he had found a wife, which would have enforced his resignation and the taking up of a living.

However, Sedgwick never found a wife and remained a lifelong bachelor, but in 1818 the post of Woodwardian Professor of Geology became vacant as John Hailstone did find a wife at the age of 58 after several dalliances and was obliged to resign. An election ensued and there were two candidates, Adam Sedgwick and Charles Cornelius Gorham of Queen's College, who later achieved notoriety by falling out with the Bishop of Exeter over baptism in 1847, in an event known as the Gorham controversy (Chadwick 1971, Vol. 1, pp. 250–270). Both candidates were evangelical clergy, although Gorham, the more conservative of the two, had the backing of most evangelicals in Cambridge, including Isaac Milner and Charles Simeon. Neither candidate had any doubt that the Earth was ancient and did not consider Genesis as literal truth as far as the age of the Earth was concerned. In this they reflected the views of most educated Anglicans and also evangelicals in both the Church of England and the Presbyterian Church of Scotland. At the time of the election Gorham clearly knew more geology than Sedgwick but at present nothing is known of his geology beyond his acceptance of an ancient Earth.

In the election Sedgwick received 186 votes compared with Gorham's 59 and after that Sedgwick took up geology with a vengeance. He gave lecture courses each term, and spent every summer in the field throughout England and Wales for the next 40 years. In the 1820s he worked in the north of England but his most important work was in Wales beginning in 1831. That year he spent from August to October in North Wales working out the geological succession below the Old Red Sandstone or Devonian. He began in the Shrewsbury area in August with the young Charles Darwin, who later left Sedgwick on 20 August near Bangor to return home for the shooting season, but joined the *Beagle* instead. Sedgwick gave Darwin a superb grounding in geology, which he used to great effect on the *Beagle* voyage (Roberts 2001).

Sedgwick failed to work down the geological succession, as in North Wales the Devonian is present only in Anglesey. Thus he had to start in

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Fig. 1. Adam Sedgwick (1785–1873).

older rocks and try to link them to the Old Red Sandstone. He covered vast distances on foot and climbed most of the mountains of Snowdonia.[2] In 2 months Sedgwick had worked out the basic stratigraphy and structure of a complex area. In the same year Roderick Murchison (1792–1871) travelled through South Wales looking for what lay below the Old Red Sandstone. He was lucky, as near Ludlow, the Silurian (using today's terminology) lies conformably beneath the Old Red Sandstone (Devonian). Also, an evangelical vicar aided him: the Reverend Thomas Lewis (1801–1858), who had learnt geology from Sedgwick, had worked out the succession in his parish of Aymestry (Secord 1985, pp. 55–56). From 1836 to 1847, several geologists including Sedgwick worked in Devon and Cornwall to elucidate the age of various strata. Rudwick has charted comprehensively their work and Sedgwick's vital role (Rudwick 1985). Although Sedgwick was not a prolific writer, he was one of the main geologists who worked out the Lower Palaeozoic stratigraphy from the Cambrian to the Devonian. Yet he was a convinced evangelical. From a 21st century perspective with creationist controversies occurring in many countries, this may seem rather unlikely. However, this may depend on one's perception and definition of an evangelical. Bebbington has given one of the best historical treatments of British evangelicals (Bebbington 1989) and my definition (Roberts 2009, note 2) is based on his.

Concerns of evangelicals

In Britain and the USA evangelicals were the strongest part of the Protestant churches in the early 19th century (Bebbington 1989; Wolffe 2006), including Church of England. It is easy to 'read back' contemporary understandings of evangelicals in relation to science into the 19th century but that does evangelicals an injustice. Although they were conservative Protestants who put great emphasis on the authority of the Bible, they not were literalist in regard to Genesis and geology, although many claimed to be 'literalist' in the sense of accepting the plain meaning of the Bible. Some were literalist in regard to Genesis, but these were a declining proportion through the century. In this paper I use 'literalist' in regard to the interpretation of Genesis, rather than the whole Bible. This is not an ideal term, as someone like Sedgwick would be literalist on the Gospels but not Genesis. Most educated Christians, whether Anglican or not, accepted modern science, especially geology (Roberts 1998, 2008), although a few opposed 'old-Earth' geology on theological grounds.

The conventional picture of science and religion during this period is that there was conflict with the new science of geology, but that does not do justice to the numbers of clerical geologists. The conflict thesis of science and religion tends to colour many historians' perspectives (Brooke 1991) and thus it is often assumed that evangelicals had to be literalists. The corollary of that is that if a Christian accepted science and particularly geology then they were thus 'liberal' rather than evangelical. This was the argument of Cannon (1978) in an article entitled 'Scientists and Broad churchmen: An early intellectual network'. She posited a network of 'liberal' scholars at Cambridge and Oxford, whose liberal perspective enabled them to embrace the implications of geological science. In *Gentlemen of Science*, Morrell & Thackray (1981, pp. 225–229) argued that liberal Anglicans dominated the fledgling British Association for the Advancement of Science, yet they overlooked the fact that Sedgwick was an evangelical. Use of the term 'liberal' for certain Christians requires caution. In contrast to more conservative Christians, whether evangelical or Catholic (in the Roman or Anglo-Catholic form), liberals are more questioning of many aspects of theology, especially miracles, the nature of the atonement and the authority of the Bible. Later in the 19th century, they were more inclined to take a radical critical view of the Bible, regarding Genesis as myth and the Old Testament as unreliable history. However, to make the rejection of a 'literal Genesis' and a 6 day creation the mark of a liberal results in the error of having to classify the many evangelicals, such as Sedgwick and Thomas Chalmers, who accepted geological time as 'liberal'. Chalmers was the leading Scottish evangelical, who did much to give the Victorian church there its evangelical flavour (Bebbington 1989, *passim*). At Oxford and Cambridge there was a broad tradition of intellectual endeavour that could be termed liberal, but not in the radical sense outlined above. Some, such as Hare at Cambridge and Baden Powell (1796–1860) at Oxford, were antecedents of the liberal Anglicanism associated with *Essays and Reviews* (Anonymous 1860), a work of English liberal theology, but others were not. Baden Powell was notorious for denying the miraculous, which was uncommon in that period. The Oriel Noetics of Oriel College, Oxford (Edward Copleston (1776–1849), Richard Whateley (1787–1863) and others) were mildly liberal. Sedgwick's Oxford counterpart William Buckland (1784–1856) received much support from J. B. Sumner (1780–1862) and G. S. Faber (1773–1854), both leading evangelical theologians of his day, and from Bishop Barrington (1734–1826) of Durham, an evangelical sympathizer. These examples undermine the simple liberal–evangelical divide, which is based on the supposition that liberals accept the findings of science and evangelicals do not. Of the four leading Anglican clerical geologists, Henslow, Buckland, Conybeare and Sedgwick, none were liberal in the sense of a radical questioning or rejection of the miraculous, the atonement or biblical authority. Buckland and Conybeare, who both became deans of cathedrals, were on the liberal, or moderate, fringe of evangelicalism and only Sedgwick was clearly evangelical.

Sedgwick as churchman

Before we consider the religious beliefs and theology of Sedgwick and how they impinged on his science, we need to consider Adam Sedgwick as a churchman and cleric, and how he was situated in the Church of England. Sedgwick was very much part of the Anglican establishment, both at Cambridge and in the wider church. He was evangelical but had nothing to do with conservative Evangelicals or Recordites (Hilton 1988, pp. 10–11).

His career at Cambridge shows him to have been a don who was very much in the mainstream of the Church of England and that his clerical life was run in parallel with his geological work. He was never a profound theological thinker, but on political issues he often showed an independent mind. In 1829 he opposed the university petition against Catholic emancipation, and in 1834 he chaired a meeting to abolish religious tests (i.e. acceptance of the Anglican 39 Articles) to proceed to a degree.[3] This condition did not change until 1871, when Gladstone, a staunch high Anglican, was Prime Minister. In 1834 Sedgwick was made Prebendary of Norwich, which both enhanced his income and required him to be canon in residence each year. However, he seems to have enjoyed this, particularly when he could preach on St Paul and his letters. A few years later his name was suggested as the new Bishop of Norwich and in 1853 he turned down the Deanery of Peterborough (Clark & Hughes 1890, Vol. I, 336, 432, 485; Vol. II, 248).

Sedgwick was a Low Churchman and was strongly critical when one of the leaders of the Oxford Movement, John Henry Newman, left the Church of England to become a Roman Catholic priest in 1845. To him the Anglican *Book of Common Prayer* formed the basis of his churchmanship, and his correspondence with Canon Wodehouse shows that he would have liked a modification of this book in a Protestant direction, thus going against the Anglo-Catholic trend of his day. He was no 'party man' as were some evangelicals, and he mixed widely in the church, becoming friends with both Bishop Stanley, who became Bishop of Norwich in 1837 and his son A. P. Stanley, a liberal Anglican (Clark & Hughes 1890, Vol. I, 485; II 399). In contrast to that he was also friendly with the strongly evangelical Dean Francis Close of Carlisle, with whom he corresponded on personal matters as well as the interpretation of Genesis 1. Surprisingly, Clark & Hughes made no mention of this friendship in their biography. In 1843 John Salter, a young palaeontologist with aggressive evangelical views, accompanied him on his summer field-trip to North Wales, and on Sundays they often studied their Polyglot Bibles together in English and Greek.

This brief portrait of Sedgwick shows a diligent clergyman who combined his dual calling as don and cathedral canon. He was an evangelical but not narrowly so, and was very much an accepted member of the Church of England; in fact, a good churchman. In this period about a third of Anglican clergy were evangelical, including archbishops, bishops and deans. Having situated Sedgwick in the Church of England we shall now consider his understanding of theology and science.

Sedgwick on theology and science

Sedgwick was not a theological innovator and was not involved with Liberal Anglican restatements of faith such as *Essays and Reviews* (Anonymous 1860). He felt little need to modernize traditional Anglican teaching. His theology was scripturally based but, unlike Conybeare, did not take much notice of the German biblical critics. His theology was somewhat unreflective, but still deep and sincere, as he seemed to have been a Christian free of doubt and questioning, in marked contrast to more progressive Christian thinkers.

That raises several questions, the first being, 'What effect did his faith have on his science?' There is no evidence that he had a crisis of faith over science nor any conflict between geology and Christianity. Some of his perspectives changed: he was a catastrophist until 1831, when he partially adopted uniformitarianism. Details on how Sedgwick understood both catastrophism and uniformitarianism are not relevant to this paper, as from 1820 at the latest Sedgwick was convinced of the vastness of geological time (of the order of millions of years if not more). In the early 1820s, like most British geologists, he believed the biblical Flood to be a worldwide event, which had deposited sediments known as diluvium, hence diluvialists. (These sediments are now considered to be glacial deposits.)

Sedgwick on geology and Genesis

When Sedgwick was made Professor, most educated Christians had made their peace with geology, if, of course, they were ever at war. There was minimal opposition to geological time from 1780 to 1810 (Roberts 1998, 2007; Rudwick 2004), possibly because many were unaware of new ideas of geological time, and many adopted either a day–age interpretation, according to which the days of Genesis were very long periods of time, or the chaos–restitution interpretation, which, like Haydn's *The Creation*, posited that God first created the chaos of indefinite duration (Genesis 1:2) and then re-ordered the whole of creation in 6 days to be 'a new created world', which was developed by Chalmers, Townsend (1813), Faber (1823) and Sumner (1833) from older interpretations (Roberts 2007). Some biblical commentators, such as the evangelical Thomas Scott (1788–1792), Sedgwick's Cambridge colleague Charles Simeon in the 1790s and Francis Close in 1826, simply made no reference to geology. However, their apparent literalism may be indifference or a pietistic emphasis, rather than hostility to geology. The treatments of Genesis in relation to geology by Buckland in *Vindiciae geologicae* (1820) and Conybeare in the *Outlines* (Conybeare & Phillips 1822) are seen far better as mainstream Anglican thinking than as an attempt to push the boundaries of biblical interpretation in a liberal direction. However, despite both making a strong case that their accommodation to geological time was well grounded in scripture and tradition, both were slightly defensive.

Even so, interpretations of Genesis were not static, and had gradually changed from the end of the 16th century, when most commentators assumed an age of the Earth of some 6000 years. Widely held 'old-Earth' views such as those of Chalmers ascribed a strong historical component to Genesis, but by mid-century more figurative, or even mythological views were becoming increasingly common. Within the Anglican Church biblical literalism virtually disappeared from publications after 1855, only to reappear in the late 20th century with young-Earth creationism being adopted by numbers of Anglican clergy. Sedgwick was active in geology for half a century from 1818, during which time, at least among the educated, biblical literalism on Genesis almost disappeared and the biblical Flood was no longer considered to be world-wide but only local in its extent. Much of this theological 'readjustment' caused little religious angst and friction, but the spate of 'anti-geologies' that began in 1818, led by ecclesiastical conservatives, evangelicals and several lay Christians, caused some controversy. Initially, these were eirenic, as was Thomas Gisborne's *The Testimony of Natural Theology to Christianity* (1818), which in contrast to Paley's *Natural Theology* (1802 reprinted 2008), presented a natural theology based on a literal 6 day creation with an implicit rejection of geology. However, some years later these turned to virulent attacks by George Bugg (1769–1851), writing first in the *Christian Observer* and then in his two-volume work *Scriptural Geology* (Bugg 1826–1827), and then by Henry Cole (1792?–1858) and Dean Cockburn of York (1774–1858), who focused on Sedgwick and Buckland.

The days of Genesis

A brief study of Sedgwick's letters, writings and life (Clark & Hughes 1890) demonstrates that he was not troubled by supposed geological challenges to his evangelical faith. Sedgwick does not seem to have published anything on the relation of geology to Genesis. Throughout his tenure of the Woodwardian professorship there is no doubt that he accepted an ancient Earth and thus a 'stretched view' of Genesis 1. He was very ample in his view of geological time and, according to John Rodwell in reminiscences to Francis Darwin in 1882, Darwin said of him in 1831, 'What a capital hand is Sedgwick for drawing large cheques on the Bank of Time' (Burkhardt & Smith 1985, p. 125). If Sedgwick accepted either of the two common interpretations of that time, the chaos–restitution or day–age, he would have no problem in reconciling vast geological time with a conservative view of the Bible.

A survey of contemporary theological writings shows that chaos–restitution was the most widespread 'reconciliation' of geology and Genesis in the period 1810–1850 and that the biblically literalist anti-geologists, such as Cockburn, George Fairholme (1789–1846) and Robert Fitzroy (1805–1865; the captain of the *Beagle*), were in the minority, even among evangelicals (Roberts 1998, pp. 247–250). It is easy to regard the chaos–restitution interpretation of Genesis as special pleading, but it was widely held until mid-century. It was a development of long-held interpretations of Genesis (Roberts 2002, 2007). Hugh Miller (1802–1856) questioned it in a footnote in *Footprints of the Creator* (Miller 1849, p. 332), his anti-evolutionary critique of the *Vestiges* (Chambers 1844) in 1847. This he expanded in *The Testimony of the Rocks*, published posthumously (Miller 1857), both in the Preface and in two chapters on Genesis and geology. He explained why he felt it necessary to reject Chalmers' gap theory, which had been widely held for 50 years in favour of his concept of 'The Mosaic Vision of Creation'. In the Preface, Miller spelled out the geological reasoning behind this change. He wrote, 'I certainly did once believe with Chalmers and with Buckland that the six days were simply natural days of twenty-four hours each . . . and that the latest of the geologic ages were separated by a great chaotic gap from our own' (Miller 1857, pp. x–xi). This was reasonable to catastrophists, who believed that each geological era was ended by a catastrophe. Miller explained that there was no problem with 'the Palaeozoic and Secondary rocks', but there was with recent strata. He continued, 'During the last nine years [written *c*. 1856], however I have spent a few weeks every autumn in exploring the later formations'. From his study of the Pleistocene, he concluded that many of our 'humbler contemporaries', especially molluscs, existed long before man. Thus 'No blank chaotic gap of death and darkness separated the creation to which man belongs from that of the old extinct elephant . . . and hyaena, or for familiar animals . . . [that] lived throughout the period which connected their times with our own' (Miller 1857). As a result Miller rejected the whole idea of chaos then restitution, and adopted the view of six prophetic days of creation. Chalmers' ideas were more congenial to catastrophism than to uniformitarian geology, with its seamless geological development through time.

Within a few years the Reverend Gilbert Rorison was arguing for a totally poetical interpretation of Genesis in Wilberforce's very conservative *Answers to Essays and Reviews* (Wilberforce 1861, pp. 281–286) and the chaos–restitution interpretation rapidly went out of fashion, except for nascent fundamentalists.

Unlike Conybeare, Buckland and others, Sedgwick never seems to have written at any length on his understanding of Genesis 1. The little we have consists of comments in his *Discourse*, and two letters, one written at the height of his controversy with Dean Cockburn and the other in 1858 to Francis Close (1797–1882). These few writings show that Sedgwick was not convinced by any contemporary interpretations but had no problem either with Genesis or geology. He thought there were many irresolvable problems and seemed to keep the two in separate compartments.

In his 2 hour sermon in Trinity College Chapel on 17 December 1832, later published as a *Discourse on the Studies of the University* (Sedgwick 1969) he made scant reference to the Bible or geology. However, in Note F, along with a tirade against the anti-geologists, he gave a summary of his belief in the Bible and its relation to science in two pages (Sedgwick 1969, pp. 104–105). His position is clear: 'But if the Bible be a rule of life and faith—a record of our moral destinies—it is not (I repeat), nor does it pretend to be, a revelation of natural science' (Sedgwick 1969, p. 104).

This may sound like Stephen Gould's NOMA ('non-overlapping magisteria') (Gould 1999), where by science and religion are kept totally separate, but Sedgwick took the historicity of the Bible for granted. He explained how the Bible depends on both internal and external evidence, but science does not, as 'it is based on experiment alone'. He criticized those who looked for evidence of science in the Bible, as 'They [the writings of Scripture] were addressed to the heart and understanding, in popular forms of speech.' Thus God is 'capable of jealousy, love, anger', but this is not literal. Sedgwick extended this to descriptions of the natural world, citing the (alleged) 'fulminations of the Vatican against those who . . . maintained the motion of the earth'. And so he moved to geology, which speaks of 'vast intervals of time, during which man . . . had not been called into being'. In other words, geological time is biblically and theologically irrelevant, as 'Periods such as these belong not, therefore, to the moral history of our race; and come neither within the letter nor the spirit of revelation' (Sedgwick 1969, p. 105). This contrasts with the concordist interpretations of Genesis that were so popular at that time, such as those by Buckland, Chalmers, Sumner and a plethora of less well-informed clerics, who wished to prove that geological science was in concord with their own biblical interpretation. Sedgwick found concord by keeping the two separate, and here he went against the grain of most orthodox thinking in Britain, yet was evangelical when he preached.

After a tirade against the anti-geologists, which we shall consider below, he then gently criticized concordists: 'Another indiscretion (far different from the egregious follies I have just noticed) has been committed by some excellent Christian writers on the subject of geology. . . . they have prematurely . . . endeavoured to bring the natural history of the earth into a literal accordance with the book of Genesis' (Sedgwick 1969, pp. 107–108), and extending the length of the Genesis days, Sedgwick continued: 'The impossibility of the task was however (as I know by own experience) a lesson hard to learn; but it is not likely to be attempted by any good geologist.' From this we can conclude that in earlier years Sedgwick had followed some concordist approach, either day–age or chaos–restitution, but realized that this could not work and thus preferred some kind of separation, as outlined above. As for no attempts by 'good geologists' his prophecy was wrong. His friend Buckland continued to do so, as did Miller (1857) and the US geologists Silliman, Hitchcock and Dana (Davis 2003, pp. 34–58).

In 1844 Sedgwick became embroiled in controversy with the Dean of York, which will be discussed below. According to Clark & Hughes, 'Soon afterwards he wrote a long letter to an unknown friend, who felt doubts and difficulties'. Sedgwick wrote:

The first two verses . . . are an exordium, declaring God the Creator of all material things . . . After the first verse there is a pause of vast and unknown length, and here I would place the periods of our old formations, not revealed because out of the scope of revelation. . . . After the word 'deep' there is a pause. The work of actual present creation begins. The spirit of God broods over the dead matter of the world, and in six figurative days brings it into its perfect fashion and fills it with human beings (Clark & Hughes 1890, p. 79).

There is nothing novel in this, as it is similar to various interpretations put forward over the previous 200 years and shows some similarity to those of Whiston (1696), Buffon (Buffon 1778), de Luc and Townsend. However, he has broken with the theory put forward by Chalmers and Sumner, which considered the 'restitution' to take place in six solar days. It is an indication that the ideas of Chalmers were beginning to break down and, as we saw, Miller had a part to play. It is a pity that Clark & Hughes did not flesh out this letter so that it could be put into context. Despite the fulminations of the Dean of York, on this matter Sedgwick was traditionally orthodox and could have claimed many precursors from at least the previous two centuries.

Ten years later Sedgwick's conservative theology became apparent when he raised serious doubts about Hugh Miller's revelatory day theory of Genesis in a letter to his friend Dean Francis Close of Carlisle in 1858. One of the first to expound Miller's ideas on 'the Mosaic Vision of Creation' was Close, who gave a lecture to the Young Men's Christian Association (YMCA) in London in 1858 (Close 1859) and made extensive use of Miller's book. Close was a leading evangelical and was Dean of Carlisle from 1856 (Munden 1997, p. 49). He was not universally liked and was often regarded as an extreme evangelical, and while at Cheltenham was known as the Pope of Cheltenham. In the 1820s, while at Cheltenham, he preached on early Genesis, but took Genesis literally and ignored geology (Close 1826). He cannot be strictly considered an anti-geologist at that time, as he made no mention of any geological findings and appears simply to have assumed that Genesis should be read literally. In this, he seems to resemble Thomas Scott and Charles Simeon, two leading evangelical commentators of a preceding generation, who simply made no reference to science and sought to explain its spiritual message. Within 30 years he moved to the scientifically informed non-literalism of his YMCA lecture.

Close took considerable interest in education and while at Cheltenham founded two schools and a teachers' college, which is now part of the University of Gloucester. For this reason Villiers, the new Bishop of Carlisle, asked Palmerston to appoint him as Dean. Hennell described Close's activities as Dean as a continuation of his work at Cheltenham, with a night school for adults, a Bible class for men, and lectures on scientific subjects. On the last Hennell wrote, 'He tended to favour the "Genesis and Geology" type of theme, with emphasis on the literal truth of Genesis' (Hennell 1979, p. 120). Nothing could be further from the truth, and Hennell has simply perpetuated the unsubstantiated contention that evangelicals must be literalist.

Hennell did not provide any references to these scientific lectures, but Close gave one such lecture to the YMCA at Exeter Hall in London in either December 1857 or January 1858. Exeter Hall was built as an evangelical meeting place near Westminster Abbey in 1831, and was used by evangelicals of all shades. It was the location for the annual 'Lectures delivered before the Young Men's Christian Association'. These probably started in 1844 and Dean Francis Close gave a lecture entitled 'Hugh Miller's "Testimony of the Rocks"—God in his Word and in his Works'. In this lecture Close was true to form in his mode of preaching, as the introduction to the published lecture stated that, 'The following lecture was spoken extempore and taken down by reporters. . . . The Lecturer is aware that this course has betrayed him into a colloquial style' (Shipton 1858, p. 240).

Close's style was sermon-like and patronizing in a typically Victorian way when teaching young men of a lower class. As well as enthusing about geology, Close was critical of some scientists for their hostility to Christianity and of Baden Powell, who has been mentioned previously for his liberal theology, for regarding the 'Mosaic Cosmogony' as contrary to science. Baden Powell was also criticized for holding 'the doctrine of progressive creation . . . till monkeys become men, and so on'. This was before Darwin's Linnaean Society paper of the same year. Close made the distinction of God's two 'books', the word of God and the works of God. To emphasize the harmony between science and Christianity Close referred to his attendance of the British Association at Cheltenham when he 'went from class to class'.

Before he discussed Miller's ideas, Close gave a survey of the succession in the geological column, which was remarkable if given extempore by an amateur. The theological heart of Close's address was his comparison of Genesis and geology and his discussion of Miller's *Testimony of the Rocks* and McCausland's *Sermons in Stones.* McCausland (1806–1873) was a distinguished lawyer, who graduated from Trinity College, Dublin, and who, according to the Dictionary of National Biography, 'published religious works, the most popular being *Sermons in Stone* first published in 1856'. *Sermons in Stones* is fairly well-informed in geology and totally opposed to evolution. McCausland favoured a long-day interpretation and looked to Whiston, 'Des Cartes' and de Luc for support (McCausland 1865, p. 127).

Close based the argument of his lecture on these two writers and concluded 'it is hard to conceive that it can be otherwise than the true one' (Shipton 1858, p. 259). He regarded McCausland as improving on Miller's sweeping vision and had reservations on Miller, 'I exceedingly regret that our friend Hugh Miller has . . . indulged in some very mythical imaginations' (Shipton 1858, p. 265).

It is not possible to work out the exact context of Sedgwick's letter to Close, but it is clearly Sedgwick's response to the printed version of Close's lecture to the YMCA, rather than the collected lectures, which has a preface dated 31 March 1858. Presumably Close had sent a copy of the lecture to Sedgwick, who replied fairly promptly. Unfortunately, the letter is probably a handwritten copy of the original and omits some personal details at the end of the first paragraph that are not directly relevant to the lecture. Sedgwick began by complaining about his health and wrote that gout was giving him sleepless nights. This was typical for Sedgwick, as he was always ill in Cambridge but revived in the mountains. He was a frequent correspondent with the Close family and was especially fond of Anna Diana Ackworth, Close's daughter, to whom he wrote often.

The main thrust of Sedgwick's letter is that he picked up Close's comments that Miller had 'indulged in some very mythical imaginations' (Shipton 1858, p. 265) and voiced his own concerns that Miller's interpretation of Genesis might do some harm, as his over-schematic approach was geologically wrong. Sedgwick wrote:

Hugh Miller was a man of *great natural genius*, + in some parts of geology, admirably well informed, but it is not always safe to follow him, when he travels beyond his own beat—His 'Testimony of the Rocks' is in its way a noble work—it may do much good, but it *may do some harm* +.

He also wrote:

I make no difficulty in the words *Morning* + *Evening*, they are only I think meant to mark the beginning + end of periods or days,—the Mosaic day is assuredly not 24 hours, + if we once admit a prophetic extended meaning of day, our souls are then free, + we are permitted to give any indefinite period, + the word day.

But then he wrote:

I do not like the scheme of stretching the Bible, like an elastic band, till we can wrap up our hypotheses in its sacred leaves (Sedgwick to Close, 27 March 1858).

This letter is of great significance as the leading evangelical geologist wrote it to another evangelical. Both had a high view of the Bible and both were more than convinced by geological findings. Both took Genesis 'non-literally' yet Sedgwick, cautious as usual, was reluctant 'of stretching the Bible, like an elastic band' and preferred to wait as this 'will end in harmony, + true accordance with the word of God' (Sedgwick to Close, 27 March 1858). Undoubtedly, Darwin and Goodwin in *Essays and Reviews* would have dismissed this stance, as both had a mythological view of Genesis, but it demonstrates the shift away from the 'chaos–restitution' interpretation. It also shows that Sedgwick had slowly changed his theological understandings of Genesis during his life, and never rejected them as revelation, even though he was emphatic that they did not contain any science.

Controversy with the anti-geologists

As we live in a world where creationism in its many forms gains popularity by the day, to the extent that recently the Council of Europe has made a statement against both creationism and intelligent design, we may imagine that it was as common in the early days of geology as today. It was not. To attempt to express it numerically, in my researches I found that about 15–20% (possibly an overestimate) of Church of England clergy, out of about 130 considered, accepted a 6 day creation between 1810 and 1855. Several of those, like Close, later rejected a young Earth. I have looked at several hundred clergy who touched on the subject of geological time from 1855 to 1970, and only one, Griffiths Thomas, writing in 1919, held to 6 days, but previously had accepted both geology and evolution.[4]

Before about 1815 most writers who held to a 6 day creation did not attack geological time and tended to discuss time in Genesis from a 'biblical' point of view, as did Simeon (1832) and Scott (1788–1792). Ironically, within a year of Sedgwick's election to the professorship, there was a spate of anti-geologies (or scriptural geologies) for the next 40 years, which died out in the 1850s. I am aware that most historians, whether Millhauser (1954) or Mortenson, who is an employee of 'Answers in *Genesis*', the leading young-Earth creationist (YEC) organization (Mortenson 2004), refer to flood geologists as 'scriptural geologists' but I prefer the term 'anti-geologist' used by Miller in *The Testimony of the Rocks* in his chapter 'The geology of the anti-geologists'. Miller as an evangelical was not going to let others claim the term scriptural. Anti-geologist is theologically neutral and focuses on attitudes to geology, not the Bible. This is brought out in Lynch's selection and introduction of *Creationism and Scriptural Geology, 1817–1857* (Lynch 2002, Vol. 1, pp. ix–xxiv). However, many of the 'anti-geologists' would not identify with the term, as they would claim to be in favour of geology but not old-Earth geology as has O'Connor argued (O'Connor 2007, p. 362).

The 'anti-geologists' reached their peak in the mid-1820s and annoyed uniformitarian and catastrophist alike. Their argument was that (old-Earth) geologists were mistaken and ungodly. Some had good scientific credentials outside geology, such as William Brande of the Royal Institution, John Murray, a chemist, and Andrew Ure (1778–1857) of Glasgow; others were evangelicals (e.g. Bugg, Nolan, Cole, Best, Mellor Brown and Young) and some were traditionalist clergy (e.g. Vernon Harcourt (brother of a co-founder of the British Association), Cockburn and Edward Nares). Despite their variety most anti-geologists had a common theme: the Earth was a few thousand years old and had been created in six 24-hour days, and the strata were laid down in the biblical Flood. Many emphasized that there was no death or suffering before the fall (Genesis 3) and thus no animals had lived for more than a few hours before Adam. This was to retain the centrality of the atonement, as Christians believe that death is the curse of sin. (Most orthodox Christians such as Sumner, Chalmers and Bishop Samuel Wilberforce did not consider that animal death before the fall affected the atonement.)

The importance of the 'anti-geologists' can be overstated as they attracted much attention, particularly in retrospect. The 'anti-geologists' were attacked most vigorously by other Christians, as was *A New System of Geology* by Ure (1829), which was scathingly reviewed anonymously in the *British Critic* of 1828. Lyell identified the reviewer, 'A bishop, Buckland ascertained (we suppose Sumner), gave Ure a dressing in the British Critic and Theological Review! They see at last the mischief and scandal brought on them by Mosaic systems' (Lyell 1881, Vol. 1, p. 268).

The evangelical anti-geologists 1817–1845

Many anti-geologists were evangelical clergy and laity. The first work that challenged geology was *The Testimony of Natural Theology to Christianity* (Gisborne 1818). Gisborne was a friend of William Wilberforce (father of Samuel) and the last patient to be treated by Erasmus Darwin in 1802. The book was peace-making, but objected to geology, because the existence of death in the animal world implicit in the existence of prehistoric life before Adam contradicts the view in the opening lines of *Paradise Lost*, which was often considered to reflect the true interpretation of Genesis 3:

Of man's first disobedience, and the fruit
Of that forbidden tree, whose mortal taste
Brought death into the world, and all our woe (John Milton, *Paradise Lost*, Book 1, lines 1–3).

The storm broke in the 1820s in the *Christian Observer*, and began with reviews of *A Treatise of the Three Dispensations* (Faber 1823); this was classic theology on the 'dispensations' of Abraham, Moses and Jesus Christ, but the third chapter 'Respecting the length of the six demi-urgic days' caused the problem. Here Faber summarized geological findings under the guidance of Buckland. George Bugg took great objection. Several years later Bugg wrote to the *Christian Observer* criticizing the editor S. C. Wilks for taking the 'side of modern geologists' and listed the five difficulties of the Bible versus geology, which were:

1) Geology claims that death was there before Adam sinned.
2) Geology denies the Six Days of Creation.
3) 'Scriptural Creation' is handed over to Geology.
4) Prevents missionary work among the Hindoos.
5) Removes the basis of the Sabbath (Bugg 1828).

A few years after Faber's work, Bugg published his magnum opus *Scriptural Geology* (Bugg 1826–1827), in two volumes, which was an answer to Buckland. Bugg claimed that 'whatever is contrary to that Bible must be false'. He started from the premise that the Mosaic narrative gave the general order of the strata with one physical revolution on the third day and that 'Christian Geologists are bound in honour and conscience to agree'. He continued with is a variety of theological argument, a rejection of contemporary geology, and a reinstatement of the biblical Flood as the source of all strata. Bugg's motivation was theological, as he was unable to accept animal death before the fall.

Frederick Nolan (1784–1864) was a notable Oxford divine of his day. In many ways his career parallels that of Faber. Both were leading evangelical theologians publishing prodigiously on evangelical beliefs. The pair made forays into geological science, Nolan rejecting it and Faber welcoming geological findings. In 1832 Nolan was elected to the Royal Society and in 1833 he gave the annual prestigious Bampton Lectures on theology at Oxford, published with the title *The Analogy of Revelation and Science established* (Nolan 1834). Nolan argued that the findings of geologists were mistaken and the Earth really was a few thousand years old. Buckland's anger was undisguised, as his wife Mary wrote to William Whewell on 12 May 1833:

> we have had the Bampton Lecturer holding forth in St Mary's against all modern science, ... Denouncing all who assert that the world was not made in 6 days as obstinate unbelievers, etc, etc, (Morrell & Thackray 1981, p. 234; 1984, p. 168).

Although Nolan's lectures were soon eclipsed by Keble's Assize Sermon on 11 July 1833, which marked the start of the Oxford Movement, they highlighted a rumbling problem within the churches. At that time geology was the science of the day with its strange extinct beasts and its vast timescale, with the present day 'towering o'er the wrecks of time'. There were other evangelicals who took up cudgels against geology during those two decades, but they passed the peak of their activity in about 1840 and thereafter dwindled. There are a variety of reasons for their decline. A major factor was simply increasing age; younger evangelicals were more open to geology, following on first from Chalmers and Faber, then Smith and Miller.

'Scientific' anti-geology

'Scientific' and anti-geology may seem to be an oxymoron, but some anti-geologists argued that their geology was more scientific than conventional geology. But was it? A frequent contributor to the *Christian Observer* during the 1820s and 1830s was George Fairholme (1789–1846), who signed himself as 'A Layman on Scriptural Geology'. Fairholme was a Scot and was probably educated at home rather than university. He wrote the *General View of the Geology of Scripture* (Fairholme 1833) and the *Mosaic Deluge* (Fairholme 1837). The preface of the latter discussed the theological results and scepticism caused by geology and especially the rejection of a universal deluge: 'there cannot be conceived a principle more pregnant with mischief to the simple reception of scripture'. Fairholme emphasized the universality of the Deluge: 'if false ... then has our Blessed Saviour himself aided in promoting the belief of that falsehood, by ... alluding both to the fact and the universality of its destructive consequences to mankind' (Fairholme 1837, p. 61).

In the *General View of the Geology of Scripture* (Fairholme 1833), he gave an appearance of geological competence by citing geological works. However, his geology does not bear comparison with that of major geological writers of his day. His lack of geological competence is best seen in his discussion of the relationship of coal to chalk. Fairholme wrote:

> the chalk formation is placed far above that of coal, apparently from no better reason, than that chalk usually presents an elevation on the upper surface, while coal must be looked for at various depths below the level of the ground (Fairholme 1833, p. 243).

He had previously discussed this (Fairholme 1833, pp. 207–210) and concluded, having misunderstood an article in the *Edinburgh Encyclopaedia*, that

> Nothing can be clearer than this account; and it appears certain, that, as in the case of the Paris Basin, this lime-stone formed the bed of the antediluvian sea, on which the diluvial deposits of coal, clay, ironstone, and free-stone, were alternately laid at the same period (Fairholme 1833, p. 209).

It is clear that Fairholme regarded Carboniferous Limestone and the Cretaceous chalk as the same formation, and he wrote that coal fields,

> lie among sandstones ... but have, in no instance, been found below chalk, which is one of the best defined secondary formations immediately preceding the Deluge.

Thus the Cretaceous strata were pre-Flood and the Coal Measures were deposited during the Flood. He continued,

> But during the awful event [the Deluge] we are now considering, all animated nature ceased to exist, and consequently, the floating bodies of the dead bodies must have been buoyed up until the *bladders burst*, by the force of the increasing air contained within them (Fairholme 1833, p. 257).

It is impossible to agree with Mortenson's assessment that 'By early nineteenth century standards, George Fairholme was quite competent to critically analyze old-earth geological theories' (Mortenson 2004, p. 130). Although Fairholme took it upon himself to criticize geology, he did so from sheer ignorance, as is evidenced by his claim that Chalk always underlies Coal. Fairholme, like all anti-geologists, attempted from his armchair to find fault with geology, but his 'scientific' objections were simply misunderstood geology. Then, as now, the advantage of writing such works is that the refutation of their absurd arguments is beyond the patience of rational people. The geological fraternity had very little respect for the anti-geologists and the response was frequently biting sarcasm, often led by Lyell.

Sedgwick was engaged in public controversy with anti-geologists on at least two occasions. The first occasion, in the early 1830s, he almost brought upon himself by some scathing remarks in an appendix to *A Discourse on the Studies of the University*, where he devoted several paragraphs to a devastating critique of anti-geologists. By the time Sedgwick completed the manuscript in November 1833, Oxford had witnessed Nolan's Bampton

Lectures. After he stressed that ‘Geology can neither lead to any false conclusions, nor offend against any religious truth’, Sedgwick launched into the anti-geologists:

> But there is another class of men who pursue Geology by a nearer road, and are guided by a different light. Well-intentioned they may be, but they have betrayed no small self-sufficiency, along with a shameful want of knowledge of the fundamental facts they presume to write about (Sedgwick 1969, p. 106).

Sedgwick then gave sample titles such as *Mosaic Geology* and *Scriptural Geology*, and named authors such as Bugg, Penn, Nolan and Forman. These, according to Sedgwick,

> Have committed the folly and sin of dogmatising on matters they have not personally examined, and, at the utmost, know only at second hand—of pretending to teach mankind on points they themselves are uninstructed (Sedgwick 1969, p. 106).

Having read works by Bugg, Penn, Nolan and other similar writers, this is a fair comment. Except for George Young, their geological comments emanated from an armchair rather than a windswept ridge in Snowdonia. Perhaps Sedgwick exaggerated when he referred to their ‘mischievous nonsense’, ‘irrational cosmogony’ and that they are ‘confined within the narrow fence of their own ignorance’. As for seeking dialogue with them, he continued, ‘We are told by the wise man *not to answer a fool according to his folly* [Proverbs 26: 4–5]; and it would indeed be a vain and idle task to engage in controversy with this school of false philosophy’ (Sedgwick 1969, p. 106).

It was inevitable that a response would be forthcoming, and Henry Cole (1792–1858) provided this in 1834 in most intemperate language. Cole had graduated from Clare College and was ordained but moved in and out of the Anglican ministry never obtaining a living. He published widely and became a Doctor of Divinity in 1854 (Mortenson 1999). Even Mortenson described him as ‘largely ignorant of the facts of geology’. Cole devoted 134 pages to refuting Sedgwick in *Popular Geology subversive of Divine Revelation! A Letter to the Rev. Adam Sedgwick, Woodwardian Professor of Geology in the University of Cambridge; being a Scriptural Refutation of the Geological Positions and Doctrines promulgated in his lately published Commencement Sermon* (Cole 1834*a*). Cole spent the first 50 of his 134 pages demonstrating that the first three verses of Genesis 1 deal with the first day and denying some intervening ‘chaos’ before the first day. ‘The second argument goes directly to prove the *non datableness* of geognostic facts . . . otherwise than as scripturally dated’ (Cole 1834*a*, p. 7). The third argument was to show Sedgwick’s moral code to be contrary to the word of God. Cole’s book was full of vituperation directed at Sedgwick.

The whole basis of Cole’s argument was that the only Christian and orthodox way of interpreting Genesis was to accept a creation in 6 days and that anyone who did not was an ‘infidel’. He dismissed any arguments for geological time as they are ‘in direct opposition to, and contradiction of, the eternal truth of divine Revelation,—and that, therefore are false, dangerous and impious!’ (Cole 1834*a*, p. 10). Nowhere did Cole consider whether previous generations of Christians had not held to a literal Genesis, which in fact many did not, both since the Reformation (Roberts 2002, 2007) and in the early church. Cole makes sorry reading as the reviewer in the *Christian Observer* noted Cole’s complaining ‘about “palpable evasion” of the Divine veracity, “willing ignorance”; “infidel scoffers”, “the graceless geologist”, “heaven-marked infidelity, presumption and falsehood”’ (Anonymous 1834, p. 373). The 20 page review in the *Christian Observer* continued in this vein and pointed out that not only is Sedgwick condemned for infidelity and other crimes worthy of the stake, but his views are shared by ‘hundreds of pious clergymen and thousands of pious laymen’ (Anonymous 1834, p. 371) including ‘Chalmers [Thomas, the leading Scottish evangelical], Faber [George, an Anglican evangelical theologian], Sedgwick, Buckland, Conybeare, Bishop J. Bird Sumner [the evangelical Bishop of Chester, later Archbishop of Canterbury], and numerous other divines’. Although it was anonymous, the review had the hallmarks of the editor S. C. Wilks, a friend of Conybeare, who used his editorial position to keep the anti-geologists at bay. Cole responded with a letter, which Wilks refused to publish, but which was published at Cole’s personal cost of £30, an enormous sum for an unbeneficed clergyman.

Sedgwick seems to have ignored Cole’s attack, but his next brush with anti-geologists was with a leading dignitary, Dean William Cockburn of York, some 10 years later. For 10 years Cockburn fought long and hard against geology, particularly addressing Buckland and Sedgwick, and when York hosted the British Association, he delivered a blistering attack on the geological views of the BA. In 1838 Cockburn published a 23-page pamphlet *A Letter to Prof Buckland concerning the Origin of the World.* His emphasis, like that of many anti-Geologists then and now, was on facts, and he claimed to take these geological facts from Buckland’s book (i.e. the ‘Bridgewater Treatise’, Buckland 1836) and to demonstrate that these facts are incompatible with Buckland but compatible with Moses: ‘First, that your theory is incompatible with the facts made known to us by geological discoveries, and, secondly, that these facts are reasonably to be explained by attending minutely to the historical account given by Moses’ (Cockburn 1838).

He addressed a further pamphlet to Murchison in 1840 on *The Creation of the World*, in which he gave his alternative geological history, with the first volcano occurring in the Cambrian, and the Flood depositing the fossils, with trilobites lying at the bottom 'with scarcely the power of motion' (Cockburn 1840, p. 18). His final flourish was that there is 'no valid reason for supposing that all the Eocene, Miocene and Pliocene' were deposited in a time that 'exceeded three days', thus concluding that 'the opinion of common sense will ultimately prevail' (Cockburn 1840).

Cockburn not only drew the ire of the 'reverend geologists' but also Lyell, who wrote to his sister in September 1839 after staying with Sir Robert Peel, then leader of the Opposition. After giving some strictures on Cockburn, he turned to Peel and said 'Bye the bye, I have only just remembered that he is your brother-in-law', to which Peel replied, 'Yes, he is a clever man and a good writer, but if men will not read any one book written by scientific men on such a subject, they must take the consequences' (Lyell 1881, Vol. II, p. 51). Cockburn's later work (1849), addressed to Adam Sedgwick, *A New System of Geology*, continued the same theme as addressed to Buckland and Murchison.

Cockburn felt rebuffed by all geologists, especially his fellow clergy Buckland and Sedgwick, so when the British Association went to York in 1844, he offered a paper, which was read on 27 September and published as *The Bible defended against the British Association* (Cockburn 1845). The paper began with criticisms of Buckland and a series of rhetorical questions, such as 'Where did the first-formed seas come from and how could there be any rain?' (Cockburn 1844, p. 4). After dismissing Buckland he presented his alternative geology, with all strata laid down in the Flood. He explained the fossil record by the differential mobility of creatures as 'The heavy animals who, in the flood that is covering the land are unable to fly fast enough to the hills' (Cockburn 1844, p. 13), an argument held by young-Earth creationists (YECs) today.

After he presented the paper, the Dean sent a copy to Sedgwick, who 'in his reply, confined himself almost exclusively upon the Dean's supposed ignorance' (Cockburn 1844, p. 16). To Cockburn's annoyance Sedgwick soon curtailed his responses and refused to have his letters published. On Monday 30 September 1844 Cockburn wrote to Warburton, the president of the Geological section, for further discussion, which was refused. Sedgwick's critical response to Cockburn met with differing reactions. *The Times* and the conservative evangelical *Record* (which was far narrower than the *Christian Observer*) supported Cockburn, but the *Spectator* and Miller's *Witness* did not. Probably because of Cockburn's influence Sedgwick was snubbed by both the City Council and the cathedral chapter (canons), who refused to dine with him during the meeting, but this may have been as much cathedral politics as conviction. Two of the canons were sons of Edward Harcourt, Archbishop of York: Leveson Vernon Harcourt (1788–1860) was an anti-geologist, who wrote the *Doctrine of the Deluge* (Harcourt 1838), and William Vernon Harcourt (1789–1871), who was a founder member of the British Association in 1831 and no scientific supporter of his Dean. However, cathedral politics has its own rules, as has been wittily described by Anthony Trollope in his Barchester novels.

Cockburn had presented a paper to the British Association that was, by the geological standards of its day, plain nonsense. It is difficult to see how Sedgwick could respond to it. Sedgwick and other geologists had endured Cockburn's semi-coherent geological ramblings for several years and responded with no avail. Buckland had previously written to Sir Robert Peel, Cockburn's brother-in-law, in support of Sedgwick. This hardened attitudes, but in the 1840s more people were convinced by the whole tenor of geological argument in favour of prehistoric worlds, and an increasing proportion of the clergy, Anglican, Roman Catholic, Presbyterian and Non-conformist, accepted the scientific arguments of the geologists and reconciled this with some kind of non-literal interpretation of Genesis.

The anti-geologists continued into the mid-1850s, but were a declining force, although there was a brief flowering in Scotland in 1858 after the publication of Miller's *The Testimony of the Rocks*. They had never gained much support and their influence was short-lived. Although almost certainly numbers of Christians from 1855 held to 4004 BC as the date of creation, publications are probably absent. By 1855 most educated Christians, whether evangelical or not, accepted geology, even if many were initially hostile to Darwin in 1859. However, that is another story.

Summing up

The focus of this paper has been deliberately very narrow, as it is only on Sedgwick's understanding of Genesis 1 in relation to geological time and his brushes with anti-geologists. Sedgwick on Noah's Flood has been briefly considered by Young in *The Biblical Flood* (1995, pp. 113–114), and his reaction both to the *Vestiges* and *The Origin of Species* has been covered many times (Moore 1979; Secord 2000). Sedgwick, as the most evangelical of the early 19th century clerical geologists, has considerable relevance today, because creationism and its rejection of geology is gaining popularity and has infiltrated Sedgwick's church, the Church of England. An awareness of how evangelicals 200 years ago understood geology in relation to the evangelical beliefs of the authority of the Bible and the text of Genesis will shed light on the present controversies and may prevent or halt the oversimplified dichotomy of science versus religion and geology versus Genesis. The religious aspects of the controversy cannot be ignored but need to be understood. No better example from both the history of geology and of evangelicalism can be found than Adam Sedgwick.

Very often the concern about creationism has been over evolution and thus the controversy has been presented as evolution versus creationism. Consequently, it is considered to be more about Darwinian evolution than anything else. Yet fundamental to all creationism is an attack on the whole of geology, although intelligent design evades the issue of the age of the Earth. So long as the controversy is centred on the 'icons of evolution' such as the peppered moth and Haeckel's embryos the doubtful nature of geology can be assumed because questions have been raised against historical sciences in general. The founder of 20th century creationism was George McCready Price, whose books (e.g. Price 1906, 1923) formed the basis of every subsequent development, and who spent his life trying to overturn all geological science with its 'long ages'. He argued that evolution 'all turned on its view of geology, and that if geology were true, the rest would seem to be more or less reasonable'. Ultimately, the controversy is geology versus creationism, or, as I have presented elsewhere (Roberts 2009), between a critical realist and naive realist approach to both theology and science.

I can be fairly certain that most readers will be convinced of all the geological arguments for a vast timescale, and that they consider the issue as simply not worth considering on the grounds of its absurdity. At present there are a few YEC geologists who have either degrees or doctorates. The most significant are Steven Austin, Kurt Wise and Marcus Ross, who now teach in US evangelical colleges that demand staff to believe in a 6 day creation. Many US evangelical colleges, such as Wheaton, do not make this demand (Moshier *et al.* 2009). Despite their small numbers, young-Earth geologists have a very high profile and with the recent Radioisotopes and the Age of the Earth (RATE) project,[5] which questioned radiometric age-dating, have considerable influence on the general public, who, if they do not actually believe their arguments, begin to doubt orthodox science.

It is also easy to assume that the influence of a few Christians will be minimal, except in the USA. However, about one-third of the world's population is Christian, and about 5% of the world's population are evangelical and that figure is rising rapidly. Coupled with the support of creationism by conservative Muslims, that means a significant number of people, who are highly motivated and organized. To give a historical parallel, when Constantine recognized Christianity as the official religion of the Roman Empire in AD 313 only 10% of the population were Christians.

On the surface the controversies of today seem to be a continuation of what happened in the early 19th century, but, despite similarities, that is not the case. Effectively, the anti-geologists went extinct by 1860 and one cannot trace any line of descent from them to the YECs of today. As Numbers (1992) presented the story in his book *The Creationists*, today's creationists were effectively started with the publication of the book *The Genesis Flood* by Whitcomb & Morris (1961), who based their ideas on those of G. M. Price, and his series of anti-evolution and flood geology books, published from 1905. Price did not belong to any 'mainstream' or revivalist church but to the Seventh-day Adventists, who broke away from mainstream Protestants in the mid-19th century. Against all expectations, creationism has continued to grow within all churches and has spread throughout the world.

Most of the criticism of creationism has come from secular scientists and liberal Christians, so that the former can be dismissed by creationists for being atheist and the latter for being liberal, theologically, thus reinforcing creationist views. Most critiques of creationism assume that today's creationism is a throwback to before 1800 when Christians accepted the Bible literally, with the corollary that the Earth is 6000 years old. Against that most creationists claim that until Hutton, orthodox Christians accepted a 6000-year-old Earth. With the emphasis on Hutton (a deist) and Lyell being almost the only people who argued for geological time, the way is clear to claim that geological time is a fruit of the Enlightenment and thus contrary to orthodox Christianity. This is a favourite argument of creationist writers.

No historian of geology can accept this oversimplified picture, and the case of Adam Sedgwick living a few decades later totally undermines this view. Here was a leading geologist of world renown who challenged many popular perceptions, especially of those who would consider themselves educated; he was a major contributor to elucidating the geological column, yet was a man of evangelical beliefs. We may regret his rejection of evolution, which was understandable for a man of his day, but conveniently forget that most geologists and physicists agreed with him at the time.

Sedgwick had a very expansive view of geological time, which he combined with a reverent and expansive view of the book of Genesis and its account of creation. He was happy to accept both without attempting to shoehorn all science into the Bible.

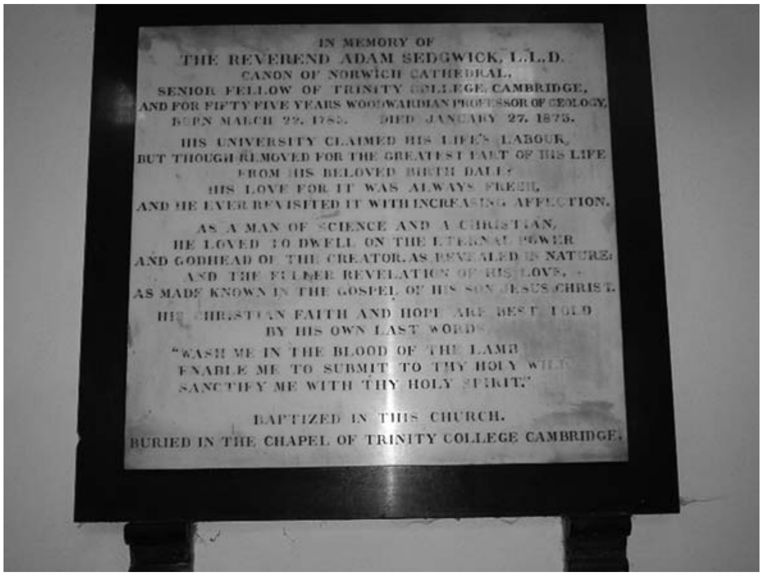

Fig. 2. Adam Sedgwick's memorial tablet at St Andrew's Church, Dent.

His letters give a few hints of his interpretation but sadly he never committed these to a full exposition.

Although a man of both clear religious convictions and broad sympathy, he showed little tolerance for the activities of the anti-geologists and incurred the wrath of Cole and Dean Cockburn. He was not afraid to expose the absurdity of those beliefs, not that it did him any lasting harm, except in York.

To Sedgwick there was no conflict between his geology and his evangelical beliefs, and this is summed up in the wording of his memorial tablet at St Andrew's Church, Dent (Fig. 2):

> As a man of science and a Christian he loved to dwell on the eternal power and godhead of the Creator as revealed in nature and the fuller revelation of his love as made known in the Gospel of His son Jesus Christ.

I thank R. O'Connor and M. Kölbl-Ebert for their comments as referees. The transcript of the letter from Sedgwick to close is reproduced by kind permission of the Headmaster of Dean Close School, Cheltenham.

Appendix

Letter by Adam Sedgwick to Francis Close, Dean of Carlisle
(reproduced with permission from Dean Close School, Cheltenham)

Cambridge. March 27, 1858

My dear Dean,

I am not in good health, the gout steals away any sleep by night, + by day smashes me torpid, irritable + stupid: but I am not insensible to kindness, + try to thank the friends who remember me in the way you have done. . . . .

Hugh Miller was a man of *great natural genius*, + in some parts of geology, admirably well informed, but it is not always safe to follow him, when he travels beyond his own beat—His 'Testimony of the Rocks' is in its way a noble work—it may do much good, but it *may do some harm*—for when men connect certain difficult passages of the bible with any scheme of interpretation which has gained their confidence, they are almost certain to look with suspicion, + ill will, on any man, who does not accept this interpretation + to suspect them of infidelity—

That God created all worlds, + gradually through the operation of his spirit brought them into the order + symmetry in which we now see them, + that man the last being of Creation, are points in which we all agree, but so far as regards the Earth, how was this order brought about? Why what succession.

I make no difficulty in the words *Morning* + *Evening*, they are only I think meant to mark the beginning + end of periods or days,—the Mosaic day is assuredly not 24 hours, + if we once admit a prophetic extended meaning of day, our souls are then free, + we are permitted to give any indefinite period, + the word day—However long it is but an atom of a part of eternity—In regard to the first 8 verses of Genesis, we can only in the first instance, get a glimmering of their meaning, from a knowledge of the Hebrew, or possess a good translation—the words are difficult, + are perhaps meant to be so; + there may be a great physical truth lurking in them, what future discoveries in science may help to clear up,—I do not profess to comprehend them. If I remember rightly, Hugh

Miller, puts within the 1st + 2nd days, the whole older Palaeozoic Creation—If the 3rd day represents the Carboniferous period, the previous conclusion is inevitable—Now in the older Palaeozoic periods (old red, Silurean, Cambrian etc we have multitudes of fishes, some of a very high type, + a magnificent marine fauna, many of the creatures with beautiful organs of senses—for example many of the old Trilobites had eyes, all analogy, the old Nautilus, + orthoceratites must have had very perfectly formed eyes—They *were less*-motive + highly predaceous creatures, + had need of eyes—

The Fauna could not exist without a flora—but that Flora (He says) was marine! I believe it was in good part, but we have a few land plants, some reptiles, in the old sand period; x we have no right to argue from negative evidence—Here there is a first + great difficulty, which none of the authors in question appear to have cleared up—

Again let us come to the 3rd day—the period of the vast Forests, which supplied the materials of our coal Beds, according to Hugh Miller—the interpretation here, is at last plausible, yet not without difficulties, for we have a vast abundance of highly organised Fishes of the period, we have a few *reptiles*, + a great Fauna—All the species new—there is hardly so much as one, that can be regarded as the natural descendant of any species that lived during the former days—

I do not believe that the Forests felt not the influences of light—a reference to McCausland's claim that there was no sunshine until the Permian, i.e. after the Carboniferous Among the coal plants are occasional Coniferous trees, are we to suppose that they grew without light? The Fishes of the period had eyes, so far as we can judge as well fitted for light, as are the eyes of living fishes.—Here there is again a difficulty, which Miller has not cleared up.—

I do not like the scheme of stretching the Bible, like an elastic band, till we can wrap up our hypotheses in its sacred leaves.

The Permian formation was not the beginning of the reptile age—but it is true that reptiles have their great prominence during the secondary period—beginning (say) in the Permian, + ending with Chalk, but the reptiles were not by any means all marine—and as for fishes, they had perhaps a nobler type in the Anterior, or Palaeozoic period.—there is a difficulty here also—but perhaps it is not insuperable—a few mammals (animals with hot blood + giving suck) did exist, during the secondary period—more than even Mr Miller thought of—for many have been discovered within the past year—Still the Tertiary period, is *the grand period of Mammal life*; + through it we ascend to the period of man—the last created of Heaven—as to any subsequent difficulties, they belong to the Historian + Divine, rather than to the Geologist—

Don't think me a bad man, if I tell you that when puzzling my brain (during long by gone years) about this chapter, I have sometimes fancied, that the 3rd + 4th days, had by some mistake of translation been made to change place—formerly I tried all sorts of hypotheses to little satisfaction, so of late years I have little troubled my head with hypotheses, not doubting that in *the end*, all, *all* difficulties would vanish—

I am sure, if we go on honestly, our difficulties will be less + less—H. Miller has given us a noble sketch, but so far as he is hypothetical he is unsafe—

Some of the gorgeous notions that decorate his pages, only dazzle my eyes, + make my head giddy; nor can I honestly subscribe to all that MacCausland states in the quotation in question.

Your remark about the whales is just + true—it is simply the case of a bad translation_(1) that God created all worlds (2) that they parted? Into their present condition, by successive changes in conformity with his will, + with of his ordering (3) that Animal life began in a humble form (4) that two epochs followed, marked by the organic progress (5) that a still higher progress was marked by the Creation of Mammal types—(6) Lastly that man was created, and that the creative power, was by its own inherent will,—all this is I think at present made evident, even to our gross senses,—and I admire as much as you do, that grand idea of poor Miller, that our own time (till the consummation of all earthly things, when a new Heaven, + a new Earth shall rise up before the Chosen Children of God) is to be regarded as a long protracted sabbath, or rest from the labour of new creations—Surely it is good to have gone so far—

There are difficulties in morals, in politics, in religious life—they are a grand part of our probation, Why should we expect at once to clear up all difficulties presented to our senses by the natural world? It will not do for us to shut our eyes like terrified children, we must note these difficulties manfully, + with an honest spirit, + then God will bless our labours—

I dread the seduction of. . . . . hypotheses—

After what has been done, + done honestly, I have no fear for the final result, + I believe as formerly, as I believe my own existence, that any discords that may now appear among the Elements of our present Earth, will end in harmony, + true accordance with the word of God I ought to ask your forgiveness for this ugly scrawl, ever my dear Dean

Very truly + gratefully your's

[signed] A. Sedgwick

Notes

[1]An earlier version of this paper was presented at the 'Electrifying Experimentation' conference at Sheffield University in March 2006.

[2]For example, on one day he walked over 18 miles and climbed 6000 ft, as well as making many geological notes and collecting many rock specimens.

[3]Despite Darwin's radical dissenting background, he was enough of an Anglican to gain a degree and potentially be ordained.

[4]In the 21st century, on the basis of my own dealings with Anglican clergy, I would estimate this figure at between

5 and 10%. Kevin Logan, a creationist Anglican vicar, told me he had arrived at a similar figure. In fairness to clergy in the early 19th century, geology was a young science; today's clergy do not have that excuse.

[5]One conclusion of the RATE project was that decay rates speeded up in the year of Noah's Flood, but it overlooked that the extra energy would have boiled away the oceans and fried Noah.

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Some nineteenth- and twentieth-century Australian geological clerics

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Abstract: Despite the wide diversity of beliefs, personalities and geological expertise of 10 'clerical geologists' of varying Christian denominations who worked in Australia, mainly during the nineteenth century, there is little indication that they saw any contradiction between a belief in a divine being and the pursuit of geology. There was a continuity of these attitudes throughout the century, within the changing social and professional geological environment as Australia moved from being a set of independent colonies to a federation. Four of the 'clerical geologists', Johannes Menge, W. B. Clarke, J. E. Tenison Woods and Walter Howchin, made significant contributions to geological science, which deserve to be better known internationally.

An eclectic group of 'religious' investigators (see Table 1 and Fig. 1) participated to varying extents in the development of geology as a science in Australia from the earliest period of European colonization into the first quarter of the twentieth century. Space will not allow discussion of the work of all these men. Mayer has presented a paper on the early Anglican priest C. P. N. Wilton (Mayer 2009). The lesser geological interests of Father Bleasdale (Grigsby 1969) and the Reverend J. C. Corlette (Corlette 1893) allow them to be omitted, and the last-named in Table 1, Edmund Gill, the most recent of the group, can only be given a brief comment. A Baptist, Gill was forced from his post at a church youth training scheme because of his belief in the theory of evolution (Griffiths 1996, p. 89). Father Curran's better-known geological work was significant (Duffy 1969), but further research on his life is called for. Those omissions offer a fruitful field for future research. The important geophysical work of Father Pigot, within the longstanding interest of the Jesuit Order in geophysics, has been described elsewhere (O'Connell 1952; Drake 1988; Strong 1999, pp. 300–302).

Of the workers discussed here, the scientific contributions of Clarke, Menge, Woods and Howchin were perhaps the more significant, as their work as practitioners of geology continued over a considerable time span and covered important geological issues. Campbell's role, although he was involved in mining and metallurgy, was more notable through his popular writing on prospecting, and his other educational work. Backhouse made original geological observations but they were scattered and did not become part of the mainstream knowledge of Australian geology. Salvado's role in the story is as a recorder and promulgator of Australian geological knowledge into continental Europe.

Although T. H. Scott's time in Australia was brief, he made early collections that, when taken to England, focused attention on Australian geology. The other Scott, an astronomer, is important in his support for the scientific view of creation *vis-à-vis* a rigid biblical interpretation. So too is J. D. Lang, the most enigmatic member of the group, who, by sending fossils to Edinburgh, began the serious study of Australian vertebrate palaeontology. Lang, like Salvado, also spread knowledge of Australian geology and, like all the others, insisted on rationality in interpreting the Bible. Although some of these people were based in Sydney their influence was spread more widely through Australia (Fig. 2).

With colonization by Britain extending across the Australian continent from Sydney, beginning in 1788, it is to be expected that clergy of the Anglican Church were predominant in the early days of European settlement. A number of these men were graduates of Cambridge or Oxford, who would have studied at a time when geology was 'all the rage'. In this Anglican category can be mentioned the Reverends Thomas Hobbes Scott, Charles Pleydell Wilton, William Scott and W. B. Clarke. They would also have been affected to a large degree by the natural theology writings of the Reverend William Paley (1743–1805), whose works were carried by many travellers, as noted by the young Samuel Stutchbury (1798–1859) in the list of the 'North Atlantic Reading Society' on board the *Sir George Osborne*, en route to Australia in 1825 (Branagan 1996*b*, pp. 187–192).

Paley's theology was 'underpinned by the natural philosophy of the *Natural Theology*, in which knowledge of the attributes of the deity is derived from an empirical study of nature' (Crimmins 2005, p. 449). Paley's *Natural Theology* (Paley 1802), unlike his earlier works, was not

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Table 1. *Some Australian 'clerical geologists' of the late nineteenth and early twentieth century*

Archdeacon Thomas Hobbes Scott	1783–1860
The Reverend Charles Pleydell Wilton	1795–1859
The Reverend John Dunmore Lang	1799–1878
James Backhouse	1794–1869
The Reverend Lancelot Edward Threlkeld	1788–1859
Johannes Menge	1788–1852
Dom Rosendo Salvado	1814–1900
The Reverend William Branwhite Clarke	1798–1878
The Reverend William Scott	1825–1917
Father John Bleasdale	1822–1884
Father J. E. Tenison Woods	1832–1889
The Reverend J. C. Corlette	1838–1900
The Reverend Joseph Campbell	1858–1933
The Reverend Walter Howchin	1845–1937
Father Edward Pigot	1858–1929
Father J. Milne Curran	1859–1928
Edmund Gill	1908–1986

based on his lectures but was freely written, and is 'the most original and entertaining of Paley's works' (Crimmins 2005, p. 449). First published in 1802, it went through an astonishing nine editions in the last 3 years of Paley's life. A vital ingredient was the use made from 'his own investigations of nature, bringing home stones and plants and analysing the bone structures [of animals] consumed at the table' (Crimmins 2005, p. 449). Charles Darwin was at Christ's College in 1828, and later wrote of Paley's work as being 'the only part of the Academic Course which . . . was of the least use to me in the education of my mind' (F. Darwin 1892, p. 18). Referring to Paley's *Evidences of Christianity* (Paley 1823) 'I could almost formerly have said it by heart' Darwin wrote to John Lubbock on 22 November 1859 (Burkhardt & Smith 1991, p. 338).

The Venerable Archdeacon Thomas Hobbes Scott (1783–1860)

The Venerable Archdeacon Scott does not fit simply in the Anglican list outlined above. Scott arrived in New South Wales for the first time in 1819, as a layman clerk accompanying his brother-in-law, John Thomas Bigge (1780–1843), sent out by the British Government to undertake a 'Royal' Commission into the affairs of the Colony (Ritchie 1970, 1971). Although the Enquiry probed into many aspects of the life of the Colony, it was influenced greatly by prominent personalities in the Colony, and resulted in the recall of the greatest of the early Governors, Lachlan Macquarie (1762–1824). Following a period in France, Scott had matriculated at the age of 30, gaining a BA degree at Oxford in 1817, and an MA the following year. This was prior to the appointment of the Reverend William Buckland (1784–1856) as first Reader in Geology at Oxford, so Scott's exposure to geology there was probably minimal.

On his return to England in 1821 Scott submitted plans to the Colonial Office for chaplains and church schools in New South Wales. He took holy orders the same year, becoming Rector of Whitfield in the Diocese of Durham. Then in October 1824 Scott was appointed Archdeacon of New South Wales (at that time within the Diocese of Calcutta) with wide responsibilities and powers. On his return to New South Wales, although he was hard-working, especially with respect to education, which he wished to be closely linked with the Anglican Church, his Tory persuasion and former (and continuing) association with some members of the colonial 'establishment' made him unpopular with the progressives in the Colony (Border 1962, 1967).

It is not easy to discern any deep theological thinking in Scott's work. Rather, his Christianity seems to have been essentially pragmatic. Concerning geology, Scott might have developed his interest during the Bigge Enquiry, when there was extensive investigation of the coal mining that utilized convict labour, being undertaken some 150 km north of Sydney at what later became known as Newcastle. Whereas the *Sydney Gazette* claimed Scott 'evinced an entire freedom from the shackles of bigotry' the *Australasian* wrote less favourably about his tolerance (Wyatt 1949).

Whatever the influence, Scott began to note the geology of the areas he visited, and to collect specimens, both by personal effort and by exchange. On the basis of his colonial experience to this time he published a useful, but in parts misleading, short paper on the geology of New South Wales and Van Diemen's Land (Tasmania), which gained wide circulation (Scott 1824). In 1829 he was 'stranded' for some time in the newly established colony of Western Australia (Scott 1831), and used the period to build the first chapel for Anglican worship there; again, he collected geological specimens. He amalgamated the collections, and in 1831 donated them to the young Geological Society of London, which he had joined in 1824. Scott's geological collection became part of the basis for his interpretation, from afar, of early Australian geology (Scott 1824; Vallance 1975; Branagan & Moore 2009). No picture of Scott has been located.

The Reverend Dr John Dunmore Lang (1799–1878)

'Presbyterian clergyman, politician, educationist, immigration organizer, historian, anthropologist,

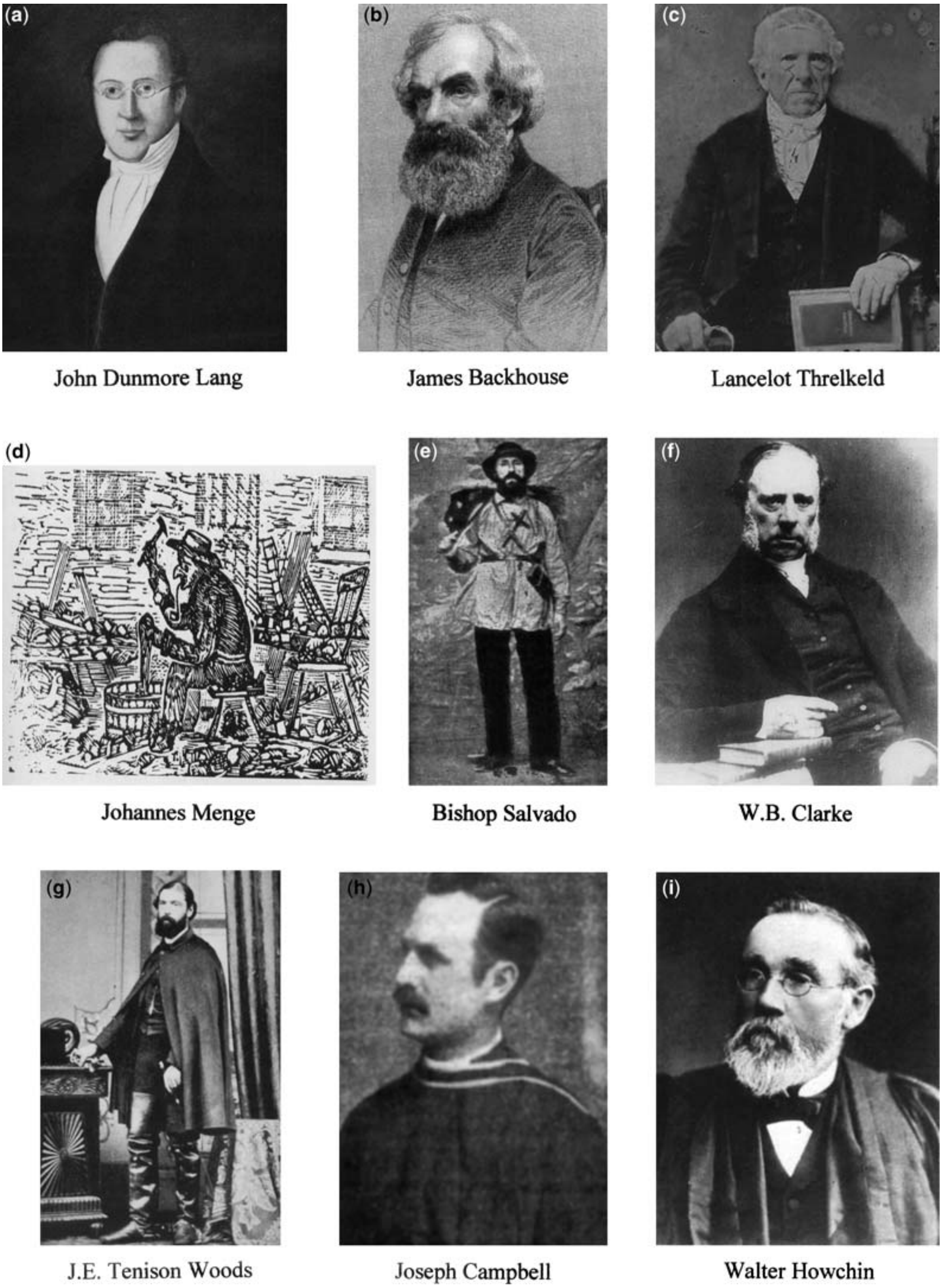


Fig. 1. Portraits. (**a**) The Reverend J. Dunmore Lang; (**b**) James Backhouse; (**c**) the Reserved Lancelot Threlkeld; (**d**) Johannes Menge; (**e**) Bishop Dom Rosevido Salvado; (**f**) the Reverend W. B. Clarke; (**g**) Father J. E. Tenison Woods; (**h**) the Reverend Joseph Campbell; (**i**) the Reverend Walter Howchin.

Fig. 2. Map showing the spread of 'Christian geology' in Australia.

journalist, gaol-bird and "Patriot and Statesman"' (Baker 1967), Lang (Fig. 1a) is one of the most interesting personalities of this story. This is because an interest and knowledge of geology can be added to the activities mentioned above. Lang was a mass of contradictions: a pugnacious clergyman, bigot and enthusiast for natural history; conservative in many ways; liberal in others. Many aspects of Lang's life have been fully described by Baker (1985, 1998). Transcriptions of many of Lang's activities can be found in the two volumes by Gilchrist (1951), although, as Baker (1998, p. 214) pointed out, Gilchrist's referencing was unreliable, and he edited the writing without indicating clearly what was still original. McLaren (1985) listed more than 4300 writings by, or about, Lang's turbulent life, which is encapsulated in the cartoon shown in Figure 3.

Lang entered Glasgow University at the age of 12, as was then common, graduating MA on 11 April 1820. He wrote of his 8 years at university (as required for ministers of the Church of Scotland) that 'most of the theology students embraced the opportunity afforded them of attending voluntarily other classes beside those prescribed by the Church ... I attended regularly for modern languages, anatomy, chemistry and natural history' (Gilchrist 1951, Lang 77: Item 8). He added that 'the Professor of Natural History [William Meiklham] had a popular [evening] course of lectures for his students'. However, although Baker (1985, p. 13) indicated that Meiklham, unlike many of the university's professors of the period, was a hard-working and effective teacher, Lang did not attend the lectures for very long. Nevertheless, he had an abiding interest in technological innovation, and certainly benefited from these early contacts with 'science', however brief.

Lang arrived in Sydney in May 1823, and it was not long before there was some dissension, through a rather rude official rejection of Lang's application for financial help to build his 'Scots Church' for the local Presbyterians. Lang had expected this help, based on such assistance being extended to the Anglicans and Roman Catholics. His reaction caused him to lose the support of some influential sections of the community. There was to continue a similar history of controversy throughout Lang's life.

Perhaps more by accident than design Lang played an important part in the development of the story of Australian vertebrate palaeontology, through his friendship with George Ranken (1793–1860), resident of Bathurst, in central New South Wales (Long 1967). Ranken was apparently the first European to observe and realize the possible

Fig. 3. The Reverend J. Dunmore Lang in combative mood: 'The Church Militant'.

significance of the bones encased in sediment in the caves at Wellington, which had become known to Europeans in the mid-1820s and had been visited by the artist Augustus Earle (1793–1838) in 1828 (Hackforth-Jones 1980, pp. 102–103).

Ranken extracted some bones and showed them to Lang, who, thinking they might have more than local significance, took them to Sydney and wrote about them briefly in the *Sydney Gazette* (25 May 1830, p. 3). He probably also showed them to interested locals such as the Surveyor-General [Sir] Thomas Mitchell (1792–1855).

Lang departed, on 14 August 1830, for England, on the second of his many overseas journeys primarily seeking funding, moral support and clergy for his Presbyterian 'empire'. He took Ranken's collection of bones with him, and some additional written material about the bones, which Mitchell had put together, for Robert Jameson (1774–1854), the Professor of Natural History at Edinburgh University. Lang's letter to the *Sydney Gazette*, together with Mitchell's 'Additional Information illustrative of the Natural History of the Australian bone-Caves and Osseous Breccia' were published in the *Edinburgh Philosophical Journal* (Lang 1831), all being attributed, incorrectly, to Lang.

In November 1829 Mitchell had already made an effort to examine Bungonia Caves, 180 km SW of Sydney 'to look for antediluvian remains like those found by Mr. Buckland', but he was unsuccessful in finding them (Foster 1937, p. 434). Mitchell quickly took the opportunity to visit the Wellington Caves in late June 1830 with Ranken, making numerous sketches and collecting specimens, as described by Oldroyd (2007) (Fig. 4).

This marked the beginning of Mitchell's major contribution to the study of Australian vertebrate palaeontology (Mitchell 1831), documented in some detail by Oldroyd (2007; see also Foster 1937, pp. 435–438; 1985, pp. 141, 204, 252, 311; Lane & Richards 1963; Osborne 1991). It was through this work that Mitchell came in contact with the 'emerging' expert Richard Owen (1804–1892). Owen subsequently was to make his name largely on the basis of his studies of the Australasian fossil megafauna (Branagan 1992; Holland 1992; Oldroyd 2007).

On his third return voyage to Britain (1833–1834) Lang wrote the work for which he is possibly best remembered: *An Historical and Statistical Account of New South Wales, both as a Penal Settlement and as a British Colony* (Lang 1834), which contains an excellent section on the geology and landscape of Australia (Lang 1834, Vol. 2,

Fig. 4. Fossil bone cave, Wellington, NSW. Sketch by T. L. Mitchell used by W. [J. B.] Pentland.

Chapter 4). The third edition (1852) was criticized in Britain by the *Westminster Review* (Anonymous 1853), which 'suggested the title should read "The History of Dr. Lang, to which is added the history of New South Wales" '(Baker 1967, p. 77). Nevertheless, it was widely read and ran to four editions.

Lang summarized Australian geology, and quoted a curious reference (not located) from Johann Friedrich Blumenbach (1752–1840). This suggested that the vast island continent of New South Wales was originally a comet (Lang 1834, Vol. 2, pp. 171–172; Vallance 1975, p. 18). Lang perhaps thought there was something in this idea, as Australia had a 'depressed centre, the east coast was apparently elevated or heaved up by some violent convulsion of nature'. Lang thought that Blumenbach should pay a visit, which, of course, never occurred. Catastrophic ideas had not been forgotten by Lang (and others), who wondered if the postulated 'Asiatic Flood' was caused by massive volcanic eruptions in the South Pacific, as suggested by Peter Pallas as long ago as 1771 (see Stein 1842). Lang quoted Buffon's idea that the 'South Sea islands were the tops of ancient mountains of a large landmass (Lang 1834, Vol. 2, p. 172).

In June 1843, after a protracted campaign, Lang became one of the elected representatives in the New South Wales Legislative Council for the then distant Port Phillip District (Melbourne, Victoria), defeating, among others, Sir Thomas Mitchell, mainly because Lang clearly favoured the separation of Victoria from New South Wales, whereas Mitchell had not made his opinion clear on the matter. Moreover, Mitchell was detained in Sydney on official business, thus being absent from the hustings. In Lang's campaigning and, as elected representative, he travelled some 200 miles (320 km), from Geelong to the Glenelg River, through the volcanic area of western Victoria and was impressed with this landscape. He wrote that in the 'stony rises' (in Victoria) 'he could count a dozen volcanic cones, from a long time past, unimaginably slow processes of cooling and natural erosion' (Baker 1985, p. 228). He thought that the volcanoes had probably been erupted on an ancient sea floor, and that uplift had followed. After a later visit to Mt. Macedon, NW of Melbourne, he thought this was a younger volcanic region (Lang 1846, pp. 6–7). We know now that the Macedon rocks are older, and that the western volcanic region was always above sea level.

Of perhaps more significance in the present context was Lang's lecture on *The Mosaic Account of the Creation Compared with the Deductions of Modern Geology* delivered in Melbourne in 1846 and published (Lang 1846), according to the title page, 'at the request of the audience' (Fig. 5). Lang's written work indicates his expertise as a preacher and partly explains his success on the hustings. There is an easy flow and fine presentation. He wrote:

> [Geology] is one of the latest-born of the numerous and increasing family of the *isms* and the *ologies*. Phrenology, doubtless, has been still later in coming into the world; and as to Mesmerisms, it is still so young, and so imperfectly developed, that it has not yet got the fact of its duty registered, far less its alliance with the respectable family of the sciences recognized. But Geology is a science, and no question; nay, it is one of the most vigorous and promising of the whole tribe. Unlike certain of the other sciences, it can scarcely be said to have had a period of infancy and nonage at all; and considering the rapid development it has exhibited during the last half-century, it may almost be said to have sprung into life, like the goddess Minerva from the head of her father Jupiter, full grown and in full armour (Lang 1846, p. 1).

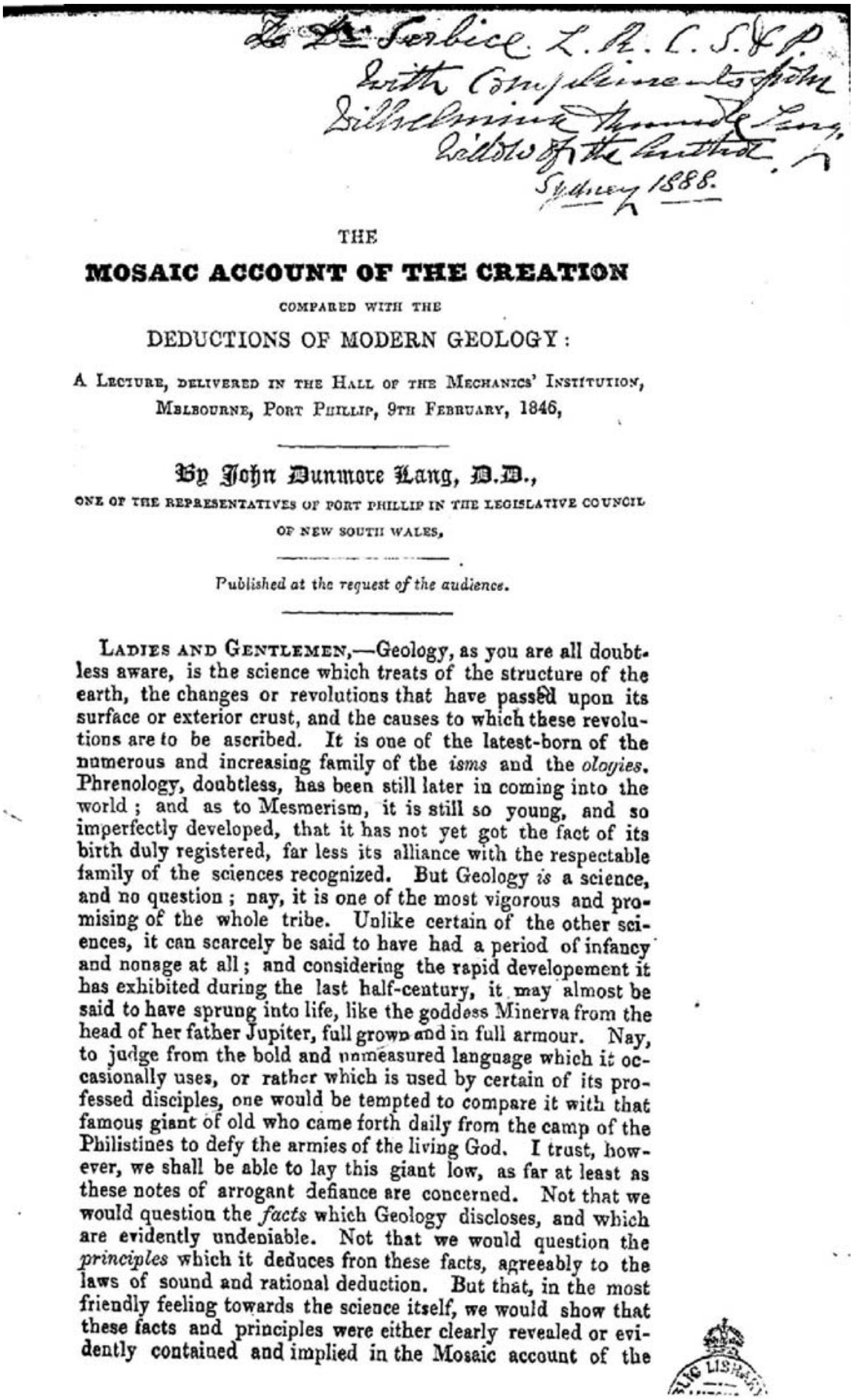
Lang also wrote:

> such a succession of events, written as with a pen of iron in the rock for ever, carries us back to a period of time in the history of our planet inconceivably remote. "How," it may be asked, "does this prodigious antiquity of the earth agree with the Mosaic record?" Perfectly, I reply (Lang 1846, p. 8).

Lang told the Melburnians that science is to be believed: 'Genesis Ch.1 v. 1 is to be understood [as] a general introduction to all that follows, [which] by no means implies the various acts of creation . . . followed immediately . . . Geology and Astronomy . . . unite in informing us that this interval was one of an inconceivably protracted duration.' He wrote: 'Geology compels us to make unlimited drafts upon antiquity'. He pooh-poohed the 'received opinion' that '6000 year ago the vast universe . . . was one dreary waste', adding 'it is a mere interpretation based on ignorance and presumption', with no foundation in the Bible, quoting the opinions of divines from a wide range of Christian traditions, including even the Roman Catholic Dr. Wiseman, and finishing with several US professors.

Lang quoted extensively on New South Wales geology from the writings of Alexander Berry (1781–1873), specifically Berry (1825). Berry was a former student of St Andrews, Scotland, and knowledgeable about James Hutton's ideas. Berry presented his own practical observations, including the recognition of an angular unconformity (similar to those Hutton recognized at Jedburgh and Siccar Point), on the Clyde River, some 120 km south of Sydney, at the edge of what is now called the Sydney Basin. This unconformity between Ordovician and Permian rocks represents a time break of some 200 Ma. Sadly, Lang and Berry were involved in a contentious series of court cases about property issues, in which Berry sued Lang for libel in late 1858 (Baker 1985, pp. 409–421).

Lang summarized his 'Mosaic' lecture: 'there is nothing in my opinion that tends so strongly to



To Dr Forbice L.R.C.S.&P.
with Compliments of John
Wilhelmina [illegible] Lang,
Widow of the Author.
Sydney 1888.

THE

MOSAIC ACCOUNT OF THE CREATION

COMPARED WITH THE

DEDUCTIONS OF MODERN GEOLOGY:

A LECTURE, DELIVERED IN THE HALL OF THE MECHANICS' INSTITUTION, MELBOURNE, PORT PHILLIP, 9TH FEBRUARY, 1846,

By John Dunmore Lang, D.D.,

ONE OF THE REPRESENTATIVES OF PORT PHILLIP IN THE LEGISLATIVE COUNCIL OF NEW SOUTH WALES,

Published at the request of the audience.

LADIES AND GENTLEMEN,—Geology, as you are all doubtless aware, is the science which treats of the structure of the earth, the changes or revolutions that have passed upon its surface or exterior crust, and the causes to which these revolutions are to be ascribed. It is one of the latest-born of the numerous and increasing family of the *isms* and the *ologies*. Phrenology, doubtless, has been still later in coming into the world; and as to Mesmerism, it is still so young, and so imperfectly developed, that it has not yet got the fact of its birth duly registered, far less its alliance with the respectable family of the sciences recognized. But Geology *is* a science, and no question; nay, it is one of the most vigorous and promising of the whole tribe. Unlike certain of the other sciences, it can scarcely be said to have had a period of infancy and nonage at all; and considering the rapid developement it has exhibited during the last half-century, it may almost be said to have sprung into life, like the goddess Minerva from the head of her father Jupiter, full grown and in full armour. Nay, to judge from the bold and unmeasured language which it occasionally uses, or rather which is used by certain of its professed disciples, one would be tempted to compare it with that famous giant of old who came forth daily from the camp of the Philistines to defy the armies of the living God. I trust, however, we shall be able to lay this giant low, as far at least as these notes of arrogant defiance are concerned. Not that we would question the *facts* which Geology discloses, and which are evidently undeniable. Not that we would question the *principles* which it deduces from these facts, agreeably to the laws of sound and rational deduction. But that, in the most friendly feeling towards the science itself, we would show that these facts and principles were either clearly revealed or evidently contained and implied in the Mosaic account of the

Fig. 5. Title page of J. D. Lang's *Mosaic Account of the Creation* (Lang 1846).

impress the mind with exalted and sublime ideas of the infinite Creator as the wonders which the kindred Sciences of Geology and Astronomy unitedly disclose' (Lang 1846, p. 9–10).

James Backhouse (1794–1869)

Following Lang we look at a perhaps unexpected figure, the Quaker missionary James Backhouse (Fig. 1b), who worked in schools for the poor, and believed in temperance and prison reform. Combined with training in a plant nursery in Norwich, where he learnt about Australian plants, Backhouse sought an opportunity to undertake missionary work in Australia. Obtaining limited financial help from the Quaker London Yearly Meeting he left England with George W. Walker (1800–1859) in September 1831 for Hobart, Tasmania, and an epic journey, through Australia and South Africa, which lasted 6 years. The two were an ideal pair, Backhouse with 'his sense of humour and straightforward simplicity . . . initiative, imagination and ardent spirit' combining perfectly with Walker's 'methodical organization and secretarial skill' (Trott 1966, 1967).

On arrival in Hobart, Backhouse immediately made contact with the criminals and the poor, and seems to have been well received, because of his unofficial status and his rather gentle, non-aggressive nature. This even included a mild exhortation to some sailors not to kill sharks wantonly (Backhouse 1843, p. 38).

In June 1832 the missionaries set off from Hobart by ship for the feared convict settlement at Macquarie Harbour on the west coast of Tasmania. The journey was not without incident, Backhouse commenting: 'we suffered a storm . . . the billows, spiritually as well as outwardly, at times went over our heads' (Fig. 6). They were forced to put into Port Davey, an almost uninhabited bay on the SW coast, where they were stuck for 17 days, and where Backhouse used his time wandering in search of geological and botanical knowledge, finding, among other things, 'an island of asbestos with vertical veins of quartz' (Backhouse 1843, p. 38).

On arrival at their destination, Backhouse noted, with some surprise:

> Macquarie Harbour had not the desolate appearance we had been given to expect . . . behind the mountains on the east of Macquarie Harbour, rises a magnificent, snow-covered range; the most striking point of which is the Frenchman's Cap, having the form of a quarter of a sphere, perpendicular on the south, and towering 5,000 feet above sea level' (Backhouse 1843, pp. 39–40).

Despite the fine scenery, the Harbour was a gloomy place in the eyes of the prisoners, because of the privations they suffered. Backhouse noted there had been 85 deaths in 11 years (from 1822), only 35 from natural causes. Twenty-seven prisoners had drowned, eight had been killed accidentally (chiefly from trees falling), three were shot by the military and '12 were murdered by their comrades'; 112 had absconded, of whom 62 'perished and nine were murdered'. Backhouse suggested there was some evidence of cannibalism (Backhouse 1843, pp. 39–40).

Geology was not forgotten: 'Birches rocks has a very prominent one [rock outcrop] rising above the

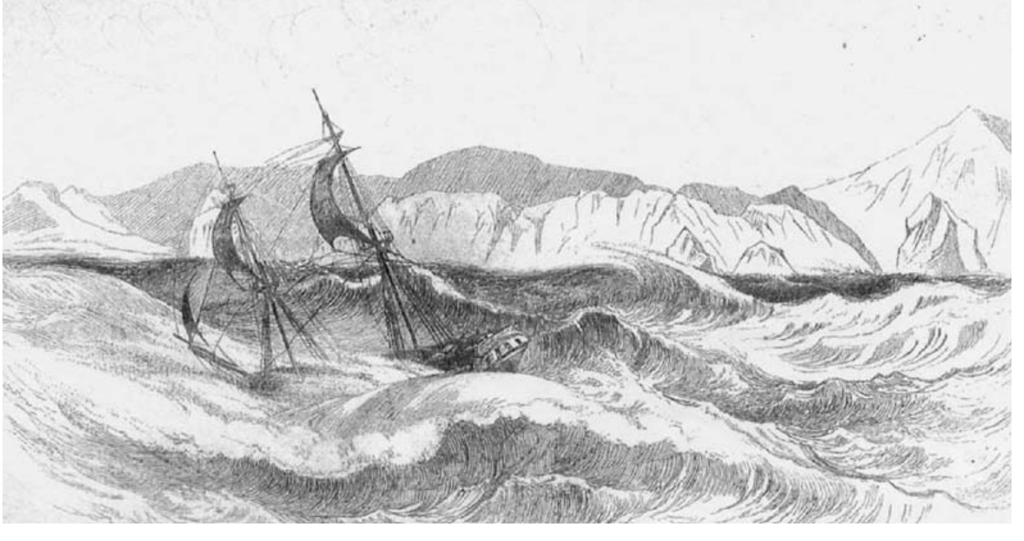


Fig. 6. Voyage to Macquarie Harbour (James Backhouse).

rest like a steeple, in some of the bays there is a slaty rock a few degrees from vertical rising above the surface for a considerable extent' (Walker & Backhouse 1840, B732).

Religious activities were noted: [they] 'had a religious opportunity with the pilot, the four soldiers and one of the pilot's servants.' But work with and for the convicts was of more importance. They:

> met in the prison for worship and had an interesting time. After reading a portion of the sacred volume, strength was afforded to testify largely of the love and mercy of God in Christ to repenting sinners and to those who have turned from their sins and daily seek the help of the holy spirit to perfect holiness in the fear of the Lord and also to point out the folly and wickedness of a life of sin (Walker & Backhouse 1840, B732).

In his preaching to the prisoners Backhouse encouraged 'Roman Catholic prisoners to join', as he pointed out to them: 'we were no class of ordained clergymen' (Backhouse 1843, p. 456). These prisoners steadfastly refused to be preached to by the 'official' Anglican clergy. Feelings on these matters were particularly strong in that period. (For the Anglican view of Catholicism, see, for instance, Wilton (1833, Vol. 2, pp. 98–309).) Lang was also vehemently anti-Catholic, writing that his opinion 'of ... their monstrous system of priestcraft and superstition is well-known'. However, despite his abhorrence of the Catholic beliefs, Lang, unlike Wilton, believed firmly that, as British citizens they deserved the same civil religious rights as everyone else (Baker 1985, p. 192).

It is not surprising therefore that the Catholic prisoners were not enchanted by sermons and admonitions from such sources. Such attitudes seem to have persisted a long time in Tasmania, as Lieutenant-Governor William Denison (1804–1871), writing of his time there in the 1850s, said 'Sectarian and religious party feeling run higher than I have ever known', but he added 'men of all denominations unite in speaking well of George Washington Walker', who had returned to marry and live in Hobart in 1840 (Denison 1870, Vol. 1, pp. 82–83).

Travels by land in northern Tasmania allowed Backhouse to make geological observations recorded in numerous sketches. Backhouse noted 'Ben Lomond presents a remarkably castellated bluff to the south ... this mountain is said to be volcanic, and to have a lake, in an extinguished crater, at the top' (Backhouse 1843, p. 137) (Fig. 7). The idea that Ben Lomond was an extinct volcano was incorrect. P. E. Strzelecki (1797–1873) referred to the 'immense masses of greenstone which constitute(s) the dentiform crest of Ben Lomond' (Strzelecki 1845, p. 94). Although he used the term 'eruption' it seems to refer here to an episode of broad extent rather than to a specific local event (see, for instance, Strzelecki 1845, p. 121). The locality was later the site of extensive tin-mining from granite rocks adjoining the high plateau, which consists of what we now call dolerite. The region was mapped in some detail by Alexander Montgomery (1862–1933) in the early 1890s (Montgomery 1892). He called the dolerite 'greenstone (diabase)'. The highest point of the range was thought at the time to be the highest elevation in Tasmania. Mt Ossa in west–central Tasmania is now known as the highest point on the island.

Smaller geological features elsewhere in Tasmania also caught Backhouse's eye. On the Clyde River 'the land [of George Dixon] consists of basaltic hills. In one place a rock like a steeple stands between a cliff and the margin of the river.'

Further south:

> When at Macquarie Plains, upon the Derwent, we visited a fossil tree, which is imbedded in basalt, in the point of a hill, near a cascade, in a creek that empties itself into the river. The tree is erect, and may possibly prove to be standing where it has grown. About 10 feet of its height are laid bare by removing the basalt, which is here porous and cracked. The tree is about 10 feet in circumference at the lowest part that is bare. Some of the exterior portion has become horn-coloured flint: much of the internal part is opaque, white and fibrous; some portions of it split like laths, others into pieces like matches, and others are reducible to a substance resembling fibrous asbestos.
>
> The grain of the wood and of the bark is very distinguishable. Fragments of limbs of the same kind have been found contiguous to the tree; and pieces of petrified wood of similar appearance are abundant scattered over the neighbourhood. The structure of this tree is such as is considered to belong to coniferous trees; the only one of which, now found in this Island, of size equal to this petrifaction, is the Huon Pine' (Backhouse 1843, p. 152).

The geological features of Norfolk Island, another convict colony, visited from Sydney, were of special interest to Backhouse. He noted 'two remarkable arches, in the basaltic rock ... some portions of which are columnar basalt' (Backhouse 1843, p. 264). Backhouse reported on Norfolk Island for Governor Bourke (1777–1855), one of three reports he made on convict settlements in the [then] colony of New South Wales.

Of interest in the present context was the visit by Backhouse and Walker to the Aboriginal mission on Lake Macquarie, north of Sydney and set up in 1826 under the care of the Congregational minister, the Reverend Lancelot Edward Threlkeld (1788–1857) (Fig. 1c), of the London Missionary Society (Backhouse 1843, pp. 64–66; Champion 1939; Gunson 1967, p. 529). Threlkeld's work with the Aborigines, and particularly his studies of the language (including recording some 'geological' words) and customs (Threlkeld 1834) in 1840 attracted visits from Horatio Hale (ethnologist, philologist; 1817–1896) and Alfred T. Agate (artist;

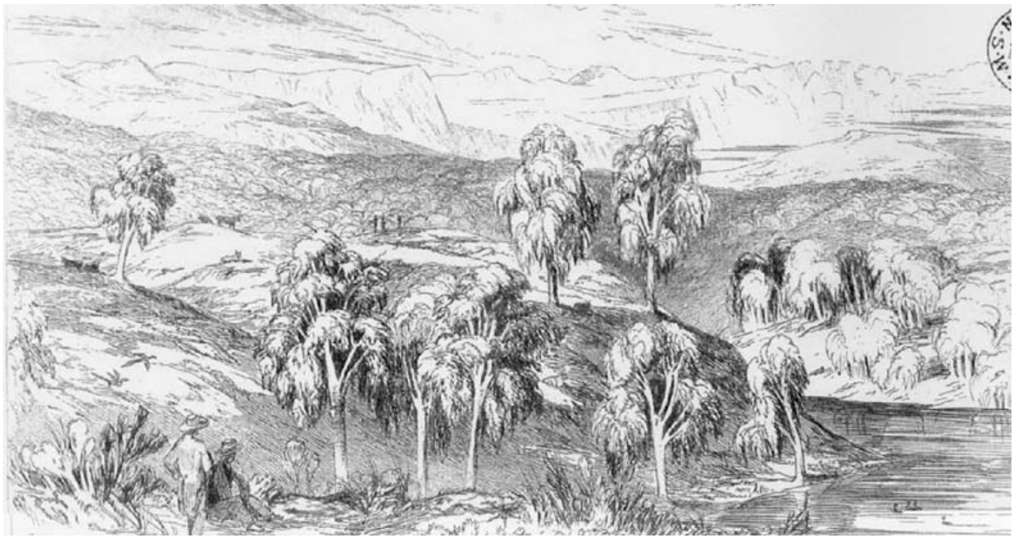


Fig. 7. Ben Lomond scenery (James Backhouse).

1812–1846), members of the Wilkes United States Exploring Expedition, as well as the Quakers. However, the mission had not pleased Lang, who attacked it several times, notably in 1836, and Threlkeld sued for libel. Threlkeld's case was settled in his favour, but he was only awarded one farthing damages (Gunson 1967, p. 529).

Before the mission was closed in 1841 Threlkeld opened a coal mine on his property to augment his diminishing income. This was in direct opposition to the monopoly that had been awarded to the Australian Agricultural Company in the 1820s (Branagan 1972, pp. 65–66). Like Wilton and Lang, Threlkeld was vehemently anti-Catholic, as suggested by the title of one work: *An Appeal to common sense; being a comparison of Mohammed and the Pope with the Messiah: addressed to Christians* (Threlkeld 1841; Gunson 1975).

Possibly *en route* to Threlkeld's mission Backhouse noted 'banks of Pumice-stone, north of Port Jackson drifted with a south-east wind and a high sea' (Backhouse 1843, p. 461), a feature that had attracted the attention of other observers over the years (Gibbons & Gordon 1973; Branagan & Moore 2009).

On board the *Eudora* to Albany, King George Sound, Western Australia, Backhouse observed 'Kangaroo Island: its cliffs are lofty, dark, and horizontally stratified'. But he used the quiet shipboard time spending 'much of the day in private, religious retirement, and placed books of a religious tendency, in the way of the officers of the vessel, who now and then looked into them'. Geology was evident near Albany: 'at the foot of Mt. Melville and Mt Clarence [there are] two small, rock-capped granite hills' (Backhouse 1843, p. 522). These features had been remarked upon by many visitors, such as Darwin (Laurent & Campbell 1987) and Phillip Parker King (Branagan & Moore 2009). Later, Backhouse described geological features of the Fremantle–Perth region of Western Australia (Backhouse 1843, p. 529).

Backhouse was interested not only in the broad theories of geology, but also in practical aspects, and when in Sydney took the opportunity to visit the tunnel being constructed by the government's mineral surveyor, John Busby (1765–1857). It was a well-planned project designed to carry water from the Lachlan Swamps to the centre of the rapidly growing town and overcome the problems of water shortage and pollution in the town's original water-course (Branagan 1996*a*) (Fig. 8). The work was 'nearly completed the tunnel being arched with hewn stone; it is two feet wide, four feet high and about two miles long. The water from it is laid in iron pipes into various parts of Sydney, but it is not yet distributed to private houses. The Botany Swamps are natural reservoirs being extensive basons [sic], in sandstone rock' (Backhouse 1843, p. 456). He went on to describe the plants of the swamp region.

Of more particular note was the journey, mostly on foot, from Sydney over the Blue Mountains to the Wellington Valley of New South Wales (Backhouse 1870; Mackaness 1965). One reason for the journey was to report for Governor Bourke on the Aboriginal station at Wellington. Unlike many of the ordained clergy, Backhouse 'saw the inner

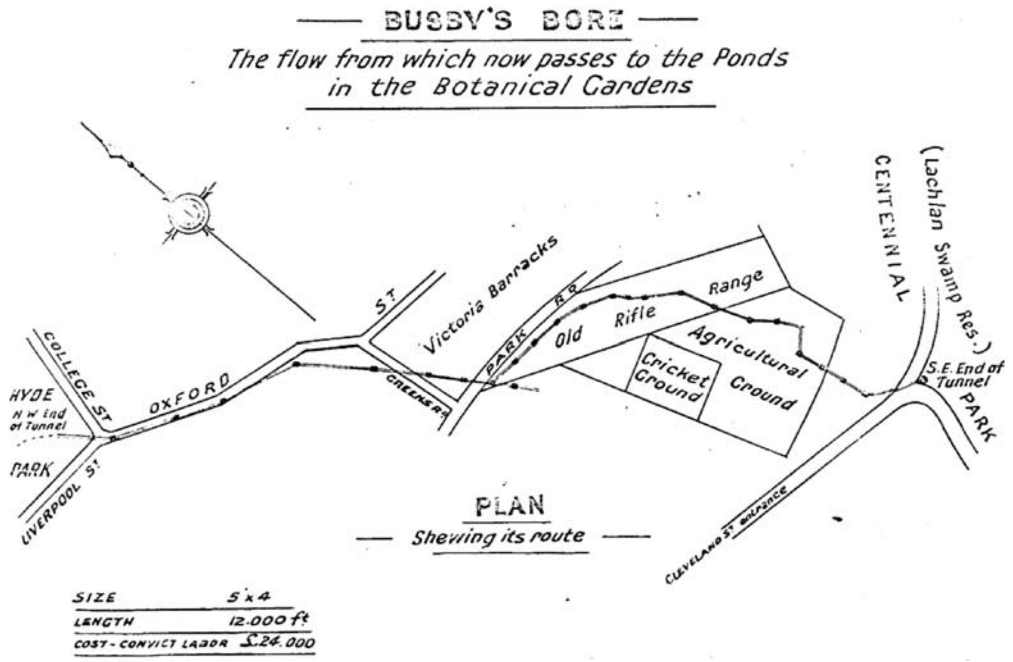


Fig. 8. Busby's Bore, Sydney water supply.

core of real religion ... in the Australian Aboriginal' (Trott 1966, p. 46) in contrast to the generally prevailing opinion (see, e.g. Wilton 1833, p. ix). Backhouse noted the changes of geology *en route*, but had no success in finding fossils at Wellington.

Johannes Menge (1788–1852)

Johannes Menge (Fig. 1d) arrived in South Australia in January 1837, as mine and quarry agent and geologist to the South Australian Company, a private organization, led by George Fife Angas (1822–1886). Menge probably became involved with Angas through the British and Foreign Bible Society, for which Menge was, in 1836, working in London, as well as teaching Hebrew and Chinese at a private academy. He arrived accompanied by four German miners, optimistically employed 'to work the quarries of stone and lime and procure additional supplies of water from artesian wells', and he resided first at the company's settlement, Kingscote, on Kangaroo Island. Here Menge devoted himself particularly to the problems of obtaining a stable water supply and suitable building materials, writing 'I cannot wish for metals and gems before the land is cultivated and Kingscote has a shape of a human dwelling place'. He corresponded with a Dr. Pauli (not further identified) in Lübeck, writing from 'under the canopy of heaven, Nepean Bay'. He was not too enthusiastic about moving to the chosen mainland site, Adelaide. Although 'spoken of as a fine valley with fruitful soil, I am in no hurry to go there as flat country has as little attraction for me as flat souls' (O'Neil 1982, p. 10).

Born in Steinau, Germany, Menge had little formal education when young, but he had a brilliant mind, and later studied theology with the 'Reformed Theologian' Dr Johannes Geibel (1776–1853) (Killy & Vierhaus 2002, Vol. 3, p. 654). His geological talents were apparently recognized by the agnostic Karl von Leonard (1779–1862), who took Menge under his wing at Hanau, and put him to collecting, sorting and selling minerals. Menge followed this by travelling widely through Europe, including Iceland and well to the east in Russia (Killy & Vierhaus 2002, Vol. 7, p. 64). His liking for solitude might have been a major reason for his decision to travel to South Australia, but, as O'Neil (1982, p. 9) suggested, the persuasive powers of Angas might well have played a strong part.

However, O'Neil (2002, p. 68) commented that Pastor Augustus Kavel (1798–1860) from Klemzig (Silesia) was also influential, as he was concerned to arrange, through Angas, 'passage ... for his congregation which wished to flee from religious persecution'. O'Neil went on to suggest that Menge looked for 'a life without restrictions ... an opportunity promising religious tolerance and scientific investigation' (O'Neil 2002, p. 69). Although there were numerous German settlers in South Australia Menge soon gained uncertain fame for his rather unorthodox behaviour, which apparently included the carrying out of energetic fieldwork equipped with two hammers swung for balance as he moved quickly accompanied by the singing of Lutheran hymns. Nevertheless, his fieldwork produced results, and he was soon advertising the fruits of his mineral and fossil collecting and attempting to sell special collections (Fig. 9).

Menge also continued his interests in Christian proselytizing, publishing blends of linguistic science and mystical theology. He kept up his interests in languages, developed over a number of years, as he wrote to his son in 1827: 'the other day I read in the New Testament five chapters in each: 1. Latin, 2. French, 3. Italian, 4. Spanish, 5. Arabic, 6. Modern Greek, moreover five hebraic, five arabale [sic], and five turkish psalms, two chapters Tartaric in Genesis ... as well as five to six pages in Pensées de Pascal *Sur la Religion'* (Menge 2002, p. 13).

Sadly, his unorthodoxy affected attitudes about his geological advice, even by his mining assistants, as when his sensible ideas about providing safe water supplies for Kingscote were rejected. His desire for a theological college in the desert, the Bible 'translated into the Aboriginal idiom', and his dream of a 'language school for a mission to China' (Menge 2002, p. 13) were other disappointments. Menge developed 'an empathy with various Aboriginal Tribes and was said to have had a knowledge of at least three Aboriginal dialects' (O'Neil 1988, p. 383). It is said that Menge refused to teach Hebrew to Governor George Grey (1812–1898) and his wife Eliza because

Advertisement in the *Southern Australian*, 18 September 1839

With a view to promote the science of geology in South Australia, the undersigned purposes making up a series of collections of the Rocks, Minerals, Gems and Metals he has discovered whilst rambling within the ranges of this province.
The first collection of the series will be issued in November next; the second on 1st. January 1840 on the following terms
£4 each collection of 100 specimens.
A subscription list for a single collection of the whole series has been opened, headed by His Excellency, The Governor, Osmond Gilles Esqu., Rev. C. B. Howard and lies for further signatures at the office of Messrs. Flaxman and Rowland
Charge to subscribers for one collection £3
Charge to subscribers for three collections £8
John Menge, Geologist
Klemzig
1st. September 1839

Fig. 9. Menge's mineral sale advertisement.

Grey would not open a school of mines (Loyau 1883, p. 174).

Perhaps Menge's major contribution to the development of South Australia was his recognition of the agricultural and viticultural propensity of what he called 'New Silesia', but which Surveyor-General Colonel William Light (1786–1839) named 'Barossa Valley' mis-spelling it after the original 'Barrosa' region of Spain (Killy & Vierhaus 2002, Vol. 3, p. 654; O'Neil 2002). Menge's restless energy saw him making a wide range of mineral discoveries, including opal, clay for potteries, and good observations of geology, commenting that 'no country in the world is so well adapted for promoting the science of geology and mineralogy' (O'Neil 2002, p. 73).

By 1847 Menge had pinpointed the location of 500 mineral sites in the colony. However, by this time, according to Cawthorne (1859), Menge's thoughts were turning to 'think more about Eternity than about Time'. Cawthorne discussed Menge's approach to organized religion at a time when there was a theological split in the local Lutheran community. Menge regarded religion 'as an entirely personal matter ... if he belonged to one church more than another, he probably preferred the society of the "Moravian Brethren". Be this as it may, he exhibited one leading trait in his religious character ... FAITH.' Menge died a lonely death on the Castlemaine goldfield, Victoria, in mid-October 1852, but he is by no means forgotten. He is often remembered today as the 'father of South Australian mineralogy' (see, e.g. O'Neil 1988); it has also been suggested that he 'may be called the father of Australian geology' (Van Abbé 1962, p. 365), but others have a better claim to this 'title'.

Dom Rosendo Salvado (1814–1900)

An interesting minor character of this story is the Benedictine priest Dom Rosendo Salvado (Fig. 1e), who later became the Bishop of Port Victoria (Port Essington), a settlement established on the north Australia coast in 1838, but which 10 years later was completely abandoned (Spillet 1972). However, Salvado's title persisted (Stormon 1977, p. 246). Salvado and several companions arrived in Western Australia in 1846, full of zeal to 'christianize' the Aboriginal people. Under enormous difficulties they set up their mission at New Norcia, some 128 km north of Perth. Lacking funds for even basic supplies, Salvado, in ragged garments, seized on the idea of using his talents by giving a piano recital in Perth. Amused at first by the prospect, the citizens turned up in droves and, probably to their surprise, were presented with a 3 hour recital of great charm and expertise, and support for the mission became a reality. Salvado proved 'a great apostle to the Aborigines, with what was for those times an unusual insight into their minds and enlightened ideas about their possible future' (Stormon 1977, p. ix).

Apart from his christianizing (the monastery survives to the present), Salvado's claim to scientific fame rests with his contributions to Australian anthropology (mainly social). Part 2 of his *Memorie Storiche* included a mini-dictionary (vocabulary list) of two Aboriginal dialects (Stormon 1977, Appendix, pp. 255–266), one of the few such vocabularies, up to the 1850s, similar to that by the Reverend L. E. Threlkeld noted above.

In relation to geology Salvado did no original work, but, like most educated people of the period, he was interested in the topic, and clearly read widely on the subject, particularly as it was developing in Australia. Between 1851 and 1853, while in Italy and waiting for additional support for his mission, and partly in defence of his mission against defamatory remarks made by a Perth layman (Stormon 1977, pp. xiii–xiv), he penned the *Salvado Memoirs*, published in Italian in 1851. This book was translated and published in Spanish in 1853 and in French the following year. It included chapters on Australian flora and fauna, and 'Geological Features and Minerals' (Stormon 1977).

Salvado's geology emphasized a wide variety of opinions: 'The physical formation of Australia has given rise to weird and wonderful conjectures about its origin' (see the comments above by Lang concerning Blumenbach's ideas); 'Some geologists hold that it is composed of primitive formations, others of secondary or calcareous ones, and some think it volcanic. What is certain is that there is evidence of all three kinds.' He wrote of the western Victorian volcanicity, which had been described by Lang and a little later by Westgarth (1846), and which was to be the subject of more intense study only a few years later by Alfred Selwyn and his staff of the newly established Geological Survey of Victoria (Selwyn 1856). Salvado wrote: 'in the mountain chain called the Australian Pyrenees there are many volcanic mountains and traces of great lava flows, which makes it impossible to doubt that this region was convulsed by subterranean upheavals and scorched by volcanic fires' (Stormon 1977, pp. 216–217). He commented on the 'Burning Mountain' at Wingen in the Hunter Valley (Branagan & Diessel 1993; Oldroyd 2007; Mayer 2009), originally thought to be an active volcano. He noted its real cause, a burning coal seam, and compared it with a similar occurrence at Holworth, near Weymouth in England, where it was explained by both William Buckland and the geologist De la Beche (Stormon 1977, pp. 184–185).

As described above (concerning Lang and Mitchell), the Wellington cave deposits were already noteworthy. The aging and ill Georges Cuvier (1769–1832) in Paris must have had little time to examine the Australian fossils sent to him from Scotland in 1832 (he died on 13 May), but Jameson received the news that the large bone was the 'thigh bone' of a young elephant. This message echoed around the scientific world, among the interested circles of both Europe and Australia, and was repeated by many others.

Thus Salvado wrote: judging by fossils . . . found in a limestone cave . . . and pronounced by Cuvier . . . the bones of a young elephant', suggesting that Salvado was familiar with some of Cuvier's publications, such as the fourth edition of *Recherches sur les ossements fossiles*, which appeared 2 years after Cuvier's death (Cuvier 1834). Salvado continued: 'I am inclined to believe that in the remote past such animals lived in the continent and perhaps even today survive in the vast unknown interior' (Stormon 1977, p. 188). Salvado was not the only person who thought such animals might still turn up living in isolated places in the very large, and still relatively unexplored interior of the Australian continent; for instance, Ludwig Leichhardt (1813–?1848) had similar thoughts (Branagan 1994, p. 118). It was Cuvier's protégé, Joseph Barclay Pentland (1797–1873), who first assumed the responsibility of describing the Wellington cave fossils, publishing his results in the *Edinburgh Philosophical Journal* (Pentland 1832, 1833), accompanied by a sketch of the original cave location, drawn by Mitchell and later reproduced in his *Three Expeditions into Eastern Australia* (Mitchell 1838, Vol. 2, p. 362) (Fig. 4). (The author of these papers, and an earlier note (Pentland 1830), was shown as W. Pentland, and was often mentioned as William, but it was almost certainly J. B. Pentland.)

Thus Salvado spread knowledge of Australian geology into continental Europe, notably into regions where readers would not be so familiar with the English language publications on the subject.

The Reverend William Scott (1825–1917)

On 12 March 1858 the *Empire* newspaper of Sydney reviewed the book *Geology and Genesis: a Reconciliation of the Two Records* (Wight 1857) by the Scottish Presbyterian minister the Reverend George Wight, who was then visiting Sydney. The reviewer (Anonymous 1858) commented that it was a 'subject which we would not choose for discussion in the columns of a general newspaper . . . [we] do not seek to raise untimely discussion of a topic so fruitful of controversy', but because of the author's presence it 'might be deemed discourteous if we declined to notice it'. The reviewer commented that 'the question of agreement between Genesis and geology 'should remain an open one until the professors of geology can agree among themselves. They have scarcely settled the alphabet of their science'. This volume was a reworking of Wight's earlier work, which had been published in 1842 (Wight 1842) and drew recommendatory notes from W. L. Alexander. Although not identified in the review, W. Stanley Jevons (1835–1882), then assayer at the Royal Mint, Sydney was apparently the author (Mozley 1967). Although it was an interesting review, it did not provoke any short-term reactions amongst the newspaper's readers. Earlier, the Sydney *Empire* of 30 January 1857 reprinted a review (Anonymous 1857*a*) from the London *Athenaeum* of Henry Lord Brougham's *Natural Theology* (1856), and there was some follow-up. Six months later (4 July 1857, p. 3) the same newspaper reprinted a review (Anonymous 1857*b*) from the English *Examiner* of 28 March 1857, on Hugh Miller's *The Testimony of the Rocks: or Geology in its Bearings on the Two Theologies, Natural and Revealed* (Miller 1857), so there was clearly some interest persisting among the local intelligentsia. The newly appointed Colonial Astronomer, the Reverend William Scott (1825–1917), an Anglican clergyman, who had been Taylor Mathematical Lecturer at Cambridge and had only just arrived in the colony, took up the challenge. In December 1858 Scott told the [local] Philosophical Society:

> believers in revelation should know that their Scriptures contain and are intended to contain, a revelation of religion alone; and that the book of nature is the only book which God has given to man in which to read the laws of material creation . . . the writers [of Scripture] were ignorant of the truths which astronomy and geology have since brought to light (Scott 1858; see also Mozley 1967, p. 419).

The Reverend William Branwhite Clarke (1798–1878)

The Reverend William Branwhite Clarke (Fig. 1f) was one of the most important of the personalities considered here. Together with Father J. E. Tenison Woods and the Reverend Walter Howchin, he made major contributions to science, and notably to Australian geology. The study of Clarke's geological work by historians has left his religious life little examined, although there is a considerable corpus of writing, mainly in letters, that deserves serious study. We do know that, in accordance with his bishop's wishes, he rejected the opportunity to take up a professorship at the newly established University of Sydney in 1856, because of its essentially secular status (Jervis 1944, pp. 446–447; Moyal 2003, Vol. 1, pp. 444–445). Also the Reverend Dr Woolls (1814–1893) commented that Clarke was a 'liberal theologian' (Rowland 1948).

Clarke built up a long-standing friendship with the naturalist William Sharp Macleay (1792–1865). Their periods as students at Cambridge overlapped, but they apparently did not meet there. They both arrived in Sydney in 1839, Macleay in March, and Clarke 2 months later. Clarke came equipped with a copy of Murchison's *Silurian System* (1839) and an introduction to Macleay from Murchison, and they met later in the year. Although he was always encouraging, Macleay was to act as an important critic of some of Clarke's hastily conceived geological ideas.

In 1842 they discussed the possible age of Australian coals, Macleay (in a letter of 26 June 1842; letter in the author's possession) believed that the evidence of the presence of the *Glossopteris* flora suggested a definite Palaeozoic age, whereas Clarke pressed, at that time, for an Oolitic age. They even argued as to the way coal might have been formed: possibly by combustion suggested Macleay, and Clarke thought he meant before burial, but Clarke (1 July 1842) pointed out the biblical limitation of a heat source as: 'Moses in Gen.1.10.11 declares, vegetation followed upon the earth's appearance above the primaeval waters, & preceded even the *appearance* of the Sun & the creation of the water-creatures.' Macleay answered (4 July 1842) clarifying his ideas: that the vegetation was carried to deltas, where there might also have grown new trees. All the vegetation was gradually covered by mud, then sands were deposited, and later there was a tremendous underground fire.

Macleay was not intimidated by Clarke's quoting of the Bible, and wrote:

> I doubt *(nay, I will go further) I do not believe* that vegetation preceded the appearance of the Sun and of every kind of Aquatic animal. I must believe my senses or put faith in the geological evidence against such an antiquity of grass, herbs and trees . . . [and there is much more].

Macleay's scepticism was summed up in his later remark:

> I cannot consider the Bible as a scientific book according to the vulgar meaning of the word scientific; and although I do not consider that Moses wrote anything inconsistent with the truth, I confess I have as much confidence in his opinion of the binomial theorem as I have in his dictum on Geology.

The Macleay letters quoted above have been published by Moyal (2003, Vol. 1, pp. 112–120); the intervening Clarke letter (unpublished) is in the author's possession. Despite such verbal fire the friendship remained strong.

Clarke was particularly delighted to tell Macleay about his discovery of a 'fossil forest' of some 500 exposed tree stumps at 'Kurrur Kurran' in the Lake Macquarie region (Clarke to Macleay, 16 July 1842) (Fig. 10a and b). It proved to be one of a number of such occurrences in the region, in what are now recognized as being coal measures of Permian age (David 1907). It is interesting that there was an attempted 'takeover' by creationists of these 'fossil forests' in the 1980s. In a lecture given after the Mount St Helen's eruption, the destruction of timber and its subsequent rapid alteration following that catastrophic event was linked with the Lake Macquarie fossils to suggest the rapid formation of the fossils, and the limitations of geological time (Mackay & Snelling 1984; see also Osborne & Branagan 1988).

Clarke wrote to Lang on 27 June 1851 (Clarke 1851), enclosing one of his many geological publications, commenting that the value of geology to colonists should be evident. Clarke continued that he (Clarke) 'had not sought to gain from his claim to be the discoverer of gold: in Australia [men] will, I hope, be led to see that there has been a higher power at work among us than men's' (Lang 1851: Lang Papers A 2226, Vol. 6, 553–556). Nevertheless, Clarke was not well off and he was no doubt pleased when the colonial government offered him paid work in the 1850s during the gold rushes, and in 1862 he was voted £3000 by the Legislative Assembly for his work.

In the present context, the Australian reaction to Charles Darwin's most famous publication, *The Origin of Species* (Darwin 1859), is of interest. Finney (1993, pp. 97–113) has discussed this topic in some detail, but with only short discussion of clerical interests, concerning Clarke and Woods. The first Australian discussion of the book seems to have appeared on 26 June 1860 in the *Sydney Morning Herald* (Anonymous 1860). The writer (not Clarke) commented:

> This vexed question with which the scientific world is so much agitated, is discussed in the fullest manner in the new number of the *Edinburgh Review* in an article of forty-six pages. A summary was given of Mr. Darwin's hypothesis and his chief experiments were noticed And, after considering the opinion of Buffon, Cuvier, Owen, Wallace, Agassiz, and other eminent naturalists, the writer, in conclusion, expresses his decided adhesion to the views of Cuvier, Owen and Agassiz, in opposition to those maintained by Buffon, Lamarck, the 'Vestiges', Baden Powell and Darwin. An eloquent article on this subject, by M. Auguste Laugel appears in the last number of the *Revue de Deux Mondes*. The writer favours Mr. Darwin's views, and hopes that their dissemination will be practically advantageous by favouring the acclimatisation of animals and plants.

In general, the reaction to Darwin's book among Australian scientists was muted. However, Clarke devoured *The Origin* and wrote enthusiastically to Darwin in support (Clarke, August 1861, and see Darwin's reply 25 October, 1861, both published by Moyal 2003, Vol. 1, pp. 551–553, 560–562; see also Nicholas & Nicholas 1989, p. 127; Finney 1993, p. 103). Gerard Krefft (1830–1881) of the Australian Museum, Sydney was also enthusiastic about the theory (Finney 1993, pp. 108–112), but Macleay found it wanting, and was not convinced. He wrote to Clarke saying that although he considered Darwin, a 'first rate naturalist' he felt Darwin had 'cushioned' facts against his theory and ignored the relevance of other facts. He thought Darwin's concept of the Creator was that he made the world and its inhabitants, fell asleep and left it to manage itself'. Macleay added that he considered himself 'a Pantheist, but then I believe in his [the Creator's] special Providence ... the constant and active sole Creator and all-wise Administrator' (Mozley 1967).

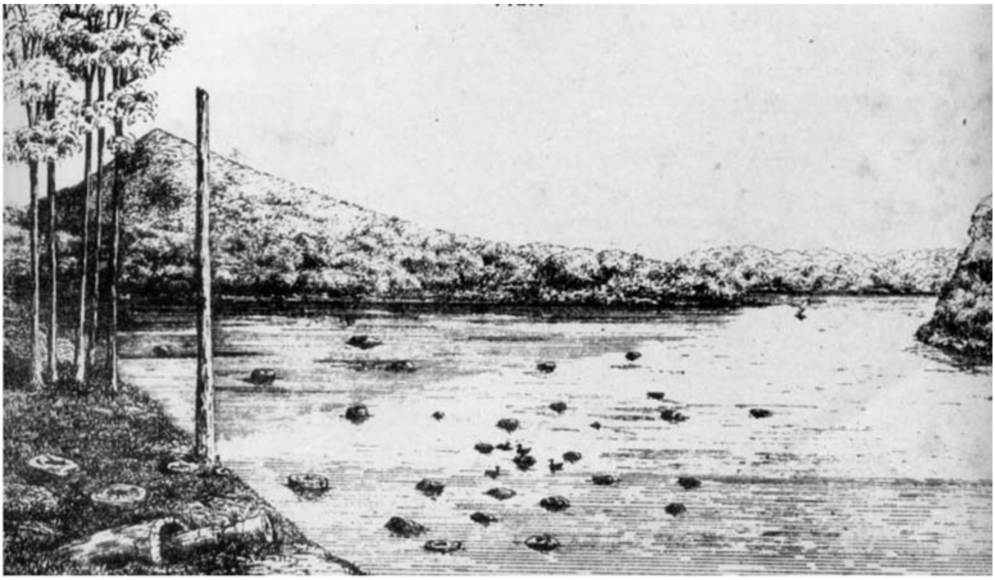
Clarke did not have great success with others of the colonial cognoscenti, and even the landscape artist, Conrad Martens (1801–1878), Darwin's friend from the *Beagle* voyage, could not be inveigled into even opening the book. He told Darwin 'your book of the season, as the reviewers have it, I must own I have not read it, although Mr. Clarke offered to lend it to me. I am afraid of your eloquence and I don't want to think that I have an origin in common with toads and tadpoles' (Martens to Darwin, 20 January 1862, quoted by Nicholas & Nicholas 1989, p. 127).

Father J. E. Tenison Woods (1832–1889)

A slightly later figure, and different in many ways from Clarke, was the Catholic priest, Father Julian Edmund Tenison Woods. Although English born, Woods shows the influence of his time spent studying in France, particularly concerning geology, and he also had a somewhat personal approach to higher human authorities within the church, which might be evidence of further French influences.

Woods had an extraordinary career as missionary, educator and founder of religious orders of nuns, while still pursuing geological pursuits and aspects of biological science. After a series of attempts to work within various religious orders, particularly the French Marist Fathers studying at Lyons, and in the Auvergne, over 6 years his health stopped further progress towards ordination. Woods met Bishop Robert William Willson (1794–1866) in October 1854 and accepted his offer to go to Tasmania. He arrived there with three other religious workers in January 1855, and was appointed a chaplain to the Tasmanian prisons, just when Bishop Willson had persuaded the British Government to cease transportation to the colony. There

(a)



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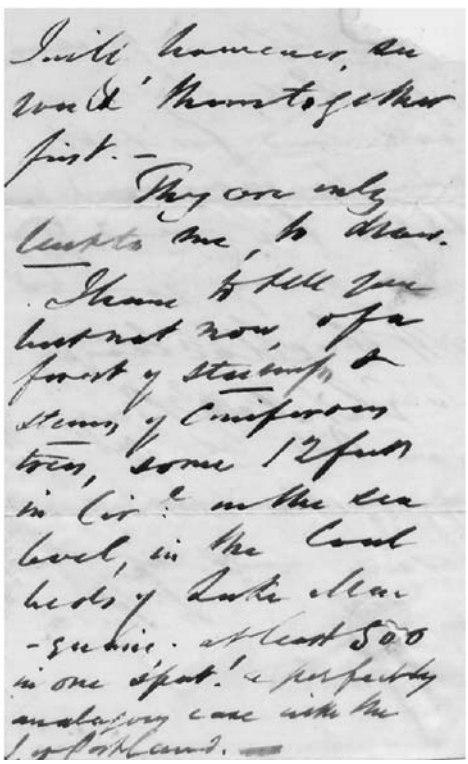


I will however, see
could' them together
first.—
They are only
wants one, to draw.
I have to tell you
but not now, of a
forest of stumps &
stems of Coniferous
trees, some 12 feet
in Cir.e on the sea
level, in the Coal
beds of Lake Mac
-quarie. at least 500
in one spot! a perfectly
analogous case with the
I. of Portland.

Fig. 10. (**a**) 'Kurrar Kurran' Lake Macquarie 'fossil forest'; (**b**) relevant letter (Clarke).

was a falling out with the Bishop, and Woods relocated to Adelaide later in 1855, where one of his brothers had settled, and where Woods subsequently became seriously ill. After his recovery he undertook further studies at the seminary set up by the Jesuits at Sevenhills, some distance north of Adelaide. Here he was also able to indulge his geological interest in his spare time.

His report on metamorphism in the Mount Lofty Ranges (Woods 1858) is one of the earliest on the subject in Australia, and in his concluding statement he expresses his perspective on the ultimate role of God in creating the world as he was observing it, thus:

> The sea beats overland where the busy hands of man have now raised a city [Adelaide], using for that purpose the very spoils which the ocean left behind, but while it did so, it spared a spot where fire had exerted its underground ravages ages before, leaving rocks and stones to tell to man, the magnitude and power of the earth's great framer (Woods 1858).

Ordained in January 1857 by Bishop Francis Murphy (1795–1858) Woods was sent several months later to Penola in the SE of South Australia (Press 1979; Player 1989). This was on the road from the coastal town of Robe and on the direct line to the rapidly developing Victorian goldfields. This road was covered by people of many nations, including a considerable throng of Chinese, whose arrival via Robe managed to evade the strict immigration controls at Melbourne and Geelong in Victoria.

Woods found himself in a virtually unknown geological paradise (but see Burr 1846, for some earlier observations). By incredible efficiency he was able to carry out both his church duties, including considerable travel by horseback, and geological studies. In very limited spare time, he began to elucidate the geological history of the region, often working late into the night to record his findings. They included a study of the volcanic region around Mt. Gambier, and of more significance, pioneering work on the origin of the karst systems of the Mt. Gambier–Naracoorte region (Figs 11 and 12). Woods published some of his findings in local and Adelaide newspapers, and, by 1862, had put together a book, which set out his conclusions on many aspects of the region, and appeared in London the same year. It is still a valuable resource (Woods 1862). Woods's ideas on the formation of caves were far in advance of those held in Europe and much closer to present understanding (Hamilton-Smith 1996). Earlier (1859), Woods benefited greatly from advice he received from Charles Lyell, and we can see this particularly in his publications (Woods 1859, 1860*a*, *b*, 1862, 1865) on the subdivision of the Tertiary strata of South Australia and Victoria, which used Lyell's percentage ideas (Archbold 1989).

Woods did little serious geological work between 1867 and 1871 because of his involvement as Director of Catholic Education in South Australia, and his co-founding with Mary Mackillop (now beatified) of the Sisters of St Joseph. This order was established essentially to teach the poor. However, during 1867–1868 he wrote a series of articles on science and revelation for the Adelaide

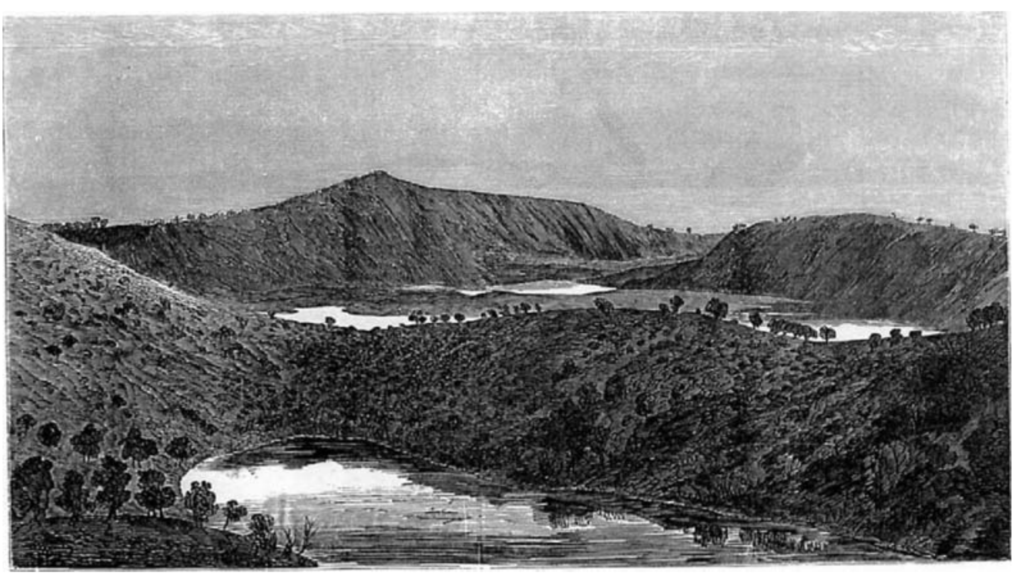


Fig. 11. Mt. Gambier double crater (Father J. E. T. Woods).

Fig. 12. Narracoorte Cave (Father J. E. T. Woods).

Catholic newspaper, an 'attempt to bring together the two dominant interests in his life' (Woods 1867*a–c*, 1868*a–f*; Press 1979, p. 212).

Through an invitation from Matthew Quinn, Bishop of Bathurst, New South Wales, Woods moved there in 1871 to carry out missions and encourage religious vocations and Catholic education. Among his students at St Charles Seminary, Bathurst, was John Milne Curran (1859–1928), who became an enthusiastic student of geology.

At Bathurst Woods' extraordinary scientific productivity increased again, and there were many publications over the next 17 years, covering not only geology (including palaeontology), but also biology and history. In 1879–1880 he was elected President of the Linnean Society of New South Wales, and the Royal Society of that same colony awarded him its prestigious Clarke Medal in 1882.

In 1883, after falling out with some Australian bishops, and following the settled establishment of the several orders of nuns he had helped found, Woods became, in a sense, a Christian explorer. Through his friendship with Governor Sir Frederick Weld (1823–1891), himself an enthusiastic amateur geologist (Louch 1976), Woods travelled to the Malay Straits, where he investigated the geology, and particularly the tin mineralization and coal deposits, of the region, at the same time carrying out his preaching whenever requested (Tenison-Woods 1887). He was later in China and Japan. In the latter country he managed to visit important sites, such as the Bandai volcano, and carried out an assessment of the country's coal deposits, probably on behalf of the British Navy, which was anxious to know the availability of coal and its localities relative to the British coaling stations being set up to counter a perceived threat from Russia in the region. Woods' collection of rock and mineral specimens from Japanese sites that are now largely inaccessible because of development is housed in Sydney (Branagan 1996*c*; Player 1989).

Despite his own involvement in essentially commercial pursuits Woods recognized the problems that foreign involvement had introduced into Asia, and particularly how it affected religious matters. He wrote: 'All friends of the true interests of Christianity must wish that the territorial conquest and the work of the missionary had been kept entirely apart' (O'Brien 1994, p. 61).

In the 1860s Woods was probably too preoccupied with his own publications and religious duties to take much note of Darwin's *Origins* when it appeared. He seems to have been more concerned, at the time, with questioning the somewhat peripheral work of Charles Lyell *The Antiquity of Man* (Lyell 1863). Woods was not convinced that the evidence for the sequential nature of the Stone Age, Bronze Age and Iron Age was strong enough for total acceptance (Woods 1864), but Finney (1993, pp. 104–105) has seen Woods' book as an attack on Darwin's ideas.

We gain an idea of Woods' reaction to Darwin's work mainly through his biographers. Milne Curran (1859–1928), himself then a geologist of some standing, wrote: 'Tenison Woods held Dr. Darwin in great esteem. He admired his careful methods and admirable restraint.' Curran continued that Woods wrote:

> Natural Science has become strangely mixed up with some of the most important questions of religion and philosophy ... differing as many of us do from [Darwin's] conclusions ... I add my humble tribute of admiration for his philosophical methods of enquiry ... in such hands the interests of truth are safe in the long run (Curran 1890, p. 410).

'He loved science because' twas all to him the handiwork of the Master he loved to serve' (Curran 1890, p. 409). O'Brien had a slightly different stance, stating firmly:

> Science did not lie at the heart of Woods' life. ... his scientific lectures were intended to attract people who might then listen to him on questions of religion ... He belonged wherever he went: a lover of God's creation, a lover of God's people, a lover of God (O'Brien 1994, p. 61).

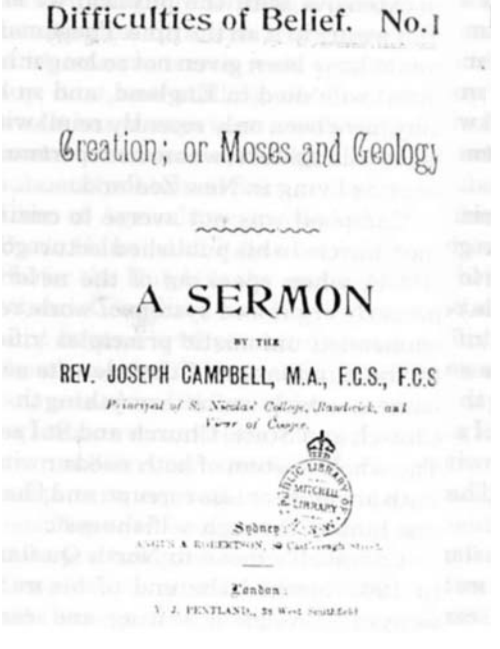
The Reverend Joseph Campbell (1858–1933)

Campbell (Fig. 1h) lived a life of considerable variety. After brilliant progress through the University of Sydney, where he studied many subjects and graduated BA in 1880 and MA in 1882, with the Belmore Scholarship for geology and agricultural chemistry, he made his mark, at one time or another, as an experimental metallurgist, photographer, author, headmaster, lecturer, preacher and agricultural experimenter, not to forget geologist. Towards the end of his life he probably came to be regarded also as somewhat of an eccentric (Branagan 1998, 2005).

Initially from a Presbyterian background, and having married a rich woman, Campbell wrote that he 'took [Anglican] Holy Orders, not as a living, but to bring Science to bear on Theology and to help the Church in my leisure' (Branagan 1998, p. 30). Perhaps his solid financial position allowed him to voice strong opinions about many matters. He was not averse to criticizing the social and religious systems, recommending: 'unionistic principles "purified" by the elimination of that detestable selfishness which ruins everything both in Church & State. The whole system of both needs renewing. Both are more or less corrupt' (Branagan 1998, p. 30).

His preaching, with sermons more than long by present standards, were well attended world-wide, particularly during a 3 year sojourn in England during the late 1880s, following his stint as a Commissioner for the 1886 Colonial and Indian Exhibition, London in 1886.

Even as late as 1900 Campbell saw the need to defend the progress of geology and to argue that this science, and the theory of evolution, did not clash with the tenets of Christianity or biblical


Difficulties of Belief. No. I

Creation; or Moses and Geology

A SERMON

BY THE

REV. JOSEPH CAMPBELL, M.A., F.C.S., F.C.S

Sydney:

London:

Fig. 13. 'Difficulties of Belief' (the Reverend Joseph Campbell).

Fig. 14. 'Science, Industry, Christianity' (the Reverend Joseph Campbell).

writing: 'His intimate knowledge of geology assisted him in the course of sermons illustrating in a very practical manner the intimate relations between religion and science delivered with a dash of humour' wrote an unidentified reporter for the *New Zealand Illustrated Magazine* (Anonymous 1900) (Fig. 13).

After his first wife's death, in London in 1900, he moved to North Queensland in 1904, where he remarried. In Cairns, while still giving popular lectures on aspects of geology and mineral exploration his experimental work turned to the production of cotton. During a period of extreme drought and shortage of food in 1919 Campbell virtually saved the town's inhabitants by converting his paper pulp machine to crush maize.

Having resigned his clerical position, Campbell moved to Sydney in the early 1920s. Here he set up a Scientific Advisory Bureau and tried to interest scientists and the general public in his practical and philosophical concept of the close links between science, religion and industry, a topic he had begun to develop in Cairns (Fig. 14).

The Reverend Walter Howchin (1845–1937)

Walter Howchin (Fig. 1i), a Primitive Methodist minister, began his ministry in Northumberland, England, in 1864, where his interest in geology was aroused. At that time he came in contact with Henry Bowman Brady (1835–1891), a polymath, essentially a pharmaceutical chemist, who had became renowned in geological circles for his studies of Foraminifera, notably those collected on the *Challenger* expedition. Howchin followed

Brady's example, his first scientific papers, published in church journals (1874–1875) being on deep-sea dredging (Ludbrook 1983, pp. 377–378). In 1876 he published, jointly with Brady, on Carboniferous and Permian Foraminifera. A bout of tuberculosis caused his resignation from the English ministry, and on medical advice he and his family migrated to South Australia in 1881. His first work in South Australia was as editor of the weekly *The Christian Colonist*, followed by 12 years as Secretary of the Adelaide Childrens' hospital.

In South Australia, although he remained an ordained minister, Howchin never 'held a circuit', but took occasional services. Ritson (1922, p. 830) wrote, however, that 'he exercised brilliant ministry ... his sermons were clever, lucid, Gospel Truth', and Wheaton (1937, p. 1) recorded 'that to Professor Howchin the world of nature was a record of Divine Authority'.

As his health recovered Howchin began again to study a wide range of geological matters, and to participate in the affairs of the local Royal Society, becoming editor of its journal for about 50 years, and publishing over the years 77 papers, beginning with one on Foraminifera of the South Australian Cretaceous rocks in 1884. His enthusiasm gained the co-operation of other ministers, the Reverends E. H. Ingamells, B. S. Howland and S. R. Andrews, in a variety of geological field work. The last named was successful in the search for Cambrian fossils (Sprigg 1986, p. 69), and, according to Wheaton (1937, p. 2), 'other ministers became personally interested in "these handiworks of God, and were given the clues to some of the secrets of the Infinite" '.

Sprigg wrote that a farmer was puzzled seeing Howchin at the bottom of a well sunk into the Permian glacial rocks in the Inman Valley, south of Adelaide, apparently interested in some rather ordinary-looking rocks. Expecting Howchin to tell him he was seeking 'precious metals', he was surprised when Howchin told him he was seeking 'Truth' (Sprigg 1986, p. 69).

In 1902 Howchin was appointed lecturer in geology and palaeontology at the University of Adelaide, being named Honorary Professor in 1918. After his retirement in 1920, Howchin continued to carry out extensive fieldwork, notably on the Late Precambrian glacial successions (which he regarded as Cambrian) and the Late Palaeozoic glacial rocks (Fig. 15). In all, Howchin established the framework of South Australian stratigraphy. His work was recognized internationally by the award of the Lyell Medal of the Geological Society of London.

Howchin's *The Building of Australia and the Succession of Life* (Howchin 1925) repeated, to some degree, material first published in his earlier book *The Geology of South Australia* (Howchin 1915) but, in dealing with the earliest appearance of life on Earth, as evidenced in the fossil record, he made no attempt to go back to a 'first cause'. It is clear from this book that Howchin had accepted much of the theory of evolution, and was happy to take up geological themes without needing recourse to theological musings. Howchin was, according to Ludbrook (1983, p. 377) regarded 'both as a man of science and as a humble Christian engaged in the reconciliation of science and religion'.

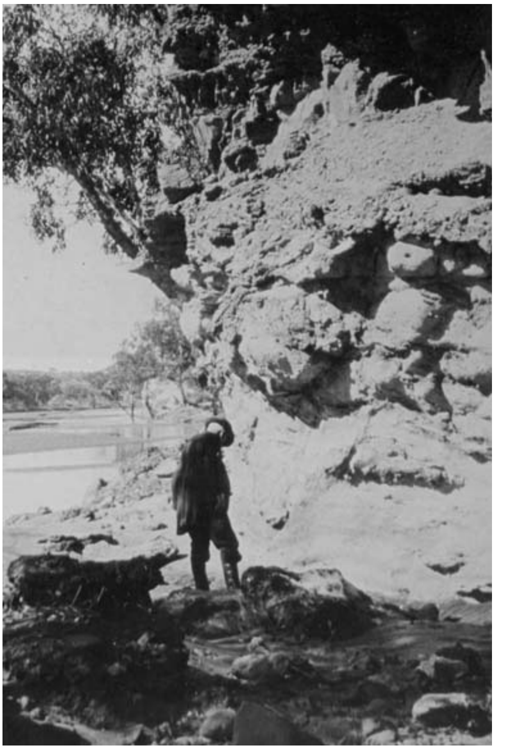


Fig. 15. Howchin, examining Late Palaeozoic glacial succession outcrop, Finke River, N.T.

Conclusions

This paper has described the life and work of some Christian clerics (and associated religious personalities) in Australia, with some consideration of the interweaving of their geological and religious work. I know of no Jewish or Islamic religious practitioners who could be included in the list, even in the present generation, although there were certainly Jewish lay-people particularly interested in geology, but apparently no religious leaders. This is, perhaps, a fruitful field waiting to be further researched.

Although Australian geological work in the nineteenth century did not have major repercussions for the development of geological theory, the exploration of the continent pointed to a natural environment that was markedly different from Europe, and the discovery of the extinct megafauna, mentioned above, also drew attention to the special character of the island continent. In relation to the differing populations of Australia and the European countries of the period the number of 'clerical geologists' in Australia might perhaps seem rather high. However, the clergymen actively involved in geological research were probably no more than 1 or 2% of the total number. The greater proportions were clearly among the Anglican and Roman Catholic clergy, both denominations that usually call for a higher level of education of their clergy, and although all their studies were largely based on biblical truths, they were more aware of broader and newer developments in theology.

However, as Laudan (1987, p. 224) pointed out, 'Geologists' religious attitudes were not monolithic. Some geologists treated Scripture as testimony, some denied its relevance', and this was certainly true in Australia. However, this paper has dealt only with the 'positive' belief in the 'truths' of geology, and essentially with the reconciliation of geology and the Bible. The clerical geologists discussed here clearly recognized that both the Bible and geology had particular places. However, there were some Australians, who, although making good geological observations, tended to keep interpretations within the bounds of biblical interpretations. Such was the gold-seeker Enoch Rudder (1801–1888), of Kempsey (Vallance 1975, pp. 28–29).

There were undoubtedly clergy who violently opposed the attitudes discussed in this paper. Some Australian clerics must have been antagonistic to geology, seeing it as a likely 'opponent' to the fundamental tenets of biblical Christianity. However, despite the popularity of authors such as Price McReady in the USA, his ideas did not seem to have had much influence in Australia. This seems to be a much more recent phenomenon, inspired by US fundamentalism, essentially from the 1950s. Aggressive opponents of geology are by no means evident in nineteenth century Australia.

As mentioned above, a number of the clerics discussed here made significant contributions to the science of geology: Clarke's work was largely stratigraphic, clarifying particularly the Late Palaeozoic and Mesozoic successions of eastern Australia; Woods' work involved Mesozoic and Tertiary stratigraphy, of both South Australia and NE Australia, and his ideas on the origin of caves through action in the phreatic zone were ahead of their time. Howchin's glacial work, most particularly on the Late Precambrian, was some of the earliest work world-wide, although it took many years to sort out. Menge's contributions were in mineral discovery and the recognition of fertile soils.

Following the establishment of the various colonial (and later state) geological surveys we do not see any marked change in the activities of clerical geologists. Those mentioned in this paper continued to contribute to geology through the established scientific societies, to which many survey members also belonged. The meetings of the Australasian Association for the Advancement of Science see a continuing co-operation of clerics and professional geologists.

The opportunity for pursuing a virtual double profession, such as carried out by some of the people discussed above, is almost non-existent today, although no doubt there will always be notable exceptions. Would the words of the eminent William Whewell (1794–1866) have been accepted by perhaps all of the personages discussed above?

> The two sciences (Geology and Theology) may conspire, not having any part in common, but because, though widely diverse in their lines, both point to a mysterious and invisible origin of the world (Whewell 1846, p. 106).

Some perhaps would argue that there were parts in common.

Many colleagues have contributed to my understanding of this topic. T. G. Vallance (1927–1993) during his life gathered much information from a variety of sources, often obscure, to which I have been granted access through Mrs H. B. Vallance. A. Player (Sisters of St. Joseph) aided my understanding of the work of Father Woods. R. A. L. Osborne worked with me on aspects of creationism and on the history of speleology, as did E. Hamilton-Smith. K. Cable (1929–2003) was always helpful on the history of Anglicanism in Australia. The Mitchell Library, Sydney and Fisher Library, University of Sydney provided access to manuscripts and rare books and permission to reproduce Figures 1(a), (c), (f), 5 & 13. The School of Geosciences, University of Sydney provided financial assistance. Discussion with colleagues from many countries at the INHIGEO Symposium held at Eichstätt, Germany in August 2007, organized by M. Kölbl-Ebert, provided encouragement in a fruitful environment. Figure 1(e) is reproduced with permission from New Norcia Museum; Figure 1(i) with permission from the State Library, South Australia; Figures 10(a) and 15 with permission of the University of Sydney, Archives.

Useful constructive comments were made by D. Oldroyd and B. Cooper.

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Geological observations by the Reverend Charles P. N. Wilton (1795–1859) in New South Wales and his views on the relationship between religion and science

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Abstract: The Reverend Charles Wilton arrived in the colony of New South Wales, Australia, in 1827 to take up an appointment as chaplain in an outer Sydney parish. His interest in the natural sciences, particularly in geology, led him to undertake many excursions to study and describe the largely unknown natural features of his adopted country. A transfer to the then small town of Newcastle to the north of Sydney gave him the opportunity to carry out more detailed and scientifically well-reasoned studies of such geological curiosities as the 'Burning Mountain', initially thought to be a volcano, the giant concretions along the Hunter River, and also of the coal measure sequence cropping out along the nearby coast. Wilton felt a strong need to communicate his discoveries, both for the benefit of science and the enlightenment of the general public. He achieved this by contributing to a short-lived journal he had founded and through many scientific publications and newspaper articles. His main purpose, however, was to demonstrate that there was agreement between science and religion. This conviction led him to criticize other naturalists who explained natural features and processes by accepting some latitude in the literal interpretation of the biblical account of the creation and of Noah's Flood. Some of his actions and behaviour, following his arrival in the colony, met with disapproval and censure from his superiors. However, he atoned for his early errors by the subsequent conscientious fulfilment of his clerical duties and by the communication of his work in the natural sciences.

During the 1820s, scientific investigations in the British colony of New South Wales were still primarily carried out by amateur naturalists and interested members of the general public. After almost 40 years of European settlement, no institutions of learning or scientific organizations had been established, and few people with expert knowledge in a particular field of science had been appointed by the Colonial Government. In the absence of an established local tradition in the pursuit of science, Wilton relied on knowledge and experience previously acquired in England as a basis for his investigations into the natural world of his adopted country. His occupation as a clergyman gave him the opportunity to follow his main interests in the examination of the geological features and curiosities and of the fauna and flora, both living and fossil, that he encountered on his excursions.

Personal background

Charles Pleydell Neale Wilton was born on 24 October 1795 in Upper Swell near Stow on the Wold in Gloucestershire, the son of the Reverend William Wilton and his wife Charlotte, *née* Jelf. He was educated at St. John's College, Cambridge, from where he graduated with a BA in 1817. Ten years later, in 1827, the University awarded him a MA (Marshall 1967). He became a Fellow of both the Cambridge Philosophical Society and the Ashmolean Society of Oxford. In July 1820 the Bishop of Gloucester ordained him as deacon and in December of that year as priest in the Church of England (Elkin 1938, p. 144). He married Elizabeth Plaistowe, in the parish of Awre, Gloucestershire, in 1823.

Wilton commenced his clerical duties as a curate in this same parish. He may have lost his curacy in June 1826,[1] following the death of his superior, Archdeacon Charles Sandiford (1752–1826). In the same year Wilton served briefly as curate of Stowting in Kent. With prospects for preferment apparently limited and by then embarrassed with debts,[2] he accepted the position of chaplain in the colony of New South Wales. He and his wife arrived in Sydney in April 1827.

Wilton was assigned to the parish of the Fields of Mars and Castle Hill, in what was then part of outer NW Sydney, and in addition was appointed Master of the Female Orphan School in nearby Parramatta (Fig. 1), the colony's second settlement west of Sydney. For these offices he received a stipend of £400 as well as a house (Marshall 1967). In addition, his wife was given the salaried position as matron of the school. By the standards

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Fig. 1. Map of part of New South Wales drawn by Alexander Findlay (1790–1836). Most of the localities referred to in the text are highlighted in bold type. With permission of the National Library of Australia, Canberra.

of the time his financial position would have been regarded as comfortable. However, his early years in Sydney were not happy ones. They were clouded by controversy and marked by accusations and censure from his superiors, and he tendered his resignation in late 1828 and declared his intention of returning to England.[3]

Wilton's troubles arose from his close association and friendship with F. W. Unwin, an attorney of dubious reputation. Following the announcement by the Bank of New South Wales of an additional share issue, to be paid for by instalments and not issued to buyers until paid in full, Unwin appears to have attempted to create shares consisting of fictitious bills drawn on Wilton, an agreement that neither of them had the means of honouring.[4] Wilton excused his involvement in these irregular dealings by stating that he had only lent his name to the transactions. His superior in the colony, the Archdeacon T. H. Scott (1783–1860), viewed the matter in a more serious light. He was greatly concerned that one of his chaplains should be involved in a fraudulent practice with potentially serious consequences to the public and to the reputation of the Established Church. Scott found further cause for complaint against Wilton in the performance of his duties as a clergyman and the alleged unauthorized use and mismanagement of the orphanage accounts. He came to the conclusion that Wilton was 'a young man of little judgement, of less experience and of no conduct ... I find him to be quite unfit for either station he fills in this colony'.[5]

Wilton, who at the time of the scandal had felt that he had no option but to resign, soon reconsidered his situation and, some months later, asked for permission to withdraw his resignation. The then Colonial Secretary, Sir George Murray, wrote to Governor Ralph Darling: 'While I am disposed to acquiesce in Mr. Wilton's urgent wishes for permission to recall his resignation, from a reluctance to ruin his prospects in life, yet I can not pass without reproof the impropriety of his behaviour in affixing his acceptance to Bills of doubtful character.' However, he made it clear that Wilton was on notice, adding: 'I think it fit to admonish Mr. Wilton that, if his future conduct shall not be such as to merit the approbation of the new Archdeacon,[6] Mr. Wilton must be removed from the benefice.'[7]

These remarks seem to have had the desired effect. Wilton's appointment, in 1831, as the third Chaplain of Christ Church (now Christ Church Anglican Cathedral) at Newcastle, some 150 km north of Sydney, appears to have been a turning point in his personal life. Now aged 36, his future exemplary conduct belied the earlier judgement of Scott concerning his suitability for the duties of a clergyman. Three years after the death of his first wife, in 1836, Wilton married Charlotte Albinia Sullivan, the daughter of a magistrate. In addition to his clerical duties, which extended over a large area beyond Newcastle, he supervised the work on his own farm and took an active part in community affairs. Wilton died in Newcastle on the 5 June 1859, survived by his widow and two of his children.[8]

Wilton's geological work in New South Wales

Wilton appears to have taken an interest in the natural sciences, particularly in geology, during his years at Cambridge. Soon after he left the university and before being ordained, he was active in Sussex investigating the local geology[9] and writing about fuller's earth in the Chalk formation (Wilton 1821). During his term as curate at Awre he examined aspects of the geology along the shore of the River Severn (Wilton 1830*a*). It is clear from his later writing that he was familiar with much of the contemporary European literature on geological topics and issues, and that his knowledge extended to other fields of the natural sciences.

Although a firm belief in the truth of the biblical account of the creation and of Noah's Flood were fundamental to Wilton's thinking about the Earth, he displayed a capacity for methodical study and reasoned interpretation of geological features and processes. He was of the opinion that

> contrary to earlier misleading views, geology, founded as it now is upon rational principles, is going on rapidly towards maturity. The time now is past for ignorance to assert, that this earth is a portion of another planet, knocked off by a blow from the tail of an unruly wandering comet, or that the remains of organised bodies, so universally prevalent in the several stratifications beneath its surface, are mere *lusus naturæ*, productions generated in the womb of the earth by its own creative powers.... [Men] have learnt at length the happy lesson of making use of their rational powers, and ... for the visions of heated imagination have wisely substituted the results of careful inquiry. Mankind has begun to feel that facts are of greater value than chimerical ideas, and that to believe in these matters at least, they must receive nothing contrary either to the deductions of reason—to clear demonstration—or to well authenticated reports (Wilton 1828*a*, pp. 191–192).

Wilton adhered to these principles in his generally accurate descriptions and rational interpretation of the natural phenomena he observed in the field. However, an enquiry into the formation of the Earth and the origin of its major features was, in his view, unnecessary, as the answer was already provided in the biblical account of the creation and of Noah's Flood. Wilton thus approached the study and interpretation of geology on two levels: first, as a dedicated naturalist, who conscientiously examined the natural environment and drew rational conclusions based on his observations, and, second, as a believer in the Bible, which provided him with the 'ultimate truth' about the creation and about the single 'revolution' that had affected the Earth subsequently (i.e. the worldwide Flood). Wilton was astute enough to recognize that processes were in operation, both within and at the surface of the Earth, that led to observable changes. However, he did not consider the action of these processes was such as to detract from his belief that the Earth owed its existence, including the basic construction of its parts, to divine decree. In the four examples of his geological work in New South Wales that are discussed below, Wilton showed himself to be an objective, open-minded naturalist. He made detailed observation in the field, he measured, described and compared the natural features under investigation, and, when the evidence warranted it, he drew reasoned conclusions in accordance with the knowledge of the time.

The 'Burning Mountain'

The discovery of what was thought to be a volcano, at Mount Wingen in New South Wales, soon to become known as the 'burning hill' or the 'Burning Mountain', gave Wilton his first opportunity to apply his knowledge of geology in the colony and, at the same time, to resolve a question that had aroused considerable interest and curiosity among the local population and even in Europe.

Less than a year after Wilton's arrival in New South Wales, *The Australian* newspaper of 19 March 1828 announced the discovery of a 'volcano' about a hundred miles (160 km) NE of Newcastle (Fig. 1). Since the start of European settlement some 40 years earlier, no active volcano had been recorded in Australia. The apparent first discovery of such a natural phenomenon therefore engendered much excitement and was considered to be of considerable importance. The newspaper report stated 'that the volcano emitted a brilliant light, and had every appearance of being long in a state of activity', and that 'the sulphuric smell which accompanies the flame immediately betokens its nature'.

More details of the discovery reached the public when a further article in *The Australian* reported the results of a journey to the 'volcano' by a Mr Mackie, a young man from Cockle Bay (now Darling Harbour), Sydney, who it was said 'possesses an ardent thirst after science, and whose habits and education have principally been directed to that end'.[10]

Mackie reported seeing a dense volume of flame, mingled with smoke, emerging from a small crater 12 feet (4 m) in width and 30 feet (10 m) long and lying 'between the peaks of two mountains' (at 548 m above sea level, the use of the term 'mountains' seems to be an overstatement). Although he supposed that the fire was the result of volcanic action, he was unable to find any lava at the site. This led him to conclude that the fire had not been burning for long and that 'It does not appear as if an eruption had ever taken place'.[10] Excavations close to the 'crater' did, however, uncover a stratum of 'strongly bituminous' coal, which, he believed, provided the fuel for the subterranean fire. The connection Mackie made between a burning coal seam and what he thought to be a volcanic phenomenon suggests that he may have had a cursory knowledge of the literature expressing Wernerian views. Werner (1786), in his scheme of rock classification, recognized two categories of volcanic rocks. The first of these included the 'true volcanic rocks' or 'true lavas', represented by matter of a more or less blistered appearance containing a kind of hornblende crystal; and, in addition, pumice and volcanic ash. According to his manuscript notes (Wagenbreth 1967, p. 89), Werner believed that such rocks were formed by the burning and melting of combustible material at depth and erupted from volcanic vents. In his second category he placed 'pseudo-volcanic' rocks, which were composed of 'lava-like slag' and 'all kinds of half-burned clays', formed by the heat given off by burning of coal formations. In Werner's scheme the 'Burning Mountain' would have been regarded as a pseudo-volcano. (It should be noted that Werner considered basalt as a sedimentary rather than a volcanic rock.)

Wilton was interested in this report and republished the newspaper article in the journal that he had founded soon after his arrival in the colony (Wilton 1828*b*). He was eager to visit the 'volcano' himself, and was able to do so early in February 1829. As he examined the site (Fig. 2), Wilton soon realized that the fire was unrelated to volcanism. In a letter to the editor of the *Sydney Gazette*[11] and in a communication to the *Edinburgh Journal of Science* (Wilton 1830*b*) he rejected earlier accounts of the discovery of a volcano in New South Wales. From a study of the literature available to him (he mentioned in particular the work of Humboldt, although he did not cite any of his publications), he could not discover any exact similarities between documented volcanic action and the fires at Mount Wingen. This prompted him to pronounce the phenomenon to be unique: 'one other example of nature's sports'.[11]

The absence of any lava at the site led Wilton to conclude that the reported crater was simply a cleft between two sandstone ridges formed by the burning of underlying material and the collapse of rock into the resulting cavity. This process opened up chasms about 2 feet in width and up to 15 feet deep (Fig. 3) from which sulphurous columns of smoke emerged, and whose margins were 'beautified by efflorescent crystals of sulphur'. The large area of the mountain that exhibited 'an appearance of disruption, similar to that where the fire is at present in action', suggested to Wilton that it had been burning for a very long time 'far preceding the memory of man'.[11] During at least four visits to the mountain he was able to trace the progress of the fire and recorded a temperature of 170 °C at the margin of one of the clefts (Wilton 1833*a*). More recent studies have revealed temperatures of between 100 and 300 °C.[12]

To explain the cause of the fire on the 'Burning Mountain', Wilton first enumerated the various

Fig. 2. Mount Wingen or Burning Mountain. A faint column of smoke rises from cracks in a conglomeratic sandstone of Permian age. The site of the fire has moved several hundred metres upslope from the location at which Wilton first observed it almost 180 years ago.

theories that had already been proposed. Some had suggested that it was a 'real volcano', others that it was 'a mere seam of coal on fire' or 'a mass of ignited sulphur'.[11] Unlike Mackie, Wilton did not find coal on the mountain and, without such evidence, he was reluctant to name this substance as the fuel that fed the fire. However, for the benefit of those who held such opinions, he added helpfully that he had found coal deposits only 7 miles from the mountain. His own, rather inconclusive, view was that the fire was due to the burning of material below the surface, which from time to time had been ignited by either electricity (lightning strikes) or by other unknown causes. The heat and steam from the fire, he argued, was able to escape to the surface after fracturing the overlying rock to form vents or chasms.[11] Many examples of these chasms can be seen today traversing the burnt-out areas of the hill. According to D. Oldroyd (pers. comm.) 'the usual view of the origin of the Burning Mountain is that it was ignited by a bush fire'.

Curiously, having deduced from the evidence in the field that the fires were not caused by volcanic activity, Wilton concluded his journal article (1830*b*, p. 273) by referring to the occurrence of earthquakes in 'volcanic countries' and proceeded to list reports of such natural events in New South Wales, including an occasion when a very loud noise was heard coming from the direction of the 'Burning Mountain' before its discovery. Given his stated views on the origin of the fire, the addition of this information, apparently pointing to an explanation contrary to his own findings, seems puzzling. It is possible that his passion for inquiring into the origin of natural phenomena compelled him to mention the earthquake–volcanism link, even though he did not seem to think it applicable to his investigation.

By chance, Thomas L. Mitchell (1792–1855), famous for his exploration of inland eastern Australia (Mitchell 1839; Oldroyd 2007), visited the 'Burning Mountain' in the same month as Wilton in 1829. However, neither man seems to have been aware of this coincidence. Mitchell would later compare the fire at Wingen with that burning at Holworth near Weymouth, the probable cause of which was ascribed by Buckland & De la Beche (1836) 'to rain water acting on iron pyrites and setting fire to the bituminous shale'[13] (Mitchell 1839, p. 22). The scene of the fire was presented in a romanticized sketch, meant for European eyes, which appeared in Dumont d'Urville's account of his voyage around the world in 1837–1840

Fig. 3. Chimney or chasm that provided a vent for the fire and smoke, at the time when it was burning at this locality. (Note the barren ground left after the fire has moved on.)

Fig. 4. 'Le Mont Wingen, Australie.' Sketch by an unknown artist that appeared in *Voyage autour du monde* (Dumont d'Urville 1848) The dimensions of the 'crater' or chasm are exaggerated. (Note the inclusion of a cone-shaped mountain in the drawing, giving the reader the impression that the scene depicts volcanic terrain.)

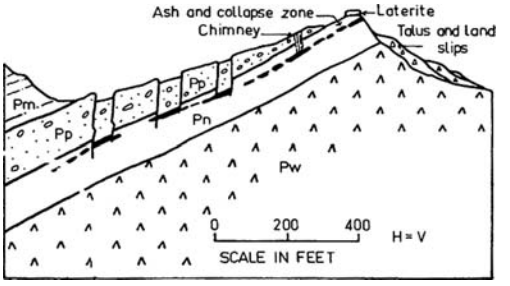

Fig. 5. Geological cross-section, 1 mile (1.6 km) north of the Burning Mountain (Rattigan 1967). Pw, Werrie Basalt; Pn, claystone and conglomerate with a thick coal seam near the top; Pp, conglomeratic sandstone; Pm, sandstone and diamictite. All rocks in the sequence are of Permian age.

(Dumont d'Urville 1848, Vol. 2, p. 370) (Fig. 4) and which showed its various features to dramatic effect. In his brief mention of Mount Wingen, which the author did not visit, he agreed that the fire did not seem to be related to volcanism. Nevertheless, perhaps to enhance its appeal to readers, the unknown artist of the sketch included in the drawing a volcano-shaped mountain. Branagan & Diessel (1994, p. 23) have suggested that the image of the cone-shaped peak may have been based on a sketch by Mitchell (1839) of Mount Muralla, which can be seen in the distance from Mount Wingen.

Although the 'Burning Mountain' continued to be referred to as a volcano (Raymond 1832; *Illustrated Sydney News* 1866[14]), geologists visiting the site in later years (e.g. David 1907; Abbott 1918; Rattigan 1967) demonstrated conclusively that a burning coal seam was the cause of the fire (Rattigan 1967, p. 183) (Fig. 5).

The Newcastle coal measures

Although Wilton was one of the first naturalists to examine the Newcastle coalfield, Berry (1828, pp. 234–236) and Scott (1824)[15] had preceded him. Wilton gave a cursory account of the stratigraphic succession of the Newcastle coal measures, and a description of their lithologies, from outcrops in coastal exposures. He also recorded the occurrence of coal at various localities in the Hunter Valley, and was certainly the first to give an impression of the wide extent of these Permian Coal Measures (Wilton 1832*a*, p. 182).

Wilton further noted that the coal exposed in the cliff faces to the south of Newcastle cropped out as three parallel horizontal beds but that, in some places, it had an occasional dip. He also noted that the coal seams alternated in parts of the cliff with slaty clay, sandstone and shale with impressions of leaves, and in other parts with 'mill-stone grit' and hard cherty rock (Wilton 1832*a*, p. 183). The three coal layers that Wilton observed (Fig. 6) were probably, in ascending order, the Nobby's, Victoria Tunnel and Fern Valley Seams, which crop out between Newcastle and Redhead. Early investigators of Australian geology often used familiar European stratigraphic and lithological terms when they encountered outcrops of similar appearance in the colony. Wilton used the term 'mill-stone grit' (the name of a formation in the Pennines, stratigraphically adjacent to the Yorkshire coal measures) to describe the coarse-grained sedimentary rocks he observed in these cliff sections, applying it, probably, to either the Merewether Conglomerate or to the Redhead Conglomerate.

Wilton's description of the Newcastle coal sequence as being of 'independent formation', suggests that he was familiar with the published work of the Scottish geologist Robert Jameson (1774–1854). The latter had applied this term, derived from Wernerian stratigraphic nomenclature, to coal deposits in county Dumfries in Scotland (Jameson 1805, p. 79; Torrens 2003, p. 148).

Fig. 6. Cliff section between Newcastle and Redhead, showing an outcrop of the Permian Newcastle Coal Measures. The three coal seams interbedded with layers of sandstone and shale should be noted. Nearby, the sedimentary sequence exposed in these cliffs contains strata of coarse-grained, clastic debris, which Wilton referred to as 'mill-stone grit'.

Wilton seems to have been referring to limonite-filled joints when he described thin lamellae of ironstone, 'the surface of which is traversed by square and widely spaced sections, and which are seen, both on the face of the cliff parallel with the beds of coal, and extending into the sea, forming the strand at low water' (Wilton 1832*a*, pp. 183–184).

As he made his way along the beaches from Newcastle to Redhead, Wilton noticed smoke and sulphurous vapours emerging from the cliffs at several locations, and concluded that some of the strata were on fire. In more recent years, burning cliffs have often been noticed along this section of the coast (C. Diessel, pers. comm.) and it is relatively simple to note that coal provides the fuel for the fires. It is surprising, therefore, that Wilton, as in his investigation of the 'Burning Mountain', refrained from identifying coal as the burning matter (Wilton 1832*a*, p. 184, 1832*b*).

Petrified wood

Leaf impressions and the trunks and stems of petrified trees attracted Wilton's particular attention. He collected many specimens from coastal cliff exposures near Newcastle and from various localities in the Hunter Valley, particularly from the rich occurrences at Holdsworthy Downs. These included a tree trunk measuring 5 feet in circumference, 11 inches in height, and weighing 203 lb. The appearance of many petrified tree trunks in this area in a perpendicular position presented him with the image 'of a large forest of felled timber' (Wilton 1834, pp. 28–30) and led him to conclude that they had been buried in their growth position, after the biblical Flood, by more recent alluvial deposits and a developing soil. He identified the petrified remains as a pine of the genus *Callitris*.

As he was anxious, for his own information, as well as for the sake of science in general, 'to ascertain the nature of the several varieties of petrified wood in my collection—what relation they bore, if any, of the timber at present in vegetation in the vicinity of their respective localities', Wilton sent samples to Professor Robert Jameson in Edinburgh, to be passed on to William Nicol, a 'Lecturer on Natural Philosophy'. In his published study of these specimens Nicol (1833, p. 155) concluded that all were siliceous in composition and were representatives of the coniferous order. The genus *Callitris*, which Wilton identified his samples as, is the cypress pine or native conifer of Australia, which grows extensively today in many parts of southeastern Australia.

A singular formation of limestone

Following the valley of the Hunter River, near the small settlement of Glendon (Fig. 1), Wilton stumbled on what he referred to as ‘a singular formation of limestone’.[11] He noted about 50 rounded and oval-shaped masses up to 12 feet (4 m) in diameter, partially protruding from the enclosing clay, both in the bed of the river and on its banks (Fig. 7). Their appearance reminded him of the kraals of a Hottentot village. The close association of these bodies with the clay formation, and the fact that some were just beginning to be exposed in the river bank, led him to conclude that the rounded masses had not been shaped by the ‘recent action of waters of the river’. He clearly regarded their formation as having occurred within their enclosing matter and referred to these large concretions as *lusus naturae* or freaks of nature (Wilton 1832*a*, p. 185).

At the same site Wilton also noticed what he referred to as a ‘curious group of crystals of limestone’[11] (Fig. 8). In a later publication he described them as four-sided crystals of sandstone, both single and in groups and, drawing on the experience gained during fieldwork in Sussex, he noted that the latter resembled in shape ‘the ore of sulphuret of iron, or pyrites, so common in the chalk of England’ (Wilton 1832*a*, p. 185). His description of these curious crystals appears to have been the first published account of glendonite, a pseudomorph after ikaite ($CaCO_3{\cdot}6H_2O$) (Kaplan 1980; Carr *et al.* 2005). It was not until many years later that glendonite was officially named after the locality where Wilton had discovered it (David *et al.* 1905). Both the concretions and the glendonite occur in the Glendon Siltstone Member within the Mulbring Siltstone of Late Permian age.

Fig. 7. Giant calcareous concretions cropping out along the banks and in the bed of the Hunter River near the village of Glendon. They occur in the Glendon Siltstone Member within the Mulbring Siltstone of Late Permian age.

Fig. 8. Glendonite, a pseudomorph after ikaite, as found in outcrops of the Glendon Siltstone Member within the Mulbring Siltstone of Late Permian age.

Wilton the educator and communicator

[We] hold, that it is his [man’s] bounden duty . . . to improve his mind by study and application, and to exercise his faculties in searching out, and surveying the countless wonders of the World . . . which were created for his use and instruction (Wilton 1828*c*, p. 3).

Wilton did his utmost to promote and facilitate these worthy goals and to act as a role model through his own work. As a young man in England he had already alerted his readers to the wonders of geology in a little book entitled *Geology and other Poems* (Wilton 1818). Shortly after his arrival in the colony he founded and edited the *Australian Quarterly Journal of Theology, Literature and Science*. Although it was hardly a success, as only four issues were published, it provided him with the opportunity to try to inform and educate his readers about the marvels of nature and to encourage them, in the words of Alexander Pope,[16] to ‘look through Nature up to Nature’s God’ (Wilton 1828*c*, p. 2).

Through his newspaper and journal articles Wilton hoped to inspire his readership, both in New South Wales and in his native England, to take an interest in their natural surroundings so as to increase their general knowledge and to derive spiritual benefits from the experience. As Oldroyd (1996, p. 134) has remarked, at that time ‘geology was the science of choice for a considerable number of clergymen in Britain’. Wilton, as an enthusiastic participant in this trend, was greatly pleased that geology was also taken up by many members of the general public. He approved of and wrote humorously about the preoccupation with the study of the subject by amateurs in England, which he believed had 'assumed an important feature in the national character':

Since the laborious investigations of a Buckland, the whole country may be said to have run mad after caves of hyena's [*sic*] and the bones of giant mammoth. Every lady has her *Outlines of Geology* [Conybeare & Phillips 1822[17]]—her bag and her hammer: and no drawing room is considered complete in its furniture, which has not its little cabinet and museum. Nay—to such an extent has the mania diffused itself . . . [that] the veriest link-boy in the metropolis . . . discusses most profoundly the qualities of *Micaceous Schistose*, and the properties of *Primitive Trap* (Wilton 1828*a*, p. 192).

Thus Wilton's efforts over many years were towards engendering a similar curiosity, if not a mania, for geology and the natural sciences in general in his adopted country. Through his writings he also encouraged scientific enquiry, in the belief that such application in Australia would lead to new geological discoveries, including organic remains, to match those made in England (Wilton 1833*b*, p. xviii). It appears that, at the time he expressed these sentiments, he was not yet aware of the discovery, in 1830, of a large number of fossil bones by Mitchell in the Wellington Valley in the interior of New South Wales (Mitchell 1831, 1834; Oldroyd 2007). Wilton's passion for popularizing natural science is particularly apparent in one of his newspaper articles,[18] in which he combined a description of the great scenic attraction of the Newcastle area, as if in a tourist guide directed at prospective visitors, with an introduction to the natural history of the region.

Wilton also hoped that his large collections of specimens should be of benefit to the public after his death. In a letter to the Reverend W. B. Clarke (1798–1878) written in 1843, he stated that he had decided to present his collection of specimens to the Australian Museum (established in 1827). Aware of its educational value, and not averse to garnering some personal glory, he proposed to make this bequest under the proviso that the specimens 'not be buried in boxes under the museum', but 'be arranged and catalogued, as the Wiltonian collection' (Moyal 2003, p. 138). We do not know what persuaded him to change his mind in later years, as in his will he bequeathed his collections, together with 'a Manuscript of the Natural History of Newcastle', to his friends the Rev. W. B. Clarke and William Keene, 'upon trust' to prepare the manuscript for publication and to send the specimens 'to England to be named and classified and then to be sold'.[19] There is no evidence in the literature of the time that Wilton's manuscript has ever been published, nor do we know what has become of his collections.

Wilton, the naturalist in search of God's truth

Much as he was dedicated to the exploration of nature and to the communication of his findings, Wilton's greater purpose, expressed in much of his writing, was to demonstrate the complete accord, as he saw it, between the evidence presented by science and the revelations of the Bible. He introduced this theme in the first article he wrote for his newly founded journal, which he entitled 'On the connection between religion and science' (Wilton 1828*c*, pp. 1–6), and returned to this favourite topic in many later publications. He was convinced that the results of all geological investigations, although providing us with new knowledge, also lead us to a greater understanding of God's work and provide us with 'the extension of truth'.

In dealing with the controversial issues of his time, which gave various interpretations to the biblical account, Wilton's views were what we would describe today as fundamentalist. He believed firmly that there were essentially only two great geological events: the creation and the biblical Flood. These convictions led him to criticize the views of those who accepted a less literal interpretation of the Bible to accommodate geological conclusions based on field evidence and changing ideas about the Earth.

While still living in England, Wilton had already become involved in debates on issues relating to the connection between geology and religion. Granville Penn (1761–1844) had published a book entitled *A Comparative Estimate of Mineral and Mosaical Geologies* (Penn 1822), in which he argued, essentially, that geological knowledge obtained by observation in the field could not be reconciled with the biblical account of creation and of Noah's Flood. This was anathema to Wilton, whose central thesis was founded on the conviction that the insights gained from the study of nature were in accord with the revelations of the Bible. In a lengthy critique of Penn's work he countered the latter's suggestion that there may have been 'other revolutions on this globe prior to that universal one [the Flood] recorded by Moses', with the sincerely felt but over-simple response that, as the Bible is wholly silent about such events, we have no right to assume that they occurred (Wilton 1826, pp. 70–71). To lend emphasis to his views he added:

To attempt to explain the exercise of miraculous power by second or natural causes is at once the height of folly and the climax of presumption. It surely becomes a finite being to learn rather to give implicit credit to the facts, however mysterious, recorded in Scripture (Wilton 1826, p. 36).

Writing some years later in his own journal Wilton was less categorical, but equally convinced of the correctness of his views:

> It is true that the Bible was designed not to teach geology, but religion—not the structure of the Earth but the way to heaven . . . What therefore, might have taken place, during any intermediate state of our planet, between the Creation and the beginning and that of the six days, must be a matter of mere conjecture. Not that we are of opinion that such a state did ever exist. The possibility of it we pretend not to deny, but we doubt its probability for it would seem to limit the wisdom, as well as the power of the creator, were we to suppose him to make a world out of the ruins of a former one (Wilton 1828*a*, p. 194).

In referring to a former world, Wilton was taking issue with a statement by Buckland who, although a firm believer in the biblical Flood, nevertheless admitted the possibility that 'this planet is built on the wreck and ruin of one more ancient' and that Moses in his declaration 'does not deny the prior existence of another system of things' (Buckland 1820, p. 24).

Although Wilton somewhat reluctantly conceded the possibility that an interval of time had passed between the creation and the beginning of the 6 days, his inclination was to agree with the widely held view of his day that the Earth was created in 4004 BC (Wilton 1828*a*, p. 196). He held equally orthodox opinions on the length of the biblical day. After considering suggestions that each of the days of the creation might range from 6000 years to an indeterminate length of time, to account for certain geological phenomena, he concluded that only a period of 24 hours was compatible with the Bible. But '[t]hat reasoning cannot be counted correct', he argued, 'which from false premises affects to deduce just conclusions' (Wilton 1828*a*, p. 198). According to his own reasoning, and given his rock-like faith in the biblical accounts, he believed himself to be justified in rejecting some conclusions based on science, however justified they might appear to be, where they clashed with premises based on the Bible, which could never be false.

Penn (1822) accepted that a range of animal species, which had existed prior to the Flood, are now extinct. He went further in arguing that representatives of many genera and species were not taken into the ark and that there was a new creation of animals and plants after the Flood. Wilton gave much space in his response to rebutting this claim. He relied on an article by Adam Sedgwick (1785–1873) (Sedgwick 1825*a*, *b*) to differentiate alluvial from diluvial formations and cited the example of the Irish elk, remains of which had been found in both pre- and post-Flood deposits (Wilton 1826, pp. 50–51).[20] Although this animal was now extinct, possibly as a result of being hunted by man, these finds were, in Wilton's mind, proof that this large creature and, consequently, all other now extinct species of animals, were also taken into the ark. Further examples, which he cited in support of his case, referred mainly to large quadrupeds, such as the mammoth and, drawing on the work of Cuvier (1817), a 'gigantic buffalo', found preserved in Siberian ice. He must have been aware at the time (1826) that numerous species of invertebrates had been discovered that had no living representatives and that could not all have become extinct after the Flood, as a result of human activity or the effects of some other natural agency. His selective use of the evidence probably weakened his case among many of his contemporaries.

In a later article on the colony of New South Wales, including aspects of its geology, Wilton (1833*b*, p. xviii) briefly referred to the presence of 'marine shells in a state of petrifaction and high preservation on eminences in the interior, far above the present level of the ocean'. He explained their presence by stating that in geological terms, the colony's formation was coeval with that of other portions of the globe and, like them, 'has been subjected to that one grand convulsion of nature, the Noachian Deluge'. In his later articles on scientific topics (e.g. Wilton 1834, 1846), he did not return to the subject of the biblical Flood and its role in the geological history of the Earth. It is possible that the overwhelming evidence that had accumulated, particularly as demonstrated in the work of Lyell (1830–1833), which pointed to natural processes and causes, rather than divine intervention, in the deposition of strata and the emergence and demise of species, had a restraining influence on Wilton's writing, even if it did not lead to a change in his convictions. As Vallance (1975) has pointed out, accounts of biblical geology continued to be published in Australia over the following two decades (e.g. Lang 1846; Rudder 1854), before discussions of this topic ceased to appear in the literature.

Although Wilton upheld the biblical account of the formation of the Earth, he could not fail to notice that processes that eroded the surface of the land and deposited sediment upon it must have been active subsequent to the Flood. He acknowledged that 'alluvial depositions' were of a recent date (Wilton 1826, p. 71) and that 'inundations' or flash floods emanating from the mountains could cause erosion in lower-lying areas. He was also aware that the strata making up Nobby's Head (a small island off the Newcastle coast) contained coal seams and beds of rock similar to those making up the nearby coastal cliffs (Branagan 1972). As sedimentary layers formed by the Flood must have been evenly deposited, it was clear to Wilton that the island had been separated from the mainland by some natural event, after the Flood. He seems, then, to have envisaged a local flood washing away part of the land and leaving a remnant in the form of an island (Wilton 1832*a*, p. 185) (which, given the scale of the structures, was not wholly implausible). To differentiate these naturally occurring events from the biblical Flood, Wilton conceded that natural processes capable of shaping the Earth's surface had operated in recent times. He referred to these post-Flood events as 'minor or lesser catastrophes', or as 'partial revolutions' (Wilton 1826, p. 71, 1833*b*, p. xviii).

Wilton did not openly take part in the debate that pitted plutonists against neptunists in Europe. However, in presenting his case against a volcanic origin of the 'Burning Mountain', he seems to have placed himself firmly into the plutonist camp. In referring to the work of Humboldt on volcanoes he declared that:

> the products of their eruptions are derived from the inner regions of the globe, which would otherwise be inaccessible to observation; and the primary phenomena which they exhibit and the extraordinary effects by which these phenomena are attended, give us the only information which we possess respecting those tremendous agents, which are imprisoned within the adamantine walls of our planet (*Sydney Gazette*, 14 March 1829).[11]

In this statement, Wilton clearly acknowledged the operation of dynamic processes within the Earth and their capacity to alter the expression of its surface. It is likely that he regarded volcanic activity as part of his declared minor catastrophes or partial revolutions.

In a passing reference to neptunist ideas, Wilton referred to the fallacy of supposing that granite was deposited from water in order to explain the regular nature of its crystallization. The formation of granite by such a process implied to him the passing of a considerable length of time, which, in his view, was clearly inconsistent with the Mosaic account (Wilton 1826, p. 11). Wilton appears to have rejected Werner's (1786) theory of the origin of granite, by precipitation from water, on religious grounds rather than on the basis of geological evidence or chemical possibilities.

Wilton's career has been mentioned in some historical accounts of the early Church in New South Wales (e.g. Elkin 1938; Rowland 1948). However, his work received little attention from fellow naturalists during his lifetime or from historians of science in later years. In England, his contributions to natural science and religious thought seem to have aroused little interest, although in France two writers (Boué 1832, p. 145; Melleville 1842, p. 5) referred to his critique of Penn (1822) (Vallance 1975, p. 28). It is ironic, therefore, to see his name appear in modern-day creationist literature (Snelling 1993), and to find his work analysed in a recent issue of a theological journal (Edgar 2000).

Conclusion

Charles Wilton was one of a number of English clergymen who left their native country during the first half of the nineteenth century to take up positions in New South Wales (see Branagan 2009). He was a keen naturalist with a special interest in geology. At the time, the scientific enquiries he conducted in his adopted land, particularly in the field of geology, made a useful contribution to the knowledge of its natural world. His popular form of writing served to enlighten many people in the colony, cleared up one major misconception (in relation to the 'Burning Mountain'), and informed his readers of the natural features of the land beyond their settlements. From an early age, Wilton held the firm belief that the insights gained from the study of nature were in full accord with the biblical accounts of the creation and of Noah's Flood, and that the pursuit of such enquiries would bring people closer to God's truth. Wilton appears to have had a complex personality that manifested itself in sometimes contradictory behaviour and thinking. However, his dedication to the pursuit of knowledge and his passionate belief that it was his duty as a clergyman to communicate his findings to both scientists and to the general public is unquestioned.

I thank H. Torrens for kindly sending to me a number of documents relating to Wilton's family history and activities in England. I am grateful to C. Diessel, who took me on a tour of the cliff exposures near Newcastle that Wilton had described and who provided me with much relevant information. I also thank D. Branagan for information on Wilton's publications in Australia. I am grateful to R. Barwick in the Department of Earth and Marine Sciences at the Australian National University for his help with the map reproduced as Figure 1. My thanks go also to my two referees for their helpful and constructive comments.

Notes

[1]Hay, R. W. to Bourke, R. 1 April 1832. *Historical Records of Australia*, **16**, 587.

[2]Howick, H. G. Viscount to Darling, R. 11 March 1831. *Historical Records of Australia*, **16**, 107–108. An enclosure with this communication contains a letter from a Reverend Dr Wrench to Viscount Goderich, the then Secretary of State for the Colonies (p. 108), giving a list of Wilton's creditors and the amounts they were owed. The total debt amounted to £78 17s 10d and, with interest added, increased to £97 0s 0d. The author has not found any records to indicate that Wilton ever repaid his creditors. He never returned to the UK.

[3]Scott, T. H. to Darling, R. 30 December 1828. *Historical Records of Australia*, **14**, 562.

[4]Darling, R. to Murray, G. Sir 17 May 1829 (Enclosure Scott, T. G. to Darling, R). *Historical Records of Australia*, **14**, 746–747.

[5]Darling, R. To Murray, G. Sir 17 May 1829 (Enclosure Scott, T. G. to Darling, R.). *Historical Records of Australia*, **14**, 748.

[6]William Grant Broughton (1788–1853) was appointed Archdeacon of New South Wales in 1828. He and his family arrived in Sydney in September 1829.

[7]Murray, G. Sir to Darling, R. 1 January 1830. *Historical Records of Australia*, **15**, 313.

[8]The author has been unable to locate obituary notices for Wilton in newspapers published in New South Wales at the time of his death. Neither the Newcastle Regional Library nor the State Library of New South Wales hold copies of the *Newcastle Chronicle* of 1859, the newspaper most likely to have published such a notice.

[9]Catalogue of Minerals found in the Neighbourhood of Midhurst, Sussex area. MSS listed in Catalogue of GSL Library 1881, p. 254. MS in the Library of the Geological Society, London, E Tracts, C48. The manuscript is undated and is catalogued under the name of the Reverend C. Hilton. As it contains a reference to a book published in 1822, it must have been written later, but before October 1826 when Wilton donated the manuscript to the library (List of Donations to the Library from June 1823 until June 1829). *Transactions of the Geological Society*, Second Series, **2**(3), 1829, unpaginated after p 421.

[10]The volcano. *The Australian*, 30 July 1828.

[11]The Burning Mountain of Australia. *Sydney Gazette*, 14 March 1829.

[12]*Burning Mountain Nature Reserve, Plan of Management*. New South Wales Parks and Wildlife Service, 1993.

[13]Bituminous shales in the Upper Jurassic Kimmeridge Clay Formation.

[14]*Illustrated Sydney News*, 16 May 1866.

[15]Archdeacon T. H. Scott was Wilton's superior during his first 2 years in Sydney. Scott was one of a number of English clergymen who came to New South Wales and took a keen interest in its geology.

[16]Alexander Pope (1688–1744), 'An essay on Man'. Epistle IV, line 332, 'But looks through Nature up to Nature's God'.

[17]The authors referred to Wilton's discovery of fullers' earth in the Chalk of Sussex, p. 71.

[18]Newcastle. *Sydney Gazette*, 10 October 1829.

[19]The will of W. C. P. Wilton, dated 12 May 1859, is held in the State Archives of New South Wales, Sydney.

[20]The distinction between alluvium and diluvium had already been made by Buckland (1823).

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Franz X. Mayr, the spiritual father of the Jura-Museum

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Abstract: Franz X. Mayr (1887–1974) was the spiritual father of the Jura-Museum. After studying science and completing a doctorate in botany he worked as a secondary school teacher. In 1921 he decided to become a priest. After a shortened study of theology he was ordained in 1923 and subsequently appointed professor of natural history at the College of Philosophy and Theology in Eichstätt. In this function he made an important contribution to the research into the Solnhofen lithographic limestone. By his collecting activities he created the basis of the Jura-Museum. Mayr was also a teacher of the general public through popular articles, lectures and field trips, and was a committed conservationist. The source of all his activities was his spirituality. Strongly influenced by scholasticism and idealistic morphology, Mayr was a moderate creationist assuming the direct intervention of God at least twice: at the genesis of life and of man. This very conservative belief does not correspond to the view of modern Catholic theology and is outdated especially considering the reflections of Karl Rahner.

The establishment of natural history collections in Jesuit monasteries, seminaries and colleges was very common in the 18th and 19th centuries. The collections of the Episcopal Seminary of St Willibald in Eichstätt, which were started in 1844, are a late example (Viohl 1987). They originally served as demonstration material for the natural science course of lectures at the local College of Philosophy and Theology. Over the course of time they were expanded by the professors of natural history according to their particular scientific interests. The development of these collections into the Jura-Museum Eichstätt was mainly the work of Franz X. Mayr (Fig. 1), who can be called its spiritual father. He was one of a large number of priests engaged in natural science, and in his case we are well informed about his motivation and his thoughts. The author was able to co-operate with him as his assistant for more than 3 years.

Mayr's life and work

Franz Xaver Mayr was born as the son of a higher customs officer in Pfronten (Allgäu) on 21 February 1887. In 1890 his parents moved to Regensburg where he grew up in a strictly Catholic family, with his five sisters, and spent a cheerful childhood and youth. The varied interests that he developed at that time determined his future life. His sister Frieda Senninger has given an account of this period as well as the later stages of his life (Senninger & Viohl 1984). Mayr's interest in nature arose very early and was promoted by family excursions to the beautiful environs of Regensburg and by hiking trips of several days with his father.

Mayr began his studies in 1906. His father had told him that if he studied natural science, he could not remain Catholic; this was the period of Ernst Haeckel and his attacks against the church. Franz Mayr, however, was convinced that he had to study science all the more, so as to defend the faith. He attended the universities of München, Kiel, Würzburg and Erlangen and took the examinations for secondary school teachers in descriptive science and chemistry.

However, Mayr's main subject was botany. With his thesis he made a considerable contribution to botanical science, by his discovery of hydropotes (which means 'water drinkers'), the organs of water and marsh plants for the absorption of water and nutrients (Mayr 1915). Since then, hydropotes have been described in botany textbooks.

Despite a bleeding lung, which required a stay in hospital and a subsequent rest-cure of several months, Mayr was awarded a doctorate in 1914, and he took the supplementary state examination for geography in the same year. Because of his weak lung he was exempt from military service and went immediately into teaching. He gave lessons on chemistry, biology and geography at schools in Regensburg, Landshut and Aschaffenburg.

Turmoil in the period after the First World War gave Mayr's life a new direction. As he said later, he was shaken by the decline of old values and by the spread of godlessness, and felt a deep compassion for the confused and incited people, which aroused in him the desire to become a priest. In 1921 he left school teaching and began to study theology, first in Innsbruck and later in Freising. To his great surprise, in 1922 the Bishop of Eichstätt, Leo von Mergel, offered him the post of

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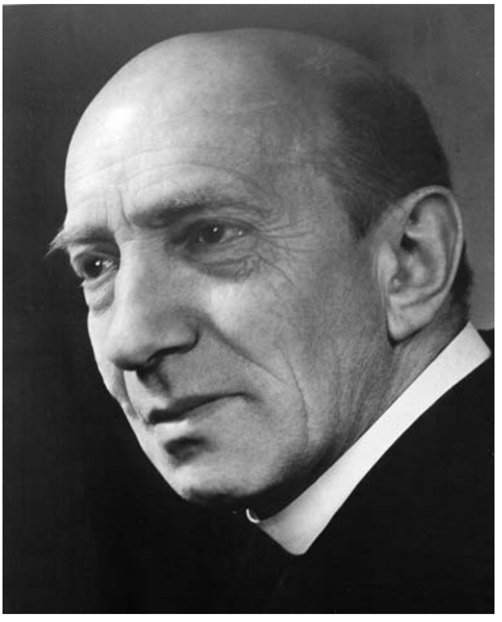

Fig. 1. Franz X. Mayr (1887–1974) (photography courtesy archive of the Jura-Museum Eichstätt).

professor of natural history at the College of Philosophy and Theology of Eichstätt. The holder of the chair, Josef Schwertschlager, was going to retire. This offer was the fulfilment of a dream for Mayr, and, of course, he accepted it. In 1923, after a shortened study of theology he was ordained priest by Cardinal Faulhaber in Freising, and on 1 October of the same year he moved to Eichstätt. This town was to remain Mayr's home until his death. He gave lectures there on chemistry, botany, geology, palaeontology and anthropology.

In Eichstätt the main focus of Mayr's scientific interest shifted from botany to geology and palaeontology, stimulated by the unique locality of Eichstätt and by the existing palaeontological collection. In those sciences Mayr was essentially self-taught, although he had attended some geological and palaeontological lectures during his studies. However, from the beginning of his activity in Eichstätt he was in touch with geologists and palaeontologists who visited the collections and learned from them. In 1924 the annual meeting of the German Palaeontological Society (Deutsche Paläontologische Gesellschaft) took place in Eichstätt, in honour of Mayr's predecessor Schwertschlager. On that occasion Mayr met the leading lights of German palaeontology. Schwertschlager gave a remarkable talk on the origin of the Solnhofen lithographic limestone, but died soon after the meeting. Mayr's first action in the geological field was to edit Schwertschlager's manuscript.

Mayr was a keen observer, and in time he gathered a significant amount of geological and palaeontological data, which he generously put at the disposal of all the researchers who visited him. It was important for him to conduct research, but not necessarily to publish it himself. It was mainly the Solnhofen limestone and its fossils that attracted Mayr's interest, and he wrote several papers on this subject (see Senninger & Viohl 1984). The most important of these is 'Paläobiologie und Stratinomie der Plattenkalke der Altmühlalb' (Mayr 1967). This publication, containing many taphonomic and sedimentological data, was an important contribution to the research into the Solnhofen limestone and is a treasure trove for all who deal scientifically with this subject, although Mayr's interpretation is obsolete. He was strongly influenced by authors of the first part of the 20th century, such as Walther (1904), Rothpletz (1909), Schwertschlager (1919, 1925) and Abel (1922, 1935), who assumed a periodical drying up of the deposition area of the Solnhofen limestone. He defended this idea against the view of Barthel (1964) and von Edlinger (1964) of a permanent water covering (for a modern view of the Solnhofen limestone, see Barthel *et al.* 1990; Viohl 1990, 1998).

Mayr was also a great collector and enlarged all the sections of the existing natural history collections of the College of Philosophy and Theology, especially the palaeontological section. Equipped with a hammer and rucksack, and in the beginning still in a cassock, the regulation dress of priests, he set off for the surrounding country and the quarries, and in marches of several miles he carried his collected stones and fossils home. However, he did not find the most interesting fossils himself, but had to buy them from the quarrymen or the quarry owners. Although the prices of fossils were low until the 1960s, Mayr's budget often did not suffice to purchase rare specimens, and he was forced to pay for them out of his own pocket. The most precious fossil he was able ever to acquire was the Eichstätt specimen of *Archaeopteryx*. He presented it to the public at the inaugural meeting of the Friends of the Jura-Museum in 1972, and he gave a preliminary description of it (Mayr 1973). With Mayr's help, other institutions, especially the Bavarian State Collection of Palaeontology in Munich, were able to purchase many interesting fossils from the Solnhofen limestone.

Mayr not only collected beautiful fossils. He also paid attention to phenomena that in the past were scarcely noticed but can give information on the palaeoenvironment, such as different stages of preservation, traces of life, different types of marks (deposition, current, scratch marks, etc.), characteristic bed surfaces, and other sedimentary structures. The collection of the Jura-Museum has many examples of such phenomena.

With his collector's enthusiasm Mayr laid the foundation of the Jura-Museum, which he had dreamt of in the 1930s. He had been given the idea by the Munich palaeontologist Stromer von Reichenbach that he should make his treasures accessible to the public within the framework of such a museum. The name 'Jura-Museum' appeared first in the annual report 1932–1933 of the director of the College of Philosophy and Theology. After the war, in 1953, Mayr installed a small geological–palaeontological exhibition for the Historical Society in the Castle of St Willibald. However, this was not yet the imagined Jura-Museum, and many years were still to pass before this could be realized. On Mayr's insistence, the Episcopal Seminary, as the legal owner of the collections, came to an agreement with the Bavarian State on the founding of the Jura-Museum, which was opened in September 1976. Unfortunately, Mayr was not to see the new museum, because he died on 21 June 1974.

Mayr was not only an academic teacher, but also a teacher of the general public, and he tried to open people's eyes to the wonders of nature by popular articles (see Senninger & Viohl 1984), lectures and field trips. In 1924 he founded the district group of the Bund Naturschutz, a conservational organization, whose president he was until 1972. He was the authorized representative for conservation for many years, and as a result of his activity two valuable areas in the district of Eichstätt were protected.

Mayr's spirituality and creationism

The source of all his activities was Mayr's spirituality. He regarded nature as the second book of revelation which heralds the grandeur and glory of God, as does the Bible. In the beauty and diversity of nature he saw a vision of the divine wisdom. On the basis of this view Mayr considered himself as a priest able to work scientifically. In nature he found inexhaustible material to praise God. It was the aim of all his activities to convey this vision to other people, and particularly to his students. In an article on the natural history collections of the College of Philosophy and Theology he wrote: 'They should in a special way draw the impartial visitor's view beyond all the wonders of nature to the one who has created all' (Mayr 1964). As a motto he mounted the word of Saint Augustine over the collection: *Creatura clamat creatorem*. In his view, even his work as conservationist became a priestly activity. When he retired as the president of the conservational group in 1972, he said: 'Nature is the creation of God. Nature conservancy is worship'. Mayr's spirituality was admirable and convincing, because he lived exactly what he taught. However, his theology was extremely conservative, and a modern scientist can hardly endorse it.

Scholasticism, with its strong hierarchy of being, which at that time was the prevailing philosophy at Catholic colleges and seminaries, had a formative influence on Mayr's theological thought, and was imparted to him especially by the writings of the neoscholastic philosopher Hedwig Conrad-Martius (1938, 1944). This was supported by other scientific ideas, which, like scholasticism, had their roots in the philosophy of Plato and Aristotle. These were, on one hand, idealistic morphology, which still had adherents in Germany in the 20th century, such as the botanist Wilhelm Troll (1984) and the palaeontologists Edgar Dacqué (1921), Otto Schindewolf (1950) and Oskar Kuhn (1981), and, on the other hand, the neovitalism of Hans Driesch (1909).

Like other supporters of idealistic morphology, Mayr accepted evolution in the Darwinian sense only within the narrow limits of the principal types, which he supposed originated by macromutations (with reference to Goldschmidt (1940)). However, these remained rather enigmatic. In his opinion, God had intervened in evolution at least twice: at the genesis of life and of man. Mayr rejected the transformism of Teilhard de Chardin (1959).

As we can see from Mayr's correspondence, his view was widespread in the Catholic world at that time, but not only there. A typical example is the famous Protestant palaeontologist Friedrich von Huene from Tübingen, who discussed the role of angels in evolution in a letter to Mayr in 1955. He considered that the hierarchical order of angels corresponded with the hierarchy of zoological systematics (Turner 2009).

A real difficulty for devout Catholics was the transition from animal to man, because in his encyclical *Humani generis* of 1950, Pius XII defined the doctrine of the direct creation of the human soul by God as *fides catholica*, whereas he had no objection to the idea of an origin of the human body from animal ancestors. However, Mayr argued in favour of the philosophical principle *anima forma corporis*. This means that the human being is a whole of body and soul, and it would not be possible to insert a human soul into the body of an animal. The alternative for Mayr would have been the assumption of a new creation of the human body and soul by God, which cannot be accepted by science. The assumption of such a miraculous event would imply the renunciation of a scientific explanation of the origin of man. It seems problematic also from a theological point of view, as a direct intervention of God would make him a cause among other causes in the world.

Another view: creation and evolution as complementary aspects

Here another solution of the problem is proposed, which is mainly inspired by St Thomas Aquinas and Karl Rahner, and represents a modern view of Catholic theology.

Evolution always produces new entities, which differ from the preceding entities by new qualities. The origin of life and man are striking examples. The metaphysical question is: how can less become more? The Christian answer is: by the creative action of God. A further question arises: how can the creative action of God be thought of? In a term of Rahner (1961, 1977) becoming is 'active self-transcendence'. With this expression Rahner stated that an entity does not only passively receive a new quality by God, but is also active in its achievement. This concept necessarily implies contingency in the evolutionary process.

In the philosophy of St Thomas Aquinas God is the *causa prima*, the prime cause, which must sharply be distinguished from the *causae secundae*, the secondary causes (Hirschberger 1965). The prime cause is not a cause among other causes in the world or the first member in a causal chain, but the basis of the world and all beings. All causal connections with which science is dealing lie on the level of the secondary causes. This is the world of the phenomena for which science has to give rational explanations (e.g. for the appearance of life and man in evolution). The prime cause, or God, will never come onto the horizon of science, which has to be methodologically atheistic. In a Christian view, however, God is present in any being as its intrinsic state and the condition of its possibility of active self-transcendence. The creative action of God which is beyond space and time, makes the self-transcendence of finite beings possible, which necessarily occurs at a special point of space and time. Hence a Christian can say both that the world has evolved and that it has been created; evolution and creation are not opposites, but complementary aspects of one reality.

Although Christian teaching stresses the creation of the human soul directly by God, this does not mean that God acts here differently from other cases. The peculiarity of this creation means that God makes possible a self-transcendence to an individual being of spiritual uniqueness. This is valid for the first human as well as for every human being.

The conflict between the theory of evolution and Catholic doctrine that seemed to have existed at Mayr's time can be regarded as resolved now. Any form of creationism that invokes God as a reason, instead of invoking a scientific explanation, is not only bad science, but also bad theology.

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Religious convictions as support in dangerous expeditions: Hermann Abich (1806–1886) and Heinrich Barth (1821–1865)

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Abstract: Abich and Barth came from a North German bourgeois background and received a strict religious education. Later, when studying at the University of Berlin, both came under the strong influence of the geographer Carl Ritter and of his Pietist family. Abich became the doyen of Caucasus geology, and engaged in intensive and often perilous fieldwork in the region between 1842 and 1876. The help he received during his first two years in the field convinced him that it was God's will for him to bring this work to completion. His trust in the Bible was so firm that, after setting foot on the summit of Mount Ararat, he asked himself where exactly Noah's ark might have landed. Barth's most outstanding achievement was the exploration of the central Sahara and southern Sudan between 1849 and 1855. Here he worked mostly alone. In relationship to Muslims, he demonstrated an uncompromising and therefore convincing Christian faith. He survived the dangers of the desert and various illnesses with resilience, which he attributed to his unshakable faith.

During the first half of the 19th century in Germany protagonists of both Romanticism and the Christian Reforms grappled with Enlightenment thought. Wide Protestant circles, particularly Pietists, revived the use of the Bible and continued to feel comfortable and secure under the alliance of throne and altar. Pietism[1] had developed within the Protestant churches in Germany in the 17th century and reached its first peak of popularity in the middle of the 18th century. Several centres were established all over the country (e.g. in Halle an der Saale). At the beginning of the 19th century, there was a revival of this religious reform against orthodoxy in the Lutheran and Reformed Churches. Personal faith combined with emotional warmth and missionary enthusiasm were the guiding principles of life. Pietist practices involved active participation in worship and deepened biblical interpretation in private meetings. These practices were important to Protestants, who, since the times of the Reformation, recognized nothing but the Bible as their ultimate authority. However, during the Enlightenment an increasing number of scientific discoveries and conclusions gave reason to doubt biblical veracity and undermined this basis. Therefore representatives of Physico-Theology and of Pietism opposed the Enlightenment and encouraged a deepened engagement with the Bible. Pietism influenced even legal philosophy, literature and the arts.

This revival had different regional shades. After the formation of larger German states by Napoleon, Pietism by its more open style played a role in establishing better relations between the various religious groups. These were now more mixed than in the smaller states that had previously existed (in former times, the sovereigns of states had the right to determine the religious practices there).

A good example is Prussia. The foundation of the University of Berlin in 1809 was a milestone for scientific life. The new ideas of Wilhelm von Humboldt to combine research and education attracted eminent professors and lecturers. Among them were outstanding representatives of romanticism, who propagated the idea of a unity of nature and spirit, or the integration of the individual into entities such as the state or religion. These teachers looked back for a supposed perfection in the past; for instance, in the early ages of the world's peoples. This was why they had a special interest in cultivating historical traditions. More generally speaking, historicism was blossoming, not only in the humanities, but also among scientists.

For example, since the end of the 18th century, the history of the Earth was being reconstructed on the basis of index fossils. The earlier simple search for rocks and fossils was thus followed by the attempt to put the finds into a systematic context. Among geographers, it was first and foremost Carl Ritter (1779–1859) (Fig. 1) who brought static and statistical descriptive geography to life by investigating historical situations. Alexander von Humboldt (1769–1859) had lived and taught since 1827 in Berlin. He and Ritter were interested in filling the gaps of geographical knowledge either by their own expeditions or by discussions with explorers. Of course, students were fascinated

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Fig. 1. Carl Ritter (1779–1859). After Lenz (1981, p. 28).

by the breadth of the intellectual climate of this 'Zeitgeist'.

Among them were Hermann Abich (1806–1886) and Heinrich Barth (1821–1868), who showed in an exemplary way what energy could be generated by this environment. Both were reared in and influenced by the specifically North German intellectual climate of the first half of the nineteenth century. They both had middle-class backgrounds, where new opportunities were opening up at that time, not only economically but also in terms of education. The effects of both men's religious upbringing were reinforced during their time as students in Berlin.

For Abich and Barth the work of Carl Ritter, professor at the University from 1820 until his death in 1859, was of leading importance. Ritter was born into a pietistic family and had married a woman in Halle with the same religious background. He had a close relationship with his students, who were small in number at that time, and they were often invited to his home. He stayed in contact with some of them for decades (Plewe 1965). 'The Christian Faith was the compass of his life' (Beck 1979, p. 31). In a note dated 21 May 1857 (Beck 1979, p. 18) he summarized the position from which he worked in the field of geography as follows: 'For humankind during its brief temporal existence, our planet Earth is the cradle, the house and institute of education for a higher existence in Eternity'. Thus, descriptive geography ('Kompendien-Geographie', concerned with stating facts) and what might be called 'philosophical geography' ('Problem-Geographie', which focused on causal contexts) were amplified by theological concepts (see Gumbrecht 1855; Lenz 1981; Plewe 1981; M. Büttner undated). Alexander von Humboldt (*Kosmos*, von Humboldt 1847, II, p. 26) also wrote that the power and goodness of God can be inferred from the world order and the beauty and magnitude of nature. It is obvious that in this kind of perfect world, Abich's and Barth's trust in God was necessarily intensified.

Hermann Abich (1806–1886)

Hermann Wilhelm Abich (Fig. 2) was born in Berlin on 11 December 1806, and was the son of a Prussian Inspector of Mining, Heinrich Karl Wilhelm Abich. His family were Reformed Protestants, and he grew up among the well-to-do and well-educated Berlin bourgeoisie. From early on in the family home, he met many eminent scientists such as Alexander von Humboldt, Leopold von Buch and, in particular, Carl Ritter. Under their patronage, he obtained his doctorate at Berlin in 1831 and was called to the chair of geology and mineralogy at Dorpat (now Tartu) in Estonia in

Fig. 2. Herman Abich (1806–1886). Archive Académie des Sciences, Paris.

1842. Soon afterwards he started his first expedition to the Caucasus, undertaken under the auspices of the Russian Government (Abich 1845). The exploration of the Caucasus was to become the mission of his life, which he pursued in the field until 1876. He was ideally suited for the task, both scientifically and in terms of his strong character, which stood the test of many perils and was rooted in a firm trust in God (see dated letters published by Abich (1896), also Seibold & Seibold (2006)).

At that time, large parts of the Great Caucasus were a permanent trouble spot. As Abich was travelling at the behest of the government he enjoyed the support of local and regional authorities and had a military escort most of the time. However, the extremely unstable weather was a formidable handicap. Abich moved from icy peaks at 15 000 feet to subtropical lowlands infested with malaria. His most dramatic challenge, however, came when he attempted to conquer Mount Ararat.

The steep and largely pathless terrain was treacherous. 'I fly through the air down the precipice', he wrote, and 'the nag follows and lands on me with its full load' (24 June 1862). He had another lucky escape when one morning a 4 foot poisonous snake was discovered in the coat he had rolled up to make a pillow (8 August 1845). In addition, malaria was a severe problem, and incapacitated him at times for weeks on end.

The religious basis of Abich's attitude is evident from many letters; for instance, in one written on 14 October 1852: 'I trust firmly that in the end, God will bless my plans with success as he has done in the past.' His was a faith based on the Bible, on 'the living Spirit of the Holy Scriptures, as opposed to the letter that killeth' (Abich 1897, Preface, p. v). He stood on the summit of Mount Ararat and wondered where the landing place of Noah's ark might have been, writing: '[a] wonderful impression resulted from the certitude to be in the very place towards which all peoples of the Old World have been, and still are, looking in prayerful adoration—that point from whence all the lineages of the peoples originated' (8 August 1845). He saw no trace of the ark.

After the first successful undertakings, Abich decided against his family's wishes to prolong his stay in the Caucasus, explaining the reasons for his decision in a letter to his mother dated 12 December 1845 and sent from Tiflis. He regarded the exploration of the Caucasus as his God-given mission to which he thought he had been led in some miraculous way (Abich 1896, 1, p. 264).

Abich's prolonged efforts resulted in about 190 comprehensive and wide-ranging publications. They covered many fields, such as morphology, glaciology and structural geology of the Greater and Lesser Caucasus. Being an experienced petrographer, volcanism was one of Abich's main subjects. Thermal springs, mineral resources, hydrocarbons, coal, salt and ores were treated, as well as palaeontology as the basis for stratigraphy and geological mapping. As he wanted to help the local people, he also frequently included useful practical information. A wealth of the most varied observations and drawings relating to natural history and archaeology completed the rich spectrum of his work. As a result of all this work he became the 'Father of Caucasus Geology'. Twenty years later he wrote: 'My works, though not entirely futile, will not survive me long; but the good and faithful will be judged by the Almighty, and this fund I shall carry with me as a form of credit for the higher life' (16 July 1865).

Heinrich Barth (1821–1865)

Heinrich Barth (Fig. 3) was born into a Lutheran family in Hamburg on 16 February 1821. His parents had an artisan or craftsman background, but his father, Johann Christoph Heinrich Barth, gained a high reputation as an overseas merchant, and the fortune he made enabled his son Heinrich to get an excellent education. From October 1839, he studied at the University of Berlin, mostly philology, as he had an exceptional talent for languages.

Fig. 3. Heinrich Barth (1821–1865). After Schiffers (1967, title page).

Like Abich, Barth was particularly influenced by Ritter, who promoted him and his work all his life. After gaining his doctorate in 1844, Barth spent several years in the Mediterranean region. With the results of his research there, he obtained his 'Habilitation' in 1848. His paramount achievement, however, was the work he undertook on an expedition to the central Sahara and the Sudan. This 'British Sudan Expedition' was led by the missionary James Richardson, whose brief it was to establish trading relations, while at the same time trying to contain the slave trade. Barth was chosen to join because of his geographical knowledge and linguistic skills, along with a young German geologist and astronomer Adolf Overweg. The group set off from Tripoli on 25 March 1850. As a consequence of the hardships they encountered, Richardson died in March the following year, and Overweg was murdered in September 1852. Thus, the whole enterprise was soon in Barth's hands. He returned to Tripoli after more than 5 years, on 28 August 1855. On foot, camel and horse, he had covered roughly 20 000 km. In contrast to Abich, his contributions to geology and even to morphology were modest. His main geographical contribution was the continuous route description expressed in the title of his main publication *Travels and Discoveries* (Barth 1965). In a relatively primitive way he noted approximately every 5 minutes the compass direction of the route and the distance according to his camel's speed. He never used astronomical positioning. But at the other hand, he noted many details of the topography, climate, vegetation and fauna. He also gathered ethnographical and economic information and recorded no fewer than 49 languages in the Sudan. In many places, he was the first European visitor (see von Schubert 1897; Schiffers 1952, 1967; Barth 1965).

In his obituary of Barth, the President of the Royal Geographical Society wrote: 'A more intelligent, indefatigable, trustworthy and resolute traveller can rarely be found and we all deplore his untimely end at the age of 44' (*Geographical Journal* 1866, pp. 134–136).

Barth survived the dangers of the desert and of the floods and swamps of the Sudan thanks to his remarkable staying power, his tenacious will to achieve his aims, and his unshakable trust in God (Weinand 1967). Once (like Abich) he was even declared dead for a while. Among other dramatic incidents, he described how he almost died from thirst in the Idine Mountains in the Northern Sahara. Finally he was saved by a passing native (Barth 1965, pp. 46–50).

Even as a youth, Barth had never been particularly fit physically. During the expedition, he repeatedly suffered from dysentery, rheumatism, fever and other afflictions, even though he was well equipped with medicine. However, he regarded his perilous circumstances as being part and parcel of a risky enterprise rather than as trials from God (Weinand 1967).

After a visit to Richardson's grave Barth noted (1965, p. 573, 27 March 1851):

> It was late in the evening when I returned to my tent, engrossed with reflections on my own probable fate, and sincerely thankful to the Almighty Ruler of all things for the excellent health that I still enjoyed, notwithstanding the many fatigues which I had undergone ... I esteemed him [Richardson] highly for the deep sympathy which he felt for the sufferings of the native African, and deeply lamented his death' (Barth 1965, p. 573, 27 March 1851).

Barth also survived robbers and hold-ups. What was most surprising at such moments was that he successfully fended off all Muslim challenges to abjure his faith. This is how he described the situation shortly after the start of the expedition when they had fallen into the hands of a caravan crew with a fanatic leader:

> The whole affair had a very solemn appearance from the beginning, and it was apparent that this time there were other motives in view besides that of robbing us ... But it is probable that the fanatics thought little of our future destiny; and it is absurd to imagine that, if we had changed our religion as we would a suit of clothes, we should have thereby escaped absolute ruin ... We were sitting silently in the tent, with the inspiring consciousness of going to our fate in a manner worthy of both our religion and of the nation in whose name we were travelling among these barbarous tribes, when Mr Richardson interrupted the silence which prevailed with these words: 'Let us talk a little. We must die; what is the use sitting so mute?' (Barth 1965, pp. 73, 74, 27 August 1850).

In the end, they were allowed to travel on.

Barth always remained the friendly Christian, generous with small gifts, and called himself Abd el Kerim, 'the servant of the Merciful'. He always carried the Qur'an (and an edition of Herodotus). His linguistic ability enabled him to enter into profound discussions with the people of the desert. In these conversations, he answered for his faith so firmly and impressively that he always escaped even the most fraught situations, although often after paying ransom.

Richard-Molard (1947, p. 116) has summarized matters as follows: 'He [Barth] was a natural force'. He radiated unshakable faith and calm, and his mild eyes held anyone's gaze. 'His father had imbued him with the strong Protestantism of North Germany and with the firm trust in the grace of Providence for the elect.'

However, unlike Abich, Barth did not say much about his faith in his reports and letters (Plewe 1965). At his funeral oration on 29 November, 1865 the Reverend Müllensiefen commented as follows: 'Regarding his relationship with God, he did not lay open his inner feelings to everyone, yet he had a sanctuary where he never disowned his Christianity. In the manifold dangers that confronted him, he always found his strongest support in his infinite trust in God' (von Schubert 1897, p. 174).

Conclusion

In spite of the same religious base, which enabled the two men to work fearlessly under dangerous conditions, some differences illustrate the variety within the German Protestantism. They are of course accentuated by their characters.

Abich can be regarded as a typical Pietist: communicative and full of idealism, he pursued his life's mission to explore the Caucasus region in the firm belief in God's protection. He accomplished it with personal modesty. The mission was what counted, not his person. He was always ready to help, and his letters show his close and active affinity for others. In spite of his modesty, his work and person found wide recognition and he received many international honours.

Barth, in contrast, was a lone wolf. His Lutheran upbringing can be seen in a more individual faith: the person alone answering before God. He was reserved by character. His motives were more ambivalent than Abich's. He was certainly ambitious with a patriotic touch. Perilous endeavour fascinated him. Of course, he fully agreed with the humanitarian aspects of the expedition, but his personal fame meant much for him, partly because he hoped for suitable employment after the mission. Yet, like Abich, he mobilized enormous strength by his trust in God's protection on his travels.

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Note

[1]Compare with Roberts (2009, endnote 2, p. 345).

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Reverent and exemplary: 'dinosaur man' Friedrich von Huene (1875–1969)

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Abstract: Friedrich Freiherr (Baron) Hoyningen, better known as von Huene, was a palaeontologist who made major contributions to vertebrate, especially amphibian and reptile, taxonomy. He was the dinosaur doyen of the Institute and Museum of Geology and Palaeontology, University of Tübingen, and an important figure in the German scientific community for seven decades. Unlike his peers, he was a pious evangelical Protestant whose life and research were strongly influenced by his beliefs, which were unusual for a scientist in the 20th century and even for most contemporary Christians, and which he maintained throughout his life. His body of scientific and religious work and his correspondence with colleagues such as Tilly Edinger and Richard Lull, and the self-taught vertebrate palaeontologist Heber A. Longman in Australia, give insights into and contrasts to his thinking, and throw light on scientific exchange in general as well as von Huene's philosophy, personal beliefs, hopes and dreams, and on how he coped with the Third Reich. Longman, a professed agnostic, was mentored by von Huene during his early work on vertebrate taxonomy at the Queensland Museum. Their relationship lasted more than 25 years, although they never met. Unlike other 20th-century 'life' scientists, von Huene's scientific work and career were affected by his religious philosophy.

Supplementary Material: Huene bibliography is available at http://www.geolsoc.org.uk/SUP 18336.

Following the discovery in the Queensland Museum of correspondence (Turner & Maisch 2003) between Professor Dr Friedrich Freiherr (Baron) von Hoyningen, better known as Friedrich von Huene (1875–1969) (Fig. 1) of the Institut und Museum für Geologie und Paläontologie der Universität Tübingen (now Institut für Geowissenschaften, abbreviated here IGTU) and the then Director of the Queensland Museum in Brisbane, Australia (abbreviated here QM), Heber A. Longman (1880–1954) (Fig. 2b), a self-taught scientist (Mather 1986; Turner 1986, 2005), I began to learn more about the life and work of both these 20th century 'dinosaur men' and their colleagues through their correspondence. This, and a visit to work in Tübingen in 2006, brought me to consider their respective outlooks on life and their scientific work. The von Huene letters (preserved in the Geologenarchiv, Universität Freiburg; UFGA) and those to Longman (preserved in the QM Archive) give insights into the long-distance relationships that can develop between scientists, as well as their methods, scientific hopes and dreams, which are often very different from the published outcome. Here I look at some of the factors that influenced von Huene's life's work, not least of which were the struggles with or effects of his religious convictions as contrasted with most of his contemporaries, such as Longman, for example.

Von Huene had an exemplary scientific career over seven decades as a world expert on fossil herpetofauna. He first studied reptiles and especially dinosaurs for his habilitation thesis and made them his own, scouring the world for evidence. He was so obsessed that he was described as 'unter die Drachen gegangen' (gone among the dragons) by Rieth (1977). Colleagues such as Hölder, Seibold, Reif and Seilacher (pers. comms) confirmed that von Huene lived focused on two things, his 'saurians' and God, and especially his desire to show how the two were intertwined. Reif & Lux (1987) first considered in depth von Huene's special thinking on his fossils, and analysed his methods and thinking on systematics and phylogeny, the theory of evolution and the religious concepts he brought to his work, which were unique for a palaeontologist in the 20th century. Reif & Lux also gave the most complete list of his publications to that date, noting that many papers were missing, especially 40–50 religious tracts. In 2006–2007 I extended their work by checking and updating all the works in the IGTU von Huene reprint library (SUP 18336); some of the numbering has been altered, omissions have been restored and figure

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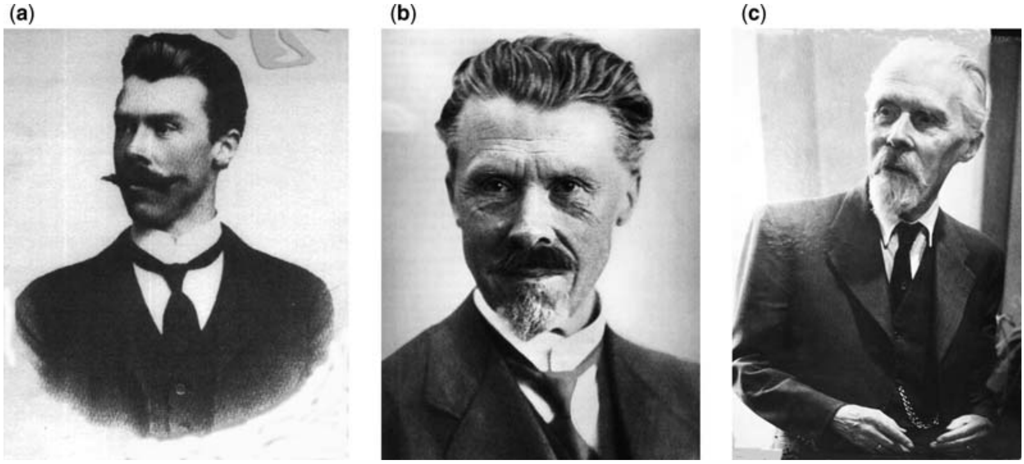

Fig. 1. Evolution of a man through time: (**a**) young Baron Hoyningen-von Huene; (**b**) frontispiece to his autobiography (von Huene 1944); (**c**) von Huene on his 90th birthday (photographs courtesy of and © IGTU).

details added. As the study by Reif & Lux was in German, this paper brings together for the first time an English summary of von Huene's religious writings (Appendix 1), copies of which were discarded ('culled') from his reprint collection at some time after his death in 1969, as they were thought to be of no interest in a scientific establishment (C.-D. Jung & W.-E. Reif, pers. comm.; one aim now is to restore a full set to the IGTU von Huene library).

In trying to assess the influence of his Christian beliefs on his palaeontological output the religious items need to be refound: this process has begun. Only a hand-written list by von Huene himself with 417 numbered items (although not all were published (see Fig. 3) and a few were left unused; Reif & Lux 1987; S. Turner, unpublished) was left as a record of his religious or philosophical output. Location of the tracts especially might prove difficult, but one or two of the books are

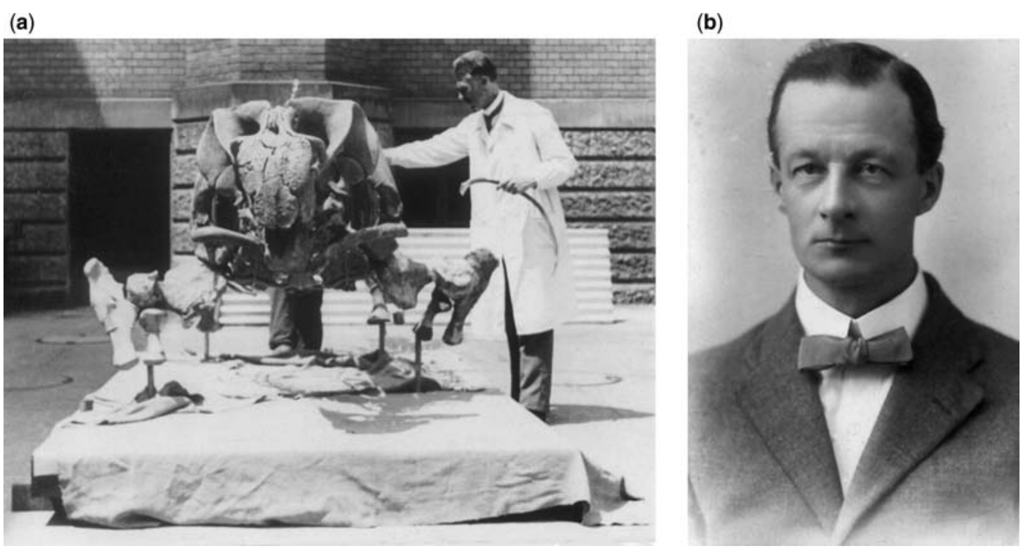

Fig. 2. (**a**) Von Huene contemplating the placement of a rib on a South African dicynodont specimen in the IGTU courtyard, *c*. 1926. (**b**) Heber Longman when first Director of the Queensland Museum, *c*. 1924 (photographs courtesy of IGTU and QM).

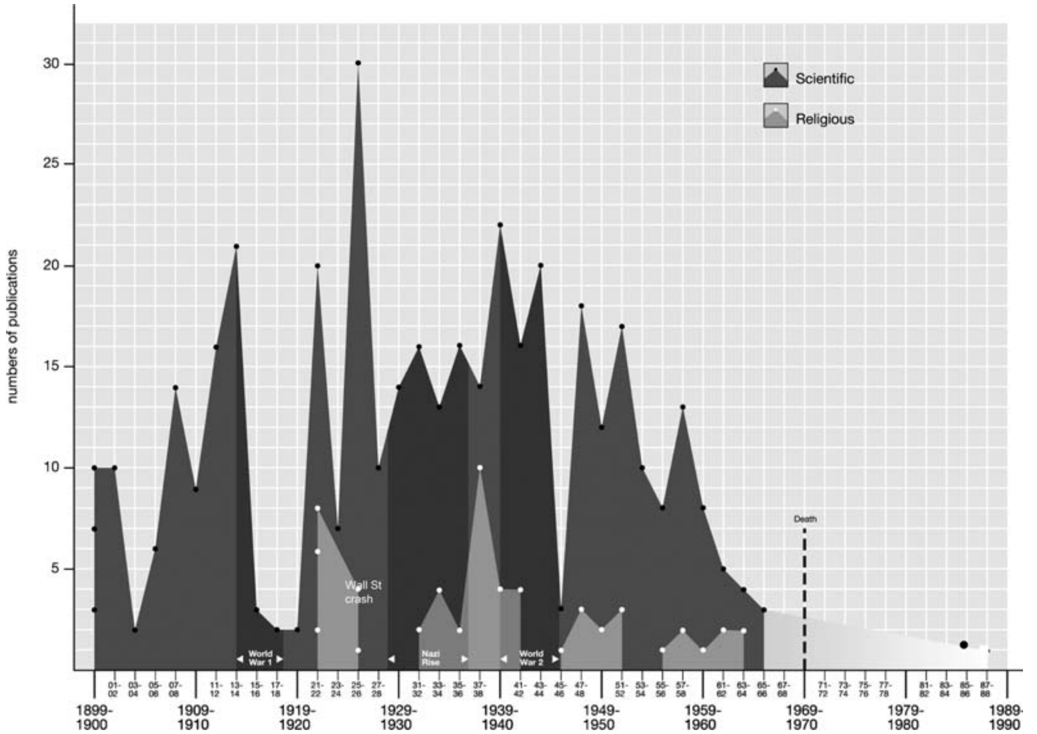

Fig. 3. Diagram of Friedrich von Huene's publication rate, 1899–1966, with one posthumous work (von Huene & Burger 1990; pale area denotes time lapse), contrasting scientific (dark) and religious writings (light; see Appendix 1), with notes on contemporary circumstances (© Susan Turner, 2007).

accessible within university libraries. Contact with evangelical and Protestant libraries and clubs in Tübingen and elsewhere has begun, and if any reader knows of the whereabouts of any of those listed in Appendix 1, please contact the author.

Here I look at his life and outline his religious–palaeontological philosophy and see how it touched some of his family, friends, students and scientific colleagues. Von Huene did leave us an autobiographical account, written in German during World War II long before his death, and early contemporaries have written about him (e.g. Hölder 1977; Rieth 1977). This paper considers some of the religious and philosophical conundrums of this man.

Von Huene's background

Born Friedrich Richard in Tübingen on 22 March 1875, von Huene was the proud descendant of a noble Baltic German family (Fig. 4b), traceable back to the 15th century. This background remained an essential part of von Huene's being, and his 'blue blood' undoubtedly separated him to some degree from his contemporaries, many of whom found him snobbish or aloof (e.g. Hölder, pers. comm.; Walliser, pers. comm.). His status resulted in some interesting responses in the New World, as his US friend Richard Lull (UFGA, Lull letters) always sent his regards to 'the Baroness' when referring to Frau von Huene. Such knighthoods ceased to exist in the aftermath of World War I and the Russian revolution, and the proclamation of the republics of Latvia and Estonia, when estates were confiscated and the nobility was forced to emigrate. Nevertheless, von Huene always regarded himself as a Baltic nobleman (see Appendix 2). His home in Tübingen, in Zeppelinstraße (now Payerstr.), was named 'Villa Baltica'.

Von Huene was tall and was physically and mentally imposing. He was not a 'talker', although he did maintain a dialogue with the media of the day, using it to spread his messages, palaeontological, museological and evangelical, and trying to combat the evils as he saw them of social Darwinism sweeping through his country (von Huene 1944). Interestingly, one meaning of the name Huene is 'giant', and he was a 'giant of a man' albeit 'drahtig' ('wiry'), with reddish hair and a complexion to match (Rieth 1977). Colbert

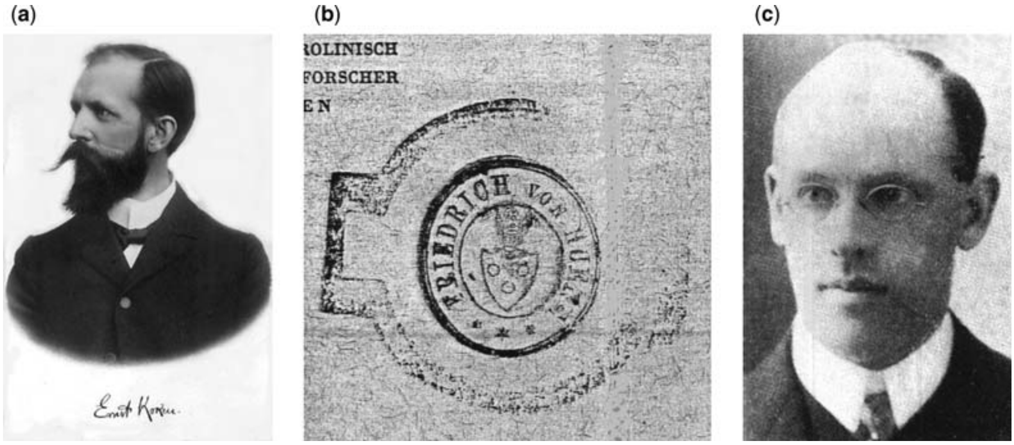

Fig. 4. Influences on Friedrich von Huene and Heber Longman: (**a**) von Huene's supervisor Professor Dr. Ernst von Koken, photograph and signature; (**b**) Hoyningen-von Huene family aristocratic crest used for his bookstamp, found on nearly all reprints; (**c**) Dr Ronald Hamlyn Harris, friend of both; (**a** and **b**, courtesy IGTU; **c**, courtesy of QM).

(1989) gave a brief description: 'a tall man, rather slender, with brownish-red wavy hair and a closely trimmed Van Dyke beard, he was a striking figure' (Fig. 1a). He was also famous for his asceticism, or miserliness, depending on to whom you talked. His visitors to his house and students who lodged there often found the going very tough (Reif, pers. comm.), and this streak comes out to some extent in his letters. Hölder (pers. comm.) remembered his prodigious walking feats (not unusual for that generation) and how he was once, at the age of 75, offered a lift on a back country road when he walking on a 120 km journey and he answered, 'I have my own car with me, thank you!' This demeanour appealed to some, such as his friend the Canadian palaeontologist, William Diller Matthew, who visited and had a 'large and ample dinner but very simple, no meat' at the von Huene home in 1920 (Colbert 1992, p. 189). Perhaps this was post World War I austerity (unknown in the USA), but it also may have been a characteristic of von Huene's protestant Baltic background. Others, such as his colleague Professor Kuhn-Schnyder (Zürich), could not adapt when a guest with the family: 'I enjoyed one week of hospitality . . . to breakfast I got milk, to evening meal rhubarb in milk. I wasn't allowed to drink a glass of wine and at ten o'clock I had to go to bed. Therefore I am resolute, if I should come once more to Tübingen, then I will go from the station to a good hotel, move into a good room, drink a good red wine, smoke a good cigar—and only then will I visit my colleagues!' (Hölder, pers. comm.). Another guest, the Parisian Professor Lapparent, invited von Huene and the young and hungry Hölder to a good lunch at a then restricted French hotel when in the field in Swabia, but von Huene insisted that 'the weather is too good for a menu' and would only take a plate of soup (Hölder, pers. comm.).

Friedrich's father and foremost influence, Johannes von Hoyningen genannt (i.e. named) Huene, was an evangelical Lutheran minister and theologian who had trained in natural science at Heidelberg as well as in theology at Göttingen, Dorpat and Tübingen. From him Friedrich was imbued with Baltic piety, which was reinforced throughout his life through the Bekennende Kirche (the 'Professing' Church of Living Christians). His father seems to have been the dominant influence on young Friedrich's deeply religious nature (e.g. von Huene 1944; Sues 1997). His mother, Alexandra Baronesse Stackelberg, was from Rittergut (estate) Paulo in Estonia. His family situation ensured him a fine education. As a baby, von Huene was taken to live in Switzerland, where the family moved when his father gained a teaching position at the Evangelische Predigerschule (Protestant Preachers' Seminary) in Basel. When he was taken back to the family estates in Livland (Pajusby and Forbushof Rittergüter near Addafer, now part of Latvia) when a young child, he began to delight in natural history, and with his brothers collected fossils from the local rocks. These studies and pastimes were always perceived as revealing the work and word of God, a philosophical grounding that never faltered throughout his life (von Huene 1944; Gross 1969). Von Huene also cited his explorer uncle, Carl von Ditmar (1822–1892; Tammiksaar 1993), who had unravelled the early history and geology of Kamchatka, as spurring on his thoughts and desire for adventure in far-distant places. Later, von Huene gained much of his early education from tutors and then, from the age of 12, in a protestant Gymnasium in Switerland.

In 1895 von Huene made his 'Abitur' (giving the right to go to university) on the Jura fossils and then studied theology and natural sciences at the University of Lausanne. He remained deeply religious, and initially contemplated a religious career like his father and took a Bible Course in Geneva (von Huene 1944). In the autumn (winter) term, he switched to Basel University, but during a visit to his birthplace, Tübingen, he saw the geological institute at the University made famous by the late Friedrich August von Quenstedt (1809–1889) (Hölder 1977), and decided that this was where he would study. Therefore, in 1897 he studied geology and palaeontology there, with the invertebrate and as vertebrate palaeontologist Ernst von Koken (1860–1912; von Huene 1912; Fig. 4a) as his teacher. Koken, created 'von' for his scientific work like a few others at that time in Germany (e.g. Quenstedt and Zittel), worked on fish, amphibians, crocodiles and mammals (e.g. Zittel 1902), along with other contemporaries, such as Louis Dollo (1857–1931) and Othenio Abel (1875–1946), who were active in vertebrate palaeontology (e.g. Zittel 1901). Koken influenced von Huene's views of evolution (Reif 1984; Reif & Lux 1987). As a student, von Huene collected fossils around Germany and in the Swiss Jura Mountains. He gained a knowledge of regional geology and landscape history, and wrote early papers on Devonian fish and the bend of the Rhine (von Huene 1944; bibliography published by Reif & Lux 1987).

During his student days von Huene had the same apartment in town as his father had had 40 years before, and he shared it with Ronald Hamlyn Harris (1874–1953; von Huene 1944; Mather 1986) (Fig. 4c), a young man from Eastbourne. This association not only improved von Huene's English but resulted in a firm friendship, which lasted until old age. Von Huene stayed with his friend on his first visit to Britain in 1901, when he met the British palaeontological coterie of Woodward, Seeley, Newton, Traquair and others, and visited the main museums and 'interesting' collections (von Huene 1944). While he was collecting Silurian fossils in 1897, he also attended the 6th International Geological Congress at St. Petersburg, where he made many useful contacts (von Huene 1944).

When von Huene applied to Koken for his theme for his dissertation, he wanted to become a systematic palaeontologist and stratigrapher, like his teacher (von Huene 1944). Consequently, von Huene primarily studied brachiopods (Brachiopoda) for his doctoral degree; on 19 December 1898, aged only 23, he completed his thesis on the inarticulate *Crania* from the Baltic region, entitled 'Die silurischen Craniaden der Ostseeländer mit Ausschluß Gotlands'. After his inaugural dissertation, von Huene was persuaded by Koken to work on German Triassic dinosaurs, and thus he became a vertebrate palaeontologist; a lifetime later he was fond of saying that he *was* vertebrate palaeontology in Germany (Hölder, pers. comm.). The delivery in the summer of 1902 of his habilitation thesis 'Übersicht über die Reptilien der Trias' ('Review of Triassic reptiles'), which received the highest grade of *summa cum laude* (von Huene 1944; Anonymous, undated *c*. 1999*a, b*; Maisch 1999*a*, *b*), made others aware of 'the abundance and diversity of the reptile fauna', although, as was common at the time, there was little on their biology or phylogeny. After he received the qualifications that enabled him to be a university lecturer, he was installed as a professor (but unpaid) with charge of the museum, having gained the position as Koken's assistant.

On 17 March 1904 von Huene was sufficiently financially established to marry Theodora ('Dora') Lawton (British by birth; they probably met through von Huene's church). Correspondence, especially with overseas correspondents (e.g. to Lull, Longman, Matthew Minor, UFGA), gives some details of this other von Huene, a man proud of and worried about his growing family of five daughters, and with occasions of 'angst'. He asked colleagues to help with jobs and for help when his eldest, somewhat 'prodigal' daughter Erika went in the 1920s to the USA (UFGA, Lull letters). The daughters, however, had to cope with this rather overbearing father and the youngest, Irmele, 'escaped' by becoming an artist, against his wishes (Hölder, pers. comm.). He was often generous with help: for example, in one letter (QM, Longman letters) he attempted to find a position in Queensland for the young Swiss, Rainer Zangerl (1902–2004), who did leave Europe, although not for Australia but for the USA, where he obtained a job at the Field Museum of Natural History, Chicago, and had a successful career.

Scientific life

His autobiography (von Huene 1944), the factual 'Arbeitserinnerungen' (autobiographical sketch of work) briefly summarized in English (Sues 1997, pp. 17–18), and the summary by Seilacher & Westphal (1969) of his work, along with the more recent treatment by Reif & Lux (1987) and Maisch (1999*a*, *b*), give basic information on von Huene's scientific life. Others researches, such as Gross (1969) and Rieth (1977), have added personal touches, but it seems likely that no personal notebooks remain.

After his thesis work, von Huene gradually turned his field of expertise to practically every group of fossilized reptiles and amphibians. To him it was important to understand the information of the fossils as accurately as possible. This applied to the description of all newly discovered species, genera and families, but he made no mention of phylogeny or other aspects of evolution. Nevertheless, the legacy of von Huene's dinosaur work is still respected, especially the work on Indian sauropods, and many of his taxa remain (Spalding 1993; Holtz 1997). For example, von Huene coined the term Prosauropoda, and described fully the pivotal *Plateosaurus* from the Swabian Triassic (Norian) (von Huene 1926, 1932; Weishampel & Westphal 1986; see Holtz 1997 for discussion). This now forms a major display in the IGTU museum. He worked 'exhaustively' on the then-unknown titanotheres of Argentina (von Huene 1929) and studied ichthyosaurs and other marine reptiles all his life (Hungerbühler *et al.* 1989; von Huene 1922; Maisch, pers. comm.).

Von Huene's illustrations are still appreciated (Paul 1988) and he is remembered in his own region (e.g. in the Stuttgart Löwentor Museum's new display on dinosaurs in 2007). He produced work on the osteology, systematics and phylogeny of various groups of reptiles and amphibians and became one of the foremost reptile systematists in the history of palaeontology, noted especially for his contribution to dinosaur palaeontology (e.g. Colbert 1968; Reif 1984; Sues 1997; Maisch 1999*a*, *b*; Schoch 2007). His life and work are commemorated by the IGTU Museum, which exhibits dinosaurs, marine reptiles, stegocephalians and therapsids, many of which he collected (Anonymous, undated *c*. 1999*a, b*; Maisch 1999*a*, *b*; Maisch & Nebelsick 2006; IGTU www.uni-tuebingen.de 2007), and by his scientific estate (e.g. Seilacher & Westphal 1969; Reif & Lux 1987), which is now mainly housed in IGTU, but also in UFGA. The largest part of his work was technical papers and monographs that addressed other vertebrate specialists (Fig. 3), with mainly straightforward descriptions of bones. Von Huene addressed palaeobiological questions in more popular representations and in museum exhibitions but he rarely tried to find analogies between recent and fossil vertebrates; once he investigated crocodile locomotion to compare it with that of dinosaurs (Reif & Lux 1987). Excavations in Europe, South America, North America and Africa provided numerous skeletal assemblages, which today constitute the most important part of the heritage of the geological-palaeontological Institute in Tübingen. As a museum worker, von Huene developed new techniques for assembly using metal framework and free-form, but as Hölder (1977, and pers. comm.) has recounted, he was an 'ideas man' but not the practical force in putting the exhibits together, despite some evidence to the contrary (Fig. 2a).

Von Huene always emphasized that he was not interested in academic teaching and therefore he never wrote a textbook on vertebrate palaeontology, although many of his monographs remain classics. When he did teach, the results were desultory. His lectures were a disaster except for the very dedicated few; Hölder recounted in 2008 that usually only two students were left, himself and von Huene's daughter Erika. However, despite his lack of political interest and relative unworldliness, he knew that he had to report his findings to an interested public and politicians. This he did in his monumental work for the museum (e.g. Rieth 1977; Maisch 1999*b*) and in popular articles and several books with his evolutionary ideas written for a (mainly) religious audience (see Appendix 1), such as his book on human evolution (von Huene 1937). In many of these he discussed topics not seen in his formal vertebrate palaeontology, such as the 'time problem' (e.g. Appendix 1, items 2, 6, 26 and especially 32) and how his ideas of evolution reflected the Old Testament account of creation.

Ist der Werdegang der Menschheit eine Entwicklung? (*Is the* [*Evolutionary*] *History of Mankind a Development*?) (von Huene 1937) was his attempt to make sense of the knowledge of human beings at that time of deterioration in Germany (von Huene 1944). The Institute copy has a blacked-out Nazi swastika on the fly-leaf, a normal post-war practice, with only one rare exception found in the von Huene reprint collection. This is a semi-popular book on human evolution, comparable with such books by palaeontologists today, but with a notable difference that brings his work more into line with the recent extreme creationists. As Reif & Lux have noted (1987, p. 103), the position of humans was one of von Huene's main themes, as well as of supreme importance in his thinking about the aim of evolution, but he concluded in this book that Adam was not the first man. His geological knowledge on time, from his early interest in Milankovitch cycles (von Huene 1944) to 20th-century studies of the use of radioactive elements (e.g. Appendix 1, item 32), led him to tackle a comparison between these and the Old Testament account of Genesis and human evolution. He awkwardly blended recent scientific 'fact' with Bible lore and showed that God made earlier 'men' before Adam. In his Foreword, dated 17 June 1937, he outlined his philosophy (roughly translated below):

> Nature to me with its Life, its births and deaths [Genesis and Extinction], is always something grand and wonderful. And that the whole of Creation is God's Work makes Nature for me even

more exalted. I was filled with increasing astonishment as I looked in the way of a palaeontologist always deeper into the course of the long evolutionary history of the organic world through geological times. And although my proper [true] field of work [vocation] is the extinct reptilian ['saurian'] world, there always remains the question concerning Mankind and its connection with the rest of Creation, but for me this has only been gleaned in a receptive mode [through reading]. With great interest at some distance, I have searched to follow the most important effective results of research on fossil man and his culture. I saw Mankind having grown out of the organic community of creatures as God's Creation. There was a gap between the archaeological prehistory of Mankind and his engagement in the ages of the so-called recorded world history. However, gradually in the latest years research on prehistory and early history came more and more together and could finally link hands. Unrestrainedly it grabbed my attention in December 1936 when I was able to read a wonderful compilation of these results out of the pen of the well-known British archaeologist Prof. Gordon Childe in his book 'Man makes Himself' …. The bridge between pre- and early history was supported. To that was added an impressive overview of the last advances of technique in A. Zischka's book 'Science breaks Monopolies' …. The totality of these great pictures can be found here, and together with the evolutionary and phylogenetic history of Creation as can be seen rolling out before the eyes of the one who is looking out from a biblical Christian point of view, can be drawn biologically…. Might it happen to some readers like the author that these mighty unified events sustainably impress on him and focus the view on the Driver [or Steerer or Coachman] of all things. So also coming out of all these bygone and present occurrences shines a deeper and direction-giving sense (von Huene 1937).

Von Huene in six chapters gave a chronological overview of palaeontology and evolutionary history and human development from the Stone Age to historical time, but added his own view of how humans began to master the environment (the last phase of 'New Time', as he called it), and the origin, aim and destiny of humans, which von Huene needed to dovetail with the Old Testament. He showed five steps on the way to modern humans in his time chart 'Human Pre-history and Time', where in the original 1 mm = 3000 years (Fig. 5a), with *Pithecanthropus* and *Sinanthropus* discussed in the text as predecessors of Adam. In this, as in his other religious writings (Appendix 1), he integrated a geological timescale rather than a literal biblical one. Interestingly, the Institute copy is annotated with extra information, with eoliths (the supposed 'dawn' hand tools found in the UK) at the top of the Tertiary, *Eoanthropus* 'dawn man' (the now-discredited Piltdown Man) at the base of the 'Diluvium' and *Palaeoanthropus*, all before Günz I (i.e. the older Stone Age). As elsewhere, he grappled with his biblical imperative versus geological time, which he got round by considering that each day of Genesis was 1000 years (but that also there was no night). He concluded that humans still have to evolve at least spiritually, a pointed need for those times.

Von Huene's scientific output

Von Huene needed to understand the information from his fossils as accurately as possible, as it was important for him to show God's unfolding creation. This made him one of the most driven and prolific of vertebrate palaeontologists (Fig. 3). He went on introducing new taxa to the literature, and in his hundreds of papers he wrote several hundred descriptive pages on fossil groups. This was always done in some haste, as he worked to encompass everything possible (Reif & Lux 1987). Gross (1969) calculated that von Huene produced 130 printed pages per year of original literature containing descriptions. He produced his own original drawings, for his view was that 'to draw is to see'; this is still the best way to record fossil material.

Von Huene produced around 420 books, papers and articles, spanning 65 years (Reif & Lux 1987; S. Turner, unpublished; Fig. 3; Appendix 1). However, behind the veneer of scientific thought of this 20th-century palaeontologist was an unusual paradigm, for von Huene as a staunch evangelical Christian had extreme beliefs about the role of God (Reif 1984; Reif & Lux 1987). These views dictated the way he lived and carried out his scientific tasks, so that, unlike his peers, much of his work was a race to reveal new taxa but without any real analysis of their context. To those who know his copious scientific output, many of his religious works, principally because they are in German and in obscure non-scientific tracts, are unknown.

Reif & Lux (1987) and Sues (1997) have noted that no hardship or sacrifice would prevent von Huene from carrying out his self-imposed obligation to conduct research for over 60 years, not just to reveal scientific 'truth' but 'to show the intricacies of divine creation to those with eyes to see' (e.g. von Huene 1944); mostly his intended audience was not his students and colleagues, and probably not even his family.

From his promising beginning, something went wrong, for he was never to gain a full professorial position, despite habilitation and his steadily increasing output of monographs and papers (Fig. 3). In 1911, a crisis occurred when Koken was ill and failing. Von Huene tried for but, despite an apparently glowing reference from Richard Swann Lull (1867–1957), he did not get the position of Assistant following Koken's death; it went to Pompeckij in 1913. Von Huene had attempted to get a job in the USA, notably at Stanford in 1910 (UFGA, Lull letters). Because of his background, he was a Russian subject (he called himself an 'Untertan', i.e. a political subject; von Huene 1944) but in 1910 he received German citizenship papers, which allowed him to obtain a passport. From March to October

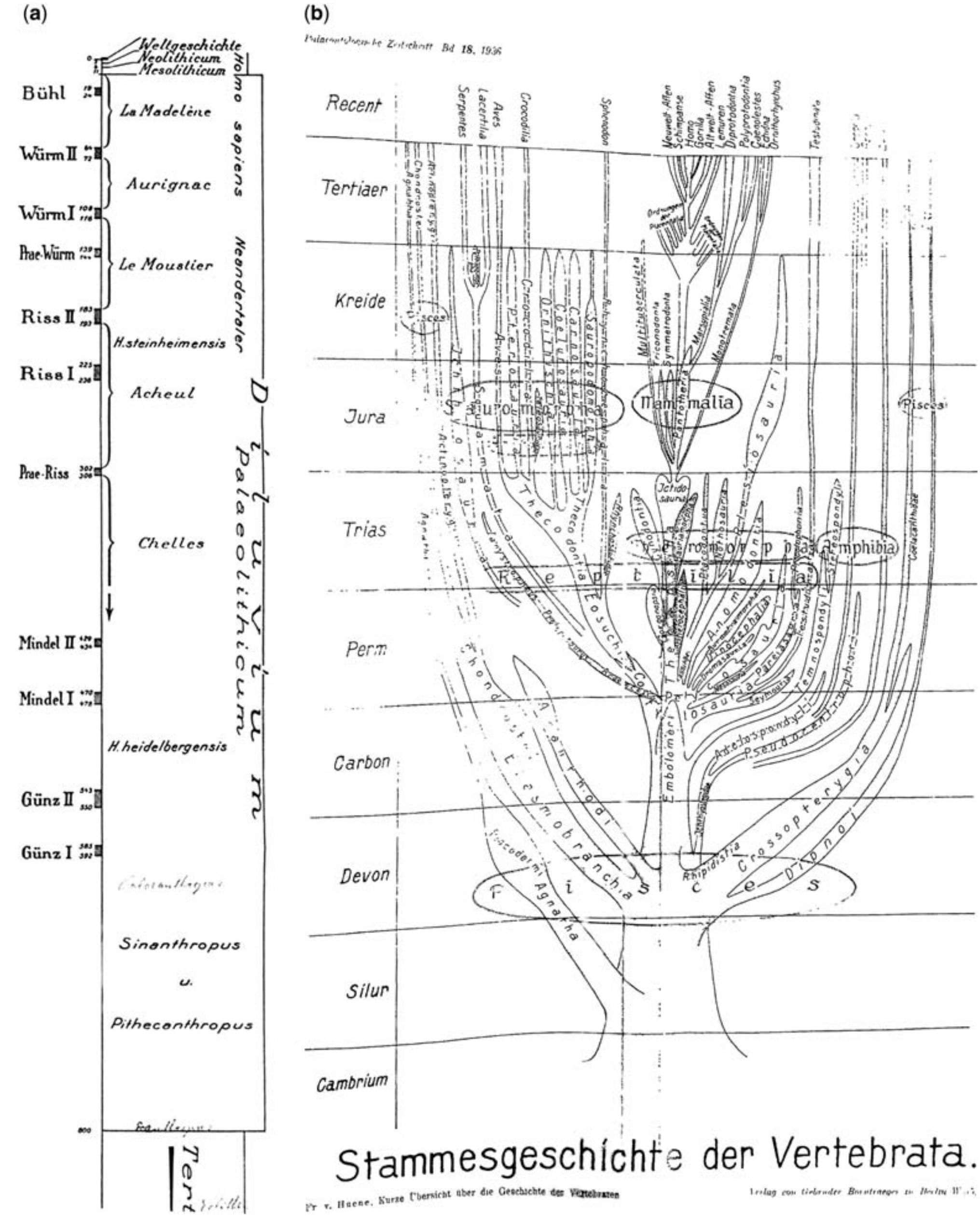

Fig. 5. Symbolic charts: (**a**) Quaternary timescale from IGTU copy of von Huene's book on human evolution (von Heune 1937), with annotations, not to his scale; (**b**) an example of von Huene's phylogenetic trees of fossil vertebrates with humans (*Homo*) in the central place (von Huene 1956).

1911 he travelled to North America to visit museums and fossil localities in Canada and the USA, and he made large collections from Cambrian to Tertiary and built a network of contacts that was to last a lifetime. Further plans to emigrate and gain a job in the USA were thwarted by the beginning of the First World War.

That war was a major block in von Huene's scientific life. In August 1914 he was a volunteer at the front, first as a private but by 1915 as an officer in the cavalry in France and Romania; his leadership capabilities he put down to his aristocratic background (van Huene 1944). However, military service did not completely slow him down because he still managed to produce at least one paper a year, maintaining his driven pace (Fig. 3). His peak years (over eight papers a year) were 1899–1901 (thesis work), 1908–1914, 1921–1923, 1925–1926 (southern continent expeditions) and the years before World War II.

In 1920 William Diller Matthew from the American Museum of Natural History visited him in Tübingen, and this visit resulted in a co-operative expedition and excavation by both museums at the Upper Triassic *Plateosaurus* locality at Trossingen (in the Black Forest, SW Germany), from which, by formal agreement, they split the finds (von Huene 1944; Colbert 1992). This went on until 1923 as a large-scale operation using 'American' (e.g. plaster jacketing) methods on the dinosaur bones in the Keuper (km5) Knollenmergel. The results exceeded all expectations and von Huene's reputation worldwide was established.

On 1 January 1923 he received a letter from Argentina; the La Plata Museum in Buenos Aires invited him to work on the Cretaceous dinosaurs there. Von Huene made a condition of his agreement that he be allowed to visit Patagonia. By summer he was there, making extended excavations. In February 1924, while he was in La Plata, he received the first letter from Heber Longman, in Australia, recounting the discovery of a dinosaur (UFGA and QM); von Huene had already written over 100 scientific papers when the correspondence with Longman began (Turner & Maisch 2003). From then, von Huene tutored Longman and predicted (wrongly, as it turned out) how dinosaurs would be found in Australia (e.g. Rich & Vickers-Rich 2003). Longman in turn persuaded von Huene to write a review paper on the sauropods for the *Memoirs of the Queensland Museum* (von Huene 1927).

In 1925 von Huene was offered a full professorship (Lehrstuhl) at the University of Cordoba in Argentina, but he rejected it. This may have been the worst mistake in his career, but it prompted the University of Tübingen to give him the position of Konservator (i.e. curator) with full pay. He then donated his entire collection to IGTU and it is still there; the 'jewel in the crown' contributing to 1000 holotypes (Maisch & Nebelsick 2006). In 1927, von Huene was promoted to Hauptkonservator, which provided more money for his growing family (Anonymous, undated *c*. 1999*a*, *b*; von Huene 1944). Von Huene had been so immersed in work that he 'slightly missed' his Silver Wedding anniversary (17 March 1929, von Huene 1944). However, at the same time the world was plunged in economic disarray, which even von Huene (1944, p. 37) noticed, as it affected his museum and plans.

Considering von Huene's religions views, how did he get on with atheistic and agnostic colleagues? His letters to Lull, Edinger and Longman (UFGA), for example, show a cordial exchange; Edinger especially showed interest in his evangelical advice. However, on occasion von Huene's religiosity would no doubt have led to 'rational' discussion with colleagues or even argument over the scientific 'facts'. Von Huene did accept that evolution had taken place but could never cope with a mechanical process (i.e. natural selection). He saw the fossil record only as revealed; the absolute truth created by God waiting for him to discover. Such a different world view did sometimes result in disagreement despite collegiate courtesy, tolerance and respect for the older man (see below). Did disappointment and even a chink in the evangelical armour ever result from von Huene's scientific finds? It seems not. Hölder (pers. comm.) has told the story of the fossil, brought in by an amateur, which von Huene pronounced to be a 'saurian' amphibian and published as one of God's wonders with a new name, only to have the ignominy of a colleague proving it to be a fossil crab. (We all make mistakes, but in von Huene's case that meant that God had revealed the wrong thing to him.) Nevertheless, such chinks were few and von Huene attained high pinnacles in scientific endeavour even when political circumstances were against him.

Von Huene's religious beliefs

Much less is known, especially in the English-speaking world, about von Huene's theoretical views on evolution and palaeobiogeography, and of his methods of palaeobiology and phylogenetics, controlled as they were by his extreme evangelical beliefs (e.g. Reif 1984; Reif & Lux 1987). Reif & Lux (1987) considered von Huene's *raison d'être* and came to the conclusion that his aim was to reveal God's creation, and in this the description of new taxa played a central role. In some cases he changed his mind rapidly; then, however, in an almost dogmatic way he stuck to one solution. Hardly ever did he provide tests for his results (although that was fairly common in pre-cladistic times). This behaviour is certainly not confined to religious men, but in von Huene's case it seems that it was his self-imposed task to report on God's plan and thus find the scientific truth.

Beginning after 1920 (Fig. 3, Appendix 1), von Huene stated in numerous non-scientific summaries and evangelical publications that his scientific research programme was guided by his religious persuasion (von Huene 1944). His wife Dora had been a victim of the influenza pandemic and this dramatic event might also have precipitated his need to evangelize. Von Huene expended much energy trying to prove that the record of creation in the Bible agreed with the fossil record, even though this record had mostly been deciphered by palaeontologists. As he aged he made no attempt to keep his religious convictions secret. This undoubtedly influenced others' perception of him, for people tended to avoid his 'weird' ideas (see Lull below). For almost the entire period of his working life, von Huene catered for two readerships: on one hand, his colleagues and scientific peers, and, on the other hand, scientifically inclined laymen and theologians interested in a synthesis of science and the Bible (Reif & Lux 1987). In this way he was working to popularize, as was Longman in Queensland, although the latter proceeded in a totally different direction (see below; Turner 2005).

The first religious papers recorded in his oeuvre (Appendix 1) were published from 1921 in Basel (perhaps because of his own earlier connections to the evangelical Protestant community there). Mainly he wrote in Protestant tracts, but he also wrote a few chapters in more philosophical works (see Appendix 1). He never doubted the accuracy of the theory of descent but he clearly did doubt that humans were part of that story; were we for him descendants of 'apes'? His major book on how 'Man' fits into the scheme of things (von Huene 1937), came out during the National Socialist period when his Christian sensibilities were probably strained to their utmost (see Appendix 1). It was well received, with a second edition in 1938.

At that time von Huene was providing long-distance mentoring to Longman in Australia, but whereas von Huene might have influenced him in his approach to descriptive taxonomy it is doubtful that Longman would have been persuaded by von Huene's speculations on relationships. Reif & Lux (1987) concluded that von Huene did not discuss phylogeny *per se* a great deal; however, in his papers there are many examples of phylogenetic trees (e.g. Fig. 5b), which are superficially no different from those of his contemporaries (such as his friend D. M. S. Watson of University of London or Al Romer of the Museum of Comparative Zoology). Although von Huene's Christianity was extreme for a scientist, Reif (1984) has stated that von Huene never doubted the fact of evolution but always took a strong stance against 'materialism and Darwinism'. In other words, he seemed to have been appalled by the development of 'social Darwinism' at the turn of the century (von Huene 1944) and by the anticlerical polemics led by Ernst Haeckel, and he clearly neither supported nor took part in the anti-Jewish (anti-Semitic) stance and pogroms of the university in the 1930s and beyond (e.g. Beyerchen 1977; Deichmann 1997). In fact, von Huene is known to have helped Jewish colleagues or families (Markert, pers. comm.), which also underpins why his stance against the National Socialist regime was not forgotten, as stated at the end of Reif & Lux's (1987) analysis.

Von Huene developed his own concept of evolution as controlled by God, neither 'internally' driven (compared with other orthogeneticists of the day) nor 'externally' driven by selection (Reif 1983; Reif & Lux 1987). Phylogenetics was for von Huene the study of God's plan of creation; this was to be found in the Bible, the 'fixed (immovable) Rock', especially the Old Testament. However, because of his chosen field, he did not restrict himself to studying the Bible but looked to nature for answers. He did develop ideas of phylogenetic systematics (*sensu* Hennig), because he thought that taxonomy should reflect phylogeny. The shape of the phylogenetic tree, however, was of utmost importance and he placed humans (*Homo sapiens*) in a central symbolically high position (e.g. Fig. 5b). Reif (1984) noted the similarity of some of von Huene's trees to the Jewish Chanuka. Certainly some of his contemporaries might also have placed *Homo* there, although for different reasons, but others (e.g. Hölder 1960, fig. 49) have shown hominids to one side of the main mammalian stem.

The theoretical side of palaeontology was doubtless presented to von Huene as a student but, as Reif (1983) has noted, the theory of evolution was not part of the German teaching programme of palaeontologists; it was a subject that only the professors discussed, with only an extremely rare mention in lectures, at conventions and in textbooks. As a student and also afterwards, von Huene was never exposed to an intensive discussion on evolution. Once he referred to the 'stimulating observations of the theory of descent' of his teacher Koken, who was one of those who grappled with different ideas, and he also referred to Dollo and the neo-Lamarckist Otto Jaekel (Reif & Lux 1987). In his numerous scientific papers von Huene did not have a particular position and it is doubtful if he ever systematically concerned himself with literature on evolutionary theory. He accepted descent but not natural selection (von Huene 1944). Reif & Lux (1987) emphasized that the theory of descent and the theory of selection must be distinguished from each other. The former had permeated German palaeontology shortly after the publication of the *Origin of Species* (Darwin 1859); for example, the idea that species originated from organisms, although not as separate events, but coming through a very long process of variation or modification, as well as through a process of splitting off (Reif 1983). However, although he was no Darwinist, there was no real conflict for von Huene between the acquired influences of his youth and learned academic opinions. For him, evolution as a whole was analogous to the development of an organism and envisaged as a bush with terminal growth (as seen in contemporary phylogenetic trees). Taxa on all levels started in an unspecialized state and the unfolding ended when they had become specialized. Von Huene would have regarded all contemporary taxa as specialized (except for *Homo sapiens*) and thus for him evolution had come to an end. With this emphasis on the process of evolution as God's unfolding (one-way) plan, he had no particular interest in extinction (von Huene 1937, 1944).

Towards the end of his life von Huene gave a glimpse into his mind in a letter to Father Franz X. Mayr, founder of the Jura-Museum at Eichstätt:

> Was wir natürlichen Ablauf der Dinge nennen, ist in Wirklichkeit etwas von Gott Geplantes und Verwirklichtes. Ich denke mir das sehr real: Gott hat Seinen Engelfürsten den ganzen Plan mit seinem Ziel mitgeteilt und die Einzelgebiete unter sie verteilt und jeder Engelfürst hat wieder seine Untergebenen, die die speziellen Dinge eines Gebietes ausführen. Diese Engelheere denke ich mir gestuft wie im Kleinen ein menschliches Heer, vom General abwärts bis zum Soldaten; jeder hat sein gestuftes Gebiet. Auf die Paläontologie angewendet: Stämme, Ordnungen, Familien, Gattungen, Arten, Individuen. So hat auch jetzt jeder Mensch seinen Engel. Diese Engelheere treten aber als solche (soweit sie die Schöpfung ausführen) gar nicht in Erscheinung, denn es geht alles einheitlich nach Gottes Willen und Plan vor sich. Darum haben wir es nur mit Gott, dem Schöpfer, in der Paläontologie u. Prähistorie zu tun. In Ewigkeit werden wir einmal mehr sehen (Senninger & Viohl 1984, p. 101; Reif & Lux 1987).

> What we call the natural course of things is in reality something planned and realized by God. I have a very businesslike conception about this: God made known the whole plan and its aim to his angel princes, and divided the separate tasks among them, and each angel prince in turn has his subordinates who execute the specific things of their area (of the plan). These angel armies I picture as hierarchical (= stepped), like, on a small scale, a human army, from the general down to the soldiers; everyone to his part. Applied to palaeontology: phyla, orders, families, genera, species, individuals. Thus, also now, every human being has his own (guardian) angel. However, in so far as they carry out creation, these angel armies do not emerge at all, for all is proceeding uniformly according to God's will and plan. That's why in palaeontology and prehistory we only have to deal with God, the creator. One day, in eternity, we will see more (all will be revealed). (Translation with the help of J.M.J. Vergoossen & C.-D. Jung)

Astonishingly, for one immersed in the history of the vertebrate fossils, this is talk of armies of angels, organized efficiently with generals and colonels, lieutenants and privates, which controlled life down to its smallest detail by direct orders from God. Senninger & Viohl (1984) noted that it is hard to believe that this is a man writing in 1955 let alone an Earth scientist, for his words are those of a medieval scholar. Is this even a man in his right mind? Perhaps we should think of von Huene as we think of classical scholars (such as Galileo, Newton, Leibniz, Descartes and Ray), or more recent scientific priests such as von Huene's contemporary Teilhard de Chardin, who were totally devout Christians but are accepted as part of the scientist tradition.

Third Reich conditions

Reif & Lux (1987) stated (but without explanation) that his 'uncompromising stance against Nazism is not forgotten'. Maisch (1999*a*) explained further that during the years of the Nazi regime von Huene clearly recognized that people despised the ideology of the Nazis. However, most academics were able to combat them (Hölder, pers. comm.), or were pro-Nazi. The universities, including Tübingen, capitulated, and Jewish academics and others were summarily dismissed from 1933 onward (Beyerchen 1977; Deichmann 1996). In early 1933 'Die Gleichschaltung' began, Hitler's 'gear shift', with the aim of 'making things uniform so that no individuality is left [especially in thinking]', and supposedly putting all society under the control of a single leader. Geologists were expected to become part of the Nazi organization; von Huene, like some others, did not. As Hölder (pers. comm.) and others have noted (e.g. Rieth 1977), von Huene was unworldly and politically naive, and totally focused on his 'saurians', and as he was already an elderly aristocrat (Fig. 1b) he probably did not concern the Nazi party but was regarded as harmless.

However, von Huene made the best of the Third Reich and war years (1933–1945). He kept his head down and tried to continue to work using material he had or could obtain, and he maintained a steady publication rate (Fig. 3). As far as possible, von Huene refused to work and co-operate with the Nazis, maintaining his faith and acting through the Bekennende Kirche, and sometimes assisting local Jewish families (Hölder pers. comm.; Markert pers. comm.). He also kept up a strong anti-Nazi output of religious tracts, and in his 1937 book on 'Mankind' stressed the moral dangers of the current era as he saw them.

Rieth (1977) recounted that, although von Huene was an arch conservative, as were many of his right-wing colleagues in the university, he did not countenance the new regime. When the assembled academics were harangued by a local Nazi Culture Minister in 1933, he (bravely, or some might think naively) walked out of the university auditorium. Perhaps in part to combat this difficult time, he wrote his religious tracts and used his influence to help persecuted scientific colleagues, such as the palaeoneurologist 'Tilly' Edinger (1897–1967), who had managed to remain at the Frankfurt Senckenberg Museum after 1933 and left Germany just in time after Reichskristallnacht in 1939, first for Britain and then Harvard (e.g. Kohring 2003; see also review by Schultze 2007), and Max Pfannenstiel (1902–1976), Professor of Geology at Freiburg University. Kohring (2003) has looked at the Edinger–von Huene correspondence, 29 letters in German from the periods 1930–1940 and 1945–1953 that throw light on the increasingly detrimental effects of the post-1933 Nazi laws on scientific practice. Edinger's letters are signed by her 'stets Ihre (dankbar) ergebene' ('I remain your (gratefully) devoted') and she acknowledges the help von Huene gave her with references for her dash overseas.

In 1945 von Huene was elected honorary professor by all the professors of the Institute. This finally gave him full official status. In 1946 he was appointed Director of the Institute, but still only in an acting capacity, when the Allies removed E. Hennig for his Nazi convictions. Despite his habilitation and sometimes giving lectures, he was never promoted to full professorship. For many years he had received low pay and almost no funding so to be promoted at the worst time in German history must have been a challenge to his faith and strength. Hölder (pers. comm.) remembered the terrible time of starvation after the war when he returned, after five years as a soldier, as assistant in the IGTU department. When von Huene asked him how he was, Hölder said he was going hungry, to which the professor said: 'Against that there is a reliable method, you have only to tighten your belt!'

Eventually, in 1948, Otto Schindewolf came to head the Institute as Ordinarius professor for Geology and Palaeontology, but in the aftermath of war, during a French-led sortie to gain fossil specimens in lieu of retribution, it was the presence of von Huene that prevented the removal of specimens from Tübingen, as occurred at other establishments that had collaborated with the Nazis or were perceived by the Allies to have been Nazi sympathizers or members (P. Taquet, pers. comm.). After 1945 he began publishing again, with especially productive years in 1948–1954, and not really tailing off until extreme old age (see Fig. 3, Appendix 1).

Champion of Gondwana

Unlike most in the early 20th century, von Huene travelled widely, studying fossils in nearly all continents (von Huene 1944). He accumulated special southern hemisphere knowledge over 50 years, which meant that newcomers to the field, such as Matley in India (E.G. 1948) and Longman in Australia, asked him for help and advice. In turn, because of von Huene's desire to unravel the thought processes of God (Hölder, pers. comm.) by revealing to the whole world the geographical and temporal distribution as well as the diversity of dinosaurs, about which he was pivotal in opening up scientific discussion, he was eager to learn about Australia, the last 'distant' continent and bastion of former life.

While in Argentina in 1923, he had written to his former student friend, the former Queensland Museum Director Ronald Hamlyn Harris (Mather 1986), to learn more about new Australian ichthyosaur material that had recently been described by Heber Longman. Thus began the correspondence between the men and attempts by von Huene to reach Australia. Longman from the mid-1920s, after he had received the first reasonably complete Australian dinosaur remains (e.g. Longman 1926, 1933), became Australia's first dinosaur 'expert' (Rich & Vickers-Rich 2003; Turner 2005). These exciting dinosaur discoveries encouraged von Huene to try to go there in 1933 (Maisch 1999*b*) to work together with Longman and to dig for dinosaurs at the Jurassic *Rhoetosaurus* and other Cretaceous localities in Queensland (see Long 1998).

Working in Australia in any academic sphere has always posed special problems because of the vastness of the continent and thus the distance between colleagues or collaborators. These impediments have been removed to a large extent in recent decades by better transport, and since the mid-1980s by fax and the mid-1990s by GPS, e-mail and the internet. At the same time, face-to-face communication is still not the rule across Australia and often the only means is a special conference, or workshop, or now video-conferencing. At the time when von Huene and Longman worked, setting up a major field expedition at a distance took ingenuity and money. Between the two men in their letters runs a poignant refrain for von Huene to 'fly to Queensland', ultimately, an unrequited desire.

As in many scientific lives there is both success and failure. The correspondence between Longman and von Huene clearly shows that they wanted to meet and to work together, with von Huene most keen to complete his global survey of saurians in the last 'Gondwanaland' bastion. The severe economic difficulties in Germany and worldwide at the time were the impediment. Their options were closing in on them as regime change in Germany loomed. Longman in his museum could not pay for von Huene's trip to Queensland; he certainly had no hope of leaving Australia once he had emigrated there. The Queensland Museum was under economic stress and Longman's salary (as Director), along with that of other staff, was reduced during the Depression years (Mather 1986).

Early in 1933, von Huene applied for funds to the 'Notgemeinschaft der deutschen Forscher' (forerunner of the modern Deutsche Forschungs-Gemeinschaft, DFG; UFGA). Sadly, his application failed and the expedition and the hoped-for meeting did not take place. The failure may just have been bad timing but the scientific 'rules' were tightening in Hitler's new regime, made almost absolute in March 1933 when Hitler abolished all associations and clubs and translated them into National Socialist organizations. From then on only the party favourites tended to gain funds (e.g. Beyerchen 1977; Deichmann 1996). Possibly von Huene's age, his lack of support for the Party, and even his increasing evangelical writings in the 1920s–1930s, led to failure of the application, and was probably also a contributing factor to the dearth of correspondence after 1936. He was still thinking about it in 1936, for he wrote to Longman, but without explaining the impediment: 'Of course I should like to come to Australia for paleontological studies, as you write, but there is a financial impossibility. Otherwise I should do it at once' (von Huene to Longman letters, 23 June 1936, QM Archive).

The 'Young man', a new Australian

Heber A. Longman, in comparison with von Huene, built on his basic English naturalist's knowledge and Cuvier's principles and used the limited resources available to pursue science when he joined the Queensland Museum in 1911. Like von Huene, Longman was a driven writer. Beginning in the literary sphere, he became a supreme educator in his local milieu, with hundreds of articles, poems and notes in local newspapers and journals. During his years in the museum Longman produced around 80 scientific papers, which added to vertebrate palaeontological knowledge of Australia in the pre- World War II era, and led to a high scientific reputation and honours later in life (Turner 2005). He benefited from correspondence with key scientists in the northern hemisphere, principally von Huene, to complement his perceptive identifications of the fossils that came his way (Longman 1930).

Born into a middle-class family at Heytesbury, near Warminster, Wiltshire, in the rural west of England, in his early life Longman had a similar upbringing to von Huene. His father, the Reverend Frederick Longman, was a Protestant minister, but unlike Johannes Hoyningen, Longman senior was a liberal Congregationalist (Gill 1986). Longman went to a 'good public' (i.e. private) school, Emwell House, and seems to have had a happy enough childhood with a doting older sister Jessie as his main companion, who later followed him to the antipodes. He migrated to Australia in 1902 aged 22 for medical reasons because of a 'chest weakness' (there were probably concerns about TB), and lived at first in Toowoomba on the high Darling Downs west of Brisbane. Longman became first a journalist and then a newspaper publisher (Gill 1986), at the same time developing his naturalist's knowledge especially in study of botany. Importantly for him, he came with a letter of introduction to the Protestant Reverend J. M. Bayley, who was also meeting his daughter Irene at Toowoomba railway station. The two young people met, fell in love, and married in 1904.

Longman in his early years in Australia became a noted field naturalist and botanist, relishing his harsh adopted country. He helped initiate the Toowoomba Field Naturalists Club with Hamlyn Harris, who had become Director of the Queensland Museum. Ronald Hamlyn Harris had gained his D.Sc. from Tübingen University in 1902 on marine invertebrates after working at the Naples marine research station and left Germany soon after for Australia, becoming first (1903) a science master at Toowoomba Grammar School, where he reorganized science teaching. He met and began to collaborate with Longman; they became foundation president and member–secretary, respectively, of the Field Naturalists' Club in 1908. Undoubtedly the most educated man in Longman's circle, Hamlyn Harris complemented Longman's development in biological thinking. Other experiences probably contributed, as in the early years of marriage, Heber and Irene tried unsuccessfully for a child and Irene had seven miscarriages in the first 12 years (Fallon 2002) possibly because of the then-unknown rhesus factor. This failure must have given Longman a jaded view of 'natural selection' but did spur his interest in eugenics. Contrary to von Huene, the challenges to Longman's philosophy resulted in the rejection of his religious upbringing and the proclamation of his beliefs in his book *The Religion of a Naturalist* (Longman 1914).

In 1910 Hamlyn Harris had moved down to Brisbane to be the director of the state natural history and anthropology museum; of 'irreproachable character, a man of the highest integrity, blameless reputation, amiable disposition, rather reserved, quiet ... he was more of a theorist than a practical man' (Mather 1986). Nevertheless, Mather (1986) noted that Hamlyn Harris understood what was needed in a research museum if it was to be a valued scientific establishment; he made significant contributions to library structure, registration and cataloguing techniques, and made good the obvious gaps in the holdings. All this must have been built on his European experience in Tübingen and Naples; his friend von Huene was similarly building the museum and library holdings in the Geology and Palaeontology Institute. Clearly impressed by the younger man, Hamlyn Harris persuaded Longman to come to Brisbane to join his staff in 1911.

Longman's work at the Queensland Museum during his years as Director from 1917 to 1945 (Fig. 2b) have been documented by Mather (1986). Longman built on his basic knowledge with extensive reading from his own library to extend his scientific reach. When faced with myriad actual specimens to identify, he made use of the limited museum resources and began corresponding with key scientists (QM archives, Longman letters). Because of his perceptive work, in the 1930s his peers invited him to be a foundation member of the 'Royal Society of Australia' (set up in 1931 after the 1923 Pan-Pacific Conference mainly by Canberra scientists, this body was never established but ultimately post-war became the Royal Society of Canberra, which disbanded in the 1970s: Fenner 1994).

Longman was also prolific, with over 200 publications, and was a 'loner' like von Huene; he too had few co-authors (see the list given by Turner 2005). Again, this was the nature of the man but also reflected his isolation in Queensland and his inability to travel. What is interesting here is his struggle as a young man to deal with his Protestant religion and how his philosophy developed into the full-blown humanism for which he became famous; for example, he was later prominent in Brisbane's Fabian Society (Mather 1986).

Influence of T. H. Huxley (1825–1895)

Longman was brought up just after the time when Thomas Henry Huxley was at his peak, and his writings were readily accessible (Desmond 1994). Huxley coined the term 'agnostic' in 1869 to explain his own position regarding God and the Bible as antithesis to a 'gnostic', one such as von Huene who claims to knows the meaning of mysteries, such as the concept of God. The term 'agnostic' seems to have first appeared in print in a note in the *Spectator* ('The Theological Statute at Oxford', 29 May 1869). We do not know, however, whether Longman's original faith was challenged when growing up or by his new life in Australia; he was only 22 when he entered his new homeland and was married 2 years later.

By 1914, however, he had nailed his colours to the mast as an agnostic in his book *The Religion of a Naturalist*, published by the Rationalist Press Association, a brave thing to do in the Brisbane of the World War I era. At that time, Brisbane was a small town with a restricted intellectual and conservative religious life, and Longman was one of the few socialists there (e.g. Fitzgerald 1984; Mather 1986). Longman had become a humanist (like Huxley), and was imbued with the same sceptic spirit adopted from Goethe by Huxley, *Thätige Skepsis*, an active scepticism, which unceasingly strives to overcome itself and by well-directed research attains a kind of conditional certainty (adopted from the last line of young Huxley's *Rattlesnake* diary) (Desmond 1994). Huxley had 'left a secular society probing human ancestry'; this was the milieu in which Longman grew up and he became one of the intellectuals proudly wearing Huxley's 'agnostic badge' (e.g. Spalding 1993; Desmond 1994). Many German scientists were swayed by Huxley's writing in the time after Darwin (Reif 1983), but what did von Huene think of 'Pope Huxley' (Hutton 1870), or even Goethe's mantra? Clearly, von Huene did not like where Darwin's ideas had led mankind into 'materialism', and he railed against it most of his life in his religious writings (von Huene 1937, 1944).

The introduction of Longman's book set the scene (repeated on the cover of the paperback version), and announced that the author 'well known in Australian literary and scientific circles, brought up as a Nonconformist ... after many years of thought and study and a period of practical work as a naturalist, has gladly embraced a humanist philosophy', (Longman 1914). The 'practical phase' was his plant collecting in Queensland, which led to material being sent to the leading botanical institution, Kew Gardens in London, and a Queensland Naturalists' expedition to Mast Island in the Great Barrier Reef, both projects that gave him much valuable new knowledge about the Australian flora and fauna, reflected in his leap into scientific publication and exhibition in 1912 (Turner 2005).

At the end of Chapter 1 on the prodigality of nature, Longman showed some of his thinking: 'The problems of space are so gigantic that the mind fails to grasp them'. The thinker who strives to realize the immensities of the universe 'feels like an ant crawling in the skeleton of a mastodon'. 'He who gazes into the heavens on a clear starlit night may well feel appalled at the panorama of planets, stars, and nebulae, and our fair, dead moon, shining with reflected glory. Even the most casual of observers must needs be thrilled, if he thinks at all of the matter, at the illimitable grandeur before him. But to the scientist, fresh from the study of cosmic theories, what a bewildering wealth of thought surges around those points of light! ... The thought comes inevitably that forces at work in other and perhaps grander spheres, under the influence of more potent suns, may have developed, each in its own rich way, '*systema naturae*' compared with which our planet's evolution might seem but trivial and man himself an insect troglodyte!' (Longman 1914).

The book covered a vast range of subjects reflecting not only the prodigality but also the indifference of nature, old faiths and new knowledge drawn from genetics and radiogenesis, immortality, the 'problem' of agnosticism, and the new 'religion' of humanism. Even though he admitted to so much ignorance in the face of the universe, no god seemed necessary for Longman, and he reiterated that man's work is of and for this world. 'Nonconformist' Longman (1914) had, by his years of study and thought as a naturalist, 'gladly come to the emancipated position of an Agnostic' and would have appreciated the 'many-coloured philosophical cloak' that agnosticism provided (Desmond 1994, p. 375). Like Huxley, Longman pursued scientific truth and did much to educate people about animals and plants in their environment. He wrote at length about unusual specimens, pathologies and unique Queensland species, and did much to dispel the popular myths of the day, such as the lungfish, *Neoceratodus*, walking on land.

Like others in the early 20th century he upheld the tenets of evolution (as did von Huene in a strange way), and was interested in eugenics. He promoted understanding of science, evolutionary theory, heredity and contemporary ideas both in scientific and popular circles, with his lectures to societies and university students (e.g. Herbert 1955). This was a responsibility he began when he became a 'museum man' and that he continued after Hamlyn Harris stepped down as director (Mather 1986). One debate on Darwinism was set up between Longman as 'the scientist' and an 'Archbishop Downey' (denomination unknown) representing religious views (Connolly 1935). Longman (e.g. 1915, 1941) returned several times to these themes.

The effects of religion

How did the beliefs of von Huene and Longman affect their lives and their science? The extreme evangelism of von Huene and the Fabian humanism or agnosticism of Longman created two men both driven to write and educate 'ordinary' people. Both touched upon human evolution in their writings, von Huene (1937) not doubting the acts of a benign Creator in his view of human development, and Longman (1941) responding to war by wanting to redefine our species *Homo sapiens* as characteristically 'turbulent' by nature.

Did von Huene's religious convictions also limit his ability to co-operate in scientific work? Of his over 400 works, only around 12 (numbering system listed mostly by Reif & Lux (1986), and updated by S. Turner (unpublished) are written with 10 co-authors, with only a rare second paper. These co-authors were: Lull (35, 37); Dr E. Reuning (first author, 136) and Dr Richard Stahlecker (188; von Huene named an anomodont genus after him) (the last two were involved in von Huene's southern hemisphere trips to South Africa and South America in the 1920s); C. A. Matley (176) of the Indian Geological Survey. His post-war co-authors were Pierre L. Mauberg (364, 369), Dr Minna Lang (365, 383), E. Bock (367), Ashok Sahni (386), and Iwan and Maria Nikoloff (410, 417). Each co-author represented a phase in his life; few, if any overlapped. Interestingly, one, Lang, was a woman, and they had a long correspondence (UFGA, in German) on religious and philosophical as well as scientific matters. Von Huene's autobiography gave a little background but few real insights into the man; Seilacher & Westphal (1969) and Gross (1969) have provided further clues. He met, knew, maintained friendships with and read the work of many of the key palaeontologists of his day (and that covered several generations) but he never seemed to waver in his beliefs or his scientific method.

Von Huene's first and most prominent co-author was Richard Lull (Gregory 1957), then at Amherst College, with whom he described and discussed the status of Triassic reptiles *Hallopus* and *Nanosaurus* from the USA in two papers in 1908. Lull was a notable professional vertebrate palaeontologist, and the two men met early in their respective careers. Lull was a champion of the pre-Neo-Darwinian synthesis view of evolution, whereby mutation(s) could unlock mysterious genetic drives that, over time, would lead populations to increasingly extreme phenotypes (and perhaps, ultimately, to extinction). He also played a role in encouraging von Huene to publish in English when he took over the editorship of the *American Journal of Science*.

However, more can be gleaned from the exchange of letters in the UFGA. There are two particularly telling sets, from Lull as editor of the *American Journal of Science* and from the Reverend J. C. Maris, in the 1950s, who was the general secretary of the International Council of Christian Churches, Amsterdam, and an editor of evangelical serials. Both exchanges record rejection of papers in von Huene's later life because of the extremity of his views: in his palaeontology for his offering on the 'crescentic shape' of the phylogeny of tetrapods to the *American Journal of Science*, and in his theology for attempting to legitimize his evolutionary ideas to the evangelical world through the medium of a book review

(Appendix, no. 41). Because of his extreme religious viewpoint, Lull recommended that von Huene should read the up-to-date ideas of Watson, Swinton and other contemporaries (von Huene letters in UFGA: Box L; Lull). In his religious writing for other evangelicals he obviously was not 'extreme' enough.

In 1962 von Huene (Fig. 1c) reiterated his conclusions from a lifetime's work, indicating again how his beliefs underpinned all he had done (even if by then perhaps that mind was beginning to turn in on itself and his thoughts might be classed as the beginnings of senility). His address, noted by his obituarist, Walter Gross (1969) as emphasizing his strong and unwavering faith and position regarding science, 'Ein sinnender Blick in die Entfaltung der Wirbeltiere', to the annual meeting of the Paläontologische Gesellschaft on 5 September (45 years ago, at the beginning of the revolution in Geosciences) also shows us some of his 'neologisms', the special ideas he had and words he coined about 'revelation' in his scientific method, which generally dissociated him from his peers (Hölder, pers. comm.):

A thoughtful look [Meditations/Reflections/Musings/Speculations on] at the unfolding [developing] of the vertebrates

A look at the genetic coherence [associations] of vertebrates, which are presented here graphically shows the step-like roots [die 'Wurzeltreppe'], thus the shortest way to the aim/goal/destination [das Ziel]. Out of the roots [die Wurzeln] of the Orders sprouts the multitude ['a throng'] of faunas. In the course of time, the mean destination or direction [Zielmäßigkeit; of evolution] steps forward [without deviation]. The abundance of fauna [diversity] must not be allowed to muddy [darken; trüben] the look. The mean destination of Creation of the Living World is Directing, then [because] the thought of the aim precedes each realization. The Creation comes to pass [geschehen] through the Creator. We see Man as the aim and end of evolution. As Life consists of Invisible and Visible and in death only the Visible ends, so is our Aim [destiny; Telos] in God's Kingdom [das Reich] (von Huene in Gross 1969; translated by S. Turner with C.-D. Jung).

Conclusions and questions

Von Huene regarded it as his 'duty' to reveal his God's work, and unlike Longman he did not find that solace in Nature that became and remained Longman's religion.

Both men were prolific in their output; however, few of their papers were refereed. Von Huene's published work is classic in its descriptive quality and of importance for all vertebrate palaeontologists. He made the IGTU collection into an internationally recognized museum of vertebrate palaeontology. He was one of the pioneers of dinosaur excavations, especially in the southern hemisphere, but sadly his hoped-for expedition to the last accessible part of Gondwana to search for dinosaurs in Australia did not take place because of the severe economic difficulties and the regime change in 1933, but also perhaps because of von Huene's character. Considering his work output and conditions, von Huene built up a fine museum with wonderful preparation facilities, skilled preparators, and an excellent photographer (W. Wetzel). Also, by gaining outside funding, he travelled to many places others had not been. After World War II he was finally chosen as 'kommissarischer' (provisional) 'Stellvertretender' Director (but only Deputy), and honoured with an honorary professorship. He died, fittingly, on Good Friday 1969.

He used his networks well, fostering amateurs, and writing to find funds, jobs and even sanctuary for family, friends and colleagues. Von Huene, despite his lack of political nous and his perhaps naive flouting of Nazi authority (Rieth 1977; Reif & Lux 1987), also survived the Third Reich, which did not significantly dent his production, and without a blemish to his name. Others were not so untainted, for as Schultze (2007) has noted, 'this is still a big problem [in Germany] to deal with the Third Reich' era, in terms of geoscientists and their behaviour.

Finally, I am drawn to ask: why does one person, a scientist, go one way and another the opposite in basic philosophy and beliefs? Von Huene had the benefit of the best European tertiary education and yet he remained doggedly rigid in his concept of science and his duty in unravelling God's mysteries to the end, considering his work God-ordained with never a doubt. He must always have maintained a strong boundary within his mind. In the end, keeping in mind that a scientist should not 'believe' but doubt, we must ask, was he really a scientist? Whatever we decide about his frenetic work, which should be viewed in the context of his time as well as his religious beliefs, he was certainly prolific beyond the norm.

His far-distant contemporary, Longman, on the other hand, with his very similar upbringing but different education, flourished and was challenged to rethink in his new land, and began to doubt almost immediately he came to Australia. Although perhaps he never become an atheist, the effect on him of loss of children was as great as that of losing a beloved child had been on Darwin and Huxley (e.g. Desmond 1994; Keynes 2001), and must have ended any belief in a benevolent god. However, in summing up his own contribution in a letter to an old colleague, he wrote:

I have had a long innings—over 34 years here . . . Museum work has certainly been of absorbing interest, . . . the most interesting phase of work here, leading on to the Dinosaurs and other weird beasties ... has involved an almost incredible amount of research, [but] it has been well worth while (QM archive, letter, 3 December 1945).

Longman was clearly satisfied with the work and life he left. Von Huene left so much undone, so much of 'God's Creation' unseen, and was disappointed not to have made his planned expedition to Queensland. However, von Huene made use of what he considered his God-given intellect the better to appreciate what he saw as the works of God, offering his researches and thinking to his deity in the highest form of reverence.

Note

IGTU: Institut für Geowissenschaften, Eberhadt-Karls Universität Tübingen, Germany. von Huene reprints in the von Huene Library, room 216; uncatalogued manuscripts, drawings and miscellanea in room 217.

QM: Queensland Museum, Brisbane, Australia. Letter files, Longman Archive and newspaper reports on the QM, 1926 folder in QM library.

UFGA: Geologenarchiv der Geologischen Vereinigung, Universitätsbiliothek Freiburg i.Br., Germany. von Huene Letters in box folders.

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Appendix 1 Annotated and translated list of Friedrich von Huene's religious writings presented for the first time

1. *110 (1921) Naturwissenschaft und Bibel. *Unser Blatt*: *christliches Monatsblatt für die gebildete weibliche Jugend* 14(5): 147–149, November. [Science and the Bible. Our Paper: Christian Monthly for the educated female youth.]
2. *115 (1921) Von der Gestaltung des höheren Tierlebens im Raum der Zeit. *Baseler Nachrichten*, Feuilleton im zweiten Blatt vom 28. Dez. 1921. [On the creation/arrangement of higher animal life in the Expanse of Time. Basel Tidings, (light) literature in two pages on December 28th]
3. *117 (1922) Etwas von den Wundern. *Christliche Volksblätter*, Basel, 90: 43–44. [Something on Miracles. Christian Folksnews.]
4. *123 (1922) Einige göttliche Lebens- und Kraftwirkungen auf naturhistorische Weise betrachtet. Kraftquellen. *Der Ruf*, 1, Aug. 1922: 237–239. [Several godly Life- and Force consequences/effects in natural historical styles/manner examined. The Source of Power. The Call/Cry/Shout.]
5. *124 (1922) Schöpfung und Entwicklung. *Der Ruf*, Christliche Monatszeitschrift für die reifere Jugend Deutschlands, Heft 10, 4 S. [Creation and Evolution. The Call/Cry/Shout - Christian Monthly for the Mature Youth of Germany.]
6. *125 (1922) Schöpfung und geologische Zeit. *Der Ruf*, Heft 10, 1 S. [Creation and Geological Time. The Call/Cry/Shout. Christian Monthly for the Youth of Germany.]
7. *126 (1922) Glaube und Wissen. *Mitteilungen des Christlichen Vereins junger Männer*, St. Gallen, Dez. 1922:52. [Belief and Knowledge. Communication of the Young Men's Christian Association (C.V.J.M = YMCA).]
8. *127 (1923) Wissen und Glauben. *Kraftquellen*: *Monatsblätter der deutschen evangelischen Jünglingsbünde*, 1.1.1923:15–16. [Knowledge and Belief. The Sources of Power. Monthly of the German Evangelical Youth Clubs.]
9. *149 (1925) Wunder. *Der Geisteskampf der Gegenwart: Monatsschrift für christliche Bildung und Weltanschauung* 5:193–194. [Miracles. The spiritual struggle of the present time. Monthly for Christian Development and World-View.]
10. *151 (1925) Was ist Leben? *Der Geisteskampf der Gegenwart: Monatsschrift für christliche Bildung und Weltanschauung* 7:256–259. [What is Life? The spiritual struggle of the present time. Monthly for Christian Development and World-View.]
11. *154 (1925) Schöpfung und Geologie. *Der Geisteskampf der Gegenwart: Monatszeitschrift für christliche Bildung und Weltanschauung* 10: 338–390. [Creation and Geology. The spiritual struggle of the present time. Monthly for Christian Development and World-View.]
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(*Continued*)

Appendix 1 *Continued*

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28. *263 (1939) Der Dienst der Naturwissenschaften an den Christen unserer Tage. "Hand an den Pflug", Beilagen zur "*Arbeit und Stille*", M.B.K.-Verlag, Mai/Juni 1939:33–37. [The Service of Natural Science to the Christian of our Days. "Hand on the Plough", Supplement to Work and Calmness]
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38. *345 (1950) *Die Erschaffung des Menschen. Natur und Christ*, Heft 1, 63 pp., Anker Verlag, Frankfurt a.M. [The Creation of Man. Nature and Christ]
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48. 409. (1963). Ein sinnender Blick in die Entfaltung der Wirbeltiere. Paper given at 1962 Paläontologische Gesellschaften meeting at Tübingen, September 5th. *Paläontologische Zeitschriften*, 37, p. 12. [Thoughtful Reflections on the unfolding of the vertebrates.]
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*Numbers based on von Huene's own unpublished reprint list, see Reif & Lux (1987) in part; full list available on request from S. Turner and at IGTU.

Appendix 2

English translation (C.-D. Jung & S. Turner) of letter from Friedrich Freiherr von Huene on the occasion of his 90th birthday to the local paper, *Tübinger Zeitung*, 24.3.1965 (mentioned in Reif & Lux 1987, p. 116 footnote; Anonymous 1965).

Bekenntnis zum baltischen Erbe [Avowal to the Baltic heritage]

As a postscript to the appreciation, which we published on the occasion of the 90th birthday of Prof. Freiherr von Hoyningen-Huene on Monday 22 March, he gave for our use the following text with a full account that he had written down 10 years before about his 'Baltic heritage: the source (origin) of our career and creations'.

From my parents I received an austere conception of family life and obligations and an absolute focus on God's Word in the Bible and to Living Christians (the Bekennende Kirche). Although [having lived] the major part of my life in Germany and Switzerland, I have never totally adhered to these countries, as much as I am indebted to them. The consciousness of my Baltic forefathers/ancestors and consanguineous relationship has at all times outweighed everything, the more now that everything has changed in the homeland. This Baltic consciousness as it was before the world wars and in my youth, lives on me even though I have not been there for almost four decades. An early-taught independence from the opinion of other people is to me an element of life, as well as total subordination to the Authority of the Word of God and God-ordained authorities. This is why I felt myself forced as a 40-year old in the First World War to volunteer for the German Army first as a private but after half a year I was leading a company. After the perceptions of that time, I thought it better to perish with honour for Germany rather than to stand by and look at the ruin. *During the time of Hitler's Tyranny, thanks to God I was never forced to make an active decision. The result could have been lethal* (my emphasis, ST). Based on education of my youth I never joined any association and still have not. My second precise affects my scientific work in palaeontology – here I have always tended to be independent from the opinion of others. In this subject there is a cooperation between the colleagues of all countries and continents. For me this research work must show the God-given Laws and Forces of Nature that have been in execution up to the Creation of Man. In this subject, especially concerning fossil reptiles, lies my whole life's work. In this I am glad to stand in the tradition of Baltic aristocrats and literati.

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James Buckman (1814–1884): the scientific career of an English Darwinian thwarted by religious prejudice

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Abstract: Buckman first practised as a chemist. He joined the Botanical Society of London in 1837, and became a significant Cotswold naturalist, in botany and geology. He was elected Fellow of the Geological Society in 1842, when he was Honorary Secretary to the Cheltenham Literary and Philosophical Institution. In 1844 his brother Edwin went bankrupt and Buckman sought a new career. His amateur interests allowed him to become one of the first English professionals across natural science. He was appointed Secretary, Curator and Resident Lecturer to the Birmingham Philosophical Institution in 1846, then Professor of Geology, Botany and Zoology at the new Royal Agricultural College, Cirencester in 1848. Buckman here started botanical experiments to 'solve the problem of the identity of species' and read papers to the British Association from 1853. These yielded praise in Darwin's *Origin of Species* in 1859, and led to development of the 'Student Parsnip' in 1860. Buckman's 1860 British Association report on his experiments, to the infamous Oxford meeting, supported evolution and the mutability of species. The Anglican Principal of the College found this distasteful and ordered the destruction of Buckman's Botanical Garden in spring 1862. Buckman's life provides a painful demonstration of the tribulations facing newly professional scientists in Victorian England. It also demonstrates the difficulties of then professing geology alone.

Allen discussed some of the problems facing newly professional British natural historians from the 1830s. One stimulus had been the well-off collector, who needed them to find, and curate collections. Other collective enterprises followed, and learned societies, state-supported explorations, government surveys and a wide range of corporate museums were instituted, for whose needs professionals catered. But, because of the control on science exercised from upper levels of society by 'gentlemen scientists', these new professionals were regarded as having 'lower' functions, with 'salaries pitched at a level with barely-educated clerks or even caretakers evidently in mind. These almost invited derelictions of duty while supplementary earnings were having to be sought' (Allen 2001, X, p. 5). Such problems are exemplified by two provincial museum curators; George F. Richardson (1796–1848, whose extra earnings came from authorship and lecturing; Torrens & Cooper 1986) or the equally inadequately paid John Gilbert (1812–1845), who emigrated, to become a noted zoological collector in Australia (Torrens 1987). Buckman's professional career, and the unpreviously recorded results of his connection with the British Association for the Advancement of Science (hereafter BAAS), provide a more complex (and forgotten) episode in professing Victorian science.

Buckman's beginnings in Cheltenham

James Buckman (Torrens 2004*a*, in *Oxford Dictionary of National Biography*, hereafter *ODNB*) was an untiring practitioner, teacher and popularizer of natural science, across a polymathic range. He was son of a Cheltenham shoemaker, and was first apprenticed in the dispensary of the Cheltenham surgeon Stephen Hemsted Murley (*c.* 1787–1875, Torrens & Taylor 1990, p. 183). Buckman continued his medical studies in London, but he soon abandoned the practice of medicine and returned to Cheltenham. Here he settled, by 1837, as a 'practical analytical and pharmaceutical chemist', in Pittville Street (Rowe 1845, p. 62). His brother Edwin (1810–1893) and brother-in-law Benjamin Norman (1799–1848) were partners as Cheltenham ironmongers and manufacturers (Rowe 1845, p. 5).

Buckman's time in London, and the popularity of natural history in the 1830s, especially botany and palaeontology, clearly fired him with enthusiasm, which he took back to the Cotswolds. In 1837 he joined the Botanical Society of London (Allen 1986, p. 206) and in 1840 the Botanical Society of Edinburgh. In 1842 he was elected Fellow of the Geological Society and in 1845 of the Entomological Society. In 1842 he published *Our Triangle*, an anonymous guide to local geology, archaeology and botany. In 1843 he published his *Geological Chart of the Cotswolds* and read his first paper to the Geological Society, whose president, Roderick Murchison, had already paid tribute to Buckman's 'fresh investigations', revealing 'a vast number of new species of fossils characterising each stratum' near Cheltenham

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(Murchison 1843, p. 87). Buckman was equally active with his earliest interest, botany, and in 1844 published major studies of both Cotswold botany and geology (Buckman 1844; Strickland & Buckman 1844; the latter was largely by him, see Buckman 1906, p. 2).

The Cheltenham Literary and Philosophical Institution

In 1833 Cheltenham inaugurated its Literary and Philosophical Institution (hereafter CLPI) (Torrens & Taylor 1990, pp. 177–189). Buckman was a member by 1840, and soon, from at least 1842, its Honorary Secretary. A local landowner, the Reverend Francis Edward Witts (1783–1854), described Buckman's new calling, in April 1844:

> He is a very talented person, and skilful Chemist, and Analyst. His energies are not confined to Chemistry, as he has devoted himself also to Geology and Botany, and is besides, what in modern phraseology is termed, an Ecclesiologist, attached to the pursuit of Ecclesiastical architecture and antiquities. He is Secretary to the Cheltenham Literary and Philosophical Institution, and a frequent lecturer there, at Gloucester, Stroud etc. . . . He has taken great pains as to Agricultural Chemistry, the Analysis of soils and manures etc. . . . With a mild, quiet, unobtrusive manner, he attracts by the intellectuality and contemplative tone of his features . . . and a deep rooted, but not offensive enthusiasm (Witts 1844).

Enthusiasm was a word that still then implied a religious fervour, a topic of which Buckman would soon learn more.

In 1844 Buckman's ironmonger brother, Edwin, for whom he was a financial guarantor, and his partner Benjamin Norman, were declared bankrupt (*The Times*, 5 June 1844, p. 1; *Staffordshire Advertiser*, 8 June 1844, p. 4; *Cheltenham Examiner*, 10 and 17 July 1844, p. 2). This disaster affected James' business, in a town as class-conscious as Cheltenham. He started to seek paid employment elsewhere, as a natural scientist. His first approach, late in 1844, was unsuccessful. He applied for the vacant post of Vice Secretary to the Geological Society of London (Buckman to Strickland, 18 January 1845, Zoology Library, Cambridge University), which went to David Ansted (1814–1880; *ODNB*). His next application, in January 1845, to the East India Company, was 'as a Geologist to examine the extent of the Coal fields in India' (Buckman to Murchison, 12 January '1844' (recte 1845) and 11 July 1845, Geological Society of London archives, M/B 35/1 and 2; Grout 1995, p. 227). This post went to the mineral surveyor David Hiram Williams (*c.* 1812–1848), who soon died of 'jungle fever' in India (Torrens 2002, XII, p. 22). By December 1845 Buckman was hoping for one of the newly paid secretarial posts at the Geological Society (Woodward 1907, p. 154) for which he was to be 'warmly recommended' by Murchison, who saw only one obstacle, Buckman's lack of German; 'very desirable in the present state of our science' (Murchison to Buckman, 14 December 1845, Buckman Archive, author's collection, hereafter BAAC). This post went instead to James Nicol (1810–1879, *ODNB*), who had been trained in Bonn and Berlin.

Buckman moves to Birmingham

In 1846 Buckman was appointed Curator and resident Professor to the Birmingham Philosophical Institution (hereafter BPI), and Secretary to its associated Literary Society. His predecessor here, the botanist–geologist William Ick (1800–1844; *Aris' Birmingham Gazette*, 30 September 1844, p. 3), had had the then normal annual curatorial salary of £100 (Torrens 1987, p. 218). The CLPI's conchologist, James Robert Campbell (*c.* 1802–1861), claimed that, with his more enlarged appointments, 'Buckman got from £150–200 (I think the latter sum) with a house and furniture—he has been anxious for some time past to give up his [Cheltenham] business; being always too much occupied to attend to it' (letter 2 March 1846, G. B. Sowerby archive, National Museum of Wales, Zoology Dept., letter 2211). The *Annual Report of the BPI* to the AGM of 27 October 1847 recorded that the annual salary for BPI curatorial duties was still only £100.

Buckman had been differently rewarded for his unpaid efforts at Cheltenham, with a testimonial microscope, presented by the CLPI, when 'we are pleased to find that the science of Geology is being brought to bear upon the practical affairs of life, Mr. Buckman in his character of geological professor, having received three retainers to give evidence before parliamentary railway committees' (*Cheltenham Examiner*, 3 June 1846, p. 2). The railway mania (Freeman 2001) was a major new means by which geologists could increase their salaries. Buckman also gave paid lectures in Birmingham, investigated local geology, and ran (and contributed to) the once renowned Geological Museum of the BPI. He was earning a living as a professional, right across natural science, for a first time.

However, unknown to him, the BPI was in serious financial trouble (Waterhouse 1954, p. 6). By the late 1840s, widespread hopes for the advancement of science, which had fuelled both the BAAS and the many philosophical and literary institutions and mechanics' institutes throughout England, were receding (Cardwell 1972, p. 71). Many were run by subscribers, who expected a monetary return from their financial investment in promoting science. When such support declined in Birmingham, Buckman was dismissed; 'owing to the state of the funds of the BPI . . . they have determined to recommend that the office of Curator be discontinued during the ensuing year, and therefore they terminated Mr. Buckman's engagement on 1 September [1847]' (*Annual Report of the BPI to the AGM 27 October 1847*, p. 11).

A post at Cirencester

Buckman (Fig. 1) now proved capable of obtaining another professional position, at a new higher educational agricultural institution. Allen, discussing the occupations of members of the Botanical Society, noted that for many contenders, life was difficult 'without capital . . . unless a man was brilliant enough to land a post at a university, or even more exaltedly, one of the very few professorships of botany or natural history like . . . Buckman' (Allen 1986, p. 47). Buckman's post was at the Royal Agricultural College, Cirencester (hereafter RAC), Gloucestershire, which had opened in March 1845. Its foundation Professor of Geology and Natural History was Samuel Pickworth Woodward (1821–1865, *ODNB*), at an annual salary of £100 (*RAC Minutes*, 20 August 1845). Buckman later reminisced about this post:

I came to the College within about two years after its foundation, and I should have been there at its very commencement. I came as a candidate for one of the first Professorships at the express wish of Mr [Edward] Holland [1806–1875, landowner and MP; see Burke's *Landed Gentry*, 1952, p. 1719], who was always a very kind friend to me. However, I found a man [Woodward] applying for the very appointment which I sought, who was out of health and a much better man than I, and who wished to live at Cirencester. I went at once to Mr. Holland and said; 'I cannot any longer be a candidate'. He thanked me for my candour and said the next vacancy would be offered to me. I came in two years after [early 1848] at the express wish of the authorities—without making any application for the appointment. I was specially appointed as the Professor of Geology and of Botany (*Wiltshire and Gloucestershire Standard*, hereafter *WGS*, 18 June 1863, p. 2).

Buckman's allegiance to Holland is demonstrated by his intention to name the new Bradford Clay ammonite, discovered there in 1858, *Ammonites hollandi*. This Buckman was never able to do, as a result of the RAC crises that soon overtook him. It was only so named in 1924 by his son (Buckman 1909–1930, plate 500).

The RAC also experienced highly chequered finances in its early years. It was the first institution dedicated to agricultural higher education in England. One early change was to a new pattern of superintendence by clergymen Principals. This, as a historian of the RAC has pointed out, was 'a quite extraordinary change of course for the Council' (Sayce 1992, p. 27), which, it was hoped, would give the College new educational respectability. On 7 January 1846, the first such Principal was appointed, first of the 'series of clerical Principals of the RAC throughout the nineteenth century, none of whom had any direct practical experience of agriculture, [which] led to the College being moulded into the traditional pattern of the ancient universities, where these Principals had been educated' (Watkins 1979, p. 98). The Reverend George Christopher Hodgkinson (1816–1880, *ODNB*) was chosen; he was a schoolmaster graduate of Trinity College, Cambridge. However, he failed to solve the RAC's financial problems and by August 1847 he 'had ceased to hold any position at the College' (*The Times*, 13 August 1847, p. 8). Money once more had to be saved (Sayce 1992, p. 32) by 'remodelling the professorships' (Woodward 1884, p. 289), and Woodward had been given notice, on 1 July 1847, to leave at Christmas (*RAC Minutes of Council*, **1**, pp. 196 and 241).

The new Principal, from 1847, was the RAC's existing Professor of Agriculture, John Wilson (1812–1888), who was also a practical geologist (Torrens 2002, XIII). Buckman replaced Woodward early in 1848, as Professor of Geology, Natural History and Botany (*RAC Prospectus*,

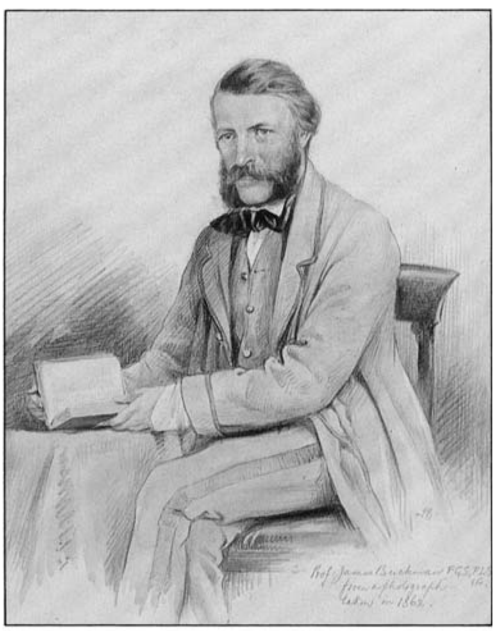


Plate 11 **James Buckman, Professor of Geology, Botany, Rural Economy and Natural History 1848–62**

Fig. 1. Portrait of James Buckman in 1862 (original at RAC; Sayce 1992, plate 11).

1850, p. 4). At Cirencester, Buckman, in familiar country, threw himself into his duties with enthusiasm. Apart from college work, during which he gave more than 2000 lectures and many more field classes, he helped advance the once famous RAC Museum and established his experimental Botanical Garden. He was elected Fellow of the Linnean Society in 1850, acted as Honorary Secretary of the new Cotteswold Naturalists' Field Club from 1851 to 1860, and was a major promoter of the Cirencester Natural History Society. He was also one of the main instigators, and first honorary curator, from 1856, of the fine collection of local Roman remains that built up to today's significant Corinium Museum. Buckman even visited the USA in 1854, as a consultant geologist, advising on coal-mining potential in West Virginia (Torrens 2002, X), as announced in the *Cheltenham Examiner* (7 June 1854, p. 4). He was also paid an annual salary of £150 in the session 1857–1858 (according to a February 1858 letter from the College secretary, copy in BAAC) to teach physical sciences on a part-time basis at Cheltenham College, the nearby public school (Hunter 1911, p. 31). He researched, and published, widely, making fundamental contributions to our knowledge of the geology, palaeontology, archaeology and botany (especially agricultural) of the Cotswolds.

In 1849 and 1850 the RAC suffered yet another financial crisis and Wilson resigned. What happened is not known, as no RAC Minutes for that period survive. An RAC historian has written of disputes amongst the professorate. These caused the Professor of Chemistry, John Blyth (1814–1871) with whom Buckman had sided, to depart (Sayce 1992, p. 40). Wilson's entry in *ODNB* added how 'in 1850 a suggestion on the part of the [RAC] Council for a thorough change of the organisation of the College into that of a school for farmers had led to Wilson's resignation' (see Brown 1862; Sayce 1992, p. 42). Confirmation of the crisis came from Buckman on 26 October 1850, when he asked Hugh Edwin Strickland (1811–1853, *ODNB*) for a 'testimonial as I am applying for the appointment of Professor of Natural History. Our [RAC] College is, I fear, on its last legs. We are all under notice and what with debt and bad management it will have great difficulties now under any arrangement' (Buckman to Strickland letter, Zoology Library, Cambridge University). Clearly, his application was to be to anywhere outside Cirencester.

Cirencester under a new Principal

Wilson was replaced in 1851 by the Reverend John Sayer Haygarth (1810–1859), another graduate of Trinity College, Cambridge. If he knew little agriculture, Haygarth knew the area well, as he had previously been curate at nearby Rodmarton. Haygarth now

> re-constituted the RAC schools of science in all their efficiency and re-engaged the same talented professors (who had received notice to leave), and the flow of students, which had been stopped by the belief, which was widely spread, that the College would close at the Christmas term, 1849, returned (cutting April 1859, Julia Sophia Buckman scrapbook, BAAC, probably from *WGS*).

Haygarth proved an inspired choice. From 1851, Buckman was named RAC's 'Professor of Geology, Zoology and Botany' (*RAC Prospectus* 1851), emphasizing the width of scientific attainments among Haygarth's staff. However, Haygarth, after less than a decade of harmony at the RAC, died on 7 April 1859, aged 47 (*Gardener's Chronicle and Agricultural Gazette* (hereafter *GCAG*), 16 April, p. 342; *Staffordshire Advertiser*, 16 April 1859, p. 5; Sayce 1992, pp. 43–44). Buckman's son, Sydney Savory Buckman (1860–1929), in his manuscript 'Autobiography' wrote of the new crisis that followed:

> The old Principal [Haygarth] died—a good and tolerant man who had steered the college well through its initial struggles—one who knew how to handle young male students. The Professors carried on during the interregnum and finally the Governors of the College elected the very opposite sort of man, by all accounts a dour, straight-laced, religious and puritanical Scotsman (Buckman 1928).

RAC under 'Constabulary' rule

The appointment of this new reverend Principal was announced in June 1859 (*GCAG*, 18 June, p. 529). The Reverend John Constable (1825–1892) was a son of the Edinburgh printer and publisher, Archibald Constable (1774–1827, see *ODNB*), who had suffered catastrophic bankruptcy just before John's birth. Constable was another graduate of Trinity College, Cambridge. This was the former college of Edward Holland, who remained Chairman of the RAC Council, which was often weak and uninformed. This must suggest that Holland was responsible for the choice of all such men, despite the fact that 'Constable was unknown in the agricultural world before his RAC appointment' (*GCAG*, 28 June 1862, p. 602).

From his arrival, in August 1859, differences arose between Constable's management and administration and RAC professorial staff. Buckman noted that 'the new Principal had scarcely entered upon the duties of his office, when he began to sow the seeds of discord with his staff of Professors' (Buckman 1863*a*, p. 3). The others were J. C. A. Voelcker (1822–1884), appointed to Chemistry in 1849 (*ODNB*); John Coleman (1830–1888), to

Agriculture from 1856 (*Register* 1898, p. 4) and George Thomas Brown (1827–1906) to Veterinary Science from 1850 (*ODNB*). Brown acted as temporary Principal after Haygarth's sudden death (Brown 1862, p. 4).

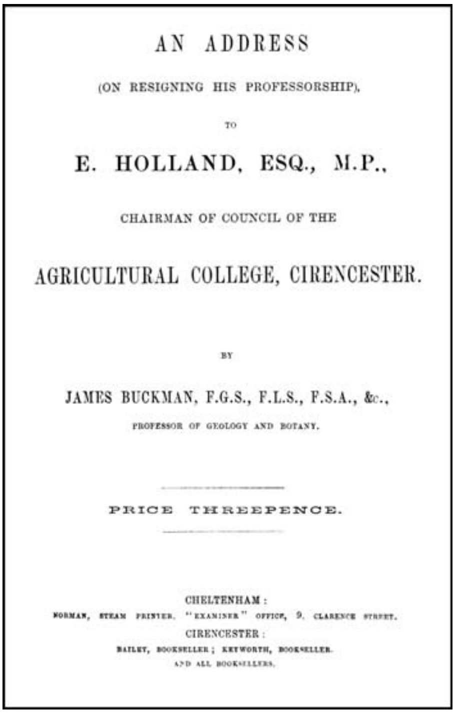
Crisis at the College Museum

The first discord involving Buckman came in November 1859, before publication of *The Origin of Species* (Darwin 1859). This concerned the RAC's Natural History Museum, which Buckman had built up (Torrens 1982, p. 73). Details were given by Buckman's son, who had already referred to the acquisition of this Museum by the RAC as a 'slightly compulsory purchase' (Buckman 1895, p. 411):

> The Principal soon had trouble with the Professors and students. My father had deposited a considerable collection of natural history specimens for teaching purposes in the College Museum. One of the first acts of the new Principal was to say that it was not right that these specimens should belong to one of the Professors and be removable at will. The collection must belong to the College and the College must purchase it. A sum of money was agreed upon, but the Principal saw that College funds could not at the time afford that: he would however agree to the price and would pay interest on it half yearly. This was agreed and carried out. Then came the question about the payment for the collections of specimens. When asked about this, the reverend gentleman the Principal—it seems there must always be, at any rate in those days, a clergyman at the head of all such scholastic institutions to look after the morals of the young men and teach them to be truthful, honest and Christian ... indignantly denied that there ever had been such a bargain: at first he argued that the specimens, being in the College Museum, belonged to the College and were College property, then he changed his ground and said that my father could take all his specimens away when he left. But the Principal, having chosen to force [such] a sale at a time [1863] when circumstances did not press for it, was not likely to be allowed to cry off that sale when circumstances—impending house moving and so forth, made such repudiation most inconvenient. My father took the case to his solicitors in the town, showed them all the evidence that he possessed in proof of the sale and particularly referred to the half-yearly cheques for interest which had been paid into his account and could be traced, and the written receipts for which could be demanded. The solicitors [Messrs Lawrence] happened also to be the official College solicitors: they bluntly told the Principal that he had not a leg to stand upon and that the College was in bad enough odour as it was without being defendant in an unsuccessful action. The money was paid: it was about a year's salary (Buckman 1928).

Buckman junior also noted that the new Principal also had problems with RAC students. An early petition, signed by nearly 50 (half of all) was circulated in December 1861 (in the BAAC). It complained of Constable's expulsion of three students, and the 'puerile way in which students were then treated'. But the first public crisis at the RAC came in June 1862 with the news that 'Voelcker and Brown had sent in their resignations, along with the probable resignations of all the other Professors' (*GCAG*, 28 June 1862). Voelcker was soon induced to withdraw his, his demands being conceded by Constable (Brown 1862, p. 11; *GCAG*, 8 November 1862, p. 1058), but the damage had been done.

Eruptions of total dissent, which split the College and its management, and filled the local and national newspapers, followed from 22 October 1862, when Brown was asked by Holland to send in his resignation (*Cheltenham Examiner*, 29 October). He refused, carried on his lectures to RAC students, outside the College, and published 'his Case' in November (Brown 1862). Coleman and Buckman now sent in their resignations (*WGS*, 15 November) and by January 1863, Voelcker rejoined them in support (*Cheltenham Examiner*, 28 January 1863). The story of this sorry episode in the history of the RAC deserves to be fully written; but to properly understand it, or sit in judgement, is not easy, for no College Council Minutes, from which we might expect real clarification, survive for the 20 year period from August 1849 to November 1869. Reliance on newspapers is dangerous, as these sided with the professoriate. The problem now confronts the historian too, as so little of Constable's view survives.



AN ADDRESS

(ON RESIGNING HIS PROFESSORSHIP),

TO

E. HOLLAND, ESQ., M.P.,

CHAIRMAN OF COUNCIL OF THE

AGRICULTURAL COLLEGE, CIRENCESTER.

BY

JAMES BUCKMAN, F.G.S., F.L.S., F.S.A., &c.,

PROFESSOR OF GEOLOGY AND BOTANY.

PRICE THREEPENCE.

CHELTENHAM:

NORMAN, STEAM PRINTER, "EXAMINER" OFFICE, 9, CLARENCE STREET.

CIRENCESTER:

BAILEY, BOOKSELLER; KEYWORTH, BOOKSELLER.

AND ALL BOOKSELLERS.

Fig. 2. Title page of Buckman (1863*a*), author's collection.

The causes of Buckman's departure

Buckman published his final resignation letter (Fig. 2), dated December 1862, to Holland, Chairman of the RAC Council, in July 1863, on announcing his departure from Cirencester (Buckman 1863*a*, unique copy, BAAC). It summarized the problems Buckman had faced. First, in November 1859, just after his arrival, Constable told Buckman that the College Geological Museum was 'out of order'. This problem was to some extent solved (see above). However, new complaints by Constable, made against Buckman's RAC performance, now surfaced.

Complaint 1: Buckman as commercial analyst of seeds

'In April 1860, having been called upon to examine some dirty seeds, my remarks brought an angry reply from the seedsman' (Buckman 1863*a*, p. 4). Constable represented to his Council that Buckman had 'brought disgrace upon himself as an analyser of seeds'. The influential *GCAG* was the source of this dispute. The sale of adulterated seed was a real problem, and was later made a crime (*GCAG*, 3 April 1869). Buckman had openly advertised how 'he may be professionally consulted in all matters relating to the Geology and Botany of estates, including the analyses of seeds' (*GCAG*, 19 May and 9 June 1860) in another attempt to augment his salary. He acted as seed consultant to many readers of this influential journal. However, on 23 July 1860 the *GCAG* reported the anger of one firm of seedsmen at a Buckman seed report (p. 679). This was the firm of Francis and Arthur Dickson and Sons of Chester, who commented further on 1 September. However, editorial comments in *GCAG* (edited by John Lindley (1799–1865, *ODNB*) and John Charles Morton (1821–1888, *GCAG*, 7 May 1888, p. 428) completely exonerated Buckman. The editors cleared Buckman of any misdemeanour, noting of the two reports upon the clover seeds that had conveyed to the Dicksons mind 'directly opposite impressions, were as nearly identical as two handsful of seed taken out of the same bag before and after a journey are likely to be' (GCAG, 1 September 1860, p. 801). The editors later wrote that any such RAC complaint must thus have 'been hurriedly laid against Buckman, before this case was concluded and ... that Buckman had done honest, skilful and useful work as a seed analyst' (1 August 1863, p. 734). Buckman should have been easily able to prove this seed analysis matter was trumped-up by Constable. Holland, Chairman of RAC Council, later apologized for his own part in this (*GCAG*, 8 August 1863, p. 754). Buckman continued to act as an expert witness in many later trials involving adulteration of seed (*Illustrated London News*, Vol. 38, 27 April 1861, p. 385). He was also elected juror for the 1862 London International Exhibition for 'Class 3a—Substances used for Food', examining and reporting on foreign seeds and other vegetable products (BAAC).

Complaint 2: Buckman and the BAAS meeting, Oxford 1860

Seldom in the history of ideas has a scientific theory conflicted so openly with a metaphysical principle as did evolutionary theory with the doctrine of the immutability of species (Hull 1973, p. 15).

This second RAC Council charge against Buckman clearly became the crux of his problems. Both Constable, 'my implacable enemy, still on the look out' (Buckman 1863*a*, p. 4), and Buckman were present at the historic BAAS Oxford meeting in 1860. This meeting has generated enormous interest because of the infamous Huxley–Wilberforce exchange on the afternoon of Saturday 30 June 1860 (James 2005). This encounter, over Darwinian theory, has acquired a legendary character (Lucas 1979), in which hindsight, on the part of the scientists involved, has been significant (Browne 1978, pp. 361–362). As a result, 'the winners' view of history' has been much more explored than the losers', including Buckman's.

Buckman read his first (geological) paper to the BAAS in 1846, as he became a professional scientist. His first BAAS report on his experimental botanical work at the RAC was read in 1853 (Buckman 1854). Buckman recorded that he had started his RAC botanical experiments as soon as he arrived, in spring 1848 (*GCAG*, 15 May 1854, p. 306, also 24 December 1859, p. 1043). The 1857 *History of the RAC* makes special mention of this garden, where 'Interesting experiments connected with the solution of the problem of the identity of species, are conducted by Professor Buckman' (Anonymous 1857, pp. 29–30; reprinted Anonymous 1858, pp. 107–108). The site of the 3 acre garden is recorded (Fig. 3).

Buckman's paper to the 1860 BAAS

At Oxford on 29 June 1860, the day before the infamous 'debate', Buckman read yet another report on his experimental botanical work at the RAC, which he had been asked to continue by the BAAS, having been awarded funds by it from 1856 to 1860 (*Reports of BAAS*, for 1856, pp. xli and 83; for 1857, p. xxxix; for 1858, p. xl; for 1859, p. l; see also Buckman 1858*a*, 1860). The progress of

Fig. 3. The site of Buckman's Botanical Garden, uprooted in 1862 (Sayce 1992, p. 41, plot 23 on 1852 map).

these experiments was also noted in the *Proceedings of the Cotteswold Naturalists' Field Club* (Lucy 1888).

His 1860 paper, to Section D, 'elicited a most interesting discussion' according to Buckman (1863*a*, p. 4). A report of his paper, entitled 'Report on Experiments on the Alteration of the Specific Forms of Plants by Culture', appeared in the *Athenaeum*. However, in the *Oxford University Herald* and *Oxford Chronicle* (30 June 1860), it was only listed, and it was not mentioned in *Jackson's Oxford Journal*. Jensen has pointed out (1988, p. 170) how bad press coverage of this Oxford meeting was. It is therefore difficult to discover details of the debate after Buckman's paper. The only report of it seems to be that in the *Athenaeum*. This reported that Buckman had noted how the grass

> *Poa (Glyceria) aquatica* had been the subject of fresh experiments, and two specimens were shown to the Section, one from the garden of the RAC, and another from Messrs Sutton, of Reading; these were identical in all their details, but the point of interest consists in the great amount of difference between the induced forms and the *Poa aquatica*, whose seeds had been used. The new specimens, indeed, had the external aspect of large examples of *Poa trivialis*, but still with very different botanical details from that species, and is, in fact, held by the author to be as distinct from *Poa aquatica* as from any other species of *Poa* whatever; still it is really a *Poa*, so that the name *Glyceria*, as applied to it, is inadmissable (*Athenaeum*, 7 July 1860, p. 26).

In the debate that followed

> Col. (William) Munroe [1818–1880, *ODNB*; 'a most trustworthy referee on that difficult order—Grasses'], after having examined the specimens produced, expressed his surprise that the two Grasses exhibited by Mr Buckman should have been produced from the same seeds. He regarded one as the *Glyceria fluitans* and the other as a form of *Poa trivialis*, or, perhaps *P. pratensis*. Mr C[harles] C[ardale] Babington [1808–1895, *ODNB*] felt sure, from the great difference between the two forms of Grasses exhibited that some error had crept in during the experiment (*Athenaeum*, 7 July 1860, p. 26, copied in *GCAG*, 14 July 1860, p. 650).

It is difficult now to judge the fact, or extent, of any Buckmanian error, but it is worth noting that Babington at least belonged to 'that generation when virtually everyone still subscribed to the idea that species were the handiwork of the Divine Artificer and fixed for all time' (Allen 2001

XX, 8). Babington, even near the end of his life, in 1887, had but 'little belief in evolution or hybridization' (Allen 2001, XX, pp. 8–9). We should note too that the taxonomy of grasses was already particularly difficult. Therefore anyone like Buckman, claiming, on whatever grounds, that grass species were mutable, would have faced a hard time in debate.

Buckman's activity at Oxford was reported to Edward Holland by Constable. Holland wrote to Constable on 14 August 1860, confirming that Buckman 'had lost caste with scientific men at the late Oxford meeting' (Buckman 1863*a*, p. 6). Buckman countered that any 'loss of caste' was quite unsupported by evidence. He explained how his 1860 report had been voted

> thanks by acclamation, after observations highly commendatory from the chairman [Professor John Stevens Henslow (1796–1861, *ODNB*)] of the section [D] and some flattering remarks by Professor Babington, who, though not agreeing with the general conclusions drawn by me from the investigation ... expressed his conviction particularly in relation to the farm thistle (*Carduus arvensis*), as he had in the previous year on the growth of flax ... That the reports ... were read and approved by the committee of the section, and ordered to be printed in their transactions is sufficient ... to remove from the mind of the most sceptical, all suspicion as to incapacity on my part in the examination that had more especially been entrusted to my care (Buckman 1863*a*, p. 13).

When Buckman's 1860 paper was published, it had been modified as usual with such BAAS reports. 'On account of the lateness of the season and the fact of the unusual period of the Oxford meeting, [when] the Report was made verbally, permission having [now] been obtained to make a full and written report when the experiments had attained to something like completion' (Buckman 1861*a*, p. 34, dated November 1860).

There was clearly scientific debate after Buckman's Oxford paper in 1860, but it now seems impossible to prove a charge of 'loss of caste' over it or that Buckman should have been relieved from his botanical teaching at Cirencester simply because of it. Perhaps, in the words of the local paper, the 'seed question and his share in the proceedings of the British Association have been made the pegs on which to hang his expulsion from the botany chair' (*WGS*, 13 August 1863).

Buckman and Darwin

Buckman had had nearly as long a connection with Darwin as with the BAAS. His first recorded correspondence with Darwin went back at least to December 1849, when Darwin thanked Buckman for the loan of fossil cirripedes, 'including the most ancient yet known' (Burkhardt & Smith 1988–2002, Vol. 4, pp. 283–284), discovered by Buckman in the Cotswolds (Strickland & Buckman 1844, p. 68). Darwin wrote to Buckman on 4 October 1857, after reading a report of one of Buckman's BAAS papers on his Cirencester experiments, 'I feel the deepest and most lively interest in these researches of yours—will you tell me whether they will be published in detail & soon?' (Burkhardt & Smith 1988–2002, Vol. 6, pp. 463–464). This paper (Buckman 1858*a*) again discussed Buckman's work on eight groups of plants, including the troublesome grasses. This was followed by Buckman's book on grasses (Buckman 1858*b*), which received an enthusiastic review (*GCAG*, 23 October 1858, pp. 788–789). In his *Origin of Species*, Darwin went on record with his opinion that 'Mr Buckman's recent experiments on plants are extremely valuable' (Darwin 1859, p. 10). One can now explore all Darwin's many citations of Buckman's work in print at darwin-online.org.uk or in correspondence at darwinproject.ac.uk.

Other events occurred at this Oxford meeting to influence the infamous Huxley–Wilberforce 'exchange', amid the vociferous debate about Darwin's *Origin of Species*, but the severity of the outcome for Buckman has not been revealed. Buckman's son summarized the state of the Darwinian debate, as it related to his father's RAC situation, in his own way:

> When the Principal's [Constable's] attention was drawn to [my father's support for the Darwinian position] he was horrified—Darwin was a heretic and all his [ideas] were in the highest degree condemnable: that anything was going on at the College which could be cited by Darwin in support of his ideas was unbearable. It is remarkably difficult for people of the present day [1928] to understand this attitude—young college students quite fail to grasp it. Yet with educated, but non scientific, people this attitude lasted till nearly the end of the 19th century and with the half-educated—the state-educated product—people of the nonconformist village preacher type and his audience—this attitude of mind still persists. But in the days which I am recording there was no class stratification about Darwinism. As one whole, the educated classes shared the Principal's opinion. I suspect strongly that my grandparents on my mother's side [chemist John Savory (1801–1871) and Martha Hames Oakey (1807–1885)]—there were none on the other—gave my father quite a bad time over this reference in Darwin's book (Buckman 1928).

The debate, about the identity, fixity and permanence of species, was then the crucial point in polarizing the two camps in the Darwinian debate (Lucas 1979, pp. 319–321 and 327–328). A heated, and nearly contemporary, debate on the *Origin of Species*, on 6 September 1860 by members of the Cotteswold Naturalists' Field Club, concluded that the Darwinian theory was simply not yet 'convincing' (Guise 1862, pp. 27–28).

Enter religion?

Buckman's was one of at least three papers that specifically addressed Darwinian theory before the infamous Huxley–Wilberforce 'debate'. Two others were given on 28 June, before Buckman's. That by the Reverend Francis Orpen Morris (1810–1893, *ODNB*) was on 'the Permanence of Species'. Of this, selections only were presented to the BAAS by the botanist C. C. Babington (Wollaston 1921, pp. 118–119). Morris's 'natural theology clashed with Darwinian theories' (*ODNB*), so he, like Babington, was anti-Darwinian. The other paper was by Dr Charles Daubeny (1795–1867, *ODNB*), an early RAC advocate. His was 'On the Final Causes of the Sexuality of Plants, with particular reference to Mr Darwin's work on the *Origin of Species*' (*GCAG*, 14 July 1860, p. 649; Daubeny 1867, Vol. 2, pp. 85–109). Daubeny gave only limited support for the Darwinian hypothesis and his paper was followed by another 'furious battle over Darwin's absent body' (Huxley 1918, Vol. 1, p. 525) between scientists Thomas Huxley and Richard Owen (*GCAG*, July 1860, p. 649; Huxley 1908, Vol. 1, pp. 261–262; Jensen 1988, p. 164). Buckman, in an early draft of his letter of resignation (BAAC), referred to this earlier 'battle':

> There was some discussion upon [my] paper, upon the result of which I was also complimented by some of the most influential naturalists. There was, it is true, a difference of opinion about the subject of species, so there has been with reference to the *Gorilla* by Profs Owen and Huxley, but are these savans to be hurled from their appointments and to be told they have lost caste for this? Surely none but a moral *Gorilla* [clearly Constable] could for a moment entertain such an idea.

This 'debate' directly stimulated the much more infamous, now confused and elaborated, exchange 2 days later, between scientist Huxley and that pillar of the Anglican establishment Bishop Samuel Wilberforce (1805–1873, *ODNB*), Vice-President of the 1860 BAAS (Jensen 1988, p. 164) and clearly affected the debate on Buckman's paper.

Contemporaries variously viewed the 'creeds' of Darwinism and the 'immutability of species' as vying between science and the church. This was the reason for the Reverend Principal Constable's reaction to the 1860 Oxford events. This whole debate undoubtedly dominated the Oxford meeting (Lucas 1979, p. 316), and the two BAAS meetings that followed (Wollaston 1921, pp. 122–123), but the Wilberforce and Constable viewpoint has never received as much attention as the Darwinian one (Jensen 1988, p. 177). That the former then had majority support (Hutchinson 1914, Vol. 1, p. 50; Lucas 1979, p. 329), with Darwinians a minority, has been ignored. First reactions to the *Origin of Species* by the public had been anything but favourable. Oldroyd noted differences between Catholic and, surprisingly more antagonistic, Protestant reactions (Oldroyd 1980, pp. 196–202 and 258). Holding such a pro-Darwinian position, and in public, made Buckman an easy target for the orthodox, Protestant, Constable camp. John Constable, ordained priest in 1849, was specifically described by his Cirencester obituarist as 'god-fearing' (*Agricultural Students Gazette*, December 1892, p. 1).

Aftermath

In August 1861 Constable told Buckman that, because he was 'overworked', he intended, with the support of RAC Council, to appoint 'an assistant' to take over all RAC botanical teaching. This Buckman could not countenance, wishing to 'give up zoology rather than his favourite botanical teaching'. The botanical replacement was Dr John Bayldon (1838–1872), who had trained as a medic, and was previously a lecturer in botany at Edinburgh University. He arrived, after an unexplained delay, in October 1861 (*Cheltenham Examiner*, 28 January and 10 December 1863), to replace Buckman as RAC botanist, 'in the middle of a session when the students of [Buckman's] class were proceeding favourably' (Buckman 1863*a*, p. 10). Bayldon was listed in the RAC's *1862 Prospectus* as 'Professor of Botany and Materia Medica', whereas Buckman was only 'Professor of Geology and Zoology'. Buckman ceased work at the RAC in July 1862, aged 47.

Despite this, Buckman continued botanical work at Cirencester, and reporting on it to the BAAS. His paper for the 1861 BAAS Manchester meeting, was not read there, as it was mysteriously 'held up in the post'. It was instead published both in the *GGAG* (26 October 1861, pp. 952–953) and in the new *Practical Farmer's Chronicle and Journal of Agricultural Science*, a journal co-edited by Buckman (Buckman 1861*b*), which lasted for only 16 months (January 1861 to April 1862). The publishers' agreement, dated 28 November 1860 (BAAC), allowed £100 annually to both editors, if sales of more than 3000 copies were reached (with further payments if greater). Clearly, Buckman was again seeking to augment his salary. Buckman read further botanical papers to the 1862 BAAS meeting (Buckman 1863*b*, *c* the manuscripts of which survive, BAAC). One was on Buckman's 'Student Parsnip', which had gone into commercial production in 1860, before winning first prize at the International Show of the Horticultural Society in London in 1862. However, both papers were based on earlier experiments and were no longer based on his RAC experimental garden. The second paper (Buckman 1863*c*) recorded results only from March 1860 to April 1861, despite being dated 'Cirencester, September 1862'. Buckman's final two botanical papers to the BAAS (Buckman 1865*a*, *b*) recorded a last summer of observations, but based only on those made in his own garden (Taylor 1864, pp. 191 and 230). This was because his RAC Botanical Garden was no longer available.

The fate of Buckman's experimental botanic garden

Buckman's Botanical Garden was ruthlessly destroyed, in spring 1862, in a act of revenge against his Darwinian position. Buckman's son wrote:

My father had carried on an experimental garden in the College grounds for the instruction of his students and to show how cultivated plants could be produced from wild stock by selective breeding from the specimens which conformed to the requirements desired. It seems hardly credible now, but it was openly taught then that our garden plants were what had been specially given by god to Adam in the garden of Eden and that they had not been changed since [see Allen 2001, X, p. 8].

Darwin in the first edition of his *Origin of Species* had referred to my father's plant breeding experiments [Darwin 1859, p. 10]. He presented my father with a copy of his work and there is a letter [dated 4 October 1857] from him asking for information, within a year or so before that work was published.

So the Principal [Constable] arose as an avenger, one ready to execute the wrath of god on his enemies. In the spring of the year [1862] when all plants were growing nicely [&] all seeds had been sewn, he gathered his forces together during my father's temporary absence from the College—he gathered the head gardener and all other workers and ordered them to lay waste the land and utterly destroy it—to dig the experimental garden up very thoroughly and to burn every tree, bush and shoot upon it. His army did their work very thoroughly. When my father returned he found that years and years of work in which students had taken as much interest as their Professor—my father had been at the College 16 years—had been entirely ruined. After many years of work only one vegetable experiment had come to the stage of usefulness to mankind [the Student Parsnip], but others were now approaching that stage. All this labour was wasted and all the selected stocks of seeds which had just been planted were destroyed.

The outrage and insult was too grave to be overlooked. My father resigned his Professorship, all the other Professors resigned in a body in support. They all had their grievances. The students raised great posters and backed the Professors, so did the townsfolk. There were indignant letters in the papers. At one time it looked as if the Principal's appeals to the College Governors [were] doomed, but the College Governors were not big enough men to admit that they had made a mistake: they found it impossible to go back on their decision of almost a couple of years before when, after great examination of candidates, they had selected the reverend gentleman [Constable] to be Principal: the [other] Professors' resignations were accepted to take place at the end of term [July 1863].

The outcome was reported in the *Worcester Herald*:

It is alleged that Mr. Buckman was 'elbowed' from the chair of botany, to make way for another, the present Professor [John Bayldon[1]]. It is further alleged that Professor Buckman had under cultivation, in his experimental garden, more than 200 plots, which were, against his wishes, ruthlessly destroyed before any new botanic garden was formed, so that, as acknowledged by Mr. Bayldon, he could only find 17 species there fitted to be removed to the new ground. This destruction of the old plots and the formation of the new ones was also resolved upon without any consultation with a gentleman [Buckman] who had been at the head of the botanical department for years, and whose suggestions ought to have been considered worthy [of] consideration. In all this, and the incorrect designation of many of the grasses in their present plots, as asserted by a critical and experienced botanist, it is no satisfactory answer that a general collection of plants as well as grasses is [now to be] in course of formation (27 December 1862, p. 4).

'Old Observer', clearly a former RAC student, wrote another damning report on 'Botany at the RAC'. This reveals that the new Botanical Garden was in a different location from Buckman's, 'now only devoted to kitchen purposes'. In the new garden

a considerable number of labels were obviously wrong, and names had been placed by some ignorant person at random, so that I could hardly believe that the Botanical Professor [Bayldon] had now any control over the garden. At any rate great blundering, or astonishing carelessness, was perceptible on all sides, to such a degree as to render the garden in its present state useless for practical instruction. [This damning indictment continues for paragraphs. It notes how] some young gentleman from Edinburgh [Bayldon], probably more familiar with *Materia Medica* than British Botany, had been sent for to enlighten the students with his northern acquirements, and that too in the middle of a session, when a course of botany lectures by the late Professor of that science [Buckman] were brought to an abrupt conclusion (*GCAG*, 6 December 1862, pp. 1154–1155).

Bayldon replied that his RAC Botanical Garden had been instituted in March 1862 and gave details of botanical activities, since his appointment in October 1861, and his plans for the future (*GCAG*, 13 December 1862, p. 1178). 'Old Observer' responded

How ridiculous it had been for Bayldon to claim that the new garden 'shall be without a rival, in its own sphere, in Europe, in a few years' ... The great majority of the old plots of Grasses and other plants were ruthlessly destroyed before the new ground was laid out, while it will be scarcely believed that in determining the alteration of the old, and in forming the new, the talented botanical professor connected with the College for 14 years [Buckman], was never called in as a counsellor (*GCAG*, 20 December 1862, pp. 1201–1202).

Such comments were confirmed by a 'Friend to the Student', who complained that the 'Principal's new Botanical Garden is shamefully incorrect in nomenclature ... since the gentleman thus substituted was a medical man' (*Cheltenham Examiner*, 10 December 1863).

Postlude

In a final confusion, Darwin wrote in April 1878 to the Scottish botanist Alexander Stephen Wilson (1827–1893)

I always felt, though without any good reason, rather sceptical about Prof. Buckman's experiment [with grasses] and I afterwards heard that a most wicked and cruel trick had been played on him by some of the agricultural students at Cirencester, who had sown seeds unknown to him in his experimental beds. Whether he ever knew this I did not hear (Darwin & Seward 1903, Vol. 2, p. 421).

Samuel Pickworth Woodward's role

Darwin's informant was Samuel Pickworth Woodward (1821–1865), whom Buckman replaced at the RAC. Darwin had recommended Woodward to the British Museum for the post that he gained there in mid-1848, months after Woodward had been given notice at the RAC (Burkhardt & Smith 1988–2002, Vol. 13, p. 371). On 14 February 1863, Woodward wrote to Darwin

if you come to a [new] ed[itio]n [of *The Origin*] I hope you will erase all mention of Buckman's exp[erimen]ts at Cirencester—it will be better not to mention his name than give it with the admission made in ed[ition] 1 [1859]. I went to see *my old* B[otanical] G[arden] at Cisseter under Buckman's managem[en]t, and took care to examine *it alone*. 'What I saw there I will not declare'—but it will be sufficient to say that one of the students (who owed the Prof. a grudge) confessed to R. Tomes (*Vespertilio*) that **he** himself had mixed the seeds intended for experiment in the Botanic Garden (Burkhardt & Smith 1988–2002, Vol. 11, p. 132).

In a subsequent letter Woodward added

Perhaps if you were of the age, & in the circumstances of those [RAC] boys you would not wonder at what happened . . . I don't care to scrawl all I have seen in this unlucky business—but you know To(mes) (the 'Bat'![2]) & he knows one of the delinquents. The only point of any practical consequence is the *value* of certain observations—& I have *seen* [emphasis here added] reason to believe that they are—nil (Burkhardt & Smith 1988–2002, Vol. 11, p. 481).

However, Woodward's cryptic reports were made over 11 months after Buckman's RAC garden had been destroyed. They raise many questions. Here are some to drive the historian mad for lack of evidence, with possible answers.

(1) Which garden was Woodward describing in 1863, Buckman's or Bayldon's? Could he have been describing Buckman's, a full 11 months after it had been completely destroyed, or was he referring to Bayldon's new, even more chaotic, garden?

(2) Did Woodward know enough of recent student ructions at the RAC? Problems involving RAC students were certainly rife, as one of those expelled, the Reverend Charles E. Whitcombe (1845–?) explained, his had been 'after condemnation on the accusation of the Principal' only (*WGS*, 2 May 1863). From Christmas 1862, RAC students were in a state of total anarchy, with widespread episodes of student window-breaking (*Cheltenham Examiner*, 17 June 1863; *Gloucester Chronicle*, 27 June 1863; *WGS*, 27 June; 4 and 11 July 1863). Five wonderfully vicious student songs were printed and began to circulate (*WGS*, 2 May 1863; copies in Julia Sophia Buckman scrapbook, BAAC).

(3) Was there unrecorded enmity between Woodward and Buckman? There certainly could have been, because Buckman replaced Woodward at the RAC, before Woodward found new employment.

All that is certain now is that Darwin removed all reference to Buckman's RAC experimental work on grasses in the next (fourth) edition (1866) of *The Origin*, after Woodward's death. Darwin seems never to have asked Buckman for his view of these claims. It is perhaps important, in the present context, to record that Woodward's 'Congregational religious convictions meant that it was impossible for him [too] to accept Darwin's ideas on evolution' (*ODNB*). Perhaps it was simply for this, religious, reason that he reported as he did on someone's botanic garden at the RAC in 1863?

The Buckmans move to Dorset

Buckman's son recorded how

[RAC] students and townspeople were very indignant that the Professors had to go but had done everything they could devise to prevent. But when it was inevitable both subscribed readily and generously to handsome testimonials, which were presented with much ceremony to the departing Professors. All the other Professors found new appointments and became noted men and I think that with all of them went some two or three students to become their private pupils. Certainly three such students retired with my father[3] and for the rest of his life he always had more applications from such pupils than his house could take: in the main these were from county families of his own county: that shows the estimation in which he was held and his reputation. Many pupils desirous of severing their connection with the College and entering as private pupils with him meant that my father must have a farm on which they could be instructed, a house large enough to supply them and the family with generous accommodation and money to make these conditions possible. My father had long had a hankering after running a farm of his own, my mother was delighted with the idea. My grandfather [John Savory] was willing to find additional capital, both to please his daughter and because farming was good in those days—corn farming was easy and the Americans were too busy with their own affairs. A suitable farm and a reasonably sized home were found in a delightful situation [in Dorset] (Buckman 1928).

Buckman and family advertised the sale of their fine Dollar Street, Cirencester property (*WGS*, 27 June 1863) and moved to the large farm, now Coombe House, at Bradford Abbas, in autumn 1863 (Torrens 2004*b*, p. 26). This was on or after 11 October, as a dried 'last rose of summer gathered from my home at Cirencester, Sunday, 11 October 1863' survives, labelled by Buckman's wife (BAAC). In Dorset, Buckman conducted his farm on 'model principles' and continued to teach paying pupils. Moreover, he continued to lead a very active life of science and helped to found the Dorset Natural History and Antiquarian Field Club in 1875. However, his science was now, again, supported from his own now nonprofessional pocket (as his obituarist noted in *Sherborne Journal*, 1 December 1884).

Buckman still continued to publish botanical experiments, to one of which (Buckman 1866, in which he now styled himself 'Professor of Geology & Rural Economy') Constable soon alluded (Constable 1867, p. 381). Another was read to the Linnean Society on 2 April 1868. It was 'On the effects of Selection in the Cultivation of Plants'. The manuscript survives (Linnaean Society archives, no. 1689) and is annotated 'not to be printed (Council Minutes, May 7 1868)'. It concerned the parsnip, carrot, beet and radish and related to work in both the Cotswolds and Dorset. However, Buckman's problems were clearly well known at the Society. A letter dated April 1868 from George Bentham (1800–1884, *ODNB*) to Darwin (which I owe to Shelley Innes) noted that Buckman's paper was

> on the rapid change he had effected in the parsnip in which [Louis de] Vilmorin [1816–1860; French horticulturist] never could succeed and some other matters of little importance about Radishes etc. But I must say I cannot have anything like the confidence in his experiments that we all have in yours. When he showed me over his experimental ground at Cirencester some eight or ten years ago [1856–1858] one could not be struck how few were the precautions against error.

With a referee's report like that Buckman's paper was not published. However, Darwin still allowed favourable comments on Buckman's work on parsnips and oats to appear in his other works. And long after Buckman's 'Student Parsnip' had had fun poked at it in *Punch* (Vol. 44, 7 March 1863, p. 91), it became the oldest vegetable featured in 1988 on BBC TV's 'Victorian Kitchen Garden'. It still came from the original growers, who had introduced it commercially in 1860, Suttons Seeds, now of Torquay. Buckman's last work on the troublesome grasses was published as late as 1876 (Buckman 1876).

Conclusion

After his death, Buckman's part in the Darwinian 'revolution' was forgotten. His son, the palaeontologist Sydney Savory Buckman, followed him into the still perilous waters of professional science, after abortive attempts as pharmacist, land agent, farmer, fossil dealer and novelist (Torrens 2004*b*). James Buckman became the victim of debate before scientists had developed any modern self-regulating attitude to their practice, which might protect them today. Scientists know that their craft is now one in which incessant scrutiny, hopefully by equals, through publication and debate, is central (Shils 1968). At the time of the 1860 Oxford meeting there were simply not enough professional scientists to do this, and many of those who might have helped were still professing across too enormous a range of science for such scrutiny to be effective; in Buckman's case across the whole of agriculture, archaeology, botany, geology and zoology. In such times, it was only too easy for an outsider to science to misjudge debate and normal scientific reaction and misidentify it as 'error', as Constable did.

A telling statement of Constable's own position is in a book he published immediately after Buckman's departure, late in 1863. In this he confirmed how 'religious differences' must have been the root cause of his problems with Buckman, and wrote:

> The very selection of a clergyman to rule [*sic*] over this [RAC] community is an acknowledgment that not merely morality is to be inculcated, but that Christian doctrine is to be the ground work of our operations. I cannot believe that a minister of Christ is placed here as Principal merely to add respectability to the Institution (Constable 1863, p. 29).

This paper was first given to BAAS's 150th Oxford meeting (Torrens 1988), which re-created the 1860 Huxley–Wilberforce 'debate'. It was read, and improved on, by a number of friends: D. Allen, P. Bowler, J. Browne, the late A. Cain, A. Desmond, B. Greenslade, D. Oldroyd and C. Russell. T. Darragh (Melbourne) uncovered John Bayldon in Australia, M. Taylor (Edinburgh) investigated Alexander Wilson's role, and S. Innes (Cambridge) led me to Buckman's 1868 Linnean submission (of which G. Douglas provided a copy) and Bentham's review.

Sources

This paper is largely based on newspaper and other ephemera. A first collection, in three scrapbooks, kept by James Buckman, covering 1856 to 1880, is in British Geological Survey archives (BGS 1/1181), Keyworth, Nottingham. A second is the scrapbook kept by his wife Julia. A third is the large collection of loose cuttings made by James Buckman (both were given me by Peter Buckman (1918–1990). Other material was given me by Peter's sister, Olive Buckman (1919–2006). All is here referred to as Buckman Archives (in author's collection) (BAAC). These have been supplemented by Charles Darwin's annotated set of *GAGC*, at Cambridge Botanic Garden, and by newspapers at Colindale, London, Worcester, Cheltenham and Cirencester. Archivists and librarians, especially those at the RAC and BGS, have been of constant, and gratefully acknowledged, assistance.

Notes

[1]The fate of the unfortunate John Bayldon (1837–1878) who alone remained, deserves record. He started his RAC Botanical Garden on 8 March 1862, but did not stay long. He had emigrated to Australia by April 1866, having abandoned botany to return to medicine. He settled, in May 1866, as surgeon–medical officer, to the Melbourne Benevolent Asylum and, from 1870, to the Melbourne Lunatic Asylum. He was finally appointed temporary Medical Superintendent at the Ararat Lunatic Asylum, in January 1872. Here he died on 6 April 1872, leaving no will. His administration records his property (with no real estate) 'not exceeding £225'. His widow Rosetta returned to England in February 1873, where she died in 1876.

[2]Robert Fisher Tomes (1823–1904), of South Littleton near Evesham, was a local landowner and geologist and zoologist who published much on geology (especially corals) and zoology (especially bats and birds, but not on botany). He donated much to the British Museum (Richardson 1904).

[3]One such Dorset pupil was Frederick Richard Vasasour Witts (1843–1900), grandson of the man already quoted in 1844 (see p. 244). Witts was listed as an RAC student only from July 1862 to July 1863 (Anonymous 1898, p. 287) but was named as one of Buckman's new private pupils, in a letter from Buckman to Thomas Warner of Cirencester (an organizer of the Buckman testimonials) dated 3 April 1864 (BAAC).

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Franz Unger and Sebastian Brunner on evolution and the visualization of Earth history; a debate between liberal and conservative Catholics

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Abstract: The point of departure for this study of the debate on links between sciences and religion is a church newspaper that appeared in Vienna after the revolution of 1848. In it we find the arguments of a particularly conservative journalist and priest (Brunner) who attacked scientific topics, such as evolution and the position of Franz Unger (1800–1871), who was a professor at the University of Vienna and who is a well-known figure in the history of science, because of his numerous contributions to cellular biology, plant physiology, biogeography and palaeobotany, and most of all because of his surveys of pre-Darwinian evolution theory. He was one of the first scientists who tried, in 1852, to suggest the temporal development of the natural world in a visual form. I propose here that the controversy between conservative clergy and liberal academics was invigorated not least because Unger was capable of using Catholic culture to communicate his concepts and representations of evolution and the Earth's development and to make them understandable. In return, Brunner understood how to exploit Unger's work and use Mosaic geology as a counterpoint for his strengthening of Catholic orthodoxy. This debate proves not to be a permanent conflict between religion and science, but to lie within the Viennese Catholic culture within which the protagonists took their stance.

The historical relationship between science and religion has been described in the history of science using either the metaphor of war or that of harmony. Such an approach would assume that we are dealing with clearly distinguishable entities of a kind that do not, in fact, exist. Any new analysis therefore demands a contextualisation or 'new cartography' (Livingstone 1997), to cope with the complex network of relationships in scientific, religious and existential debates. In the 1970s, Turner (1974, 1978) suggested that instead of proceeding on the basis of a conflict between religion and science we should think in terms of a competition between individual protagonists for cultural leadership. This idea is an important prior assumption for the present paper, which considers certain actors who represent collective bodies at a particular time and in a particular political context. These actors 'invent' and represent their place in culture and society, which they also defend. I propose that during times of social and political crisis and during periods of transformation, scientists, theologians and other people tend to use such public debates as a platform to their own advantage. In this they relate to an oppositional field, which they define as their own or as differing from it. Thus it is the reciprocal references that scientists or theologians use at times of social upheaval to guarantee their status that are of interest.

The location for this study on the debate on the evolution and history of the Earth is Vienna after the revolution of 1848. In the Vienna church journal (*Wiener Kirchenzeitung*), which was published here after 1848, we find the arguments of a particularly conservative journalist and priest Sebastian Brunner (1814–1893), who was the editor of the journal and close to fundamentalist clerical circles in the church. He attacked scientific topics, such as the history of Earth, evolutionary ideas and the new position of university professors (which involved a new model of teaching), and although he campaigned for a 'free science' he developed his own views on its relationship with the conservative strand of church politics.

At the centre of Brunner's attacks were the works, pictures and metaphors of Franz Unger, who was a professor at the University of Vienna. Franz Unger (1800–1871) is a well-known figure in the history of science (Klemun 2003), because of his numerous contributions to cellular biology, plant physiology (Unger 1866), biogeography, the history of cultivated plants (Klemun 2007) and palaeobotany (Unger 1847), his role as Gregor Mendel's teacher (Olby 1985), and most of all because of his surveys of pre-Darwinian evolution theory published in 1852 (Unger 1852; Gliboff 1998). His work *The Primeval World in its Different Periods of Formation* (*Die Urwelt in ihren unterschiedlichen Bildungsperioden*, 1851*b*, 1858)

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has also been prominent in the history of geology, since Rudwick's study on the visualization of deep time, as the 'first use of scenes from deep time, to suggest the temporal development of the natural world' (Rudwick 1992, p. 132). A landmark in visual representation of palaeontology, this work was a collection of lithographs based on drawings made under Unger's direction by Joseph Kuwasseg (1799–1859), a Styrian Romantic landscape painter, depicting scenes from different geological periods. Unger provided comments explaining the environmental and floral changes shown.

Here I analyse the debate on three levels: institutional, semantic and aesthetic. Brunner's critique of Unger as a representative of a new professorial body that enjoyed freedom of teaching and learning at the University of Vienna after 1848 (although the state returned to neoabsolutism) and the critique of Unger's ideas on evolution have been well discussed in the literature (Olby 1985; Gliboff 1998). However, here I am seeking to clarify the religious connections, and shall refer to sources that have not previously been considered.

Situating the debate between the Church and the university: the institutional aspect

The conflict between the state bureaucracy and the Catholic Church was the relevant complex source that helps us to understand the main lines of the confrontation. The freedom of teaching and learning, which was established at the University of Vienna as a consequence of the 1848 revolution, was subject to a great deal of criticism after 1852. The abolition of the constitution that was drawn up during the revolution and the return to absolutism in 1852 also endangered the new university reform that was established in 1849. Its founder, the minister Leo Count Thun, was supposed to adhere to the reform, although he was in other respects close to the conservatives, who saw the new institutions resulting from the revolution as a great danger for society. For the different ideologies, the free press, existing since 1848 and developing after a long time of suppression, and the abolition of censorship both played an important role in the mobilization of public opinion.

Wilhelm von Humboldt's ideal of universities, which was developed at the beginning of the 19th century for Berlin (Humboldt 1960) and later extended elsewhere, built on a new alliance of teaching and research instead of the mere procurement of knowledge. The history of this transformation of the German universities (McClelland 1980; Turner 1991) has concentrated on the faculties of philosophy without focusing on the fact that both biology and geology were established within them. This reform was based on a higher status of a 'Wissenschaft' that was characteristic of the incorporation of research into the mission of the university. For the realisation of this concept, the University of Vienna, which entered this fundamental stage of reform in 1849, needed excellent scientific figures. Franz Unger, who was appointed at the University of Vienna in 1849 to hold the newly established second professorship of botany, was a representative of this new type of professor. As an intellectual, he had already accounted for numerous fields in biology: the ecology of plants (Unger 1836) and phytopathology (Unger 1833). He introduced a huge repertoire of methods, and in the wake of 'Humboldtian science' (Cannon 1978) he transformed geographical categories from one natural field of research into another. He was also willing to reflect about what botany could be like as a new 'Wissenschaft'; that is, not a discipline reduced solely to traditional taxonomy but rather, for the first time in Vienna, one that covered the history of plants and their physiology. Botany had played an important role in Vienna since the 18th century. It also received constant support because of the interest of the court. Now, in accordance with Unger's approach it should abandon its status as a classifying and taxonomic science. It should shake off its museum dust and, as it were, incorporate historical thinking, as Unger publicly expressed it in the *Wiener Zeitung*, the traditional organ of the court. This declaration appeared in the context of a preprint (Unger 1851*a*) of the *Botanical Letters* (Unger 1852), a book that would bring public respect for the newly appointed professor. For Brunner and his public criticism of the new organization and reform of university (Brunner 1850, 1851*a*, *b*), Unger soon turned out to be the ideal object to personalize his preoccupations and assaults on the new direction of free teaching.

Two publications of Unger's work, the *Botanische Briefe* (*Botanical Letters*) (Unger 1851*a*, *b*) and *Die Urwelt in ihren verschiedenen Bildungsperioden* (*The Primeval World in its Different Periods of Formation*) (Unger 1851*b*, 1858) offered the immediate point of attack for Brunner's criticism. He rejected Unger's work and especially his imagery as 'a tale of creation' (Brunner 1852*b*), and wrote crude parodies of it in the *Wiener Kirchenzeitung* (Brunner 1852*c*, *d*). Brunner, being conservative and clerical, also referred to the term 'freedom', which was used in the course of the revolution, as he pointed out in his autobiography (Brunner 1855*a*, p. 197). Brunner's public influence began during the revolutionary year of 1848 when the free press, based on some 200 new journals, was also widely used by Catholic circles for their own concerns. It was in the midst of this unsettled atmosphere that he had established the *Wiener*

Kirchenzeitung. The son of a wealthy Viennese silk manufacturer, Brunner had studied theology, and by 1845 had obtained doctorates in both philosophy and theology at the University of Vienna. At the time of his journalistic activities he also worked as a preacher on feast-days and Sundays at the university church in Vienna. As a preacher he imitated the famous baroque orator Abraham a Santa Clara, with whose books he trained himself, as he described in his autobiography (Brunner 1855*a*, p. 7). In Santa Clara's eloquent but forthright manner Brunner found access to his large body of followers. In the university reforms influenced predominantly by Protestant Germany, Brunner saw a danger, in opposition to which he wanted to establish a specifically Catholic discipleship in Vienna (Brunner 1850, 1851*a–c*, 1852*a*). Brunner used the guiding concept of 'freedom', which, since 1848 (Nowak 1995, p. 122), had been claimed in different fields and by groups with different orientations, in different contexts, for their own purposes. For Brunner this constituted the core of a church that had to be freed from the bonds of the state. His notion of 'freedom' concentrated on a kind of renaissance of the Catholic University as it had existed during the counter-Reformation (Brunner 1851*c*, 1855*a*, p. 197). Accordingly Brunner's claim against Unger was that history is governed by free will and not by natural law (Brunner 1852*b*). Thus Brunner avoided confronting Unger in his own territory of religion or that of Unger in biology, and chose to stay on philosophical ground and in this way to counter Unger's concept of evolution.

The fact that in Austria the State had had institutional power over the Church since the Enlightenment, and could therefore determine the education system, was one of the reasons for the disaffection between the various groups. This power over the church became extinct with the signing of the Concordat in 1855, when the Church regained autonomy from the State (Weinzierl 1960). In the time between 1848 (1852) and 1855, until the signing of the Concordat, the turbulence resulting from the arguments pro and contra affected all the political groups who were discussing the relationship between Church and State. The Concordat contained important concessions to the Church, such as ecclesiastical control of marriage and education. From 1855 until the abolition of the Concordat in 1867, Protestants were not allowed to apply for professorships.

On the basis of the Concordat, Catholicism could be defined as the only moral foundation of the neo-absolutist state between 1852 and 1867, and of the university, and therefore the knowledge taught within it, as a defence against liberal attacks. It was no coincidence that Brunner's criticism of Unger (Brunner 1852*b–d*), first expressed in 1852, was pursued shortly before the signing of the Concordat: after all, and this is my point, it served first within the mobilization of arguments for the liberation of the Church from governmental superiority and control.

After an interval of several years the controversy again became heated. After the publication of an article in the liberal daily newspaper of Augsburg, in which the well-known Viennese theologian and priest Emanuel Veith was said to have agreed in his sermons with the statement that Unger's attempts at visualization of the history of the Earth had nothing to do with the Bible (Brunner 1855*b*), Brunner felt the necessity to formulate his opinions with the help of further arguments within religious circles. His attack on Unger became more vigorous and aggressive (Brunner 1855*c*, 1856*a*, *b*) to protect his prominent position within ecclesiastical circles at the extreme political edge of the clergy. At the height of the controversy Brunner asked: 'Of what concern to us is the pantheistic world-view of a botanist? Why do we even talk about Dr. Unger? Because he is a professor at the University of Vienna, and because the University of Vienna is a Habsburg family foundation, instituted by Rudolf the Founder, and because, in the words of the deed of foundation, signed by Rudolf, it was founded to propagate the Catholic faith and to provide spiritual counsel *in salutem animarum* for the house of Habsburg' (Brunner 1856*b*).

Most probably it was really the intensification of the Ultramontane movement (which involved an emphasis on papal authority and centralization of the church) that was the reason for Unger's breaking his silence and for his reaction, although he was a devout Catholic. He mobilized not only the liberal press, but also 401 students, who started a petition to explain to the public that any suspicion that had arisen against Unger (he was accused by Brunner of being a seducer of youth and denier of God) did not agree with the truth of his classes in the university. In the petition, preserved in the archives, that was sent to the Minister, the students justified their intervention on behalf of their honoured teacher, because 'the attacks on Unger had become the talk of the town'. The students testified that 'Professor Unger was not in the habit—either in his public lectures, which were always given behind unlocked doors, or in his microscope demonstrations, to which access was open to all—of bringing religious questions into the field of his strictly scientific discussions' (HHStA, AVA, Unterricht, Präsidium, Schachtel 23, No. 354, Petition, 10 February).

Encouraged by the commitment of the students, Unger now decided to move forward and bring a charge of insulting behaviour against the *Wiener Kirchenzeitung*. Unger's position may be deduced from a manuscript draft of his letter to the public prosecutor, according to which he 'felt himself obliged, by his public position in the state and in both the scientific and the civic worlds, to claim the protection of the law against this degradation in public opinion' (AIP, Autograph of Unger, undated, Fasz. III/2). Unger expected that as a result of his charge the Ministry of Science and Education would support him in his complaint, or 'at least would have nothing against such a complaint' (HHStA, AVA, Unterricht, Präsidium, Schachtel 23, No. 354, Unger's Petition, 29 February). Unger's petition, however, was largely played down by the Ministry, which said that Unger could indeed make a complaint but should expect no support from the Ministry. They did distance themselves from Brunner's attacks, but at the same time they stressed that Unger had been attacked because of extracts taken from some of his published works, in other words because of his authorial activity. The letter from the Minister to the Dean contained criticism of Unger's style: 'Personally I cannot view the criticism in the present case as unjustified, in that the sentences that are being censured do seem to me likely to disturb the Christian convictions on which moral order is based' (HHStA. AVA, Unterricht, Präsidium, Schachtel 23, No. 354, Letter from the Minister to the Dean, 10 March). In the draft the cited sentence was corrected and completed: 'because Professor Unger's sentences are not composed with the circumspection required of a scientific presentation and many objections may be made against them'. This was desirable, the Minister's instruction continued, 'because otherwise we shall become involved in criticism that would require a serious investigation and a resolution of matters of principle. Both of these we should reject as not requiring our involvement' (HHStA, AVA, Unterricht, Präsidium, Schachtel 23, No. 354, Minister's Reply to Unger's Petition, 10 March).

Neither of the parties received support in public either from the Minister or through the Ministry, although Unger's expression and style was dealt a severe blow. Almost in the same breath Unger was hailed in the liberal press as the most important champion of the rise of science (*Illustrirte Zeitung* (Leipzig), 20 September 1856, p. 486) and Minister Leo Thun was celebrated as the greatest proponent of modernity in Austrian universities (*Illustrirte Zeitung*, 21 June 1856, p. 410). The debate on the university and its autonomy had reached a stage where it was no longer being discussed by the initial protagonists, but on the one hand institutionally and within the university and on the other hand among the church's audience.

Within the debate in the church, Brunner enhanced the agitation by depicting the relation between natural science and religion in editorials with titles such as 'Christianity and Geology' (Brunner 1856*d*), 'Geology and the Bible' (Brunner 1855*d*) and 'Believing natural scientists' (Brunner 1856*e*). He referred, as it were, to an antagonism between two either harmonious or contradicting spheres of science and religion, both of which he dated from Galileo Galilei. His narratives were intended to work against the dominance of natural science, to strengthen the influence of his personal field, Catholicism, on society. Scientism, which was gaining influence, was already perceived as so dominant that theologians tried to gain the support of theologically based natural sciences. Brunner, who now relied on Mosaic geology and its most prominent representatives abroad (William Buckland and others; Buckland 1836), focused on this harmony between cosmology and geology in one of his articles (Brunner 1855*d*, 1856*e*). It was he who boosted the popularity of these concepts in Vienna. Here, theologians and scientists had not invested as much effort as their British counterparts (Rudwick 2004, p. 313) in making the model an argument for the existence of God by seeking for evidence of the biblical creation.

It is clear there was no space for Mosaic geology in the community of scientists and geologists in Austria, more particularly because the Geological Survey founded in 1849 defined itself as a corporate institution in which the resources of the state were identified solely by stratigraphy and by the concrete task of recording all the lands of the Monarchy (Geologische Bundesanstalt 1999). Cosmological questions were completely outside their professional domain. A number of years earlier Brunner, using an anecdote aimed at Unger, had attempted to discredit the geologists in their work. He made fun of the way these experts interpreted snail shells from the rubbish of fasting nuns as a separate stratum. Brunner interpreted this procedure of the geologists as a weapon against the sacred account of the creation (Brunner 1852*d*).

Unger himself stressed, in a public announcement, that he would not have to 'defend himself in front of a competent audience' (Brunner 1856*c*) but if he had to do so, he would do it only in front of his students, in a depiction of the circumstances which resulted in litigation and finally involved a minister of education who was not very happy to deal with such questions. According to Unger's biographer Reyer, the minister tried to reach an agreement. He invited the rival parties to his office, but the two quarrelled fiercely in his presence (Reyer 1871). The fact that after this Brunner discontinued his fierce attacks can be taken as an indication that the involvement of the ministry had a calming effect on the debate.

Unger explained himself in his few statements as a staff-member and an executive of the university, and therefore as a Catholic, by claiming that his 'research in natural science never led to a contradiction with his belief in a personal God who teaches Christianity'. The full representation of his life and achievements that appeared in the same year in the liberal press also ended with a note that Unger drew clear lines between natural science and theology: 'But nowhere will it be found that this [research] flies beyond the scope of what is given, to lose itself in theology, and this could not be excused on aesthetic grounds nor could it be immediately cited as unhistorical. His knowledge, one could say, is also his philosophy' (*Illustrirte Zeitung*, 21 June 1856, p. 410).

This representation thus positioned him as a valued member of a faculty that was devoting itself to the new question of the role of science within philosophy. The attacks had given Unger a presence in the media as an extraordinarily important scientist that he would otherwise not have enjoyed. Moreover, Unger more or less chose to capitulate owing to the pressure of the Catholic university, and admitted, as a professor, to belonging to the Catholic faith, which had actually been a condition of employment at the university since the Concordat. More than 10 years later, when he was an emeritus professor, he officially criticized the papal statement of 1869 concerning natural science (the dogma of infallibility). He now referred to the 'bewildering position of the church against natural science' as 'meaningless'. This opinion was based on the established self-confidence of research in the natural sciences, which had had connotations of 'symbolic capital', to put it in the words of Bourdieu *et al*. (1994), from the beginning of the 19th century.

The speech that Unger had given as President of the Natural Science Association in Graz had its consequences for the membership. Whereas on the one hand a number of clerics left the Association, on the other hand countless interested liberals joined, and these were listed by name in the liberal press (Reyer 1871; *Grazer Tagespost*, 10 June 1869). Unlike 1856 there was now public assent to Unger's position on the part of many intellectuals who had previously refrained from making their position public.

Styles of thinking and the semantic aspects of the debate and the misunderstandings

With the term 'styles of thinking', I refer to Fleck (1999), who wanted to capture the characteristic of knowledge that refers to the propositions on which the scientific collective builds up its structure of knowledge. Styles of thinking are based upon presumptions that are a historical and sociological product of an active intellectual collective.

During the time of his university education, Unger was attracted by the romantic movement in the German territories and especially by the character of Lorenz Oken in Jena, Germany. Unger was then guided by Oken's biology and natural philosophy. Although he later abandoned this style of thinking, a connection remained in a spiritual and linguistic sense, especially in his publication *Botanical letters* (Unger 1851*a*, 1852). This publication was symptomatic of a particularly specific natural-philosophical style; for example, Unger wrote: 'Thus the plant achieves its world purpose in melancholy seclusion. But it is the same imprisoned and slumbering spirit, which scarcely dares breathe here, that bursts its bonds for ever in the animal and finally, in mankind, sings "Hallelujah"' (Unger 1851*a*, 1852). Brunner's parody of Unger as a 'Priest of Isis and a Philistine' showed that for him, Unger was making nature rather than the church his sacred temple.

Botanical letters (Unger 1851*a*, 1852) contained Unger's theory of evolution, which is no longer viewed as a mere forerunner of Darwinian evolution but as a viable alternative approach (Gliboff 1998). Evolution, like the German word 'Entwicklung', originally referred to embryonic development. It was also used as a term for progressive changes in individuals or species. As Gliboff pointed out, Unger's evolution was 'developmental' in nature, relying upon analogies between embryonic stages and ancestral forms (Gliboff 1998, p. 180). It meant that the same forces that formed embryos also played an important role in the formation of species. Unger updated this approach, reconciling it with the latest expertise in biogeography, palaeobotany and cell theory.

From Blumenbach Unger borrowed the concept of *Bildungstrieb* (formative force or drive), which became the agent of evolutionary change in Unger's theory. However, Brunner lacked an understanding of Blumenbach's term. He misinterpreted Unger's 'world spirit of force' and transformed it into a term from German materialism as propagated by Carl Vogt and Ludwig Büchner (Brunner 1856*a*). For Brunner, everyone who did not follow a clear dualism was suspect of pantheism or materialism. For example, in his autobiography Brunner attacked Baruch Spinoza as the most famous pantheistic systematic writer, whom he rejected as Jewish (Brunner 1855*a*).

Nowhere in Unger's *Botanical letters* (Unger 1851*a*, 1852) is the term 'evolution' used, but the subject ranged from cell theory and plant geography, to creation and development. In this, Brunner saw the dangerous work of the geologist who had conceived something evolutionary. This can be shown by the following poem, which he placed in his critique of Unger (Brunner 1852*b*) and especially Unger's explanations of his visualizations of deep time:

It is a neat story
About sublimate animals
That higher and higher ascend
From croaking, grunting, snickering;
Until to language itself they proceed
To become human, even,
and take up their reign
On madam mother earth
Until on ape and camel,
From donkey, oxen, pigs,
The highest human power,
The geologists appear
(Brunner 1852*b*).

Brunner dismissed the explanations that accompanied the picture as fanatical aesthetic philosophy, because, 'confusing spirit and nature, it would see the human being, like every geological product, merely as a development of his own natural power' (Brunner 1852*b*). His poem parodied the explanation in the last scene of Unger's visualization of the history of the Earth, when humans appeared, which Unger exuberantly described as follows:

Thousands upon thousands of figures have gone before as unsatisfactory attempts constantly to bring forth from their loins something more perfect. Finally the great task was achieved and the human being appeared, a masterly figure, a mirror of the act of creation, the ultimately revealed thought of the universe (Unger 1852*b*).

Strategies of conviction by means of aesthetics

Unger's works, The *Botanical Letters* (Unger 1851*a*, 1852) and *The Primeval World in its Periods of Formation* (Unger 1851*b*, 1858), epitomized a successful attempt to open up science and its newest findings to the general public, such that everybody would be enabled to develop themselves intellectually. This concern was in accord with the ideals of Wilhelm von Humboldt's humanistic programme of the promotion of scholarship to help people's self-cultivation. However, this gave the pictures a moral power that would otherwise have been given only to pronouncements of the Church. Especially because Unger included the act of creation in a spiritual sense in his narrative and visualization, they gained attractiveness as a humanistic approach for self-construction.

Success led to envy. Unger was popular at the university and had many students. For instance, following a petition to the Dean he used the largest auditoria so as to have enough space for the audiences of his lectures, which were even held in the evenings (AIP, Autograph of Unger, letters to the Dean, undated, Fasz. III/2). Unger's innovation of depicting different stages of the history of Earth like scenes in a play in the theatre, as a succession of vegetative forms, had only a few antecedents (Rudwick 1992). Unger offered a description of the pictures in his short comments, which invited viewers to place themselves directly in the scenes. He transformed the human perspective into the geological and historical landscape.

Even before the lithographs had appeared, a review was published in the *Allgemeine Zeitung*, which highlighted the following advantages: 'If thinking people would let their gaze rest, in amazement, on the remarkable multiplicity and size of our world, and would visualize the fabulous-sounding doctrines of those men who have made it their task to investigate the past life of our planet in the various mighty revolutions through which it has passed, before it reached its present perfection, then they could not suppress a profound yearning for a clear view of those vanished creations, for a comparison of then and now' (*Allgemeine Zeitung*, No 105, 833–835, 15 April 1847). Clear vision and the comparison of the past with the present were the cornerstones of Unger's approach.

This manner of visualization had many advantages. It tied up with the widely accepted 'Humboldtian' view of science (Cannon 1978) and corresponded to Unger's holistic treatment of flora as vegetation and as a unit of comparison through time and space.

This holistic view was the common core of all his writings (Klemun 2007), and the illustrations of the 'periods of formation' were the peak of this approach. With the depiction of landscape, Unger also adhered to the existing habit of visual perception, which had been established by the development of English gardens in analogy to landscape painting, and had gained a high degree of acceptance. This guided view within a garden, based on surprise, chance and variation, was fundamental to the experience of nature of an elite group, which was trained to see in this way. Travellers, for example, judged a landscape in terms of the picturesque aesthetic that was established in gardens. Between landscape pictures and real gardens there existed an identity that predisposed viewers to experience things according to habits of seeing (Hunt 1976). Unger's depictions of landscape involved one of the variations on this theme, namely the exotic, as it was staged at the time of the construction the new imperial palm tree houses and the publication of colonial travel writings (Allen 1996). This theme is detectable in the correspondence (Munich Library) in which Unger's friend Carl Friedrich Philipp von Martius (1794–1868), a specialist in palm trees and traveller to Brazil (1817–1820), provided advice for Unger on conceptual issues. In the case of the first scene the landscape contains three cryptogams, taking the place of modern palm trees. Unger had already been criticized in his first announcement for sticking, in his concepts, to recent forms, although this was the basis of the project.

In addition, the exotic in the form of a fashion for palm trees within stage settings had come to dominate theatrical productions, beginning with the drafts of Karl Friedrich Schinkel (1781–1841). This led to them becoming consumer articles. By visualizing the 'exotic', the traditional ideal of the visualization of nature was determined by an important factor, the sublime. This dominated depictions and was also expressed in various publications. The aesthetic culture of the sublime originally emanated from natural theology but also struck a chord within the Catholic culture (Klemun 2000). Unger himself stressed in his introduction to the *The Primeval World in its Different Periods of Formation* (Unger 1851*b*, 1858) that 'as in the present day, the landscapes of our painters are but seldom exact and servile copies of natural scenery, so these drawings of the primitive world only show the general character, but are not to be seen as precise reproductions of ancient periods' (Unger 1851*b*).

With Kuwasseg, Unger had managed to involve a master of the idealized and real depiction of landscape in his project (Celedin 2002). Kuwasseg's speciality was not to lose himself in details, but to capture each unit of vegetation in its characteristic features, an aspect that accorded with the ideal in the sense of Alexander von Humboldt and J. F. Schouw (Klemun 2007). Also, he produced paintings with a high level of finish (Celedin 2002). In his reconstruction of periods of the history of Earth, Unger covered the time span from 'when the surface of the earth was animated by the first organic beings, to the era of man's creation' (Unger 1851*a*). With the appearance of humans, the series reached its end-point and climax. Rudwick has noted that 'The Edenic overtones of its culminating final scene, with its overtly biblical allusions, suggests that it is not fanciful to see Unger's work as the definite assimilation of the tradition of biblical illustration into the newer genre.' (Rudwick 1992, p. 132). This argument is supported by an interesting detail that can be discovered by comparing the pencil drawing (Celedin 2002) with the printed version. In the pencil draft (Fig. 1), two men, a woman and two children form a unit that stands for humanity. In the print, however, we see a man, two women and three children (Fig. 2), who can be clearly identified as two parts of a group, with Adam and Eve as one part of the group. The fact that it was not the secular but the biblical version of paradise that was assimilated in the print arguably allows the interpretation that a traditional biblical visualization

Fig. 1. Pencil drawing by Joseph Kuwasseg: 'Jetztzeit', sepia on paper (in possession of the Steiermärkisches Landesmuseum Joanneum, Neue Galerie Graz. Inv. No. II/19.313).

Fig. 2. A copperplate illustration, published in Unger (1858).

was consciously used in the medium with the widest distribution. It must also be emphasized that Unger liked drawing and did the illustrations himself for almost all his publications. In particular, while he was travelling he collected character studies and impressions of landscapes that he put into his notebooks, and in his documents preserved in Basle many pencil drawings survive. We may assume that Unger co-operated with Kuwasseg and made available to him his palaeontological and botanical knowledge. Unfortunately, we have no direct evidence as to how this co-operation worked. In Unger's documents in Basle, however, there is one pencil sketch for the *Primeval World in its Different Periods of Formation* (Unger 1851*b*, 1858) that supports the idea that Unger had conceived this basic idea himself in a drawing. (Library of the University of Basle, Collection of Manuscripts, Unger's Estate 257, No. 9, Pencil drawing of Franz Unger).

Conclusions

It is clear that Unger was capable of using his Catholic surroundings and the Catholic culture to communicate his vision of evolution and the Earth's development together with its vegetative cover and to make them understandable. In return, Brunner knew how to exploit Unger's work and use Mosaic geology as a counterpart to his strengthening of Catholic orthodoxy. Both took fundamental, but yet different and related positions in the city of Vienna. And both of them 'invented' and represented their place in culture, based on Christian culture, society and science, which they also defended. The debate I have chosen here proves, on closer analysis of its conditions, not to be a permanent conflict between religion and science, but a specific expression of the cultural upheaval in the Habsburg monarchy, within which the protagonists took their stance.

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Geology and Genesis in nineteenth- and twentieth-century Italy: a preliminary assessment

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Abstract: During the second half of the nineteenth century and in the early years of the twentieth century the debate on the Darwinian evolutionary theory also involved the Italian scientific community. One of the lesser known results of the controversy there was the defence of creationism, often supported by the resort to the biblical Flood, in some Italian publications on geological sciences. The authors of such writings were naturalists and geologists, but also clerics and parish priests interested in the Earth sciences. They published a wide range of books, booklets and papers, particularly between 1870 and 1905. The aim of this paper is to analyse some interesting examples of this 'submerged' and heterogeneous literature, so as to understand the possible extent of its influence on the general public, as well as the level of integration between scientific knowledge, geological practice and reference to the Bible, during a period that is usually regarded as a time of separation between Genesis and geology.

During the last two decades, several historical studies based on scholarly and detailed analysis of primary sources have provided an improved picture of the development of the Earth sciences in Italy between the middle of the sixteenth and the first half of the nineteenth century. In addition to some monographs on significant, mainly eighteenth-century, scientific figures (such as Antonio Vallisneri, Anton Lazzaro Moro, Giovanni Arduino, Alberto Fortis, Luigi Ferdinando Marsili and Giambattista Brocchi) the studies by Nicoletta Morello have offered a clear and stimulating picture of the research potentiality in the history of geology and palaeontology in Italy up to the early decades of the twentieth century (Morello 1989, 1998, 2003). However, although there has been a growing interest recently in the institutional history of geology during the last two centuries (Vaccari 1999, 2001*a*, 2003*a*; Corsi 2003*a*, *b*, 2007; Vai 2003), and the publication of some biographical contributions (for example, on Giuseppe Scarabelli by Baruzzi (2006) and on Giulio Andrea Pirona by Vecchiet (1997)), there is still a lack of detailed systematic studies, particularly on the late nineteenth and the early twentieth century, and only a limited number of disciplinary aspects have been examined to date (Società Geologica Italiana 1984).

Italian geology and the issue of science and religion

To study the history of modern geology in Italy is to work within a 'research minefield', where a perception of the late nineteenth and the early twentieth centuries seems to be based on a few generalized and simplified notions, which can be summarized as follows: the reference to the biblical Flood had been abandoned since the end of the eighteenth century after centuries of biblical influence on the natural sciences; Genesis and geology were finally separated as a result of the development of fieldwork and the establishment of specialized branches of the Earth sciences; the Darwinian evolutionary theory became widely accepted and supported by the majority of Italian geologists and palaeontologists.

If all these judgements need to be reassessed in the light of new research, another topic in the history of science may also be considered in relation to the Italian case, namely the accuracy of some statements in some well-known historical studies published on the topic 'geology and religion' since the middle of the twentieth century (Gillispie 1951; Moore 1986; Rudwick 1986; Rupke 1996, 2002). In particular, the assumption that the 'Genesis and geology issue' in the late nineteenth century was mainly 'a British preoccupation, or, more precisely, a preoccupation in the English speaking world', as well as 'of interest primarily in Protestant communities' should be reconsidered (Rupke 2002, pp. 190–191). Similarly, questions related to the so-called 'clerical opposition to geology' (Foote 1951) should be treated in detail, to fully understand their cultural context. Rupke has noted that the works of the English 'scriptural geologists', such as George Bugg (1769–1851) or

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Granville Penn (1761–1844), in spite of their doubtful scientific quality, 'enjoyed a wide readership and carried the imprimatur of traditional learning' (Rupke 1996, p. xii). Also, some historical studies on the role of the creationists (e.g. Numbers 1992) have started to investigate several minor and often forgotten authors as forerunners of twentieth century 'Flood geology'.

Within the framework of a preliminary assessment of the 'Genesis and geology' issue in modern Italy, the study of the role of minor or unknown figures, clearly different from the 'academic geologists' of the second half of the nineteenth century, may be of value. Such a study will allow us to evaluate the phenomenon of 'popular geology' and thus understand the extent of the diffusion of scientific culture within the public during that period, as well as the attitudes of both the scientific community and the Catholic Church towards such diffusion. The meaning and the social role of popularization should therefore not be undervalued, in particular after the subdivision of scientific disciplines into specialist fields and the development of specialized university teaching. 'Popular science' was an essential way of communication to non-specialists or the general audience, who formed a high percentage of the potential readers in the late nineteenth-century Italy.

The separation between the new science of the Earth and Genesis had already been expressed by the works of several Italian scholars during the eighteenth century: the difficult reception of the theories of the Earth based on a physical–theological approach is well shown by the cautious sceptical attitude of naturalists such as Antonio Vallisneri (Vaccari 2001*b*; Luzzini 2009), as well as by the deliberate choice of ignoring the biblical scheme in the work of field geologists such as Giovanni Arduino (Vaccari 2006). Consequently, it is not surprising that in the early 1810s Giambattista Brocchi (1772–1826), one of the most prominent Italian geologists of the first half of the nineteenth century, simply summarized this previous attitude by writing that 'the geologist should not lose himself in the labyrinths of cosmogony' (Brocchi 1814, Vol. 1, p. iii) and instead should study the relative ages of the rocks observed in well-defined geographical areas without attempting the reconstruction of a complete chronology of the Earth. At that time, however, references to the biblical Flood had not disappeared from the writings of Italian scientists, but were made in different ways, although not always explicitly, by late eighteenth-century 'diluvialists' (Candela 2009) as well as by some early nineteenth-century 'Wernerians' (Vaccari 2003*b*).

Darwinism and creationism

During the second half of the nineteenth century and in the early years of the twentieth century the debate on Darwinian theory also involved the Italian geological community. One of the less well-known results of this controversial reception was the defence of creationism by a wide range of authors, such as naturalists and geologists but also unknown clerics and parish priests interested in the Earth sciences.

The available secondary literature provides an interesting picture of this debate, but needs to be further developed. The book *Darwin in Italy* (Pancaldi 1991) recognized the significant contributions by 'specialists' (i.e. naturalists, anthropologists, biologists and geologists), as well as the role of amateurs, journalists or writers of popular science. However, unlike Gillispie in *Genesis and Geology* (Gillispie 1951), Pancaldi concentrated his analysis on the professional or academic scientists, and among them especially zoologists and biologists, rather than geologists such as Gillispie chiefly discussed. It seems that Darwin was probably more read than Lyell by the Italian geologists (Vaccari 1998), although he was not received in the same way. The first Italian translation of *The Origin of Species*, based on the third English edition, was published in 1864 by Giovanni Canestrini (1835–1900) and Leonardo Salimbeni (Darwin 1864; Minelli & Casellato 2001). A year later the geologist Giovanni Omboni (1829–1910) gave a very favourable review, undermining the possible use of incomplete geo-palaeontological data against the evolution of species (Omboni 1865). Not all geologists agreed, although some prominent figures, such as Arturo Issel (1842–1922) in Genova and Giovanni Capellini (1833–1922) in Bologna embraced evolutionism. In 1874, Giovanni Giuseppe Bianconi (1809–1878), a former professor of natural history at the University of Bologna and author of several works on the geology of the northern Apennines, published a book on the so-called 'independent creations', based on zoological arguments, which claimed that palaeontological evidence could provide the decisive arguments against the Darwinian theory (Bianconi 1874; Redondi 1980, pp. 807–809). This first edition, printed in French as a long letter addressed to Darwin himself (*La théorie darwinienne et la Création dite indépendante*), sold out immediately, so a few months later Bianconi, with the help of his son Giovanni Antonio, published a revised and enlarged Italian translation (Bianconi 1875) (Fig. 1). According to Bianconi, scientific investigation based on the 'enlightened application of the laws of mechanics, physics, physiology', led to the conclusion that every part of an organism, including man, and consequently every 'organic mechanism', was the result of a perfect act of creation by the 'unlimited intelligence' of a supreme being ('eminente Intelligenza': Bianconi 1875, pp. 356–359).

LA
TEORIA DARWINIANA
E LA
CREAZIONE
DETTA INDIPENDENTE
PER
G. GIUSEPPE BIANCONI
GIÀ PROFESSORE NELLA UNIVERSITÀ DI BOLOGNA

LETTERA
AL SIGNOR
CARLO DARWIN
TRADOTTA DAL FRANCESE
DAL
DOTT. G. ANTONIO BIANCONI
DELLA ACCADEMIA DELLE SCIENZE
RIVEDUTA ED ACCRESCIUTA

BOLOGNA
PRESSO NICOLA ZANICHELLI
SUCCESSORE MARSIGLI E ROCCHI

MDCCCLXXV.

Fig. 1. Title page of Bianconi (1875).

Towards the end of the century, the debate between Darwinists and creationists opened up the question of the authority of 'Mosaic geology'. This was a relatively new issue for the Italian scientists of the second half of the nineteenth century, compared, for example, with Britain at the same period, but it was also linked to the development of some forms of popular geology that had started to appear around the 1850s. To date, this 'submerged' but highly successful literature has been only partially analysed in the Italian context, as is also the case for the phenomenon of the diffusion of popular science more generally (Govoni 2002). Consequently, it appears likely to be fruitful to carry out new systematic, detailed investigations of these primary sources, to provide an adequately documented understanding. Some examples may help us to understand the style and the general contents of this extensive and still unexplored material.

Creation, evolution and popular geology

In 1859, the year of Darwin's *Origin of Species*, an Italian general reader interested in the Earth sciences could find, among other publications, the following newly printed books: the second edition of the Italian translation of *Die Wunder der Urwelt* (*The Wonder of the Primitive World*) by 'Dr W. F. A. Zimmermann', a pseudonym for the German scholar Carl Gottfried Wilhelm Vollmer (1797–1864), author of several writings on popular science (Zimmermann 1854–1855, 1859), and the book *La vita nell'Universo* (*Life in the Universe*) by Paolo Lioy (1834–1911), a young naturalist, who later became education superintendent and city councillor in Vicenza, as well as a writer of popular science (Lioy 1859).

The Italian publisher had given the Zimmermann book a different title from the original: *Il mondo prima della Creazione dell'uomo, ossia la culla dell'Universo. Storia popolare della Creazione e delle trasformazioni del globo raccontata al popolo* (*The world before the Creation of man or the cradle of the Universe. A popular history of the Creation and transformation of the globe narrated to the people*; Zimmermann 1859). The Italian title strongly emphasized the content of this extremely successful book, which reached its fifteenth German edition in 1860 and the twenty-fifth in 1867. The separation between the moment of the general creation (the '*fiat* by the Creator') and the particular stages of formation and transformation of the inorganic and organic bodies on the Earth was clearly stated, from the first chapter. Thus, according to Zimmermann the 'Creation of the Universe' was only 'partially known', whereas the stages of its formation were 'perfectly clear' (Zimmermann 1859, p. 15). On the other hand, God 'had created the Solar System and the Milky Way', but did not come down to the Earth to 'make models of animals' (Zimmermann 1859, p. 58). The 'entirely new science of geology' was, however, praised as being responsible for 'the destruction of prejudices, errors and superstitions' (Zimmermann 1859, p. 5).

The same emphasis on the divine creation, as an unknowable event separated from the history of the Earth but also constantly present in human life, may be found in Lioy's book *La vita nell'Universo* (*Life in the Universe*, Lioy 1859). Lioy recalled the importance of the tradition of the creation in different religions, but this was not seen as an obstacle to the development of geological investigations of the changes undergone by the Earth's surface. Consequently, although Lioy considered it evident that 'there is only one supreme truth, like a lighthouse ... which accompanies the human generations: God and the Creation' (Lioy 1859, p. 17), on the other hand 'the great catastrophic changes suffered by our planet are not only demonstrated by geologists, but have been part of the universal tradition of the Creation in nearly all cosmogonies, such as those of Indians, Egyptians, Burmese, Israelis' (Lioy 1859, p. 99). Lioy's position, like that of Zimmermann, rejected the subjection of geology to religion. He agreed with William Buckland's (1784–1856) *Vindiciae geologicae* (Buckland 1820), but strongly criticized the rigid approach of the British 'Mosaic geology': 'these charlatans of knowledge', he wrote, 'are not so many in the Catholic world as in England. [George] Fairholme [1789–1846] denies every discovery of geology which seems to disagree with Genesis and [George] Croly [1780–1860] calls this science heretic . . .. There are still many who, while literally interpreting the six days of Creation, refute all the contrary results from modern scientific investigations' (Lioy 1859, p. 453).

Lioy, a self-taught naturalist and a prolific writer who was also called 'the poet of science', was strongly involved in popularizing science, especially geology. In 1868 he published the book *Escursione sotterra* (*Underground Excursion*), in which the history of the Earth was presented in a series of conversations between himself (pictured as an amateur naturalist), a doctor, a pharmacist, a lawyer, an abbot and some ladies. Lioy's careful approach toward the evolutionary theory took his readers through pages of gradual demolition of the elements of 'Mosaic geology', such as the biblical Flood, with occasional words of gentle derision (Lioy 1873).

Catholic geologists and the *concordismo*

Probably one the best-known nineteenth-century Italian popularizers of geology was a Catholic priest, Antonio Stoppani (1824–1891), another self-taught naturalist who had assembled a remarkable geological–palaeontological collection as a result of his extensive fieldwork undertaken mostly in Lombardy to study the Triassic formations (Fig. 2). His scientific career was remarkable, as he was appointed Professor of Geology at the University of Pavia in the academic year 1861–1862 and later at the newly established Polytechnic in Milan (Daccò 1991). Stoppani published *Il Bel Paese* (*The Beautiful Country*) (Stoppani 1875) a book of popular geology for young readers and teachers, which achieved an enormous readership in Italy for several decades well into the twentieth century. It consisted of a series of evening conversations in which an uncle, returned from his holiday, described the natural beauties of Italy to his little nephew. It proved to be so popular with the general reader that in the mid-1920s *Il Bel Paese* had already gone well beyond 120 paperback editions and was used in many schools as a textbook. Although Stoppani was well aware of the advances in geological science in Europe (e.g. in 1877 he translated Archibald Geikie's *Physical Geography*), he was also a declared supporter of the so-called *concordismo*; that is, the full concordance between an allegorical interpretation of the Bible and the results of geological research (although he did not put this into *Il Bel Paese*). Only in his later years did Stoppani become a reference for some Italian Catholic geologists and anti-evolutionists; in particular, after the publication of some long treatises on the role of the clergy in resolving the conflict between science and religion (Stoppani 1884), on the 'Mosaic Cosmogony' (Stoppani 1887) and on a history of creation according to reason and faith (Stoppani 1893), where he vigorously attacked the supporters of the 'man–monkey' (Pinna 1991).

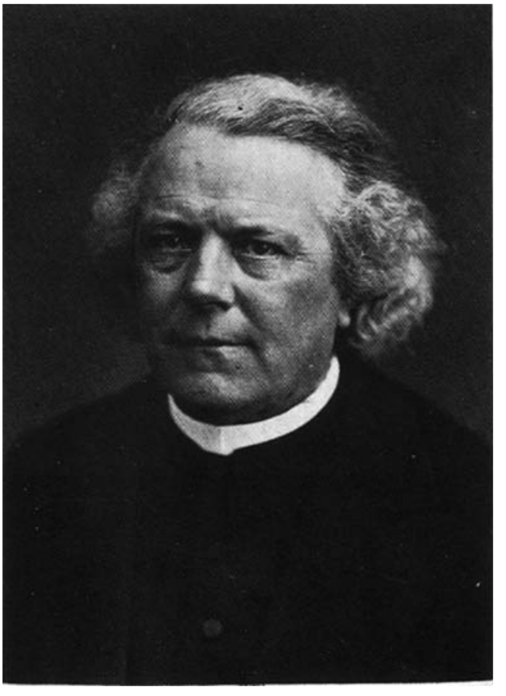

Fig. 2. Antonio Stoppani (1824–1891).

Stoppani was a priest, active scientist, teacher and popular writer, but he was not the only figure in geological sciences who tried to reconcile geology and Genesis. The case of Guglielmo Jervis is also significant. As keeper of the Royal Industrial Museum in Turin and an expert mineralogist, he was a member of the Italian Geological Society as well as of the Geological Society of London, and a correspondent of the Austrian Geological Survey (Geologische Reichsanstalt) in Vienna. He produced a detailed and invaluable survey of the mineral


LA GLORIOSA RIVELAZIONE

INTORNO ALLA

Creazione del Mondo

Con importanti dimostrazioni scientifiche

poste a fronte delle Sacre Scritture

PEL

CAV. UFF. GUGLIELMO JERVIS

Membro della Società Geologica Italiana in Roma,

Membro della Società Geologica di Londra,

Corrispondente dell'Istituto Geologico Imperiale e Reale di Vienna.

Già Conservatore del Regio Museo Industriale di Torino, a riposo.

« Grandi son l'opere del Signore, spiegate davanti a tutti quelli che si dilettano in esse ». Salmo CXI, 2.

FIRENZE

PREM. TIP. E LIB. CLAUDIANA

Via dei Serragli, 51

1902.

Fig. 3. Title page of Jervis (1902).

resources of Italy (Jervis 1873–1889), but in 1902 he also published a booklet on the 'glorious revelation concerning the Creation of the world' with scientific demonstrations in favour of the Bible (Fig. 3), in which he reinforced the question of the 'geologically interpreted' chronology of the six days of the creation: 'don't worry, believers in the truth of the Holy Scriptures. The world was actually created in six successive stages, which were represented in the human language as *days*. Six days, not in man's terms, but in God's terms; and it is certain that *these six 'days' were some millions of years long, and even more millions of the age of human beings*' (Jervis 1902, p. 24).

The Catholic Church in Italy was not silent or inactive during these crucial decades in the nineteenth and twentieth century (Redondi 1980, pp. 782–811). On the contrary, scientific arguments, more than a historical method of biblical interpretation, were freely used to combat the possible impiety of the philosophical consequences of modern science. Consequently, whereas the Catholic authorities firmly opposed the idea of human evolution with not only ideological but also scientific criticism (as in the case of Bianconi's work), in the field of geology they adopted a double strategy. Beside supporting fervent Catholic geologists (such as Jervis), although some conservative authors criticized Stoppani's *concordismo* as being too liberal, the Roman Catholic Church produced its own official scientific defence of the biblical Flood. For example, a memoir was published in December 1873 by Benedetto Viale Prelà (the personal physician of Pope Pius IX and President of the Pontifical Academy of the Nuovi Lincei in Rome), which explained 'the cause of the universal deluge' as being a sudden change of the Earth's axis, a theory already well known among 'diluvialists' in eighteenth-century Italy (Viale Prelà 1873). Moreover, up to the beginning of the twentieth century some Catholic authors (parish priests and clerics) published popular books or booklets on the subject of the 'Mosaic cosmogony' in relation to geology and the Darwinian theory (e.g. Cetta 1886; Baroldi 1901, 1902). This work, although it was probably encouraged by senior figures in the Italian Catholic Church, was not carried out systematically, but a detailed study of such 'submerged' and 'minor' sources would be valuable in helping to understand their influence on the general public.

The references to 'creation', 'religion', 'Genesis' and 'the Flood' (in either a negative or positive sense) usually did not appear in the specialized writings of professional geologists, but were much more evident in the popular literature. However, at the end of nineteenth century the fashionable and popular sciences in Italy were astronomy and physics rather than geology and palaeontology. Popular science was not a genre that became highly developed and diffused in Italy, as was the case in France or Britain: for this reason the most famous foreign authors, such as Louis Figuier (1819–1894) and Camille Flammarion (1842–1925), although considered as being nearly atheist by some Italian Catholic geologists as well as Zimmermann and others, were well known and read. Significantly, however, in the titles of most of the relevant books translated into Italian between the 1850s and the 1920s, the emphasis on the words 'creation', and 'the Flood' remained.

Conclusions

Several detailed studies of the Italian context have confirmed Rudwick's (1986) point that the eighteenth-century geologists in the field were generally not interested in finding a possible agreement with 'Mosaic geology'. Nevertheless, in Italy, more than a century later, the attitude of some scientists changed. For the development of a *concordismo* in the late nineteenth and early twentieth century, the role of the debate on Darwinism was essential, but not strong enough to affect the eighteenth-century rational and secular heritage in the geological sciences maintained by most of the Italian geologists. Consequently, these attempts at conciliation gradually faded by the middle of the twentieth century. This was due also to the reduction of the role of scientific popularization in Italy, which led to a stronger sense of separation between geology and religion in the Italian scientific community. Political, social and ideological aspects may also be identified among the causes of this process: however, to date, this topic has not been sufficiently investigated and further historical studies are needed.

This preliminary overview and inevitably partial evidence from the Italian case show that the '*Genesis and geology* story' was not confined to the English-speaking Protestant world, but also involved Catholic societies such as that of the Kingdom of Italy, established in 1861. The existence of such a 'submerged' and heterogeneous literature in Italy seems to indicate the different aspects of the debate on Darwinism among nineteenth-century geologists, and of the confrontation with a flexible kind of 'Mosaic geology', which was only partially present in the main books on popular geology.

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Natural theology in the eighteenth century, as exemplified in the writings of Élie Bertrand (1713–1797), a Swiss naturalist and Protestant pastor

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Abstract: For Élie Bertrand (1713–1797) and his like-minded contemporaries, God's design and providence set the stage for understanding the workings of the Earth. Bertrand used various methods, including field observations, to accumulate considerable geological knowledge, which he published in his *Dictionnaire universel des fossiles* (1763) and *Recueil de divers traités sur l'histoire naturelle* (1766). By examining Bertrand's life and writings, we may come to appreciate the strengths and shortcomings of his visions of the natural world. His focus on collecting, cataloguing, and classifying natural objects and phenomena fitted the classic concept of natural history in his era. On the basis of his observations, he dared to systematize and theorize. His work provides a window on his time and on attempts of natural theologians then to understand the products and operation of the world. Once a counsellor to the King of Poland, a correspondent of Voltaire, and a contributor to the *Encyclopédie*, Bertrand's name has largely vanished from view. His hope to observe the world of nature so as to comprehend the word of God yielded constructive results but did not succeed in fulfilling natural theology's boldest aspirations.

It is difficult to transport ourselves back 250 years in time so as to think like a naturalist in the mid-eighteenth century. But we need to do so if we ever hope to gain deep insight into the musings of pious Christian writers who were genuinely excited about combining the word of God with the world of nature. Their fervent hope was to reinforce their religious beliefs while furthering their understanding of the workings of the Earth.

In this post-Darwin era of secular science, it may be asking a great deal to suggest that we need to entertain the 'argument from design' when marvelling at a beautiful insect, or to be grateful for God's providence when explaining the nature of majestic mountains. However, to truly understand the history of our discipline, we must at least consider the excitement and attraction of natural theology as a catalyst for investigating topics in the Earth sciences during the late seventeenth and much of the eighteenth century. It is also relevant to consider the point recently made by Brooke (2007, p. 10) that it is possible for historians to see 'a fascinating picture . . . of scientific activity grounded in, and justified by, theological considerations'. Marshall (2006) noted that the cliché of 'warfare' between religion and science is an inadequate description of the historical record. The desire of Brooke (1991) and Lindberg & Numbers (2003) to move away from oversimplified 'conflict' models to a more complex reading of the intersections between theology and science is relevant to the following discussion. The voluminous work of eighteenth-century natural theologians, dated though it may seem, serves to reinforce these points.

The goals of this paper are to: (1) consider the nature and impact of natural theology and outline its allure for its adherents; (2) use the writings of Élie Bertrand, a Francophone Swiss naturalist and Protestant pastor, as illustrative examples of how a Christian naturalist viewed the world and made contributions to the nascent discipline of geology; and (3) comment on why the amalgam of 'the word' and 'the world' did not achieve the exciting goals of natural theology.

Natural theology and its allure

Imagine being brought up as a Protestant Christian who used the Bible as a guidepost for the operation of your entire world. Imagine being in a country that had just had a wrenching civil war and was striving for stability and a sense of order. Imagine being enthralled with the new Baconian methods of experimentation and observation to understand nature. And think of how it felt to watch Isaac Newton use rational mathematical methods to order the universe. That was the case for the British natural theologians of the late seventeenth century. The post-Civil War, post-Cromwell British gave us a panoply of Protestant natural theologians, many of whom are familiar names: John Ray (1627–1705), Thomas Burnet (1638–1704), William Whiston (1667–1752) and William Paley (1743–1805). In

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the nineteenth century, the British vision of the intersection of natural theology with then-contemporary thought was provided by the Bridgewater Treatises *On the Power, Wisdom, and Goodness of God, as manifested in the Creation*. Of particular note is Volume VI on *Geology and Mineralogy Considered with Reference to Natural Theology* (Buckland 1836). Reasons for natural theology finding such fertile ground in Britain have been discussed by Gillespie (1987).

The European and Catholic practitioners of natural theology could be said to go back to Augustine (354–430) and Thomas Aquinas (1225–1274), both of whom could see God's handiwork in the beauty and plenitude of the natural world. By the late seventeenth century, French natural science was advancing, and Fénelon (1651–1715) could tell young René Antoine Ferchault de Réaumur (1683–1757) that naturalists could show adoration of God through an exposition of the marvels of nature (Bourdier 1960). The French name that serves as the most noteworthy French eighteenth-century exemplar of natural theology is the Jansenist cleric, Abbé Noël-Antoine Pluche (1688–1761), whose *Spectacle de la nature* (Pluche 1732) was intended to attract young nobles to natural history and ended up entrancing a wide spectrum of Francophone readers. Pluche commented that nature is the best, but one of the least understood, books in the world's library. He firmly stated that fossil shells were the natural product of the sea (Pluche 1732, p. 252). He also proclaimed that, 'After faith ... we have nothing more precious than reason' (Pluche 1732, p. 504), and therefore 'Man should be religious in proportion to his being reasonable' (Pluche 1732, p. 512). Pluche went on to speak of three possible 'Ideals' for the power of human reason: (1) to wish to know nothing (indolence); (2) to wish to know everything (temerity); or, as he counselled, (3) the wish to do research and put to profit what one can know (prudence) (Pluche 1732, p. 519). Roger (1963) has seen the origin of natural theology as occurring in Britain, with Pluche following suit in France and passing the torch to Élie Bertrand, Albrecht von Haller and Jean-Jacques Rousseau.

The alluring result of all of this British and French musing about how best to comprehend the nature of God and the world was that one could combine the power of God's scriptural commentaries with the insights of contemporary science. The involved participant could have a richer vision of God while deepening his or her understanding of the working of the designed world. It was an exciting time. As Lynch (2002) observed, the eighteenth-century scholar may not have recognized the present definitional separation of 'science' versus 'religion' and may have sincerely believed in pursuing a powerful amalgamation of approaches. Thus, the real power of natural theology, in its own time, was that it melded the word and the world while forcefully demonstrating God's design. A brief definition of natural theology is that it seeks to understand the nature of God through human reason and attention to nature, as opposed to relying solely on revealed truth, as sanctioned by the clergy and presented in the Bible. In practice, it allowed the use of selected Cartesian methods, Baconian empiricism, and Linnaean visions of order in the organic realm. Along with the cosmic order provided by Newton, natural theology helped the naturalist develop a sense of optimism about understanding the workings of the planet Earth.

Protestant Swiss proponents of natural theology included Louis Bourguet (1678–1742) and Élie Bertrand (1713–1797). The Francophone Swiss are interesting because they shared with the French a language and the analytical tools, if not mechanistic philosophy, of Descartes. That is, they could employ rational elements from his *Discourse on Method* (Descartes vuvo 1637) (one should doubt established doctrines; subdivide huge problems; be systematic in reasoning; and try to be complete and rigorous in stating conclusions) while avoiding over-mechanistic explanations for God's sometimes mysterious modes of operating in the world. The Protestant Swiss also had deep religious empathy with the British clerical writers of natural theology and natural history. As Bertrand wrote, 'Let's try to study nature so as to celebrate the Author' (Bertrand 1766, p. 113).

Élie Bertrand

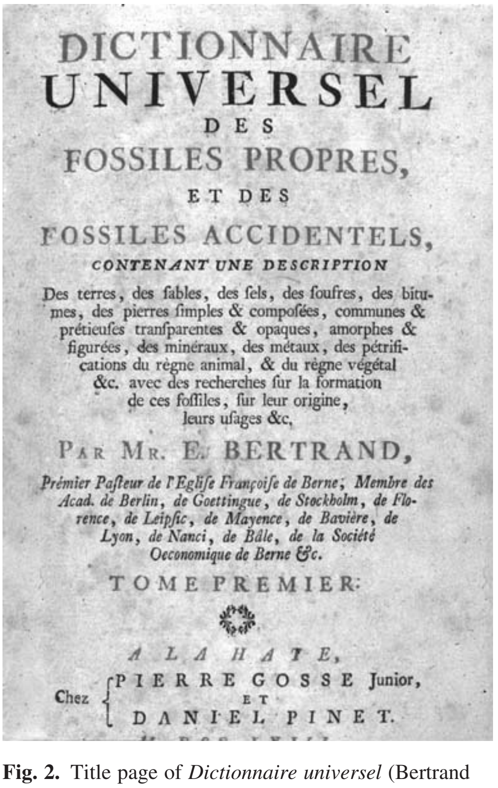
The life and thought of Élie Bertrand are instructive on many counts (Carozzi & Carozzi 1984; Weidmann 1986; Bork 1991) (Fig. 1). His dates (1713–1797) lie within the Enlightenment, and he died in the same year that James Hutton expired and Charles Lyell was born. He contributed to the famous *Encyclopédie* of Diderot and d'Alembert, and he corresponded with Voltaire (1694–1778) and other mid-century luminaries. Just one example of that correspondence is a letter, dated 5 January 1759, from Voltaire to Bertrand expressing the view that, 'Opinions have caused more ills than the plague or earthquakes on this little globe of ours'. Intellectually, Bertrand had a rich heritage. He was familiar with Cartesian logic and frequently employed the Cartesian method of breaking down major problems into smaller, more approachable packages. He could, of course, comprehend the exciting work of the French science establishment,

Fig. 1. Portrait of Élie Bertrand, painted by Sigmund Barth in 1749. From Weidmann (1986). The original painting is in the Musée du Vieil Yverdon, Switzerland.

centred in Paris. But it was British-based natural theology that drove his interest in observing nature as a means to communicate with a wide audience about the glories of God. A Protestant pastor by vocation, Élie Bertrand was also a member of numerous learned societies, and he served as a counsellor to the King of Poland. Bertrand added significantly to the accumulation of proto-geological knowledge and was a widely read author with a flair for popularizing natural history.

Some authors (Furon 1943; Guyénot 1957) have written demeaning things about how dull most of the eighteenth century was, in the context of the evolution of science and natural history. However, I have to agree with Dezallier d'Argenville (1742) that the early decades of the century were rich in advances for natural history. Also, Greene (1971) correctly observed that systematic natural history really is a brand of 'science', and that mid-eighteenth-century observers, describers and classifiers deserve a place in the pantheon of noteworthy contributors to the evolving geosciences. Knight (1976) made the point that many of the naturalists of the first half of the eighteenth century were collectors and describers, in the Aristotelian mould, rather than Platonic thinkers anxious to use mathematics and deduction to generate basic laws of nature. Bertrand fits well into the category of collectors and amateur naturalists who furthered the evolution of natural history and provided significant building stones for the burgeoning discipline that was to become geology at the end of the eighteenth century.

Bertrand's two major works are the *Dictionnaire universel des fossiles* (Bertrand 1763) and the *Recueil de divers traités sur l'histoire naturelle* (Bertrand 1766). The *Dictionnaire universel* was one of the most read natural history books of the eighteenth century and d'Archiac (1862, p. 282) commended it as being a strong contribution for its time (Fig. 2). Its goal was to systematize the complex world of nature. Johns (2003) described the situation well when he noted that the early Enlightenment dictionaries came from a culture of patronage, were typically written by single authors, were dedicated to monarchs, and had as their audience a 'cosmopolitan republic of letters'. As Roger (1980) has suggested, classifying, along with the associated endeavours of collecting and cataloguing, really was a critical aspiration of the era.



DICTIONNAIRE
UNIVERSEL
DES
FOSSILES PROPRES,
ET DES
FOSSILES ACCIDENTELS,
CONTENANT UNE DESCRIPTION
Des terres, des ſables, des ſels, des ſoufres, des bitumes, des pierres ſimples & compoſées, communes & prétieuſes tranſparentes & opaques, amorphes & figurées, des minéraux, des métaux, des pétrifications du régne animal, & du régne végétal &c. avec des recherches ſur la formation de ces foſſiles, ſur leur origine, leurs uſages &c,

PAR MR. E. BERTRAND,

Prémier Paſteur de l'Egliſe Françoiſe de Berne, Membre des Acad. de Berlin, de Goettingue, de Stockholm, de Florence, de Leipſic, de Mayence, de Bavière, de Lyon, de Nanci, de Bâle, de la Société Oeconomique de Berne &c.

TOME PREMIER.

A LA HAYE,
Chez PIERRE GOSSE Junior, ET DANIEL PINET.

Fig. 2. Title page of *Dictionnaire universel* (Bertrand 1763). From the author's personal copy of the book.

Two centuries prior to Roger's contention, Élie Bertrand had stated that our finite knowledge can grow perpetually if we collect, describe, and classify God's products (Bertrand 1763). Linnaeus (1707–1778) had already advanced his *Systemae Naturae* (Linnaeus 1735, 10th edition, 1758) and the public was attuned to seeing order in nature. Bertrand responded to this drive for order by classifying the natural products of the Earth. For him, dictionaries were fundamental to understanding any subject and had value for the specialist as well as for the common reader. He stated this clearly. 'To reunite principal objects into a dictionary, and that in a common language, is, it seems to me, to render an essential service to the public' (Bertrand 1763, p. xiij). He provided examples of valuable dictionaries in the realms of medicine, pharmacy and alchemy, and called attention to the brilliant accumulation of knowledge in the *Encyclopédie*. In his view, a strong dictionary in 'oryctology' (palaeontology, geology, mineralogy) was sorely needed, because public interest in natural history was high, yet study and progress within the field was still 'in the shadows'. The utility of oryctology was patently evident to Bertrand. Demonstrating his practical side, while offering a vision of what we now call geological maps, he called for a *Carte Oryctographique* for each country (Bertrand 1763, p. xxvj). It would reveal topography, beds of strata, wells, landslides and places where one might drill the ground in the quest for resources. He explicitly stated that: 'Contemplation of all the parts of nature always leads to God and the sage spirit which attaches to that Being, which is the cause of all that exists' (Bertrand 1763, p. xxv). Offering a book that combined study of nature with a pathway to comprehending the gifts of God was his goal in writing the *Dictionnaire*.

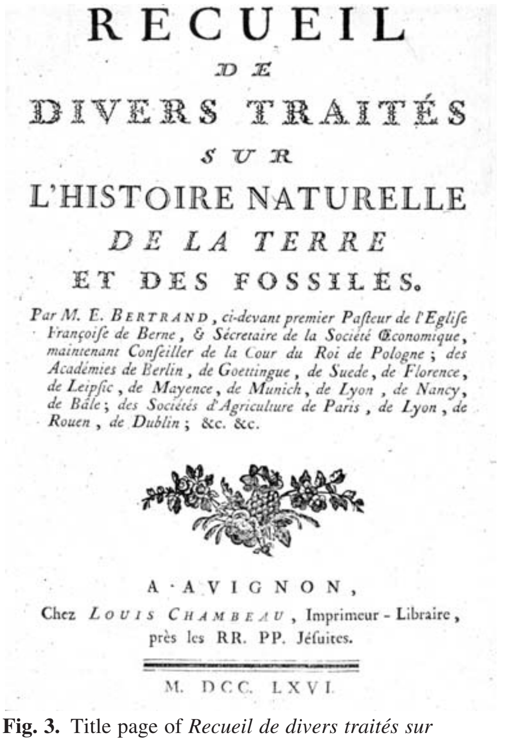
He also felt that it was important to eliminate the confusing multiplicity inherent in having distinct names from different locales. What was needed was a major amalgamation of terms and a decrease in subdivisions within a particular class of rocks or fossils. His somewhat caustic observation was that rampant splitting of names often was done to serve the egos and self-promotion of an author rather than furthering knowledge. Although he deemed the task of distilling names and creating synonymies a 'disgusting' one (Bertrand 1763, p. 65), because it was arduous and time-consuming, he saw the merit of having a universal vocabulary for fossils, rocks and natural materials. As he wrote, systematic terminology is 'the soul of true science, and the torch for one who wishes to instruct himself about nature' (Bertrand 1763, p. xv). Thus, one of the major services of the *Dictionnaire* was to provide stable names for the plethora of terms, often tied to a given country or locality, that burdened nomenclature at that time. The book was, in essence, an invaluable compendium or accumulation of discrete elements. It attempted to bring order out of chaos.

Communicating the essence of his message to his audience was important to Bertrand. Thus, he laid out (Bertrand 1763, pp. x–xij) the design and goals of the *Dictionnaire*. It is worth noting that although he wanted to illuminate the reality of God's work, he specifically commented that using the imagination, instead of experience and observation from nature, would lead natural scientists into error. The natural objects discussed were presented in alphabetical order of their French names. Bertrand felt that French was the 'universal language' of science, and that commonality was a significant goal for communicating with the reading public. Occasional synonyms in Latin, German, Italian and English were also provided. The key characters then received attention, following the Linnaean ranking concept of Class, Order, Genus, Species and Variety (Bertrand 1763, p. xvj). When possible, origins were discussed and comments made about the use or utility of particular 'fossil'; this term was used in the broad sense of anything dug from the Earth. In many cases Bertrand cited authors, such as J.-J. Scheuchzer and J. T. Klein, but asked his readers to be indulgent and not presume plagiarism on his part if a point was made but a specific original author was not named.

It was widely felt that, thanks to the power of the 'great chain of being' and of divinely established relationships within nature, affinities among organisms and inorganic products could be surveyed and summarized. In a designed world, in which organisms existed in a sequence from fungi to corals to archangels, it should be possible to place a particular animal, plant, or fossil in a recognizable slot in the scheme of things. Bertrand none the less admitted that gaps might be evident until our knowledge of nature was more complete and allowed all of the connections to be recognized. The goal of the *Dictionnaire* was huge: he hoped to offer a truly universal dictionary on such significant topics as fossils, minerals, rocks and metals. Equally impressive were the sources of the incorporated knowledge: nature itself, thanks to Bertrand's willingness to do fieldwork; various books; natural history 'cabinets' (personal collections), which he hoped would instruct as well as amuse their owners; and contributions from other scientists. Modestly he admitted that the dictionary was just an imperfect 'essay', but he went on to state: 'I do flatter myself that my work will not be entirely useless for other authors' (1763, p. xij).

If great rulers such as Frederick V, Elector Palatine of the Rhine, and the kings of Sweden and

Denmark could be attuned to the enlightening potential of natural history, why could the topic not find its way into the schools and colleges? One suspects that Bertrand's own educational experiences had not been very enlightening, because he exclaimed, 'All the teachers teach Latin and Greek, which one learns only imperfectly and soon forgets. No one learns things useful to the country, applying our time, money, talents, and studies to useful things [such as natural history]' (Bertrand 1763, p. xxxij). He continued: 'Isn't it astonishing to see twenty Masters teach dead languages and not one teach Practical Science, in which progress could make for the richness of the country and prosperity of the state?' The answer might not come to formal education programmes for many years, he feared. That was all the more reason to write informative books of a 'popular' nature. In its day, the *Dictionnaire universel* took a few steps toward educating the populace about the significance of the contemporary views about natural history, while furthering the aspirations of natural theology.


RECUEIL
DE
DIVERS TRAITÉS
SUR
L'HISTOIRE NATURELLE
DE LA TERRE
ET DES FOSSILES.

Par M. E. BERTRAND, ci-devant premier Pasteur de l'Eglise Françoise de Berne, & Sécretaire de la Société Œconomique, maintenant Conseiller de la Cour du Roi de Pologne; des Académies de Berlin, de Goettingue, de Suede, de Florence, de Leipsic, de Mayence, de Munich, de Lyon, de Nancy, de Bâle; des Sociétés d'Agriculture de Paris, de Lyon, de Rouen, de Dublin; &c. &c.

A AVIGNON,
Chez LOUIS CHAMBEAU, Imprimeur-Libraire, près les RR. PP. Jésuites.
M. DCC. LXVI.

Fig. 3. Title page of *Recueil de divers traités sur l'histoire naturelle* (Bertrand 1766). From the author's personal copy of the book.

The *Recueil* of 1766

It is Bertrand's 1766 collection of essays that provides one of the best windows onto the natural history landscape visible at mid-century (Fig. 3). It was fundamentally a selection of Bertrand's own mid-century articles describing and classifying the products of nature. The compendium was invited by a publisher who felt that Bertrand's commentaries were insightful and were no doubt of interest to a public desirous of learning more about the natural world. It was the work of an 'accumulator' rather than a paradigm shifter. As much as we celebrate the geniuses capable of shifting research programmes, there does remain a place for the plodders and toilers who lay the foundation blocks for the superstructure of science or society. As Rousseau (1979) noted, the evolution of natural science following the era of John Woodward (1665–1728) depended upon a slow and incremental 'accretion' of knowledge. Also, Glacken (1967, p. 406) related natural theology directly to the accumulation mode of Bertrand's contributions by observing that, in the minds of many eighteenth-century naturalists, it was the detailed observations that served to illuminate the great power of design.

But the *Recueil* went beyond mere descriptions of natural phenomena, however valuable they might be. In places it hearkened back to the natural theology of John Ray, as in its discussions of the 'usage of mountains'. It also (1) argued for using observations from the field; (2) treated major topics, including the nature of fossils and the structure of the Earth; and (3) even provided some theoretical speculation about the nature and origin of earthquakes and mountain ranges. The specific subtitles and dates of the original essays were: (1) Memoir on the Interior Structure of the Earth (1752); (2) Essay on the Usage of Mountains (1754); (3) Memoirs on Earthquakes (1757); (4) Essay on Mineralogy, or Distribution of 'Fossils' (1754); (5) Essays concerning the Canton of Berne (1754); (6) Letter on the Flooding of the Nile, and Use of the Mountains of Abyssinia (1754); (7) Letter on the Diminution of the Oceans, and the Origin of Mountains (1754). That last article was a strong reaction to the wild visions of the French diplomat Benoît de Maillet (1656–1738) whose *Telliamed: Or, Discourses Between an Indian Philosopher and a French Missionary, on the Diminution of the Sea, the Formation of the Earth, the Origin of Men and Animals, And other Curious Subjects, relating to Natural History and Philosophy* (1748; published posthumously and known, in manuscript form, for more than a decade; see Carozzi 1968) raised the spectres of a great age for the Earth, a dynamic record of sea-level change associated with deposition of the world's strata, and transmutation of species.

This is not the place for an exhaustive analysis of Bertrand's many specific contributions within the *Recueil*. Rather, we will focus on just a few elements that highlight his vision of natural theology in action. In discussing the interior structure of the Earth, Bertrand introduced many ideas of recent and contemporary writers, but also called on the naturalist to use fieldwork to understand glaciers, caverns, mountains and the layers of the Earth. By mid-century he was quite scathing of 'system builders' and theorists who conjectured about the world without grounding their concepts in field-based reality. Whiston, Burnet and Woodward were particular targets for the sweep of their vision, which was seemingly unrelated to empirical fact (Bertrand 1766, pp. 57–64). Bertrand criticited Woodward by stating that his musings about the Earth being dissolved during the biblical Flood represented a hypothesis, 'well removed from the simplicity that nature follows, reason approves, and a Philosopher demands' (Bertrand 1766, p. 64). He went on to say that it was better to describe realities than attempt to build 'explanations' that are counter to nature. One can almost feel his facts-only 'accumulator' mentality at work.

Despite his own warnings about theorizing, Bertrand wanted to give his readers the full story of the Earth's interior structure, so he boldly reported on its three key elements: (1) the deep interior, which was regular and uniform, and which had been generated at the creation of the world; (2) the shallow surface layers of complexly related deposits of sand, marsh and sediment, which owed their origin to the biblical Flood; (3) the superficial and recent 'accidents' that included everything from figured stones to caverns. (See Rappaport (1982) for an in-depth commentary on the interpretation of 'accidents' in eighteenth-century natural history.) We cannot read Bertrand's mind, but it is evident that there were occasions when he took what might appear to be dichotomous stances, such as arguing for 'facts' but providing highly theoretical comments about the structure of the Earth, or when he demanded careful observation of nature, but used the biblical Flood to produce major results. This disconnect might strike many observers in the twenty-first century as problematical. Was Bertrand playing the role of empirical scientist one moment but retreating to miracles when it seemed necessary to invoke God's power? It is perhaps necessary to view him in his own time and his own place. He really was the servant of two masters: emerging modern science and his theological tradition of accepting God's occasional active involvement with the world.

It is also fascinating to see Bertrand struggle with the nature of fossils (in the modern palaeontological sense, not the eighteenth-century all-inclusive vision of anything dug from the Earth). In the text (Bertrand 1766, p. 74) he claimed that the organic-seeming features were just like all other rocks and were created by God in the very beginning. But then, in a footnote on the same page, he admitted that he had been wrong in his original 1752 essay, and that by 1766 he had realized that marine fossils were truly organic remains, many of which had lived in seas that post-dated the creation. The mid-eighteenth century can be seen as a dynamic era, and the honest scholar could find himself in the jaws of a dilemma as he tried to explain the natural world without refuting his long-held religious beliefs. One minute an author could wax eloquent about the amazing amount we knew about nature, and in the next moment he could throw up his hands and say (Bertrand 1766, p. 80) that true reasons explaining many phenomena were simply unknown and it was important to admit our ignorance in the face of God's infinitely complex world.

A prime example of divine power's operation in altering the planet's structure was the biblical Flood and its impact. Again, we see Bertrand struggle with his desire to provide answers for his reader, but back away from offering a single coherent theory that would explain everything. He could firmly state that the Flood was real and had the power to create many of the features we saw in the structure of the Earth. As examples, the work of violent erosion and large-scale deposition led to existing strata, and structural cataclysms related to foundering of the vaults of the Earth's interior could have produced the complex rock structures seen in mountains. However, he had to wonder at the source of the phenomenal amount of water and how the flood mechanisms actually operated. He concluded that searching for explanations was unnecessary because the visible effects were fundamentally due to the immediate action of God. Thus, secondary causes need not be of sole concern. Natural theologians had a powerful tool at their disposal and when rational explanations faced insurmountable difficulties, they could invoke a truly divine power. As we will see, that comforting concept would have its shortcomings in a more secular world. Bertrand may be an exemplar of the rearguard of the authors struggling to combine observation and explanation of nature with the tradition of final causes.

Along with oceans, mountain ranges are among the largest and most striking major structures on the Earth's surface. They must, Bertrand felt, have been expressly designed by God to perform important tasks. Following in the footsteps of

John Ray, Bertrand proposed, in his 'Essay on the Usage of Mountains', a number of detailed reasons why our planet is graced by mountains. As noted above, the post-Darwinian cynic may snigger, but imagine the allure of comprehending the works of God and the operation of the natural world as you gaze on the majesty of mountains. Isn't it obvious that mountains supply natural beauty? They also affect climate, are the sources of springs and rivers, serve as 'skeletons' or backbones for the planet's surface, divide peoples and create natural boundaries, and are, of course, superb illustrators of God's design. Even the obvious inequalities in mountain height and nature are not due to blind causes, but are the work of a wise hand that guides providential results (Bertrand 1766, p. 107). The sky-scraping mountains of Asia and South America, as well as the low Appalachians of North America, were known quantities at the time, so their variations had to be considered. Well before Horace Bénédict de Saussure (1740–1799) climbed Mont Blanc (in 1787) and the Romantics dramatized alpine scenes, Bertrand was writing lyrically of the beauty of mountains and the potent messages they conveyed about the ability of properly interpreted nature to reveal divine beneficence. Even the bounty of wineries and the fine taste of highland game were due to the existence of just-right slopes. Such claims may strike the modern reader as over-reaching, but Bertrand had a happy vision, and he wanted his readers to join him in the celebration. For example why are there huge holes in the ground? Because caverns give proportion to the heights of mountains and thus provide orbital stability for the globe. Again, we may recoil from such explanations, but Bertrand actually did go down into caverns and was forcefully struck by their combination of crystalline beauty and dark mystery. He proposed an empirical research programme for taking cavern and hot-spring temperatures worldwide. The more we know, the more we understand. He explained (Bertrand 1766, p. 201) to the reader that, 'If we transport a Savage from North America into a European palace, he will not know the purpose of things, but that is due to his ignorance, not lack of purpose (in the palace's design).' In an almost Leibnizian view of the best of all possible worlds, Bertrand claimed that all mountains formed at the same time, provided us with innumerable benefits, and were the designed product of a mandatory set of external and internal structures. Showing the depth of his desire to combine God's word and the world, he argued that 'the authority (of brilliant precursors) cannot convince me . . . and nothing can lead me away from what the Holy Scriptures teach me, which is always in accord with experience' (Bertrand 1766, p. 206).

Following the discussion of the usage of mountains, the *Recueil* presented 'Memoires historiques et physiques sur les tremblemens de terre'. An 'Avertissement' from the publisher made the point that earthquakes are terrible events and are obviously associated with the internal structure of our globe. Furthermore, he commented that Monsieur Bertrand was among Europe's most distinguished naturalists and that readers should therefore appreciate his insights regarding major Earth phenomena. Thus, Bertrand's cataloguing of noteworthy tremors throughout recorded history was a significant advance in the public's knowledge about earthquake activity. His account hearkened back to the Ancient Greeks and Romans, all of whom saw a God as first cause in the shaking of the earth. Pagans of the past were suspect, in Bertrand's theological view, but he applauded the fact that they saw the work of a deity as critical to understanding the world of nature. Equally suspect were excessively theoretical constructs that purported to explain complex realities, although Bertrand concluded that conjecture was occasionally helpful in illuminating a topic. He shared the view of his Swiss confrère and contemporary, Charles Bonnet (1720–1793), who commented, in his *Contemplation de la nature*, 'To entirely banish from physics the art of conjecture would reduce us to pure Observation; and to what would Observation serve us if we couldn't draw out the least consequence?' (Bonnet 1764, p. xi).

Thus, Bertrand discussed the potential causes of Earth tremors: internal fire, winds, action of subterranean water, and volcanic activity. Experiments on volcanology, by Lémery, and on sulphurous vapours, by Flamsteed and Hales, were cited as relevant to understanding the violent Earth. Attracted to the potential for pyrites and sulphurous products to be a cause, Bertrand noted that the actual placing of such materials in specific zones was up to God. The keys to generating earthquakes were therefore (1) chemical action and (2) the resultant heat. Italy was prone to instability because of the richness of pyrite veins in that country, whereas Switzerland had so much surface and internal water that conflagrations were suppressed. As might be expected, Bertrand retreated somewhat from purely theoretical musings and stated that naturalists needed to describe every aspect of earthquakes in great detail. The great 1755 earthquake of Lisbon was cited as an example of a horrific event that none the less provided considerable helpful information about the nature of earthquake motions and the structural consequences of shaking edifices. Admitting that mere human beings were a long way from full understanding of why the Earth quakes, Bertrand went on to offer a valuable compendium of earthquakes through time. He reported that a quake in AD 563 killed those who deserved to die; epidemics were associated with a tremor in 802; fountains turned red after an event in 1021; and shaking continued for 40 days after a violent quake in 1128. Counting on historical records to provide exact dates could be inexact, and gathering true observations of ancient events was, Bertrand acknowledged, a difficult proposition. Thus, he concentrated on analysing the well-documented Lisbon quake and tremors felt in Switzerland after 1755. His descriptions were detailed, but his aim was broad, in that he hoped to show that events operating on Earth scale could only be due to the power of God. Here was a topic worthy of natural theology. Bertrand presented eight 'Mémoires' focused on earthquakes. All of the authors cited and contentions laid out in the somewhat repetitive accounting need not concern us here, but the underlying reason for the depth of attention is evident. If human observation and description could illuminate the workings of God's most impressive actions, a new depth of scientific comprehension could be combined with rewarding insight into the laws and powers of divine design.

Similarly, it would be gratifying to understand those amazing 'figured stones' found in mountains and throughout the rock strata. They certainly resembled shells found in modern seas. Guettard (1759) had taken Bertrand to task for saying (pre-1766) that fossils found in the mountains could not be the same as those in the sea. In the view of Guettard (1759, p. 413), 'Why have recourse to the supreme and immediate will of God, when one can explain the effect by a closer cause?' Such criticisms had weight, and here we see Bertrand's willingness to change his mind and to yield to potent observations from nature. Contrary to his prior views, by the time of the *Recueil*, he admitted (Bertrand 1766, p. 74) that he had changed his mind and could no longer deny the organic nature of marine fossils. He went on to note that it was difficult to decide if they were deposited in the rock record after the Flood itself. However, he had no doubt about what the figured stones were saying: 'It is useful to generate catalogues of fossils in order to appreciate the beauty, excellence, and grandeur of these magnificent works of the Creator' (Bertrand 1766, p. 150).

In his 'Essai de minéralogie ou distribution méthodique des fossiles propres et accidentels', incorporated in the *Recueil*, Bertrand discussed classification, specifically noting his debt to Linnaeus. He commented on the difficulty of recognizing affinities between organisms, he defended the chain of being, claiming that it would be unbroken if only we knew enough about nature, and he presented previous theories regarding the distribution of fossils in rock strata. Modern readers not familiar with eighteenth-century linguistic conventions might be surprised to find, in an essay on 'fossils', a classification scheme (Bertrand 1766, p. 389) for the inorganic products of the Earth. For Bertrand, 'fossils' included all materials found buried in the Earth's surface. Just as Linnaeus could classify organisms in the plant and animal kingdoms, the astute naturalist could subdivide the mineral kingdom. Thus, Bertrand's 'General Division of Fossils' listed: (1) earths; (2) salts; (3) bitumens and sulphurs; (4) rocks; (5) minerals and demi-metals; and (6) metals. Orderly relations could be seen within the mineral kingdom if only scholars could explore nature fully and recognize the underlying relationships that God had created. Evidence of God's providence was everywhere.

Order, in the form of a great chain of being, was evident in the organic realm. Louis Bourguet (1678–1742) had beautifully illustrated that chain in his *Traité des pétrifications* Bourguet (1742) (Fig. 4). He showed his readers a presumed 'fungus' (a 'sea-mushroom', although actually it appears to be a horn coral) as figure 1 in his plate 1. He then moved up the ladder of creation, through corals, clams, crinoids, ammonites and the known fossil invertebrates, until reaching the vertebrates. His final link in the chain (figure 441, in his plate 60) purported to illustrate a skeletal remnant of *Homo diluvii testis* ('Man, witness of the Deluge'). The impact of Bourguet's story is undercut by the fact that the specimen was subsequently shown by Georges Cuvier (1769–1832) to be a salamander skeleton. Despite attributions that today are seen as invalid, the potential for a reader to witness graphic evidence of the long parade of God's creatures, from fungi to hominids, had to be an exciting, stimulating and rewarding experience. Bertrand shared that feeling of excitement at seeing such obvious order in the organic realm. However, he was not blind to the mysteries of nature, nor to the problem of perceiving an oversimplified and diagrammatic chain. The facts that life has degrees of similarity across nomenclatural boundaries and displays shadings of classification were not lost on him. Some vegetation shows 'sensibility' to external conditions, some animals grow much like plants, some animals seem to have roots and flowering elements, and the 'zoophytes' dwell in a twilight realm between animal and plant. In the final analysis, however, he had proclaimed in the *Dictionnaire* that 'Order is one of the great merits of a properly classified collection of natural history' (Bertrand 1763, p. xiij), and he expressly endorsed the chain of being, as promulgated by Leibniz and Bourguet.

Moving from the cosmic to the local, Bertrand included materials in the *Recueil* that had a focus on Bern, Switzerland. The 'Essai de la minérographie, et de l'hydrographie du Canton de Berne'

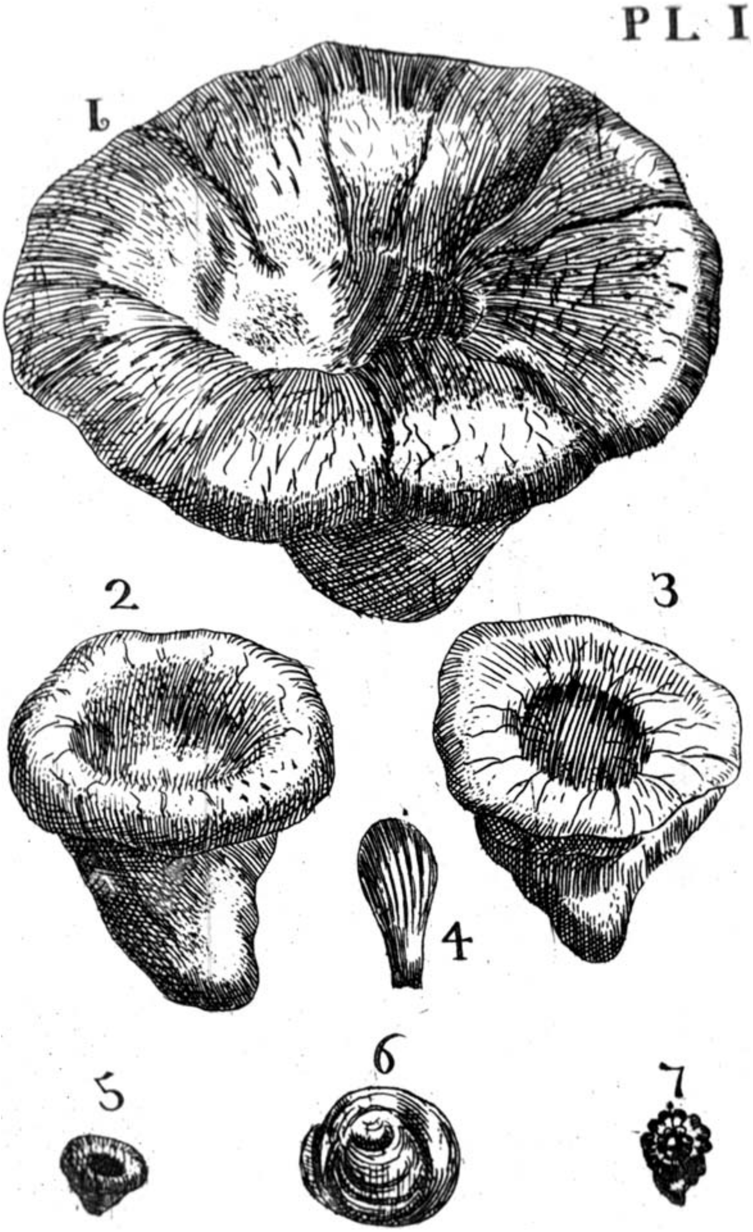


Fig. 4. The first and last figures from *Traité des pétrifications* (Bourguet 1742). From the author's personal copy of the book. (**a**) Figure 1 of plate I was said to be a 'sea mushroom' and (**b**) figure 441 of plate LX was a purported hominid (*Homo diluvii testis* or 'Man, witness of the Deluge').

and a 'Catalogue systématique des fossiles du Canton de Berne' gave the reader insight into Bertrand's application of his large-scale vision to the natural history of his home base. He bemoaned the lack of detailed knowledge about the region and the tendency of the Swiss to be dazzled by the natural history of other countries, when their own area was so rich in earthly products. He also contrasted the interests of the physicist, desirous of finding abstract laws, with the naturalist, content to observe, classify and augment knowledge through experiences flooding into his own senses.

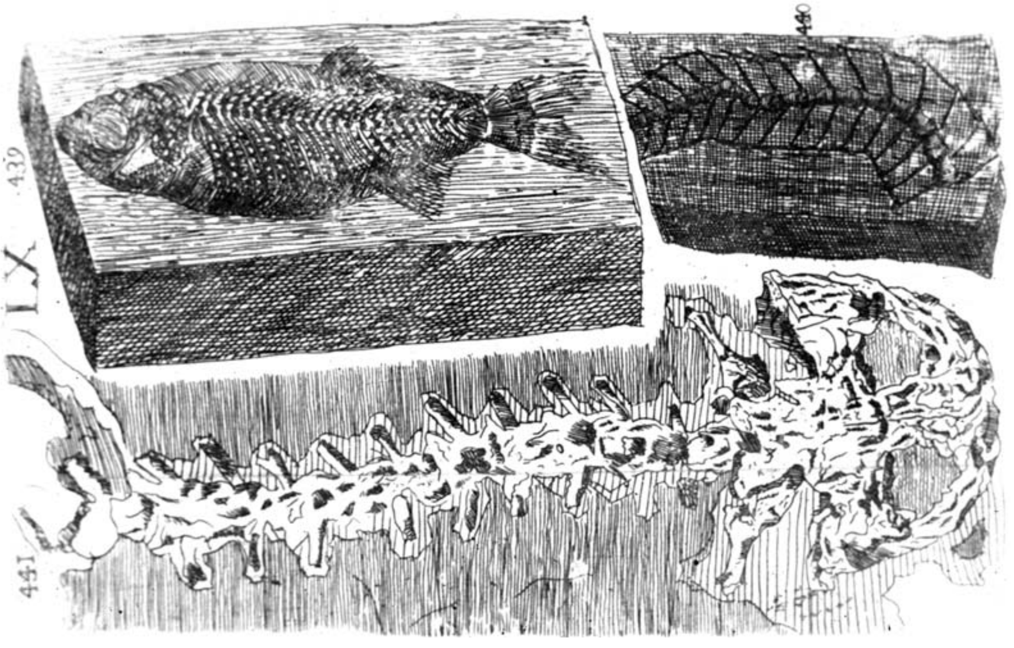


Fig. 4. (*Continued*).

If only the Swiss authorities would honour their local natural history the way the Swedes did, he lamented, Bern and the neighbouring cantons would be justly celebrated. The various fountains and mineral springs in the region around Bern received attention, as did the chemical composition of the surface and underground waters. Details aside, the key point was that all those sources of water served for the well-being of mankind. In discussing his own collection and catalogue of natural history specimens, Bertrand reported that rather than a scheme built on place names in alphabetical order, as was the case with some 'cabinets', he resorted to a systematic index based on genetic relationships. In a synopsis of his intellectual stance regarding natural theology, he noted: 'Insofar as nature is well studied, God will be better understood' (Bertrand 1766, p. 439).

The prime point of the 'Lettre sur les inondations du Nil, et l'usage des montagnes de L'Abissinie' was the familiar one that mountains exist for a reason. In this case the mountains served as a feeder system for the waters that end up in the Nile and were used to irrigate Egypt. Mountains slow the motion of clouds and cause precipitation; thus, the water accumulates and flows into fluvial systems. Bertrand recognized that it would be best to have a good map of the Nile before speaking of lead-in tributaries, but he considered all available versions to be lacking in veracity. The mountains of Abyssinia were thus seen as the providential bulwark that caused clouds to generate the precipitation that fed the Nile.

The *Recueil* ended with Bertrand's 1754 letter to the Perpetual Secretary of the Royal Academy of Sciences and Belles-Lettres of Prussia. In his 'Lettre sur la diminution des mers, et l'origine des montagnes', he commended Monsieur Formey for countering the preposterous views expressed in Benoît de Maillet's outrageous book *Telliamed* (de Maillet 1748). Accepting the fact that the waters of the biblical Flood once covered the planet, Bertrand none the less ridiculed de Maillet for his calculations about the diminution of those waters. The absurdity of presuming to calculate such events aside, Bertrand was scandalized by the length of time required, given the rate suggested by de Maillet. Such notions would require 'time immemorial' (Bertrand 1766, p. 531) and would never fit into the Mosaic chronology. Moving on to the origin of mountains, Bertrand discussed the work of Johann Georg Sulzer (1720–1779) in a positive light. Sulzer disagreed with de Maillet's mechanisms, but spoke of a shifting in the centre of gravity of the Earth, a notion that Bertrand found unacceptable. More believable, in his view, were causes related to earthquakes or diluvial deposition. Bertrand could not conceive of major mountains being formed after the creation or after the biblical Flood. He called for recognition of the fact that Earth history was likely to be limited to three dominant stages: creation, the Flood, and recent events. We must never, he contended, move away from the Mosaic chronology and the beautiful and providential design that God had given our planet.

The dream is not fulfilled

Alas, perfect design was not everywhere evident. The mission of the natural theologians did not succeed, and the illustrious career of Élie Bertrand was soon forgotten. What happened? In general terms, the paradigms shifted, the old visions were replaced, and the work of the describers was largely forgotten.

More specifically, there were 'internal' and 'external' problems associated with the alluring dream. (1) Internally, the power of the programme of the natural theologians suffered from their own bickering: everyone had the best and only theory. As Porter (1979, p. 107) put it, 'the anarchic cacophony of opinions deafened ears and invited satire'. Even Bertrand entered the fray, claiming (Bertrand 1766, p. 206) that Burnet, Moro and Buffon were brilliant men and had interesting theories, but were wrong for trying to create systems that were not predicated on the Bible. (2) By the middle of the eighteenth century, Enlightenment rationality and increasing secularism were not fully receptive to explanations having a solely religious basis. (3) It might also be noted that the *philosophes* of France were moving toward a more secular view of the world, and the visions of a Francophone Swiss pastor and natural theologian were losing their attraction. The deep motivation to see the world as a product of final causes, whether in Aristotelian terms or in the context of an active God benefiting humankind, was being replaced by an increasingly empirical stance. (4) Thus, there was an aversion to theoretical constructs that lacked any potential for empirical testing. On epistemological grounds, non-testable theories were not in line with Baconian science. (5) There was also the problem of too many data. In an era of collecting, describing and cataloguing, the number of disparate 'facts' overwhelmed any single coherent theory. Voltaire could wax satirical in *Candide* about mid-century 'explanations' for the cause of earthquakes, because there was no easy way to explain the huge amount of data and specific facts. (6) Particularly suspect were those theories that depended upon the action of an intervening God for their operation. As Laplace (1749–1827) has been quoted as saying, there was 'No need for THAT hypothesis' (De Morgan 1915). The evolution from God-driven to secular science echoes the point made by Barton (2007) that God was a critical element of natural theology and natural philosophy in the late seventeenth and much of the eighteenth century, but by the nineteenth century God was largely excluded from explanations, and the worldview gave way to natural science. It was an era in which 'geology was self-consciously created as a new kind of natural science' (Morrell, 2006, p. 614). (7) 'Externally', of course, there was the mid-nineteenth-century issue of Darwin and the demise of design. Once the world was seen as the product of natural selection and mechanistic chance, the edifice build on design foundered. Bertrand had already noted that disturbing potential, writing that, 'To attribute the formation, direction, or governance . . . to blind principles is to show that one is studying nature in a very superficial way and that one his little knowledge of the Divinity' (Bertrand 1766, p. 161).

However, by the time of Bertrand's death, change of organic form through time, and extinction of entire faunas, were well documented. Such realities hinted at an uncertain or incompetent designer. We may, of course, still see vestiges of design theory in the musings of some writers in the twenty-first century, but not from the central figures in establishment science. Sepkoski (2006) has presented an informative review of contemporary books treating the debate between advocates of evolutionary theory and those believing in intelligent design or some form of creationism. In sum, as far as the natural theologians of over two centuries ago are concerned, their beautiful aspiration of a cosmic synergism of scripture and science did not survive the Darwinian revolution.

On the individual level, Élie Bertrand's legacy dimmed because he was an 'accumulator' rather than a 'paradigm shifter'. His work as an observer, describer and popularizer was respected in his own time, but it did not have the innovative power to survive in the coming decades and centuries. At a time of spectacular illustrations, as in the *Encyclopédie* of Diderot and d'Alembert, his non-pictorial works suffered by comparison. More substantively, he could not 'deliver' on the promise of providing a gratifying synthesis of God's word and nature's record. As was the case with natural theology in general, his contributions to the evolving geosciences were helpful and catalytic when first proposed, but did not provide anything of value for the era of provocative and productive concepts that would stem from the Darwinian revolution. By the late eighteenth century, attempts to explain nature in the context of providential or anthropocentric notions related to divine purpose were losing their lustre and relevance. The exciting prospect of marrying the word and the world was becoming passé. Monsieur Élie Bertrand and his valiant efforts sank from view.

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The reception of geology in the Dutch Reformed tradition: the case of Herman Bavinck (1854–1921)

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Abstract: The favourable reception of the great antiquity of Earth by nineteenth-century Presbyterian theologians in Scotland and the USA has been well documented. Less clear is how their conservative Dutch Calvinist counterparts responded to discoveries about Earth history. Here I initiate an examination of attitudes toward geology among Dutch Reformed theologians of the late nineteenth and early twentieth centuries with a case study of Herman Bavinck (1854–1921). Bavinck was arguably the premier Dutch Calvinist theologian of his generation. In his four-volume *Gereformeerde Dogmatiek*, he discussed geology in relation to biblical teaching about the creation of the Earth. He expressed great appreciation for geology. On several points of textual interpretation, he adopted positions consistent with acceptance of an old Earth. However, working with out-of-date information, and not understanding fundamental geological principles, Bavinck concluded that the concept of an ancient Earth was unacceptable. Bavinck's ideas about geology negatively influenced subsequent Dutch Reformed theologians. Dutch Calvinists, both in the Netherlands and the USA, may have been less open to the discoveries of geology than Scottish and US Calvinists because of the nature of Dutch geology, lack of contact between Dutch theologians and geologists, and Dutch Reformed persuasion that worldviews powerfully shape the content of science.

Livingstone (2003) has demonstrated that the acquisition, dissemination, reception, application and other dimensions of scientific knowledge are significantly affected by location. Viewed on a local scale, whether science is done in the laboratory, field, museum, hospital or elsewhere profoundly shapes the way in which it is done. Viewed on a regional scale, location shapes the kinds of questions asked of nature, the methods employed to acquire information, the circulation of information and attitudes toward presumed scientific knowledge. As one example, Livingstone (2003) showed that the Darwinian theory of evolution by natural selection received surprisingly different responses in the late nineteenth century in three major centres of Calvinistic influence: Belfast, Edinburgh and Princeton.

We can clearly see a locational (geographical) component to the character and acceptance of geological knowledge. We need think only of German and US endorsement of magmatism and of British, French and Scandinavian enthusiasm for granitization during the granite controversy of the 1940s and 1950s (Read 1957; Young 2003). Whether granites of Finland or of the western USA were being studied obviously shaped views about the origin of granite. A separate topic, however, is the acceptance of geological knowledge by non-geologists, such as religious communities. Have there been geographical differences in the degree of acceptance of, say, the vast antiquity of the Earth as there were for Darwinian evolution?

There is no question that the idea of an extremely old Earth was accorded a generally favourable welcome within both Scottish and US Presbyterianism for the past two centuries (Livingstone 1989; Numbers 1992). Largely because of the influence of Chalmers (1814), Fleming (1823, 1826), McCosh (1888) and Orr (1907), all of whom were prominent, orthodox Calvinist, Presbyterian intellectuals in the Church of Scotland, the Free Church of Scotland or the United Free Church of Scotland, Scottish Presbyterians warmed to the notion of an old Earth. Arguably the most influential of all was Miller (1858), a stonemason, amateur geologist and prominent Calvinist layman in the Free Church of Scotland, who vigorously and elegantly popularized geological findings and persuasively showed the compatibility of geology with orthodox Christian belief for church audiences as well as the general Scottish public.

Among US Presbyterians, prominent Princeton theologians, such as C. Hodge (1872), his son A. A. Hodge (1860) and Warfield (1915), expressed few misgivings about the idea of an old Earth, perhaps in part because of the popularizing labours of highly regarded Calvinistic geologists such as Guyot (1884) at Princeton, Dana (1880) at Yale, and Dawson (1898) at McGill.

The question at hand

To my knowledge, attitudes toward geology within the Dutch Reformed tradition, a close ecclesiastical and theological relative of Presbyterianism, are not so well understood. Thus, in this paper I initiate

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an inquiry into attitudes towards geology, particularly the idea of an ancient Earth, by the Dutch Reformed community. I begin with an examination of the theologian Herman Bavinck (1854–1921) to (1) discover Bavinck's own understanding of and attitude toward geology, and (2) take note of his influence on two important successors, the Dutch theologian Valentine Hepp and the Dutch–American theologian Louis Berkhof.

There are two reasons for beginning with Bavinck. First, he was arguably the most profound Calvinistic theological thinker of his era, equalling if not surpassing such theological colleagues as Abraham Kuyper of the Free University of Amsterdam, James Orr of the United Free Church College in Glasgow, and Benjamin Breckinridge Warfield of Princeton Theological Seminary, himself arguably the USA's greatest Calvinistic theologian since Jonathan Edwards. Bavinck was a prolific writer on many topics from a theological point of view, including education, psychology and political thought. His greatest achievement was a massive four-volume treatise entitled *Gereformeerde Dogmatiek* (*Reformed Dogmatics*). The second reason for selecting Bavinck for study is that the century-old *Gereformeerde Dogmatiek* has just been translated into English for the first time (Bavinck 2004, 2006).

Fig. 1. Herman Bavinck (1854–1921). *Source*: Archives, Calvin College.

Who was Herman Bavinck?

Herman Bavinck (Fig. 1) was born on 13 December 1854, in Hoogeveen, in the province of Drenthe in the Netherlands (Bavinck 2004, pp. 12–15). His father, the Reverend Jan Bavinck, was a prominent pastor in the Christelijke Gereformeerde Kerk (Christian Reformed Church), a denomination that traced its roots to a secessionist movement that led to the *Afscheiding* (separation, secession) of 1834. The ecclesiastical separatists protested state support and control of the Nederlandse Hervormde Kerk, the national church of the Netherlands. The seceders, regarding the national church as elitist, lacking in piety, and lax in upholding its orthodox Calvinistic confessional standards, sought to recover fidelity to traditional Calvinist orthodoxy, liturgy and spirituality, and Presbyterian ecclesiastical government.

After one year (1873–1874) at the Christelijke Gereformeerde Kerk's Theological School in Kampen, Bavinck decided to attend the University of Leiden. Although Leiden was noted for an aggressively modernistic, scientific approach to theology that was not friendly toward Christian orthodoxy, Bavinck very much wanted to understand the currents of thought shaping contemporary theology and ecclesiastical practice. He completed his doctoral work at Leiden in 1880 with a dissertation on the concept of the state in Zwingli's theology. After graduating from Leiden, he served as a minister of a Christelijke Gereformeerde congregation at Franeker, Friesland, for a year and a half, where he drew large crowds to hear his outstanding sermons.

In 1882, at age of 28, the Reverend Herman Bavinck was appointed as a professor of theology at the Theological School at Kampen where he taught dogmatics, encyclopedia of sacred theology, ethics and philosophy. Another reform movement within the national church known as the *Doleantie* (time of mourning) culminated in the establishment of the Nederduitsche Gereformeerde Kerk (Dolerende) in 1886, when several congregations seceded from the national church. In 1892, this new seceder denomination joined with Bavinck's church to form the Gereformeerde Kerken in Nederland (GKN), and Bavinck became a minister in the new union church. In 1902, he joined the faculty of the Vrije Universiteit (Free University) of Amsterdam, an institution founded in 1880 by Abraham Kuyper. Here Bavinck taught systematic theology, succeeding the polymath Kuyper who had recently been appointed Prime Minister of the Netherlands. In 1906, Bavinck was inducted as a member of the Royal Academy of Sciences in recognition of his scholarly work. Two years later, he travelled to North America to deliver the Stone

Lectures at Princeton Theological Seminary on the topic of 'The Philosophy of Revelation.' In 1911 he was elected a senator in the Dutch parliament.

Bavinck was unquestionably the leading theologian in the complex of ecclesiastical movements that had been shaped by the *Afscheiding* and *Doleantie* separations from the formalism of the Dutch national church. A man of great intellect and thorough scholarship, he was noteworthy for his desire to be faithful to the theological tradition of pietistic and Calvinistic orthodox Christianity of which he was a part while yet engaging with and assessing intellectual and spiritual currents of his time. For Bavinck, that meant intense involvement with theological, religious, philosophical, sociological and political developments. Not stopping there, he also did his best to understand advances in geology, astronomy and other natural sciences, and to assess their effect on Christian theology.

The US editor of the translation of the second edition of Bavinck's *Gereformeerde Dogmatiek*, theologian John Bolt of Calvin Theological Seminary, observed that

> A certain tension in Bavinck's thought between the claims of modernity—particularly its this-worldly, scientific orientation—and Reformed pietist orthodoxy's tendency to stand aloof from modern culture continues to play a role even in his mature theology expressed in the *Reformed Dogmatics* . . . we see the tension repeatedly in Bavinck's relentless efforts to understand and, where he finds appropriate, to affirm, correct, or repudiate modern scientific claims in light of scriptural and Christian teaching. Bavinck takes modern philosophy (Kant, Schelling, Hegel), Darwin, and the claims of geological and biological science seriously but never uncritically. His willingness as a theologian to engage modern thought and science seriously is a hallmark of his exemplary work (Bavinck 2004, pp. 14–15).

One of his contemporaries described Bavinck as 'something of a man suspended between two worlds: a Secession preacher and a representative of modern culture' (Bavinck 2004, p. 14).

Bavinck's views on creation

Bavinck's views on astronomy, cosmology and geology occur primarily in Volume 2 of *Reformed Dogmatics* entitled *God and Creation* (Bavinck 2004). The section on creation, about 300 pages long, includes Chapter 10 entitled 'Earth: The Material World'. Although it is in this 34-page chapter that we find the bulk of Bavinck's comments on geology, relevant comments also appear in Chapter 11 on 'Human Origins' in Volume 2, and in Chapter 4 entitled 'The Punishment of Sin' in Volume 3 (*Christ and Salvation*, Bavinck 2006).

The new English translation is based on the second edition of *Gereformeerde Dogmatiek* originally published in Dutch between 1906 and 1911. The volume on creation was published in 1908. Chapter 10, however, differs little from the first edition published between 1895 and 1901. The only difference is that Bavinck added a couple of pages addressing the nature and significance of Babylonian creation documents that had come to light in the latter nineteenth century. Material directly relating to geology, however, was virtually unchanged from the first edition, with the exception of a few new footnotes and allusions to a lecture given by Sir George Darwin in 1906. Thus, in the English translation, we have access to Bavinck's ideas about geology as they stood at the end of the nineteenth century. In addition, Bavinck did not change a word of Chapter 10 in the 1918 third edition, which is basically a reprint of the second edition. Thus, he did not modify his published conceptions about geology in relation to theology in light of geological advances over a period of two decades. The fourth edition of 1928, published seven years after his death, is identical to the second and third editions.

In his effort to understand geology, Bavinck drew primarily from German theologians and specialists in biblical studies who had written on the relationship between Christian theology and the natural sciences (e.g. Ebrard 1861; Ulrici 1862: Zöckler 1877–1879; Reusch 1886; Trissl 1894*a*, *b*; Schmid 1906). Bavinck also consulted many German scientific works. Among those dealing specifically with geology were those by Burmeister (1872), von Zittel (1875), Suess (1883), Haeckel (1889) and especially Pfaff (1881). Bavinck neither mentioned nor cited works of British or US theologians. There are, however, citations of Anglophones interested in the Earth including Darwin (1859, 1896), Geikie (1880), Howorth (1887, 1893), Wallace (1903) and Wright (1906). Bavinck mentioned, in passing, de Luc, Cuvier, Sedgwick, Buckland, Greenough, Hitchcock, Dawson and Miller (three times), but he did not cite any of their works. No doubt he obtained information about them from other authors such as Pfaff, Reusch and Zöckler.

The omissions among Bavinck's citations are worthy of note. Although very widely read in European literature, he never cited the writings of Chalmers, Dana, Dawson, Guyot, Hitchcock, Miller or J. P. Smith, all of whom had written extensively on the relation of geology to Christianity. There is brief recognition that Buckland, Sedgwick and Conybeare were involved in development of geology but no acknowledgement of their Christian convictions. Nor did Bavinck mention US Calvinistic theologians who had written about the age of the Earth or the creation account, such as William G. T. Shedd, Charles Hodge or his son Archibald A. Hodge.

The virtual absence of literature citations relating theology and natural science by either Dutch theologians or Dutch natural scientists is striking, suggesting that Dutch theologians had given relatively little attention to geology and that Dutch geologists had paid little heed to biblical questions.

The interpretation of the biblical creation account

Bavinck was not a knee-jerk adherent of the traditional views that the days of creation in Genesis 1 were 24 hours long, that the Earth was created around 4000 BC, that animals did not die prior to Adam's fall, or that God created annoying new species after sin entered the world. On several points of textual interpretation he differed from traditional views.

(1) Bavinck (2004, p. 496) specifically maintained that the situation described in the first two verses of Genesis 1 preceded the first day of creation by a 'shorter or longer period', the prevailing view prior to 1860 (Roberts 2007). The first day began with the creation of light mentioned in Genesis 1: 3–5. In this connection, he distinguished between a first creation and a second creation. The first creation, he wrote, was an immediate 'act of bringing forth heaven and earth out of nothing', whereas the second creation that started with verse 3

> is not direct and immediate; it presupposes the material created in verse 1 and links up with it. It occurs specifically 'in time' (*in tempore*) and that in six days. Hence this second creation already anticipates the works of preservation and government. In part it is already preservation and no longer merely creation (Bavinck 2004, p. 470).

Bavinck made no judgement regarding how long the condition established by the 'first creation' lasted. 'Nor are we told', he asserted, 'in how much time and in what manner God created heaven and earth, or how long the unformed state of the earth lasted' (Bavinck 2004, p. 497).

(2) Bavinck believed that the first three days of creation were not like the last three. According to Genesis 1, light was formed, the waters above the firmament were separated from the waters below the firmament, the dry land was separated from the seas, and vegetation was formed on dry land during the first three days. Only on the fourth day, however, was the Sun formed and brought into its present relation with the Earth as a regulator of days and seasons. As a result, Bavinck maintained that the first three days could not properly be considered as regular solar days, the kind of days to which human experience is accustomed. The first three days of creation had a different character from our 24 hour days. They were 'extraordinary cosmic days' (Bavinck 2004, p. 499).

(3) Bavinck found it difficult to believe that the sixth day of creation was an ordinary 24 hour day because so many events transpired on that day. These included the creation of animals, the formation of Adam, the placement of Adam in the Garden of Eden, the giving of the command not to eat of the tree of the knowledge of good and evil, the bringing of animals to Adam, the naming of the animals by Adam, Adam's deep sleep and the formation of Eve.

(4) Bavinck decided that the whole set of six days of creation was not composed of ordinary days. Instead, they should be regarded as 'workdays of God', because they described 'days' of divine creative activity rather than days of human endeavour (Bavinck 2004, p. 500). He did not suggest how long God's days lasted.

(5) Bavinck stressed that the work of the second creation, taking place on six days, was not accomplished by a series of sheer instantaneous miracles. God did not simply bring plants, stars, birds, fish, land animals and humans into existence by way of pure miraculous fiats as he had at the absolute beginning. Rather, God's creative work entailed what theologians might call providence. Bavinck specifically used the word 'preservation'. The text does, after all, refer to God's commanding Earth to bring forth various creatures. Bavinck allowed that God might have used natural processes in the origin of these creatures. For example, in regard to day three, he stated, in reference to the separation of land and sea and the formation of mountains and valleys, fields and streams, that 'undoubtedly all these formations occurred under the impact of the colossal mechanical and chemical processes inherent in nature' (Bavinck 2004, p. 481). And of the fourth day, he wrote that, 'this does not imply that the masses of matter of which the planets are composed were only then called into being, but only that all these planets would on this day become what they would henceforth be to the earth. Together they would assume the role of light and be signs of wind and weather' (Bavinck 2004, p. 481).

All of these conclusions regarding Genesis 1 are consistent with acceptance of a formative Earth history that is considerably longer than 144 hours. Bavinck's interpretation of the text of Genesis 1 allowed for both an old Earth and the action of processes during creation week.

In regard to the age of the Earth, many biblical scholars had interpreted the genealogies of Genesis 5 and 11 literally, and from the numbers given in those chapters had calculated, for example, that 1656 years elapsed between the creation of Adam and the onset of Noah's Flood. Bavinck, however, never stated how long he believed that the time span from creation to the Flood was. He recognized that precise chronology could not be derived from Genesis 5 and 11.

On textual point after textual point, Bavinck adopted positions that have normally been rejected by those who insist on a very young Earth and frequently have been adopted by those who favour interpretations of Genesis 1 that differ from the traditional view. Was Bavinck perhaps ready to accept geological findings about the Earth's antiquity?

Bavinck's attitude to geology generally

Bavinck believed that geology, like astronomy, can teach the Christian a lot, provided that facts are carefully distinguished from hypotheses and speculations. He asserted that geology 'may render excellent service to us in the interpretation of the creation story' (Bavinck 2004, p. 496). The Bible and theology have nothing to fear from the facts brought to light by geology and palaeontology. In fact, Bavinck remarked that 'the facts advanced by geology... are just as much words of God as the content of Holy Scripture and must therefore be believingly accepted by everyone' (Bavinck 2004, p. 501). Any geologist of Bavinck's era would have been encouraged by his comment that 'there is no doubt that this theory of geological periods is much more firmly grounded than the Kantian hypothesis of the origin of the solar system; it is based on data yielded by the study of the strata of the earth's crust' (Bavinck 2004, p. 489). We get every indication from these comments that Bavinck was very open to geological science.

Bavinck on harmonization of scriptural interpretation and geology

In light of Bavinck's interpretation of Genesis 1 and appreciative comments on geology, we might expect to find him supporting one of the alternative interpretations of Genesis 1 so common in the late nineteenth century, such as the day–age theory advanced by Hugh Miller, Arnold Guyot, James Dwight Dana and J. William Dawson or the gap theory adopted by William Buckland and Edward Hitchcock. Bavinck did review the details of four attempted harmonizations of Genesis 1 with natural knowledge. These included the so-called ideal theory, which regarded Genesis 1 as an impressionistic, poetic description of creation rather than a historical account (e.g. Herder 1774–1776); the restitution or gap theory, which posited a long time period between the initial creation of the universe mentioned in Genesis 1:1 and the state of emptiness and waste on Earth mentioned in Genesis 1:2 (e.g. Smith 1840); the concordistic or day–age theory, which regarded the days of Genesis 1 as long periods of time (e.g. Dawson 1898); and the anti-geological theory, which insisted on creation in 24 hour days (e.g. Penn 1822). Bavinck saw problems with all four views. He found that the day–age theory, for example, conflicted with the biblical text in terms of the order of events. As he saw it, the Solar System came into being after the Earth according to the Bible, but the reverse was true for geology. According to the Bible, plants were created on the third day and animals on the fifth day, but geology had lower animals and fish appearing before plants. 'On many significant points', Bavinck (2004, p. 490) warned, 'there are clear differences between Scripture and science'. In the end, he refused to adopt any of the common alternatives to the traditional interpretation.

However, rather than allowing tension to stand between the existing status of biblical interpretation and geology, Bavinck then began to backpedal by expressing reservations about the legitimacy of claims about the geological time periods. Precisely the fact that he regarded the theory of geological time periods as better grounded than the Kant–Laplace nebular hypothesis for the origin of the Solar System made Bavinck nervous. In connection with the theory of geological time periods, he stated that the 'conflict between revelation and science has a much more serious character. On many points there is difference and contradiction, first of all, in the time and, second, in the order in which the various creatures originated' (Bavinck 2004, p. 487). Bavinck was also troubled by the vast amounts of time postulated by geologists for the age of the Earth. He knew that geologists and natural scientists of the nineteenth century had calculated the age of the Earth on the basis of the Earth's rotation in connection with the flattening of its poles, the continuous decrease in the Earth's temperature, the formation of the Nile and Mississippi River deltas and the formation of strata. But Bavinck winced at the numbers proposed by scientists such as von Cotta, Lyell and Helmholtz. Surprisingly, he made no mention of Kelvin or geologists such as Phillips, King or Walcott. According to Bavinck, von Cotta spoke of an unlimited amount of time, Lyell of 560 million years, Klein of 2000 million years and Helmholtz of 80 million years. Bavinck was troubled by the fact that even Friedrich Pfaff, whom he frequently cited, thought that the Earth was at least 20 million years old. 'The figures assumed for the age of the earth', Bavinck (2004, p. 490) concluded, 'are fabulous—as among some pagan peoples'. Plainly he regarded these values as purely speculative hypothetical estimates with little basis in fact. Thus, he warned that 'theology will be well advised to stick only to the indisputable facts that geology has uncovered, and to be on its guard against the hypotheses and conclusions that geology has added to the mix. For that reason theology should refrain from making any attempt to equate the so-called geological periods with the six creation days. It is no more than an undemonstrable opinion, after all, that these periods have unfolded successively and in that order' (Bavinck 2004, p. 506).

Not only was Bavinck unwilling to equate the days of creation with the millions of years postulated by geologists, but he was also unwilling to stretch the amount of time involved in the genealogies of Genesis 5 and 11 very much. He expressed doubt that the history of the human race could be stretched much beyond 5000–7000 years before Christ. For all of his nuanced interpretation of Genesis 1, Bavinck had not yet shaken off the idea of a very recent creation of the world.

Bavinck on geological facts and interpretations

Why did Bavinck dismiss the conclusions of geologists and retreat from exploring the implications of his own biblical interpretation in light of geology? A list of 10 general statements that he made about facts and interpretations near the end of his chapter on creation of the Earth indicates that he perceived that geology had failed to distinguish sufficiently between hard fact on the one hand and interpretation, speculation and hypothesis on the other. We consider the most telling of these 10 statements here.

In his first statement, Bavinck noted that geology was a young science not yet 100 years old. However, he then betrayed his true feelings when he averred that this was not such a big problem in earlier days when geologists such as von Buch and Saussure reigned. In those days, geology 'was absolutely not hostile to Scripture', but then geology became 'a weapon in the war against the biblical creation' when 'Lyell and others harnessed it to the doctrine of evolution'. Given this state of affairs, geology needed to be cautious (Bavinck 2004, p. 501), and theology needed to guard against making concessions to a science that is 'still completely new, imprecise, and incomplete' (Bavinck 2004, p. 507). As geology matured it would eventually correct itself.

By way of assessment of this first statement, we make four brief points. First, serious geology had already been going on for at least 150 years when Bavinck wrote. Saussure, after all, died in 1799. Second, Bavinck did not alter this assertion between 1897 and 1918. Third, his misleading claim that Lyell harnessed geology to evolution indicates that Bavinck's knowledge of the history of geology was defective. Moreover, the early days of geology included non-Christians such as James Hutton, and the later years when geology was supposedly led astray by evolution featured outstanding Christian geologists such as Guyot, Dana, Dawson and Winchell who, to use Bavinck's expression, were 'absolutely not hostile to Scripture'. Last, it appears that Bavinck's real problem was not so much the alleged youth of the science, but his inaccurate perception that geology was under the control of people hostile to Christian faith, a somewhat ironic position for a Calvinist such as Bavinck to adopt given that Calvin himself welcomed the discovery of truth no matter who discovered it (Young 2007). In any case, this first statement allowed Bavinck to downplay the significance of geological claims.

In his second statement, Bavinck likened geology to the archaeology of Earth. Even though geology could acquaint us with the conditions of the past, he wrote, it tells us virtually nothing about the cause, the origin and the duration of conditions (Bavinck 2004, p. 501). Although that assertion may have been true to some extent, it was over-pessimistic. After all, if forensic science can reconstruct the history of a crime scene from raw data, and a jury can convict a criminal on the basis of forensic evidence, geology certainly has the potential for ascertaining causes. Even in the nineteenth century, geologists could recognize igneous eruption as the cause of lava flows and deep burial as a contributing cause of metamorphism. Also, reasonable estimates of sedimentation rates or terrestrial cooling rates could be made, and that is better than knowing nothing about the duration of conditions.

The fourth statement of Bavinck (2004, p. 502) was that the Earth layers 'nowhere occur all together and completely'. However, he failed to realize that this fact does not undercut the geological periods. He seemed unaware of methods of correlation and was unaware that there is no geological reason to expect continuous, uninterrupted deposition anywhere on the Earth.

The next statement was that only a small part of the Earth's surface had so far been investigated (Bavinck 2004, p. 502). Bavinck drew on the claim of Ernst Haeckel that very little of the Earth's surface had yet been explored. Haeckel (1889, p. 355) had written that

> Our record of creation is also extremely imperfect from the circumstance that only a small portion of the earth's surface has been accurately investigated by geologists, namely, England, Germany, and France. But we know very little of the other parts of Europe, of Russia, Spain, Italy, and Turkey. In the whole of Europe, only some few parts of the earth's crust have been laid open, by far the largest portion of it is unknown to us. The same applies to North America and to the East Indies. There some few tracts have been investigated; but of the larger portion of Asia, the most extensive of all continents, we know almost nothing; of Africa almost nothing, excepting the Cape of Good

Hope and the shores of the Mediterranean; of Australia almost nothing; and of South America but very little. It is clear, therefore, that only quite a small portion, perhaps scarcely the thousandth part of the whole surface of the earth, has been palaeontologically investigated. We may therefore reasonably hope, when more extensive geological investigations are made, which are greatly assisted by the constructions of railroads and mines, to find a great number of other important petrifactions.

Assuming for the moment the accuracy of Haeckel's assessment, we note that, as with the other nine items on his list, Bavinck made this assertion in his first edition, allowed it to stand in 1908, and further allowed it to stand in 1918. During that 20 year period geological knowledge had advanced substantially. Moreover, by the time of publication of Bavinck's first edition, geology had progressed far beyond what either he or Haeckel had intimated. That was certainly the case in the USA: the West had been mapped in reconnaissance by expeditions by King, Hayden, Wheeler, Powell, Newberry and others; the Rogers brothers and others had mapped much of the Appalachians; James Hall had worked out the stratigraphy of western New York; and the geology of much of the Midwest was known at least in reconnaissance. In addition, the expeditions by Scott, Osborn, Cope, Marsh, Sternberg, Leidy, Meek, Lesquereux and others had disclosed a wealth of palaeontological information. A substantial amount of field study occurred in Russia and Italy, and preliminary work was being done in South Africa, Australia and India. Also, shortly before Bavinck published his work, the expeditions of John Bell Hatcher to Patagonia were expanding palaeontological knowledge of the southern part of South America. And with all of that, nothing turned up to challenge the basic idea of the geological periods.

The seventh statement was that 'the order in which the earth layers occur cannot be a standard for calculating the time and duration of the formation', and the eighth was that 'the time of formation of earth layers and the order of their position, therefore, is almost exclusively determined in terms of the fossils found in them' (Bavinck 2004, p. 503). Bavinck lamented that geology had become captive to palaeontology and that palaeontology had become captive to the theory of evolution. What he did not grasp is that the order of layers is a physical, geometrical phenomenon, determined by superimposition, and the employment of fossils for the determination of the position of a layer is secondary, typically more important where the relations of physical stratigraphy are uncertain. Interesting, too, is the fact that Bavinck knew that calculations of the Earth's age were based on the thicknesses of sedimentary rocks. Even though there was considerable variation in the ages calculated by different geologists, all of the estimates were in the millions of years, and yet Bavinck discounted that evidence out of hand.

The ninth statement was that, although 'in certain layers usually also fossils of certain plants and animals occur', nevertheless from such a state of affairs 'nothing can be inferred with certainty for the theory of evolution or for the geological periods' (Bavinck 2004, p. 504). At this point Bavinck introduced what has sometimes been designated the theory of ecological zonation. In essence, he maintained that, because different kinds of plants and animals live in different environments separated both laterally and vertically from one another, all that is preserved in strata is a record of different biological environments. 'The fossils', he wrote, 'are not the representatives of the time in which these organic beings originated, but of the higher or deeper zones in which they lived' (Bavinck 2004, p. 504). Not even any reputable Christian geologist (e.g. Guyot, Dana, Dawson or Winchell) adopted that view of the stratigraphic column, and Bavinck's lack of acquaintance with thick successions of strata containing diverse fossils made him vulnerable to such an egregious error. However, as a theologian largely confined to a nation of sediment spread out horizontally below sea level, it is easy to see how he might have gone astray. Bavinck's knowledge of palaeontology was also sketchy at best. He asserted that palaeontology offered very few fossils of carnivorous animals, and, referring specifically to the rhinoceros, mammoth and mastodon, he stated that the large animals of the earliest times were all herbivores. The reference to these Pleistocene animals as 'early' is puzzling. Bavinck seemed unaware of the vast array of carnivorous vertebrates that had long ago been uncovered by US and British palaeontologists in the 1800s. Creatures with such obviously carnivorous habits as sharks, ichthyosaurs, mosasaurs, pterosaurs, plesiosaurs, crocodilians and several others were commonly illustrated in geology texts long before Bavinck set out to write his volumes. Even the works by Pfaff and Burmeister that he consulted include illustrations of several extinct carnivores.

Bavinck's list of 10 statements on fact and interpretation indicates that his conception of geology was woefully out of date. Unfortunately, he made no effort to re-examine his list of comments and bring them up to date for the third edition of 1918. That failure is especially striking in light of the discovery of radioactivity and development of early radiometric methods. In the 1918 edition there was no recognition of the existence of radioactivity or its potential for dating. The failure to modify his assertions suggests the strong possibility that no one in the Dutch Reformed orbit was in a position to point out fallacies and inaccuracies to the great theologian. Bavinck had no one in the Free University with whom to consult about geology. That discipline was not introduced at the university until years later.

It is not clear on what basis Bavinck formulated his list of 10 items. Some of the comments are reminiscent of statements made by later creationists such as George McCready Price, but Bavinck made no reference to any young-Earth advocate. If a creationist movement in the Netherlands existed we are not aware of it. Did he simply concoct these items on his own?

In the end, Bavinck shrank back from pursuing his insight that geology might render excellent service in interpreting the creation story, because he never asked how Genesis 1 might be understood in light of the geological time periods on the assumption that they might potentially be valid. Instead, he wanted to dismiss the whole concept. He never questioned whether the biblical text intended to teach a chronological sequence, and although he produced numerous arguments against six 24 hour days, he balked at taking the plunge into the idea of an old Earth.

The influence of Bavinck

Bavinck's nuanced interpretation of Genesis 1 coupled with an appreciative and thoughtful approach to geology mark him as a theologian who was cautiously open to scientific findings. It is to his credit that he engaged with and evaluated writings of legitimate scientists such as Pfaff, Burmeister, Wright and Darwin. Despite this auspicious beginning, however, Bavinck lapsed into a more or less traditionalist suspicion of a very old Earth, in part because his understanding of geology was both deficient and far out of date.

Given Bavinck's stature within the Dutch Reformed community, we must ask how his approach to geology influenced others. Here I briefly examine the attitude toward geology expressed by two theologians who followed Bavinck. Valentine Hepp (1879–1950) was Bavinck's successor at the Free University of Amstersdam in the chair of systematic theology. Like his predecessor, Hepp delivered the Stone Lectures at Princeton Theological Seminary. His topic was *Calvinism and the Philosophy of Nature* (Hepp 1930). The final lecture of the series was entitled 'Calvinism and Geology'. In that lecture Hepp adamantly insisted on a strictly literal, six 24 hour day interpretation of Genesis 1 that yielded an Earth only a few thousands of years old, as well as complete absence of death of any kind in the world before Adam's fall and also a major role for the biblical Flood in producing geological change. In contrast to Bavinck's thoughtful engagement of scientific thinking about geology that ended with his inability to follow it to its conclusions, Hepp aggressively launched a vitriolic diatribe against modern geology, marked by a tone that was decidedly biting, nasty and cynical, an approach guaranteed not to win friends to one's position. Hepp fulminated against the concept of geological time periods with its talk of millions of years. He charged that 'the entire periodistic theory which transforms the days of Genesis into geological periods must be opposed in the strength of faith. This theory will have nothing of the Scripture, the authority of which extends also over the natural sciences. It is absolutely unacceptable to the Calvinist who more than any other Christian keeps guard at the principle of the authority of the Word of God' (Hepp 1930, p. 211). Hepp maintained that 'the indications of Scripture are so clear, however, that the Christian who reveres it, cannot and may not take part in the paleontological and geological hunt after millions' (Hepp 1930, p. 200). He expressed the conviction that if scientists were 'called upon to pay taxes on these millions, their computations would be a bit more cautious' (Hepp 1930, p. 197). And unmindful of all the great Christian scientists in preceding decades who accepted an old Earth, such as Kelvin, Walcott, Miller, Dawson, Guyot, Dana and Winchell, Hepp charged that the data of the natural sciences did not demand these high numbers, and that 'it is the antithesis against faith in creation that drives to these excesses. This movement is called into being by the desire to depose the Creator of the universe and the Former of the earth willingly or unwillingly' (Hepp 1930, p. 201). A serious charge indeed. He insinuated that the 'radium–lead hypothesis' was both untrustworthy and 'inspired by the evolution myth'. Hepp railed against Christian scholars who accepted the large numbers as having, in effect, run up a white flag because they were afraid to be considered unscientific, and he chastised those who adopted other interpretations of Genesis 1 in place of traditional literalism. One wonders whether his lecture audience felt some discomfort. After all, for decades Princeton Seminary had included faculty members such as Charles Hodge, his son Archibald Alexander Hodge, his grandson Casper Wistar Hodge, Jr (Hodge had another grandson, William Berryman Scott, who taught palaeontology at Princeton University for half a century), Benjamin B. Warfield, Charles Aiken, J. Gresham Machen and others, all of whom accepted an old Earth and did not insist on a literal interpretation of Genesis 1.

Some, like Warfield, were even favourably disposed toward biological evolution.

Apart from the uncharitable and unchristian tone of Hepp's address, two things stand out. First, there is little evidence that Hepp either read or sought out for advice authors with legitimate credentials and personal commitment to Calvinistic theology such as Hugh Miller or J. William Dawson. Instead, at the beginning of his lecture on geology, Hepp appealed to George McCready Price, a self-educated, quasi-geologist and a Seventh-day Adventist, who was clearly outside the mainstream of orthodox Calvinistic theology. Perhaps even more surprising is that Hepp set foot in the bastion of US Calvinism, Princeton Seminary, without showing any sign of familiarity with the writings of US or Scottish Calvinistic theologians on the relationship of the Bible to Christian faith.

Louis Berkhof (1873–1957), a native of Emmen in the Netherlands, emigrated with his parents to the USA in 1882 (Fig. 2). He graduated from Calvin Theological Seminary in 1900, pastored a Christian Reformed Church for a couple of years, received a PhD from Princeton Seminary, and served in another pastorate. In 1906, Berkhof was called to the faculty of Calvin Seminary, of which he later became president from 1931 until his retirement in 1944. Berkhof was the premier systematic theologian at Calvin Seminary for 38 years, where he shaped the theological mind of the Christian Reformed Church during his tenure via his training of the church's future ministers and his writings. Berkhof's major work was entitled *Reformed Dogmatics* (Berkhof 1932), later altered to *Systematic Theology* (Berkhof 1938). Fortunately, Berkhof's treatment of the doctrine of creation was much more objective than Hepp's and lacked his cynical tone.

Fig. 2. Louis Berkhof (1873–1957). *Source*: Archives, Calvin College.

That the shadow of Bavinck fell long and deep on Berkhof is clear from the latter's discussion of the doctrine of creation and of the nature of the six days. Bavinck's discussion of creation in *Gereformeerde Dogmatiek* is the first listing in Berkhof's section on relevant literature. In Berkhof's treatment of the six days he listed six criticisms of geological practice, some of them strongly reminiscent of Bavinck whereas others were derived from Price.

First, Berkhof wrote that the science of geology is young and still in bondage to speculative thought. The first half of his statement is reminiscent of Bavinck's first statement. Berkhof's book was first published in 1932, more than three decades after Bavinck made the similar claim in the first edition of his work. *Reformed Dogmatics* (*Systematic Theology*) was reprinted many times during Berkhof's career, but he never altered that claim before his death in 1957. *Systematic Theology* is still being reprinted, and the most recent printing in 1996 repeats the identical claim. Even today, theology students read Berkhof's insinuation that geology is not credible because it is young. Why did Berkhof not realize that geology might have matured in the decades since Bavinck? In this first claim, Berkhof also denied that geology can be considered as an inductive science, as it is largely the fruit of *a priori* or deductive reasoning: a strange claim to make in light of the empirical basis of the geological column and the recognition of biological succession.

Berkhof's second claim was that geology had done little more than scratch the Earth's surface in a very limited number of places. Hence, he stated, geological conclusions are often mere generalizations based on insufficient data, and facts observed in some places are contradicted by those found in others. This claim reminds us of Bavinck's fifth statement drawn from Haeckel. For Berkhof to make the same claim several decades after Bavinck, and to leave it unchanged for another 25 years until 1957 was another disservice to a reader seeking to learn theological truth in relation to geology as it really stands. Why would Berkhof fail to realize that geology would have progressed in the decades since Bavinck wrote? During the early twentieth century, huge strides were made in knowledge of the geology of Australia, Japan, Nigeria, Egypt, Madagascar, South Africa, India, Scandinavia, eastern Europe, the USA, Canada and many other places. In reading Berkhof's claim we would think that our geological knowledge resembled our current extent of knowledge of lunar geology.

Berkhof's third claim was that even if geology had explored large areas in all parts of the world, it could only increase our knowledge of the present condition of the Earth. Geology would never be able to give us perfectly reliable information respecting the Earth's past, a claim that is reminiscent of Bavinck's second claim. Berkhof also implied that geology had shed virtually negligible light on our knowledge of the Earth's past because it was not perfectly reliable historical knowledge. We could just as well dismiss human history as a discipline because it does not yield 'perfectly reliable' knowledge, or dismiss the utility of forensic science to reconstruct crime scenes. Neither Bavinck nor Berkhof grasped that geological reconstruction of Earth history relies on clues embedded in rocks and that the rock record contains a wealth of clues that we need to discover and interpret. In effect, Berkhof implied that if we discover a succession of sedimentary rocks with cross beds, ripples, mudcracks, channel fills and tetrapod fossils, it tells us nothing of the past. All we know is the present condition: at present the Earth contains a succession of sedimentary rocks with features that look a lot like cross beds, ripples, mudcracks, channel fills and fossils.

Berkhof's fourth point was that geologists once assumed that the strata were found in the same order all over the globe, and that by estimating the length of time required by the formation of each stratum one could determine the Earth's age. But then geologists found that the order of rocks differs in various localities, that experiments made to determine the amount of time required for formation of different strata led to widely different results, and the uniformitarian theory of Lyell was found to be unreliable. Berkhof did not realize that the order of stratified rocks does not vary unless some layers are missing as a result of erosion or non-deposition, or the rocks have been overturned. We can detect the influence of Price here.

In his fifth point, Berkhof correctly observed that efforts to determine the age of strata or rocks by mineral and mechanical make-up had failed. Afterward, geologists began to make fossils the determining factor. 'It is simply assumed that certain fossils are older than others', Berkhof (1938, p. 160) alleged, 'and if the question is asked on what basis the assumption rests, the answer is that they are found in the older rocks. This is just plain reasoning in a circle. The age of the rocks is determined by the fossils which they contain, and the age of the fossils by the rocks in which they are found. But the fossils are not always found in the same order; sometimes the order is reversed.' Here we have the repetition of Bavinck's eighth and ninth claims. A striking feature is Berkhof's failure to mention radiometric dating, a set of procedures that had been developing for close to four decades when he wrote. There was no mention of radiometric dating in succeeding reprints.

The sixth claim was that the order of fossils as now determined by geology does not correspond to the order that the narrative of creation leads us to expect. Berkhof was correct in that claim. In all likelihood, he simply borrowed the claim from Bavinck. What Bavinck, Hepp and Berkhof neglected to consider is that the problem did not lie with the geological discoveries but with the traditional interpretation of the creation days as a chronological sequence.

Berkhof's *Systematic Theology* continues to help perpetuate the pervasive allegiance to young-Earth creationism in the evangelical world, particularly in Britain, where his text has been widely recommended as a standard theological work for evangelicals.

Some preliminary speculations

On the basis of this admittedly limited sampling, I suggest that Dutch Calvinism in the early twentieth century had a greater struggle adapting to modern geology than did Scottish or US Presbyterianism. The question is why Dutch Calvinists were more suspicious of geology. Much additional work needs to be done to confirm my initial impression. Investigation of the writings of other nineteenth- and early twentieth-century theologians of the Dutch Calvinist tradition in the Netherlands, North America and South Africa is needed to ascertain their reactions to geology and interpretations of the biblical creation story. Also we need to understand more about the status of geological practice in the Netherlands. Here I make four preliminary observations that may serve as stimuli to further thinking.

First, Bavinck relied very heavily on German writers for his understanding of geology, for evaluations of the relation of geology to the creation account, and for the interpretation of the creation account. At no point did he refer to any works by Dutch writers on the first two of these matters. His references to US and British writers were minimal. His use of sources suggests that neither Dutch theologians nor Dutch Christian geologists of the nineteenth century had grappled with or written about these issues to any great extent.

Second, the Free University of Amsterdam had no geology programme during Bavinck's lifetime.

Perhaps he did not personally know any geologists with whom he might consult. The same is true for Berkhof in the USA. Because Calvin College did not introduce geology into its curriculum until a decade after his death, there was no geologist with whom he could consult. In contrast, many geologists, naturalists and scientists in nineteenth-century Scotland were also Presbyterian ministers or lay leaders: Thomas Chalmers was a chemist and old-Earth advocate who became a Church of Scotland and Free Church of Scotland minister; John Fleming was a professor of natural history at the University of Edinburgh and another Church of Scotland and Free Church of Scotland minister; John Playfair was a professor of mathematics at the University of Edinburgh and a minister of the Church of Scotland; and Hugh Miller was an amateur geologist and lay editor of *The Witness*, the official organ of the Free Church of Scotland. In nineteenth-century North America, Presbyterian theologians personally knew or were acquainted with the writings of US and Canadian geologists such as Guyot, Dana and Dawson. Charles Hodge of Princeton Theological Seminary certainly knew Arnold Guyot of the College of New Jersey, the forerunner of today's Princeton University, as well as Dana. In fact, Hodge was long-time chairman of the college's Board of Trustees and is likely to have become acquainted with most of faculty members. Many of them worshipped in the same two Presbyterian congregations in Princeton. One suspects that Hodge and Guyot had some conversations about geology. The Scottish and US theologians had access to writings of Christian geologists whom they trusted and who had proposed reasonable reconciliations of geology and theology while believing in the authority of the Bible.

Third, the Dutch geology may be a relevant factor. As an igneous petrologist, my bias leads me to suspect that the overwhelmingly sedimentary geology of the Netherlands is less conducive to comprehensive geological thinking than is that of Scotland. The Dutch public was probably not as well acquainted with geological thought as was the Scottish public. The Scots could see plenty of geology for themselves in the outcrops and rugged terrain of their land. The Dutch theologian and prime minister Abraham Kuyper once wrote that 'the arts of sculpture and architecture, which require rich, natural stone, were more readily developed in those countries where quarries abound, than in a country such as the Netherlands, where the ground consists of clay and mire' (Kuyper 1931, p. 164). For the words 'the arts of sculpture and architecture' he could easily have substituted the words 'the science of geology'.

Finally, Dutch theologians had a keener sense of the importance of a person's worldview in shaping attitudes, mores and theoretical thought. If the Dutch theologians perceived, as Bavinck apparently did, that the science of geology was shaped by a worldview hostile to that of Christianity, they might have believed that the science as a whole was tainted. Dutch theologians certainly regarded the theory of biological evolution with much greater suspicion than the Presbyterians did, and, given the connection between geology and evolution, could be excused for suspecting geology as well. Abraham Kuyper talked about two sciences: a Christian and a non-Christian science, each constructed on the basis of its distinctive worldview. Presbyterians were more inclined to follow John Calvin in accepting truth no matter who came up with it. Beyond that, the Presbyterians seem to have had a better grasp of the history of geology in recognizing the role played by Christian geologists such as de Luc, Buckland, Hitchcock and Dana. The failure of the Dutch theologians to grasp that role may unnecessarily have reinforced a bias against a science whose inner workings they did not really comprehend.

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From the beginning: faith and geology at evangelical Wheaton College

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Abstract: Geology has been part of the curriculum at Wheaton College, Illinois, since it was established in 1860 as a non-denominational, Christian liberal arts college. The school continues to maintain a strong identity with evangelical Christian theology and subculture. The first president Jonathan Blanchard recruited George Frederick Barker to teach geology and natural history on the personal recommendations of the renowned geologists Agassiz, Silliman and Hitchcock. Barker taught at Wheaton for only one year, and was followed by a succession of other young scientists who kept geology in the curriculum to the end of the nineteenth century. These teachers respected the geological evidence for an ancient Earth and interpreted the creation days in Genesis 1 as representing extended epochs of God's creative activity. In the early twentieth century, Professors James Bole and L. Allen Higley harmonized mainstream geological history and the Bible through the gap or ruin–restoration interpretation, wherein eons of geological time preceded six days of Edenic re-creation only thousands of years ago. Higley's background in geology, his role in recruiting additional science faculty staff, and his influence among fundamentalists set the stage for the acceptance by subsequent Wheaton geologists of mainstream geology and their rejection of emerging popular fundamentalist ideas about a six day creation and Flood geology. Geology was established as a major subject in 1935 and an independent Geology Department was established in 1958. Geology education at Wheaton College was profoundly influenced by the tension over creation issues in the evangelical subculture, and different models for understanding the relationship between science and Christian theology have been employed by teachers and students.

Wheaton College, Illinois is perhaps the most prominent liberal arts college representing the evangelical Christian subculture in the USA. Hamilton (1994) wrote that Wheaton has maintained its evangelical identity and survived the challenges of modernism and post-modernism by adopting the secular culture's 'curriculum, accreditation, admissions, student culture, and even a good measure of faculty culture—without yielding a fraction of its full-bodied, pre-modern supernaturalism'. Geology was included in the curriculum at Wheaton College when it was founded in 1860, and was established as a major subject in 1935. More than 30 of the some 250 graduating in geology have gone on to earn doctorates in the geosciences. However, geology continues to be a controversial topic for many Christians, particularly conservative theologians who represent Wheaton's constituency. Geology is apparently avoided or ignored as a major subject at most of the 105 member institutions of the Council for Christian Colleges and Universities (all representing Protestant Christianity in North America).

As labels for varieties of Christian belief and their meanings seem to change over time and across geographical boundaries, some clarifications are in order. In the USA there is a distinction between evangelical churches and mainstream churches that have adopted liberal theology (often questioning the importance of traditional doctrines). Modern evangelical Christians affirm the divine authority of the Bible, embrace conservative (generally Protestant) theology, and emphasize the personal experience of evangelism and conversion. Christian fundamentalism emerged from evangelicalism in the early twentieth century and tends to hold more narrow theological views, including a literal interpretation of the Bible. Distinctions between evangelicals and fundamentalists, particularly with respect to geology, will emerge in the course of this paper. Roberts (2009) has further described varieties of Protestant and evangelical belief with respect to the sciences.

From the beginning, geology was presented and practised at Wheaton College as an integration of mainstream science and biblical theism called old-Earth creationism. However, even this position encompasses many variations. In contrast, young-Earth creationism has had extraordinary appeal among conservative Protestants in North America, having gained momentum after the Scopes evolution trial in 1925 and even greater force after the publication of *The Genesis Flood* (Whitcomb & Morris 1961). Movements to promote young-Earth creationism have persuaded churches, denominations, ministries, missions, home school families, and private Christian academies and colleges to its view. Indeed, many students arrive at Wheaton with the belief that geology offers a challenge to

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Christian understandings of creation rooted in a literal reading of the Bible: that the heavens and Earth were created in 6 days only thousands of years ago and that the Earth and nature were profoundly affected by Adam's fall and the biblical Flood. In this paper we consider why mainstream geology with its ancient Earth and uniformitarian interpretation of Earth history is acceptable at Wheaton College today, in light of the college's fundamentalist roots and continued affirmation of evangelical faith.

The Creationists by Numbers (1992) is a thorough history of the creationist movement in North America with many references to Wheaton College. The present paper brings to light additional historical information on geology education at the college and on how professors have related their geological and theological views. We have deliberately narrowed our focus to geology and refer readers to Numbers for his treatment of related controversies surrounding the topic of biological evolution at Wheaton College.

Jonathan Blanchard seeks a geologist

Jonathan Blanchard (1811–1892) became the first president of Wheaton College in 1860 when it was reorganized from its original incarnation as Illinois Institute. He was a firebrand abolitionist, Wesleyan preacher, and past president of Knox College. Blanchard desired a first-rate science curriculum at Wheaton and this was reflected on the new college seal that adorned his best stationery (Fig. 1). This desire came from many sources. He had fallen under the spell of the sciences as an undergraduate at Middlebury College in Vermont. During his 12 years as president at Knox College in Galesburg, Illinois, Blanchard witnessed at first hand the impact of Nehemiah Losey (1804–1875), Knox's professor of natural science. Finally, Blanchard was disappointed that a promising undergraduate at Illinois Institute, John Wesley Powell (1834–1902), had transferred to Oberlin College in Ohio, in part because Wheaton had no science professor. Powell became a US Army Major after distinguished service in the Civil War, led the famous expeditions into the Grand Canyon via the Colorado River, and was appointed the second director of the United States Geological Survey (Worster 2001).

In the spring of 1861, Blanchard travelled to New England and visited professors Louis Agassiz (1807–1973) at Harvard and Benjamin Silliman (1779–1864) at Yale to seek a candidate for Wheaton's first professorship of Chemistry and Geology. Silliman, one of the founding fathers of North American geology, was known to be a devout Christian. Blanchard may have respected Agassiz for his reputation in science, as well as his outspoken scepticism of Darwin's theory of evolution. Blanchard apparently did not object to Agassiz's old-Earth creationist position (nor his

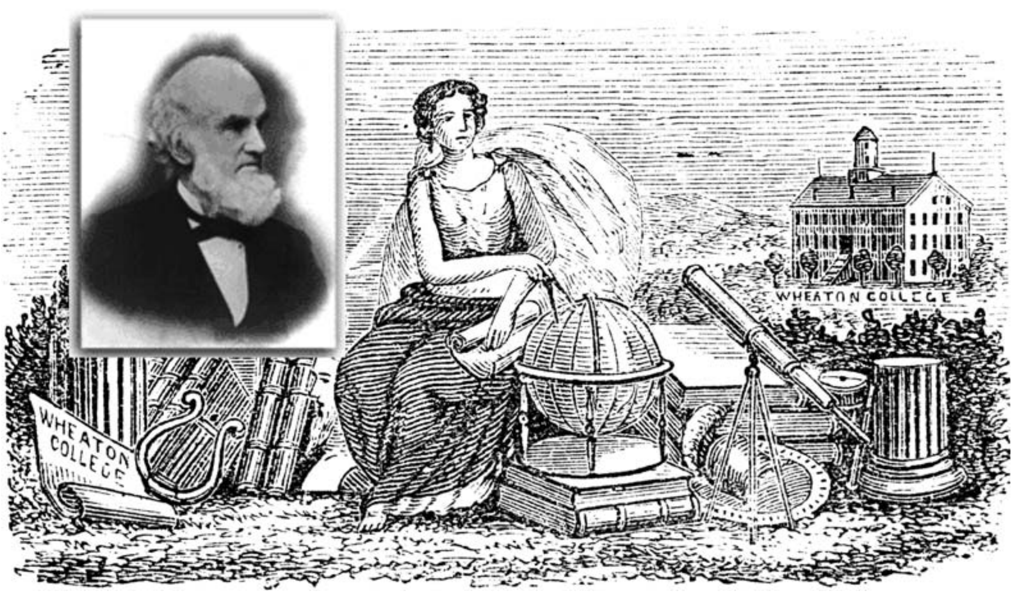


Fig. 1. Photograph of Jonathan Blanchard (1811–1892), the first president of Wheaton College, set on his official stationery seal. The seal illustrates his devotion to the liberal arts and sciences in Christian higher education. Credit: Wheaton College Special Collections and Archives.

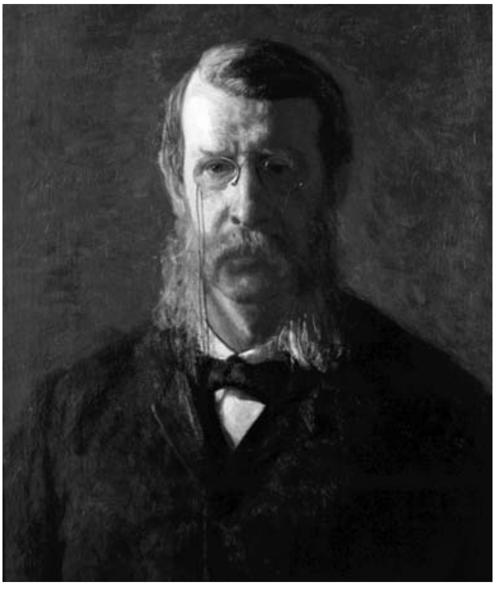


Fig. 2. Portrait of Professor George F. Barker, painted by Thomas Eakins (1886). Barker taught geology and natural science at Wheaton College during the 1861–1862 academic year. Credit: Cedarhurst Center for the Arts, John R. and Eleanor R. Mitchell Foundation, Gift of Mr and Mrs Alden Perrine, 1973, 6.1a.

Unitarian faith) or his work in glaciology that convinced British diluvialists such as William Buckland (1784–1856) that the biblical Flood had left no geological record. The professors strongly endorsed their student George Frederick Barker (1835–1910) for the job.[1] Barker graduated from Yale Scientific School in 1858 and was employed as a chemical assistant at Harvard Medical School for the next 2 years. Blanchard also received an endorsement for Barker from Professor Edward Hitchcock (1797–1864) of Amherst College, himself a practising reverend and geologist. It would be a brilliant coup for Blanchard, as Barker had an exceptional brain and was a devout Christian (Fig. 2).

Blanchard reported in a letter to students at Wheaton College that Agassiz was anxious to have Barker collect for him fossils of the Great Lakes region and, in return, promised to give Blanchard, 'out of the abundance of his specimens, enough of the world's stone creatures, or creatures turned to stone, to make us all the cabinet we could desire'. But Blanchard lamented

> This promise of Agassiz made my heart ache because I was not rich enough to hire and pay the man to take the department of natural history in our college, collect for Agassiz, and receive his specimens in nature ... Still I am not without all hope, that such a professor will commence the college year with us in September. I have seen so many instances where God has first made us to feel the necessity; and then supplied it, that I have almost a religious conviction that Wheaton College is to have an able professor in the Department of Natural Sciences ... It is not necessary that I tell you what efforts I am making to secure this said professor. If they fail, you need not share my disappointment. If they succeed you will rejoice in the success.[2]

Blanchard's efforts included, with characteristic fervour, a letter-writing campaign to fund this new faculty position. To one supporter he wrote

> Our faculty is sufficient except only a professor of geology and natural science. Being east to speak in New York and Boston against slavery in the churches, I found a young man who has aided Professor Silliman in Yale and Hitchcock in Amherst—the son of a sea captain, very capable, simple hearted and devoutly pious—the one of all other whom we want. He has his girl courted in New Haven and I have told him to marry her and come to Wheaton College and I would endeavor to get him $650 salary this year.[3]

Barker and his new wife arrived in Wheaton in time for the autumn 1861 term. Unfortunately, Barker's career at Wheaton lasted only 1 year. Much of what is known about Barker's short tenure at Wheaton College is from the journal of a student, LaRoy Sunderland Hand (1846–1925). Barker's office in the college was filled with several hundred volumes of science texts and on the walls were hung portraits of Professors Silliman, Agassiz and Dana, and ambrotypes of Yale buildings. Hand noted that Barker was 'free and merry' in social gatherings, but 'very strict and dignified in conducting his classes'.[4] Some of his actions toward female students at the co-educational institution appeared to Hand and other students as severe or even cruel (Yale did not yet admit women students). His science lectures were spellbinding and provocative:

> Professor Barker was speaking today in 'Logic' recitation (not intimately connected with the lesson) of how the Solar system might have been formed by laws already known. Supposing the materials to have been diffused in a liquid, chaotic state, attraction would tend to draw them together and the rushing together of matter would form a rotary motion as seen in water running through a funnel. The effect of this would be to throw off the planets and from them the satellites, first as dishes like Saturn's which would finally break and become spheres ... It is argued that accounting thus for the creation of the worlds does not in any way derogate the power of God as Creator but rather puts his works in a more splendid light, from the simplicity and harmony of those laws which effect such magnificent results. He spoke also of the Darwin theory of progressive life, which is that by selection new species and genera and families may be formed, thus tracing man back to the polyp, making creation the result of fixed laws and not of an instantaneous fiat. The Professor said that he had read the work and most of the numerous criticisms on it which he thought were mainly unsatisfactory. He thinks this theory does not contradict the account we have of the creation nor make us look with less wonder and confidence on the power of God. What is the use of a man's having a dog and barking himself?[5]

Blanchard took notice of George Barker's views on creation and science, and eventually expressed his apparent discontent to students in January of 1862. LaRoy Hand recorded:

The President in the history class in speaking of the theories, accounting for the creation spoke disrespectfully of the self-confidence and impudence, as it were of geologists. This was the occasion of some remark in which the unreasonableness of the church in opposing science was referred to. I know not why, but it seems true that they have raised a hue and cry and set after every man who had any progressive science to teach. From the time it tortured Galileo to the present when Geology and geologists are being cursed by every upstart minister, She has not neglected to frown upon innovation. Professor Barker says that he considers the proof ample to show that the days mentioned in the Mosaic record are periods and not literally of 24 hours each. This does not by any means contradict the Bible account and presents the creation in a more beautiful light than any other. God works by laws in all the works of nature we know and it is more reasonable to suppose the creation of a world was the result of immutable law than instantaneous fiat ... The account of the days of creation accords exactly with the discoveries of Geology which is, to say the least, a strange coincidence. The strata of rock which compose the earth exhibit different forms of life, exactly in the order in which Moses says they were created. Revelation and science agree exactly and it seems to me it is the part of religion to have for its own the beautiful truths which science reveals and not set itself up against what was intended to be its chief ally.[6]

There is no evidence that Jonathan Blanchard hastened Barker's premature departure at the end of the academic year. Barker's strictness and condescending attitude toward women were troubling to many students. In their first year of marriage, Barker's wife was unhappy with rustic life in the Midwest. She had been 'reared in affluence and luxury' in the East and she even clashed with the college over the issue of how much sugar was provided at college meals.[7] Probably the most significant factor was that Blanchard had overextended the college financially. In July 1862 the college offered Barker a contract for the next year, but told him he would have to wait for $150 still owed from the previous year.[8]

Apparently, Barker foresaw this financial shortage would be a continuing trend and in the autumn of 1862 he accepted the position of Acting Professor of Chemistry at Albany Medical College, where he also pursued a course of medical studies.

No scientist who has taught at Wheaton College ever led as distinguished a career as George Frederick Barker. At the University of Pennsylvania, he conducted research in both chemistry and physics, with interest in the emerging field of spectroscopy, telephone, telegraph and light bulb research (Fiske & Wilson 1899). Thomas Edison considered him a colleague (Pezzati 2003). In his lifetime, Barker wrote 25 books, edited the *American Journal of Science*, was a member of the National Academy of Sciences (elected 1876), served as President of the American Association for the Advancement of Science in 1879, and was a frequent expert witness in court cases and in litigation about patents (Halley 1971).

Barker left Wheaton College without collecting any fossils for Agassiz, and certainly no cabinet at Wheaton was filled with specimens from New England. However, Jonathan Blanchard continued to cultivate relationships with natural scientists and acquired specimens for the institution. Of special note in the *Wheaton College Catalog 1864–1865* was the news that: 'Major J. W. Powell, prompted by his love of science, and friendship for the Institution where he received part of his education, proposes to put up, during the summer, a cabinet illustrating the geology of the west, and Prof. Webster has the promise of a valuable collection from the east.'[9] Trustee minutes of 27 June 1865 include an expression of thanks to Major Powell for the impressive display.[10] Future catalogues would note frequent additions of mineralogical, geological, botanical and marine shell specimens to Wheaton's Cabinet.

Powell's explorations of the Colorado River and western territories had another Wheaton connection in the person of Almon H. Thompson (1839–1906). 'Harry' or 'Prof' Thompson was Powell's brother-in-law, who completed his college education at Illinois Institute in the days before Jonathan Blanchard and the change to Wheaton College. Thompson was serving as Superintendent of Schools in Bloomington, Illinois when Powell asked him to join a small party to explore Colorado and the central Rockies in 1867. Thompson was Powell's second in command for the second Colorado River expedition, which started in 1871, and later was appointed to serve as head of the Topographic Division in Powell's Irrigation Survey of Western territories (Worster 2001). Powell regarded Thompson as his 'first associate in exploration'.

Geology continued to be offered as part of the general curriculum at Wheaton College through the rest of the century by a succession of instructors or tutors having less distinguished credentials than Barker. Alja R. Crook (1864–1930) was a promising young professor who might have made a significant contribution to Wheaton's geology programme if he had stayed more than one year (1892–1893). After leaving Wheaton College to teach at Northwestern University, Crook was appointed curator of the Illinois State Museum in 1909, and contributed much of the original vision for the institution in Springfield (Hunter 1977). Rollin C. Mullenix (1869–?) taught biology and probably geology at the college between 1896 and 1905. In 1899, he and the astronomy professor Herman A. Fischer (1846–1925) joined a Union Pacific Railroad expedition to the 'fossiliferous region' of

Wyoming.[11] After completing graduate studies at the University of Chicago and Harvard he moved to Lawrence College in Wisconsin and contributed to the field of zoology (Castle *et al*. 1909). Askew (1969) speculated that the rapid turnover in science faculty, at least eight men between 1890 and 1915, appears to have been related to more attractive offers elsewhere and the debate over evolution.

Throughout the early years of the college, courses in geology and mineralogy were part of the science and mathematics curriculum. By 1877, the two courses were expanded to both autumn and winter terms of the senior year. The rationale for this was given in the 1888 catalogue:

> Geology is placed in the last year of the college work because it requires a previous acquaintance with all the other sciences. It treats of the formation and structure of the crust of the earth, dealing incidentally with the origin of mountains, coal beds, mines, and quarries. It reveals the strange story of the changes our globe has undergone in the past and points to the time when the present order of things had a beginning, tracing its development down to the coming of man, in close correspondence to the order given in the first chapter of Genesis.[12]

All-day field trips, travelling by horse and cart, to limestone quarries along the Fox River were part of geological training in the late nineteenth century.[13] Classes also travelled by train to the Field Museum in Chicago to study the natural history exhibits.

Two points are evident from the above catalogue description. First, geology in the mainstream including the emerging geological column appears to have been accepted completely at Wheaton College at that time. Furthermore, the catalogue description carries the implication that the creation days in Genesis were interpreted by Wheaton teachers as corresponding to successive geological ages (known as day–age harmonization), in the manner popularized by the leading contemporary geologists Silliman, Hitchcock and James Dwight Dana (1813–1895) (Davis 2003). Second, geology as a science was valued in the liberal arts curriculum because it was integrative (drawing from the other sciences) and it was practical in an age of industrialization and economic growth. This was the era of gold rushes, after all.

Whereas geological time appeared uncontroversial, Darwin's evolution or 'developmental theory' was met by students with both concern and acceptance, as noted in published student essays. One student wrote without any expression of shock:

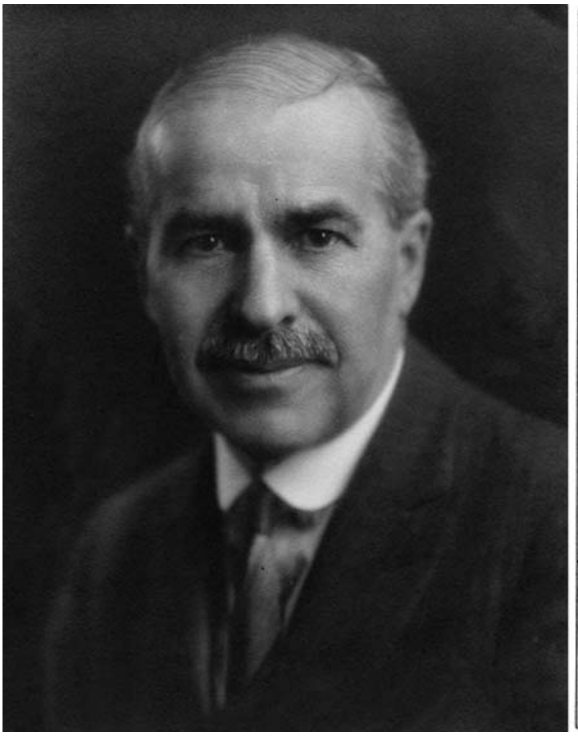
> One of the most interesting experiences we had in Geology class, when on a visit to Field's Museum, we suddenly came upon some of our ancestors who a few millenniums ago in the forests of South America or Africa hung lazily by their tails and chatted away the morning hours.[14]

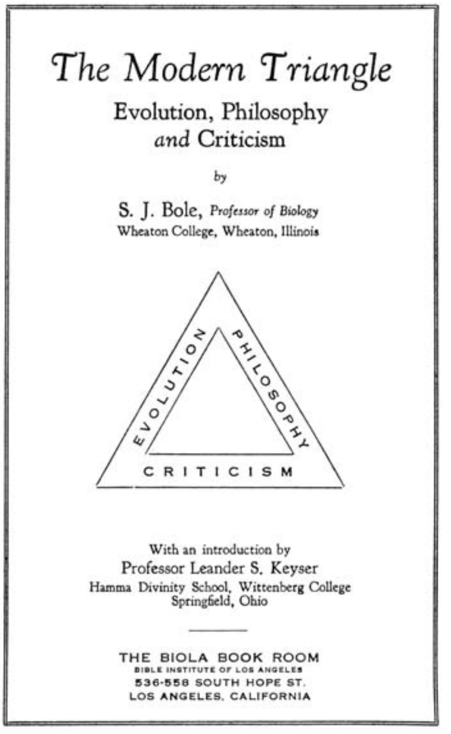
Another student expressed concern that, 'The Darwinian theory is decidedly unphilosophical in that it makes nature eternal, and says that because nature is eternal and species are by successive developments, therefore the same successions should go on eternally.'[15] There is no record of Jonathan Blanchard ever quenching open discussion of geology or evolution, although he most certainly had the authority to do so if he felt that the discussion was heretical or a danger to the community.

Charles Blanchard and the fundamentalists

Upon Jonathan Blanchard's death in 1882, the presidency of Wheaton College was given to his son Charles Blanchard (1848–1925), who held the post until his death in 1925. Blanchard defended the classical liberal arts pedagogy and curriculum against the trend among many colleges to departmentalize disciplines and offer students elective courses. Blanchard also was involved in the evangelical reaction to 'higher criticism' in biblical scholarship and naturalistic materialism in philosophy. The conservative Protestant reaction to both problems was embodied in the nine points of *The Fundamentals*, published between 1910 and 1915 (Torrey & Dixon n.d.). In March 1926, the College Trustees adopted a statement of faith for staff advocating the inerrancy and authority of the Bible, derived from a statement that Blanchard had drafted for the World Christian Fundamentals Association (Lansdale 1991).

The Fundamentals did not condemn evolution outright. The theologians B. B. Warfield (1851–1921) and James Orr (1844–1913) took pains to distinguish evolution from popular applications of Darwinism to social movements and allowed for theistic evolution (acceptance of evolution under divine guidance) as a tenable position for Christians (Livingstone 1987). Other historians of the era pointed out that fundamentalist leaders were more concerned about the dehumanizing applications of evolution to economics (laissez-faire capitalism) and sociology (eugenics). The populist William Jennings Bryan (1860–1925), hired to aid the prosecutor in the Scopes trial in 1925, was an old-Earth creationist, but his well-known opposition to evolution mainly related to its naturalistic explanation of human development (Numbers 1992). However, evolution in any form was not tenable for Charles Blanchard, who frequently attacked it in sermons as unproven and unbiblical. Blanchard tolerated the day–age harmonization of the Bible and geology, but he acted forcefully to protect Wheaton students from accepting Darwinism. For example, upon learning that Rollin Mullenix had adopted theistic evolution during his doctoral studies at Harvard, Blanchard refused to take him back (Askew 1969).




The Modern Triangle
Evolution, Philosophy
and Criticism
by
S. J. Bole, Professor of Biology
Wheaton College, Wheaton, Illinois
EVOLUTION PHILOSOPHY CRITICISM
With an introduction by
Professor Leander S. Keyser
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LOS ANGELES, CALIFORNIA

Fig. 3. Left: James S. Bole, science professor at Wheaton College between 1919 and 1930. Right: cover page of his book (Bole 1926), in which he questioned the adequacy of the geological record to support evolution. Credit: Wheaton College Special Collections and Archives.

Blanchard hired James S. Bole (1875–1956) to teach biology and geology, starting in 1919. Bole was an anti-evolutionist who gave frequent off-campus lectures. His book *The Modern Triangle* (Bole 1926) attacked 'higher criticism' and evolution (Fig. 3). Bole argued that most of the kinds of life that have ever lived on the Earth are extant, and that the oldest fossils are actually highly specialized and not products of evolution. His treatment of geology was derived from George McCready Price (1870–1953), a Seventh-day Adventist who reintroduced Flood geology and young-Earth creationism to fundamentalists with his many books and articles. Price was required reading at Wheaton College, a fact that William Jennings Bryan touted at the Scopes trial to give Price's work credibility. Bole accepted the idea of an ancient creation and a local Genesis Flood (limited to the Tigris–Euphrates valley). An old Earth was accommodated by the popular 'ruin and restoration', or gap harmonization of biblical and geological history. In this view, eons of geological time were accounted for prior to the first day of Edenic re-creation, following a satanic catastrophe that ruined the original creation. Gap harmonization was widely adopted by fundamentalists who read the Scofield's Reference Bible, which promoted this interpretation in its commentaries. Numbers (1992) observed that Bole, Bryan and other anti-evolutionist contemporaries used Price's critique of geology to refute evolution without realizing or admitting that Price's geology was incompatible with day–age or gap approaches to Genesis. Bole remained at Wheaton until 1932, when he was dismissed rather suddenly and inexplicably by the college.

Charles Blanchard died in December of 1925 before he could realize one last dream. Supporters of the recently deceased William Jennings Bryan planned to raise $25 million for a comprehensive university in his name. Blanchard lobbied hard for Wheaton College to change its name and serve as the nucleus of the new institution. However, Bryan College was established in 1930 near the site of the Scopes trial in Dayton, Tennessee.

Holding back the flood

It took several months for Wheaton trustees to secure a successor for Charles Blanchard. They appointed J. Oliver Buswell (1895–1977), who was known as an outspoken and militant fundamentalist for his defence of Christian values and fidelity to the Bible. He continued in the tradition of the Blanchards and oversaw significant improvements in the academic rigour of courses and qualifications of faculty members.

In 1924, the year before he died, Charles Blanchard hired L. Allen Higley (1871–1955) to chair the Department of Chemistry (Fig. 4). The first Wheaton professor with an earned PhD, Higley was a chemist who had served as the State Mineralogist of New Mexico; this post provided him with the background to teach advanced geology courses. Blanchard charged Higley with the task of recruiting staff with strong scientific training and Christian conviction, as well as locating a western outpost for summer field courses in biology and geology. Higley mentored the chemistry student Paul Wright (1904–1998, class of '26), who completed a PhD from Ohio State University and joined the chemistry faculty in 1929. During the 1920s, geology was mainly taught under the auspices of Bole and variously named biology departments. In 1933, the Department of Chemistry and Geology was organized under Higley's leadership.[16]

Fig. 4. Louis Allen Higley (1871–1955) taught science at Wheaton from 1924 to 1939 and was an outspoken advocate of gap (ruin–restoration) harmonization of the biblical creation account and modern science. Credit: Wheaton College Special Collections and Archives.

During the 1930s, Higley distinguished himself as an expert in fundamentalist circles on issues of faith and science. He was a frequent contributor to *Moody Monthly*, a widely circulated magazine published by the influential Moody Bible Institute of Chicago. Higley held the gap interpretation of Genesis and believed that the creation days were consecutive solar days that occurred in the recent past and not representative of geological ages (Higley 1936*a*). He taught that the phrase of Genesis 1 : 2, 'And the earth was waste and void; and darkness was upon the face of the deep' is better translated 'And the earth *became* waste and void' following his belief that the primal creation was spoiled. He believed that the only reason to force a harmonization between geological ages and the creation week was to support evolution, which he utterly rejected. Higley offered a thorough exploration of the approach in his book *Science and Truth* (Higley 1940).

Higley did not view the rock sequence as corresponding to the order of creation recorded in Genesis. He made an insightful observation that day–age harmonization would require that coarse sedimentary formations could not be deposited until the third age or day when land was made to rise above the waters and that these sediments would have to be free from all animal fossils, as sea animals were not introduced until the fifth day. His understanding of the rock–fossil sequence was somewhat similar to older European neo-catastrophist views of multiple cataclysms in Earth history (Roberts 2007). He believed that the most important of all cataclysms was a flood that destroyed life prior to the creation week, and that all subsequent understanding of creation from the Bible or geology should be deduced from this presupposition. He wrote:

> The fact of the great destruction of life in the earth is obvious. The essential thing to determine is whether or not it all took place at the flood of Noah's time. Some claim that according to the Bible, it could have occurred only at the time of the flood.
>
> This claim overlooks the fact that the Bible records another flood which took place at an earlier time. We refer to the flood mentioned in Genesis 1: 2, and also clearly implied in verses 6, 7, and 9. The context clearly implies that this was a flood that destroyed all plant and animal life, even though the word 'flood' does not appear. The reason this flood is overlooked is because this chapter is sometimes mistakenly regarded as a detailed account of what is held to be the *process* of creation (Higley 1936*b*).

To Higley, the idea of process in nature robbed God of his power and glory. Creation as presented in the six days of Genesis represented miraculous activity and perfect results. Like many literal expositors of Genesis, he interpreted God's declaration of his work as 'good' during the creation week to mean that creation was perfect and complete. 'Clearly,' he wrote, 'the omnipotent and perfect

Creator could, and of necessity would, create only a perfect world. Anything short of this would not be a miracle, but a process.' He reasoned that if creation was perfect after the creation week, it must have also been perfect in the ages before the creation week:

A perfect and complete world would imply at least some life in it, otherwise what reason would there be for creating it and then allowing it to stand lifeless and useless for ages until man was created to occupy and rule it? ... it is consistent to believe that there was life on the earth before the events recorded in the creation week, though of course, no human life (Higley 1936*b*).

Higley was not persuaded by Price's Flood geology, because it was inconsistent with the geological record as he understood it. His critique of Flood geology included the comparison of modern and ancient depositional environments to understand the origin of strata. His analysis included the following:

—Why were human fossils not mixed with other forms of ancient life if they were all formed at the time of Noah?

—Deposition of coal requiring luxuriant growth and humid conditions, and deposition of salt and gypsum requiring long periods of evaporation and arid conditions were incompatible with formation during a brief, catastrophic deluge. Furthermore, he pointed to interbedded deposits of coals and salts requiring alternating humid and arid conditions in the same region at the same time.

—The oldest living trees were known to be more than 3000 to 4000 years old, almost as long as the duration since Noah's time. The trees obviously grew in mature soils that formed from the weathering of rock containing fossils that formed under a variety of conditions requiring considerable time (Higley 1936*b*).

Higley tolerated the continued reading of George McCready Price's books on Flood geology at Wheaton, but only as supplemental material. Price and other young-Earth creationists tried in vain to obtain Higley's endorsement, and with it Wheaton's influence among fundamentalists. Price took Higley to his favourite field locations and even installed Higley as president of the Religion and Science Association. Higley reported on the first convention of the Association (in March 1936) at Moody Memorial Church in Chicago, in *Moody Monthly* (Higley 1936*c*). He commended Dr Haas of Northwestern University for his talk on 'The Geologist and Time' in which he 'proved conclusively to most of his hearers that the age of the earth must be exceedingly great ... at least hundreds of millions of years'. The Religion and Science Association did not survive the discord among members over catastrophism and the age of the Earth (McIver 1988; Numbers 1992).

Just as the catastrophists rejected Higley's gap view, so too did Buswell, who considered it ridiculous and unbiblical. In 1935 Buswell wrote an article defending day–age harmonization with criticisms of Higley and of gap theology. Higley responded by secretly implicating Buswell in a scandal to trustees. However, both men lost: Higley resigned under pressure in 1939 and Buswell was released a year later over a long list of trustee grievances (Hamilton 1994).

Wheaton's first generation of geologists

During the 1930s the science programme at Wheaton developed to the point that advanced courses in geology were possible, leading to the establishment of geology as a major degree subject. Higley and the Biology Professor John W. Leedy (1869–1953) initiated the annual summer programme for biology and geology field studies in the South Dakota Black Hills in 1934 (Fig. 5). The chemist Paul Wright received additional geological field training during the summers from the University of Iowa geologist Joe Runner (1885–1970). Wright joined Northwestern University geology field trips led by Charles Behre (1897–1986) to various Midwestern geological sites, such as the Thornton quarry and the Ottawa–LaSalle region in northern Illinois, the Baraboo Range and Blue Mounds cave in Wisconsin, sand dunes around Lake Michigan, and the Kentland (impact) disturbance in Indiana. He also began applying his chemical background to research in mineralogy

Fig. 5. Students study rocks in the Badlands as part of the field geology programme at the Wheaton College Science Station in the Black Hills of South Dakota (photo *c*. 1950). Credit: Wheaton College Special Collections and Archives.

Fig. 6. Annual geology field trip departing from the front of Blanchard Hall at Wheaton College (*c*. 1950), led by the chemistry professor Paul Wright (far right). Credit: Wheaton College Special Collections and Archives.

(Wright *et al.* 1963). When Wright approached the college registrar with plans to expand laboratory and field emphasis in physical and historical geology courses, he was told, 'You'll kill it, Doc!'[17] However starting with seven students, enrolment in those courses doubled every year for the first 5 years they were offered (Fig. 6). The first geology major, Milton W. Hale, graduated in 1935. Nine geology majors had graduated by the end of the decade. Wright's initial group of geology majors and several chemistry majors who he had influenced to appreciate geology quickly distinguished themselves in the geosciences. One of the most prominent of these students was Laurence Kulp (born 1921, class of '42), who became a professor at Columbia University and pioneered radiometric dating techniques (Kulp 1952). A chemistry major at Wheaton College, Kulp did not take a geology course until he was a graduate student at Princeton University (Numbers 1992). A number of geology and chemistry majors followed Kulp to Columbia for graduate studies or research in geochemistry and other geosciences. The Wheaton–Columbia 'pipeline' included Wesley Gathman (class of '35), Art Schulert ('43), Phyllis Alward Renzetti ('47), Donald Beaumont ('49), Karl Turekian ('49), Wayne Ault ('50), Donald Eckelmann and Walter Eckelmann ('50), Charles Tucek ('51), Paul Gast ('52), Wallace Broecker ('53; who did not complete degree work at Wheaton), Leon Long ('54), Pierre Biscaye ('57) and Kenneth Wolgemuth ('65). These and other Wheaton geologists of the period made significant contributions to petroleum geology, marine geochemistry, igneous petrology, geochronology, mineralogy and crystallography, lunar exploration and geological education. Upon Kulp's recommendation, Cordelia Erdman Barber (born 1924 class of '46) studied palaeontology under Norman Newell at Columbia. After completing her MS there in 1949 she also returned to Wheaton to teach historical geology and invertebrate palaeontology until 1954 (Spradley & Chappell 1992). Paul Ribbe (class of '56) became a distinguished mineralogist as well as editor of *Reviews in Mineralogy*, and served terms as president of the Mineralogical Society of America and the Affiliation of Christian Geologists.

Two early geology majors, Donald Boardman (1913–1988, class of '38) and Douglas Block (born 1921, class of '43) obtained graduate training and returned to teach geology at Wheaton (Fig. 7). By 1958, geology was given independent department status, consisting of Don Boardman serving as chairman with Doug Block and Gerald Haddock (born 1929, class of '56). David A. DeVries (born 1925, class of '49) replaced Block, who left Wheaton in 1968 to start a science department at the new Rock Valley College in Rockford, Illinois.

Old-Earth creationism at Wheaton College

Buswell had endorsed day–age harmonization of science and the Bible. Higley had rejected biblical

Fig. 7. Douglas Block (left) and Donald Boardman (right) holding bones from the Perry Mastodon (*c*. 1964). Credit: Wheaton College Special Collections and Archives.

catastrophism on geological grounds. However, this was happening at Wheaton at a time when Flood geology and young-Earth creationism were becoming ever more popular with the second generation of fundamentalist leaders, including John R. Rice (1895–1980), Carl McIntire (1906–2002) and Bob Jones, Sr (1883–1968). These men called their followers to separate from the world and avoid compromising literal biblical interpretations with modern ideas about creation. The anti-evolutionist Harry Rimmer (1890–1952) was a popular Wheaton College chapel speaker during the middle of the twentieth century. Although he lacked scientific credentials, Rimmer presented himself as an expert on Bible and science matters and promoted the gap harmonization of science and the Bible in a manner similar to Bole and Higley. Rimmer was another anti-evolutionist who selectively referred to Price's Flood geology where it served his critique of Darwinism. In spite of what he might have said to the college community from the chapel pulpit about geology, there is no evidence that Rimmer had any impact on what was taught in the science laboratories.

Old-Earth creationism, with its blend of evangelical faith and mainstream geology, remained a viable position at Wheaton College because during the 1950s the College essentially left the fundamentalist camp. The reshaping of Wheaton's identity as 'evangelical', as opposed to 'fundamental', was in great part led by Wheaton College's most famous alumnus, the evangelist Rev. Billy Graham (born 1918, class of '44). In his public ministry, he ignored the Scopes trial and anti-evolutionism. Graham endorsed *The Christian View of Science and Scripture* in which the Baptist theologian Bernard Ramm (1916–1992) interpreted the Genesis account as a pictorial depiction of progressive creation over geological eons (Ramm 1954). Ramm repudiated gap theology and Flood geology in the book, directing criticisms at Higley, Rimmer and Price. With this background, it was safe for Wright, Boardman and future generations of geology staff members and students to be thoroughgoing geological uniformitarians. Geology remained a divisive subject at Wheaton College, however, because the implications of geology were controversial in the fundamentalist and evangelical churches that supplied students to the college. Geology and geological history were taught from an old-Earth perspective using secular textbooks, but the teachers encouraged in-class discussion of Flood geology and young-Earth creationism because they knew those views were held by many students. G. Haddock (pers. comm.) recalled that in the mid-1950s students in Wright's second-semester course were required to read Flood geology literature and write a paper evaluating the merits of conventional and Flood geology. A paper supporting Flood geology was acceptable if the arguments reflected sound understanding of geological principles. Students found that the teachers in the Bible Department were either supportive of old-Earth creationism or at least tolerated it. Typically, those Bible professors who preferred to believe in a recent creation did so on theological grounds. None championed any scientific rationale for their position.

Prior to 1955 and the construction of Breyer Hall for chemistry and geology, staff of both the science and Bible faculties were housed in Blanchard Hall. Between 1949 and 1951, 'west enders' of the building in the science departments invited 'east enders' in Biblical Studies and Theology for a series of forums to discuss Bible–science issues, including Flood geology, the age of the Earth and the origin of man, as well as issues in psychology and the moral implications of the atom bomb. These forums were reported in the *Faculty Bulletin*. In one review, the Bible Professor Kenneth Kantzer (1917–2002) concluded, 'Not all problems, needless to say, are solved in the course of an evening's session; but from every meeting those present depart with more wisdom and understanding than they possessed upon their arrival.'[18] In another review, the geologist Cordelia Erdman observed, 'It was exceedingly helpful to have scientists and theologians together in one place, correlating information from their respective fields. If nothing more was accomplished than to unify the future presentation of Genesis 1 in various college courses, this alone justifies the seminar.'[19]

Wheaton scientists were instrumental in the formation of a new organization concerned with the relationship between science and Christian faith. The American Scientific Affiliation (ASA), established in 1941, was different from the expired Religion and Science Association (RSA) in that the members of the ASA were more interested in the intellectual questions involving faith–science issues, whereas the RSA members were interested in using science to prove the veracity of the Bible (Numbers 1992). Naturally, from the beginning of the ASA there were discussions on the best approaches to relating the biblical account of creation with scientific explanations for the origin of the universe, Earth history, and the origin of life and species (Hart 1991). Two camps emerged in the ASA, representing old-Earth–mainstream-science views and young-Earth–catastrophist views. Approaches to the history of life included special creation (*fiat* creation of each species with no or little evolutionary change), progressive creation (special creation at specified times in the Earth's history leading to higher taxonomic groups, with diversity in those groups accomplished by evolutionary change) and theistic evolution (God superintending evolution to create the diversity of all life). In the ASA, Laurence Kulp and Donald Boardman were harsh critics of Flood geology. During the 1950s, Kulp wrote articles for the *ASA Journal* (Kulp 1950) and presented talks at annual ASA conventions defending mainstream science and the antiquity of the Earth (sharing his expertise in techniques of radiometric dating).

Many catastrophists or anti-evolutionists, such as Henry Morris (1918–2006), eventually abandoned the ASA in the 1960s and established organizations devoted to creation science. Morris and John Whitcomb (born 1924) essentially reinvigorated Flood geology and launched the modern creation science movement with the publication of *The Genesis Flood* (Whitcomb & Morris 1961). Boardman criticized the scientific merits of their arguments in a review of the book published in *Christianity Today* (Boardman 1961). He refused offers from editors to write a more comprehensive review of the book for publication in the *ASA Journal* (Numbers 1992). Instead, he submitted a letter to the journal (Boardman 1967) in support of a critical review of *The Genesis Flood* by the Wheaton geology alumnus Wayne Ault (1923–1996, class of '50) that was published in the journal in 1964.

In contrast to Boardman's complete dismissal of Flood geology and young-Earth creationism, Block was more sympathetic with attempts to relate geology to literal biblical interpretations. Numbers (1992) reported that Block was unwilling, when asked by the authors, to write endorsements for *The Genesis Flood*. Block wrote a critique of the book, of sorts, that was included as a chapter in *Christianity and the World of Thought* (Block 1968) edited by the fifth Wheaton College President Hudson T. Armerding (born 1918). In that, Block commended the authors 'for comprehensively reviewing the Scriptures that describe the phenomena and significance of the biblical deluge' and agreed with them that thermodynamic laws pertaining to conservation of energy and entropy cannot apply to explanations of the creation week. Otherwise, Block defended uniformitarian approaches to interpreting Earth history after the creation week, writing that each rock formation 'has its counterpart in some present environment and is subject to comparison with current geologic processes'. Whereas Whitcomb & Morris insisted that unobservable or unrepeatable catastrophic processes were responsible for the stratigraphic column, Block complained, 'they remove the entire body of observed geologic data from any possible systematic analysis or description. This is the basic reason why even Christian students of geology, who are equally zealous for the defense of God's Word, are alienated from the views of flood geologists.'

Reminiscent of Price's desire to convince Higley of Flood geology, Morris sought support from the Wheaton geologists of his generation. Morris invited Wright, Haddock and Block to examine so-called 'man-tracks' in Cretaceous limestones exposed in the Paluxy River of central Texas. Anti-evolutionists claimed that such human tracks associated with dinosaur prints obviously refuted evolutionary theory in which Early Cretaceous dinosaurs should precede the advent of humans by well over 100 million years. The 1971 field trip coincided with the production of *Footprints in Stone*, a 16 mm documentary film that was released the following year to promote young-Earth creationism. None of the Wheaton geologists felt that the tracks were human-made, but considered they were more probably altered dinosaur tracks or possibly hoax-carvings. Their doubts were included in the film, but Wright was apparently perturbed that some of his and Haddock's negative comments were not included in the film (G. Haddock, pers. comm.). Most young-Earth creationist leaders eventually rejected the authenticity of the 'man-tracks' (Morris 1986), especially after thorough research on the features at the Paluxy River by Kuban (1986) and Hastings (1987).

The Institute for Creation Research (ICR), under the leadership of Morris, was largely responsible for promoting young-Earth creationism in North America during the 1970s and 1980s. Attempts to displace or at least balance the teaching of evolution in public schools with creation science led to legislative action in several states and highly publicized court cases (Numbers 1992). Part of the strategy by ICR to promote creation science was organizing debates between mainstream scientists and creation scientists in churches, on university campuses and at other public venues. The only such forum at Wheaton College consisted of a panel discussion in the spring of 1978, organized by the ICR Midwest Center, on the topic 'Does a Proper Interpretation of Scripture Require a Recent Creation?' Some 500 people attended the event in Edman Chapel. The science and biblical studies divisions of the college sponsored the event, but only the Bible professor Julius Scott, Jr (born 1934) represented the college as moderator. The popular creationist speaker Duane Gish (born 1921) and the Reverend Marvin Lubenow, both ICR associates, defended the recent-creation position. Walter C. Kaiser, Jr (born 1933), then a professor of Old Testament at Trinity Evangelical Divinity School and future trustee of Wheaton College, and David L. Willis, who was active in the ASA and a science professor at Oregon State University, defended the old-Earth position. Unlike the typical 'evolution v. creation' forums of that era, in which the scientific merits of the two positions were debated, this panel focused on the doctrinal and theological implications of the young- or old-Earth interpretations of Genesis (Lubenow 1978). J. Scott (pers. comm.) recalled that the quality of the discussion deteriorated after Gish asserted with provocative examples how Kaiser's approach to Genesis would inevitably lead to the decline of societal values.

The acceptance of mainstream geology at Wheaton and the lack of any official college position on the age of creation as a doctrinal issue made the college a frequent target of fundamentalist leaders and ministries. For example, ICR publications have routinely questioned the sincerity of Wheaton's commitment to Christian education and warned parents not to entrust their children, as stated by Ham (1991), 'to those who teach in a way that could very easily become a stumbling block to them'. Wheaton College presidents or administrators have issued numerous statements in response to publicized concerns about how science is taught (e.g. Chase 1987). Typically, these statements have affirmed the institution's devotion to the historical Christian faith, with a strong affirmation that 'God is indeed Creator'. Often, such statements explained how education at Wheaton involves the study of God's two books: 'the universe which is His creation, and the Bible which is His revelation'.[20]

The idea that learning from these two sources of truth could be accomplished with minimum conflict was outlined in 'Christianity and Science', a leaflet prepared in the early 1960s by five science professors, including Boardman, and endorsed by V. Raymond Edman (1900–1967), the fourth President of Wheaton College. The writers expressed the conviction that 'in the present controversy about the age of the earth ... the Bible is silent with respect to any exact chronology. We, therefore, find no conflict whatsoever between the teaching of Scripture and those scientific theories which allege that the world may be as old as five billion years.' The Wheaton scientists suggested gap or day–age harmonizations of geological history and the creation account, but warned readers that scientific data, for the reverent scientist, are always partial and subject to correction by further scientific discovery. 'The very fact that his conclusions must necessarily be based upon a limited amount of data makes almost certain that tensions will exist between the truth of Scripture, which is unchangeable, and the current scientific theories of the day, which are based on the evidence available at a particular time.'

The Perry mastodon

A remarkable opportunity for the Wheaton Geology Department began with the discovery of a large 'ice-age' bone near the college in October 1963. The bone was unearthed in the excavation of a pond on the property of the US Federal District Court Judge Joseph Sam Perry (1896–1984), in Glen Ellyn, Illinois. At the college, Douglas Block and the biologist Cyril Luckman (1910–1997) recognized the bone as the femur of a fossil proboscidean. Judge Perry gave the Geology Department permission to quickly excavate the site. Orville Gilpin (1912–2002) of the Field Museum of Natural History in Chicago was enlisted to supervise the operation, which involved a number of members of staff and students. Recovery of the skull and jaw revealed the teeth of a mature mastodon (*Mastodon americanus*). Some 115 bones were recovered, mostly in an excellent state of preservation, during 8 days of digging. Large crowds gathered to witness the operation, as news spread through the local media. Block used a megaphone from the excavation pit to provide commentary to the crowds. Judge Perry donated the skeleton to Wheaton College, where preparation of the fossils commenced as the excavation was completed. A radiocarbon date of 10 980 $\pm$ 350 years BP was obtained from wood found within the skull.

Boardman devoted much of the next 10 years to raising funds for the restoration of the unique specimen. Contributions came from local businesses and philanthropists, including Judge Perry and Dr Edwin F. Deicke (1896–1984), as well as community and youth organizations. The Richard Rush Studio of Chicago completed the restoration. An

Fig. 8. The Perry Mastodon as it appears on display in the Deicke Exhibit Hall in Armerding Laboratory on the Wheaton College Campus.

innovative design reveals reconstructed bones from the left side of the skeleton and a fibreglass model depicts the living animal on the right side (Fig. 8). In 1975 the specimen was installed on a rotating base in a window-enclosed exhibit hall in a new science building (completed 4 years earlier).

Analysis: the evolution of faith and geology at Wheaton College

The history of geology at Wheaton College presents a case study in the problem of how to relate discovered knowledge in nature (as explored and interpreted by science) and revealed knowledge in the Bible (as explored and interpreted by theology). Barbour (2000) and Bube (1994) have categorized patterns employed for relating science and religion. Conflict patterns involve the supremacy of science over theology, or the reverse. Independence patterns compartmentalize science and religion into separate spheres with little or no interaction, as in Gould's (1997) 'non-overlapping magisteria' model. Convergence or harmonization seeks to show how revealed and discovered knowledge parallel each other in quality, contributing the same kinds of information to our understanding of questions of origins. Complementary or integration models regard science and theology as contributing different kinds of information to our understanding of origins, giving us a fuller view of reality.

Mathisen & Hamilton (1997) observed that more than one of these models have characterized faith and learning at Wheaton College over its history. Convergence was the typical evangelical view in the era of Jonathan Blanchard, inspired by optimism that study of nature and the Bible would necessarily lead to the same conclusions or even that one gives credence to the other. This approach was possible in the early days of geological discovery, as long as theologians were willing to abandon literal interpretations of the creation week and apply the order of creation events loosely to the nascent geological record.

Fundamentalism emerged in the early twentieth century as a reaction to liberal theology. The desire to protect the authority and inerrancy of the Bible on all matters, at least as fundamentalists interpreted it, led to conflict or subordination models of relating faith and learning. Of course, secularists were promoting their own conflict view, in which science was taken as the all-sufficient means to objective truth and religion was discarded as obstructionist and irrelevant. Christian triumphalism, the conflict term used by Mathisen & Hamilton (1997), was applied to the study of geology and biology during Bole's tenure at the end of Charles Blanchard's administration. L. Higley seems to have blended triumphalism and convergence, as he respected geological knowledge as far as it served the purposes of corresponding to his interpretation of the Bible. However, his approach is also an example of how complex interpretations (with emphasis on ambiguous biblical passages and neglect of more traditional theology) tend to fade over time; contemporary evangelical Bible scholars and theologians largely ignore ruin–restoration or gap theology.

The Wheaton geologists who followed Higley did not take up his outspoken and public leadership in using geology to illuminate the Bible. These professors primarily invested themselves in the training of students and other projects such as the mastodon restoration, personal scientific research, and the time-consuming summer programme in the Black Hills. In the classroom, acceptance of mainstream geology, with its uniformitarian principles of interpreting Earth history, exemplified what Mathisen & Hamilton (1997) called the value-added approach to faith and learning. There is a hint of independence in this approach, as secular and sacred knowledge tend to occupy separate spheres, but they can enrich each other; for example, by geology 'filling in the details of God's creative handiwork'.

The development of an integration model for faith and learning has been a major philosophical project of Wheaton scholars over the past 30 years, led by the influential Wheaton Philosophy Professor Arthur Holmes (born 1924). The model recognizes that all academic inquiry starts with assumptions or presuppositions rooted in one's worldview. As Mathisen & Hamilton (1997) explained, these assumptions, if incorrect, can distort the outcomes of inquiry. In the integration model, secular assumptions are replaced by Christian assumptions. Revealed and discovered knowledge (derived from God's 'two books' of the Bible and nature) are both respected and both needed for fuller understanding of God's truth. For example, the apparent conflict between the Genesis and scientific creation accounts can be resolved if Genesis is understood in its ancient cultural and religious context, not the context of modern science (Walton 2001). Of course, the integration approach, especially on issues of origins, is not likely to be appreciated by secularists or comforting to contemporary fundamentalists.

Some data are available to evaluate the impact of science education (geology and other introductory sciences) on Wheaton students' beliefs and attitudes concerning science and origins issues. According to a recent survey with 952 respondents from the pool of 2263 undergraduates (*Wheaton Record*, 28 October 2005, p. 28), 47% of the students believed in a recent creation (<10 000 years) before matriculation. However, at the time of the survey only 27% of the students retained that position. This result for incoming students is similar to that of a 1999 national survey of evangelicals by the organization

Focus on the Family, in which 43% of respondents believed in a recent creation. An unpublished, long-range survey of about 2300 students entering the Introductory Geology course between 1986 and 2004 showed that a strong majority of students (2:1) affirmed the statement, 'The Earth is old, probably billions of years old.' One-third of respondents identified as freshmen or evangelical (as opposed to membership in mainline denominations) gave a negative response to the question. To the statement, 'The Earth was created in six (literal), twenty-four hour days', freshmen and evangelical respondents were closely split, with a slight preference for false over true (43% to 33% and 42% to 32%, respectively). The most emphatic negation came from science majors entering the class. Follow-up surveys of students who completed Introductory Geology indicate more acceptance of an old-Earth position, but in such settings it is difficult to determine if changes signify true understanding and modified attitudes or reflect weak commitments to prior positions, influenced by the instructor's bias. The most consistent contrast between the initial survey and the re-survey at the course's end was with regard to certainty. Over three consecutive semesters, data indicate from 7% to 22% fewer true or false (definitive) responses, with shifts to answers in the 'maybe' or 'unsure' category. Written comments by students accompanying the re-survey testify to an improved understanding of the issues. Many students also stated that their scientific perspectives were improved without any damage to their faith commitments.

Conclusion

The curriculum at Wheaton College has included geology since its founding in 1860. The first President Jonathan Blanchard hired George Frederick Barker to teach natural science on personal recommendations from three prominent geologists of his generation: Agassiz, Silliman and Hitchcock. Blanchard did not contest Barker's harmonization of modern geology and the Bible, establishing a precedent for the acceptance of mainstream geology by subsequent generations of Wheaton geologists. Commitment to old-Earth creationism, as opposed to young-Earth creationism and Flood geology, was crystallized in the 1930s during the tenure of L. Allen Higley, who distinguished himself in fundamentalist circles as an expert on Bible and geology issues. The first geology major graduated in 1935. Higley's protégé, the chemist Paul Wright, mentored students who eventually returned to the college as geology teachers with academic credentials. Any pressure to abandon old-Earth creationism was mitigated by the movement of Wheaton College, following the alumnus evangelist Billy Graham, away from fundamentalism and toward identification with evangelicalism in the late 1940s and early 1950s. The new Geology Department's reputation was enhanced by a significant number of early alumni who obtained doctorates, including a dozen or more who followed Laurence Kulp to Columbia University in the 1950s and 1960s. Through the years, geology education at Wheaton College has been cast in different models for relating faith and learning: early expectations of convergence of geology and the Bible in the nineteenth century; Biblical triumphalism in the early days of fundamentalism; leading to integration in which geological data and the Bible are studied for their complementary revelations of the processes and purposes of creation.

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Notes

[1]Wheaton College Archives and Special Collections (hereafter WCASC), letter from Jonathan Blanchard to Mary Bent Blanchard, 12 June 1861; letter from Jonathan Blanchard to students of Wheaton College, 18 June 1861.

[2]WCASC, letter from Jonathan Blanchard to students of Wheaton College, 18 June 1861.

[3]WCASC, letter from Jonathan Blanchard to Gerrit Smith, 3 July 1861.

[4]WCASC, the Journal of LaRoy Sunderland Hand, 23 September 1861.

[5]WCASC, the Journal of LaRoy Sunderland Hand, 5 November 1861.

[6]WCASC, the Journal of LaRoy Sunderland Hand, 13 January 1862.

[7]WCASC, the Journal of LaRoy Sunderland Hand, 26 September 1861.

[8]WCASC, Wheaton College Trustee minutes, 1–2 July 1862.

[9]WCASC, *Wheaton College Catalog, 1864–1865*, p. 13.

[10]WCASC, Trustee minutes, 27 June 1865.

[11]WCASC, *Wheaton Record*, July 1899.

[12]WCASC, *Wheaton College Catalog, 1888–1889*.

[13]WCASC, Anonymous, 'Geology Class Excursion', in *College Echo*, June 1893, pp. 82–84.

[14]WCASC, Alexander Thompson '89, 'Class of '98' in *College Echo*, June 1898, pp. 12–16.

[15]WCASC, Quaero, 'Progressiveism', *Voice of Our Young Folks*, February 1869, p. 1–2.

[16]WCASC, Anonymous, 'Department of Chemistry and Geology', *Faculty Bulletin*, March 1944.

[17]WCASC, letter from Paul Wright to Dillard Faries, 20 March 1984.

[18]WCASC, Kenneth Kantzer, 5 February 1951, *Faculty Bulletin*.

[19]WCASC, Cordelia Erdman, November 1949, *Faculty Bulletin*.

[20]WCASC, letter from President V. Raymond Edman to constituents, 27 October 1960.

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Theodicic creationism: its membership and motivations

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Abstract: This paper aims to facilitate understanding of the most radical form of contemporary creationism by describing the principal motivations of its adherents from the perspective of a former insider. Creationism that produces and promotes accounts of natural history that differ radically from conventional accounts—made up of so-called 'biblical' or 'young-Earth' creationists, 'anti-evolutionists' and 'Flood geologists'—is herein called 'theodicic creationism'.

Theodicic creationism is primarily concerned with defending God against the charge that he is responsible for natural evil; in other words, it is engaged in the production of a form of theodicy. Rather than accepting modern scientific accounts of natural history and then argue that these are compatible with the goodness of God, however, theodicic creationists conclude that conventional natural histories are not compatible with their view of God. They therefore begin with belief in a benevolent Creator and set out to produce an account of natural history that is compatible with it. Because almost any natural history will do for their purposes if it can shift the burden of responsibility for natural evil from divine to human shoulders, theodicic creationists are a relatively cohesive group, despite deep disagreements about the age of the Earth, the extent and role of Noah's Flood, the extent and role of evolution, and even the nature of the Bible.

When I signed up for my first geology class in college, I was a young fundamentalist Christian eager to help his fellow creationists retrofit the data of Earth history to the biblical accounts of creation, fall, and Flood. Back then, as part of an effort to stay responsible and open minded, I would occasionally read papers or speak with people who were critical of creationism. But when I did, I was often so bewildered by their seeming refusal to appreciate the issues that divided us, so benumbed by their scientistic faith, so insulted by the ready caricatures of my position, so overwhelmed by the heaps of straw men about me, and so scandalized by the charge that I alone was guilty of bias, ignorance, naiveté, blind faith commitments, and the like, that I usually came away feeling confirmed in my convictions that there is a conspiracy afoot, that the dispute between creationists and conventional scientists is more about metaphysics and politics than science, that paradigms are separated by seas of near-incommensurability, and that if I wanted to discover Truth about the histories of Earth and life, I was on my own.

My views about geology have undergone a thorough reworking over the years, and I no longer think a paradigm is something you're stuck with short of the grace of God. But I still feel that too great a proportion of would-be academic responses to creationism are too deeply marred by impatience and misunderstanding and politics to do much more than encourage today's creationists to swim against the stream just as I once felt encouraged. I suspect a part of the problem is that conventional natural scientists find creationist presuppositions and methods and conclusions to be so far from orthodox that they are simply unable to take them seriously. But even attempts to treat creationists with respect are blocked by the fact that creationism and the creationist frame of mind are simply incomprehensible to outsiders. As a result, orthodox science's criticisms of creationism often sound as wrongheaded to creationist ears as creationist criticisms of orthodox science sound to orthodox scientists.

With this paper, then, I hope first to persuade readers who are not persuaded of it already that contemporary creationism is a phenomenon worthy of serious scholarly attention—by which I mean that it should be studied as an important cultural phenomenon—and then to shine a little light of my own on something of its nature and motivations. I will begin by offering a crude typology of creationisms for the purpose of delineating my subject. Next, I will single out one particular class of creationism—what I will provisionally call radical creationism—and attempt to persuade my readers that it warrants attention by summarizing some of its resources and accomplishments. I will then describe some of the many species of radical creationism, emphasizing the enormous differences of opinion that subdivide it, but arguing that it really is a rather cohesive group motivated by a common concern.

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I will argue that what unites the radical creationists is a need to declare God innocent of the charge of creating an already fallen world, a world full of suffering and death and futility from the beginning, one in which those reddest in tooth and claw are God's Chosen, to whom should rightly go the temporal spoils if not the eternal rewards. Most Westerners profess belief in God; I will argue that what separates radical creationists from the rest is their conviction that contemporary scientific orthodoxy renders belief in a loving, personal Creator deeply implausible, and a burning desire to make it less so. What results are their efforts to justify the ways of God by radically reinterpreting the ways of Mother Nature. Toward overcoming the problem that natural evils pose for their religion, radical creationists develop what might be called natural theodicies or theodicies of nature. For this reason, the paper will conclude by setting the term radical creationism aside, and recommending theodicic creationism as the title that best picks out the most important of the ties that bind the most radical of today's creationists together. (Throughout this paper, the terms natural theodicy and theodicy of nature refer to any attempt to radically rewrite natural history that is motivated by a desire to clear God of the charge of creating a world full of suffering and death.)

I should also say briefly what this paper is not about. Some readers of an earlier draft expressed frustration over the fact, as they saw it, that I didn't address the 'creationist problem' properly. Though I note herein the impressive gains that creationists have enjoyed on the world stage of late, I fail to say what's to be done about them, how we're to protect ourselves from them—how to stop them. But it wasn't from negligence. I have largely avoided such talk for several reasons. First of all, I really don't know what should be done about creationism. Though I am worried by radical creationist attempts to gain equal access to public education via legislation, I am also worried by efforts to legislate them out of it. I know first hand how important it is that creationists be granted the freedom to work out their theories about the natural world in their own way, and how futile it is to demand anything else. So even though I see the need to protect science education from too much radical creationist influence, I do not know a good way to go about doing that. Second, I know a great many radical creationists personally, and, in general, I like them. On the whole, I have found creationists of all stripes to be creative and courageous people who are sincerely engaging the natural world and their religion in the way that seems best to them. (I am not thinking of Ken Ham and his ilk here.) They perceive a certain arbitrariness in the metaphysical commitments of their orthodox opponents, conclude that the deck has been thereby stacked against their own commitments, and risk scorn and persecution to do something about it. So third, though I strongly disapprove of much of what many radical creationists are doing, I also regard them as but one half of a larger problem. As I see it, dogmatic supernaturalism—including its radical creationist expressions—is a complement of and reaction against a culturally dominant but also dogmatic form of naturalism (see Rea 2002; Alston 2002; Plantinga 1993). Since both creationists and their critics lodge some legitimate complaints against each other, little is to be gained by echoing either of their demands to 'get your tank off my lawn!' And therefore, fourth, I think a better response—the most important response of all, and perhaps the only one that can be made responsibly at present—is to try to understand creationists, maybe even learn to sympathize with them a bit.

And that brings me back once again to what this paper is about. It is an attempt to facilitate understanding of radical creationism by identifying what I think is its distinguishing mark and primary motivator: the desire for some account of natural history—any account—that shows how God could be innocent of the charge of creating a world full of natural evils.

A typology of creationisms

The many varieties of creationism on the market today can be grouped into three broad classes. Intelligent design creationism (ID) is concerned primarily with the existence of God. IDers produce contemporary versions of the argument from design, which moves from the bewildering intricacy of our world, to the probability that it is designed, to the existence of a Designer. Intelligent design creationists do not concern themselves much with the interpretation of scriptures or fret over the age of the Earth; their concern is simply to demonstrate the intellectual propriety of belief, and sometimes the impropriety of disbelief, in God the Creator (Behe 1996; Dembski 1999).

A second broad class of creationism might be dubbed (rather awkwardly) theistic evolutionism, or perhaps scientifically orthodox creationism. As these titles imply, creationists in this second group have little or no quarrel with the conventional modern sciences; they are perfectly willing to accept Big Bang cosmology, deep geological time, the naturalistic origin of life, the evolutionary development of all life, and so forth. This very diverse group includes some who believe in both God and conventional modern science but do so unreflectively, but it also includes Aristotelians, Hegelians, Whiteheadians, Nevilleans, and others who embrace very complex philosophies of nature that are used to interpret the scientific category of causation and thereby the theological category of creation (Aquinas 1265; Hegel 1827; Whitehead 1978; Neville 1992*b*). To shed much more light on this group would involve getting into a lengthy discussion of some extremely complex philosophical theories of being and causation and 'God' that are well out of the scope of this paper. For our purposes here, it is enough that readers are aware of the existence of those who both accept the conventional natural sciences and believe in a 'Creator'. Readers should also know that the positions held by such persons are sometimes very sophisticated and very carefully worked out.

A third group of creationists gets called by many names, most of which are inappropriate in several senses. I will call them radical creationists for now, and argue later in the paper that theodicic creationists is an even better name for them. Radical creationists are radical in that they strive to reinterpret all of the data of natural history to show that it is compatible with their interpretation of religion. These are the creationists who are sometimes called anti-evolutionists, young Earthers, Flood geologists, and biblical creationists—none of which are very apt titles.

Because I will be asking most of my readers to expand considerably whatever they think they know at present about this diverse third group, I must here note some of its more stable features. I do so hesitantly, not wishing to give the impression that radical creationism can be characterized by a mere list of doctrines. Nevertheless, most radical creationists hold the following views: they believe in a personal God who created the universe, they generally believe that the opening chapters of Genesis are historically accurate enough to merit judging and framing scientific theories by them, they almost universally agree that Earth has hosted life for only thousands (not millions or billions) of years, and, most importantly, they almost universally agree that no member of the animal kingdom died prior to the sins committed by Adam and Eve in the garden of Eden—which implies that most of the multicellular-fossil-bearing portion of the sedimentary rock record had to develop some time after the appearance of humans on Earth. A fuller and better-nuanced description of radical creationism will come to light in the course of the paper, but many readers will find the discussion easiest to follow if they hold these five points in mind throughout.

In the rest of this paper, then, we will consider only this last class of creationists: those we are provisionally calling radical creationists.

Resources of contemporary 'radical' creationism

So-called radical creationism has grown tremendously over the past several decades in the United States and elsewhere. Of course, despite Darwin, Laplace, and other scientific revolutionaries, most Christians probably never stopped believing in a Creator; but scientifically literate individuals and groups willing to openly defend special creation and a literalistic reading of the Bible with appeals to science were relatively rare in the USA before the 1960s. Although scientific creationism has been slowly building steam since the early 1900s among Seventh-day Adventist Christians, the 1961 publication of a creationist textbook entitled *The Genesis Flood* (Whitcomb & Morris 1961) inspired a movement that crossed denominational boundaries (Numbers 1993).

Today, besides enjoying widespread popular appeal in the United States and a growing international and even inter-religious audience (Dean 2007; Goldstein 2007), radical creationism boasts its own journals, conventions, research facilities, research programs, professionally trained specialists, museums, and educational institutions. I will here summarily describe some of its resources and accomplishments in greater detail toward substantiating my claim that the radical creationist phenomenon warrants serious scholarly attention.

Unfortunately, I am not willing to document some of the claims I make in this section as thoroughly as they could be documented. I have several reasons for withholding; I'll mention two. First, to provide more thorough documentation would involve outing friends and potentially ruining careers. In some instances, this ruin would descend upon people who are promoting very conservative forms of radical creationism; in other instances it would descend upon people who are pushing the limits of radical creationism from within; and like wheat and tares, it is impossible to pull up one without the other. Second, and most importantly, I believe that radical creationism must be allowed the freedom to evolve; if the orthodox scientific establishment does not allow creationists that freedom, then it behaves just as the church has sometimes behaved: it demands faith, and persecutes infidels. Furthermore, it is my judgment that radical creationism is here to stay for a while, for better or worse. It can work among us as a group of naive and poorly educated dogmatists who are capable only of disseminating slick propaganda and mounting successful political campaigns, or it can be allowed to evolve into an increasingly sophisticated and self-critical tradition of its own. In some important creationist circles, it is now doing the latter. If its most responsible, most creative, and most progressive lights are put out by well-meaning but poorly informed inquisitors, there will be no one left to prevent the shrillest of creationist voices from dominating the scene. For these reasons, in what follows I will name the names only of those who are already well known as creationists. This deficiency is, I hope, offset by the fact that my own prior involvement with creationism gives me first-hand knowledge of much that I say below; I may therefore be regarded as a primary resource where no other authority is cited.

Radical creationists do publish in conventional scientific journals. Consider a sampling of papers by prominent radical creationists John Baumgardner (Baumgardner 1985; Baumgardner & Frederickson 1985; Bunge *et al.* 1996, 1998), Harold Coffin (1976, 1983, 1987), Wayne Frair (1963, 1972, 1979, 1980, 1982*a*, *b*, 1983, 1985), Richard Lumsden (Lumsden & Murphy 1984; Murphy & Lumsden 1984*a*, *b*; Hildreth & Lumsden 1988), and Andrew Snelling (Snelling & Dickson 1979; Giblin & Snelling 1983; Snelling 1984; Dickson *et al.* 1985, 1987*a*, *b*). This list of creationist authors and their peer-reviewed publications could easily be expanded; but radical creationists also have several journals of their own. These journals publish material that generally would not find a home in standard professional journals: research reports and other developments of creationist theory from across the sciences, plus book reviews, literature notes, criticisms of conventional science, and news items of interest to radical creationists.

Origins is a publication of the Geoscience Research Institute.[1] The GRI is located in southern California adjacent to Loma Linda University (though it does not belong to the university). (It is sometimes confused with the Department of Earth and Biological Sciences at Loma Linda University, to the detriment of that department.) GRI is sometimes the apologetic and sometimes the research arm of the Seventh-day Adventist church, which has historically attached great importance to the doctrine that God created the universe in six days and rested the seventh.[2] The GRI has employed several full-time scientists almost since its inception in the late 1950s; these men and women hold terminal degrees in fields such as geology, biology, physics, and anthropology. The GRI also has posts in Argentina and France, and hosts annual symposia that are attended by Adventist creationists from around the world.[1]

The Creation Research Society is publisher of the *Creation Research Society Quarterly*. The CRS enjoys tax-exempt status in the state of Michigan, where it began, but operates a research facility in Arizona that was funded by one of the millionaire founders of Amway Corporation.[3]

The Creation Science Fellowship, based in Pittsburgh, Pennsylvania, has hosted an international conference on creationism every four years since 1986 (a total of five such conferences so far), and a sixth conference was planned for 2008. Proceedings of each conference are published in attractive hardbound volumes. Included papers are often written by professionals with terminal degrees in the fields on which they write, on subjects ranging across the sciences and into law, education, and biblical hermeneutics.[4]

Answers in Genesis is publisher of the *Journal of Creation*. Though most of its resources are based in Australia, the AIG also has offices in New Zealand, Canada, the USA, South Africa, and the UK. AIG stands apart from the other institutions listed so far in being devoted primarily to the popularization of radical creationism through speaking engagements and popular publications, though its staff scientists also do some research.[5] The Santee California-based Institute for Creation Research is also primarily devoted to popularization—through talks, debates, field trips, media of various kinds (some of which are available in several languages), and a museum—though until recently it too employed a full-time staff of PhD graduates who sometimes conducted and published radical creationist research.[6] AIG and ICR are the largest and most prominent of the radical institutions, and share largely overlapping views about science and religion.

The Baraminology Study Group (BSG) runs an online journal, *Occasional Papers of the BSG*, that publishes contributions to a creationist biosystematic theory called baraminology. (Baramin is a neologism constructed from the Hebrew words *bara* and *min* to mean *created kind*). Baraminology seeks to identify discontinuities in the biotic realm, in contrast to the continuity that is presupposed by evolutionary systematics. Unlike the other groups listed here, the BSG has no dedicated facilities; like them, however, it hosts conferences each year that are attended by professional creationists from around the world. Six such conferences have been held so far, and a seventh is planned for 2008. Proceedings of these conferences are currently posted online, and several books have been published by BSG members (Wise 2002, 2004; Wood 2003).[7]

The BSGs 2006 conference was held at Cedarville University in southern Ohio,[6] one of dozens of educational institutions in the USA that teach radical creation science to undergraduates. The Seventh-day Adventist church—long the leader in the development of creationist thought—maintains more than 80 universities around the world, including 14 in the USA and 16 in Europe.[8] According to a 1994 survey, approximately 70% of its science instructors profess what are here called radical creationist views.[9]

Radical creationists even have an institution or two offering graduate degrees in the sciences;

graduates of these programs are sought out by the many colleges and universities that are eager to offer creationist education. The Institute for Creation Research, for example, runs a graduate school that offers Masters degrees in astro/geophysics, geology, biology, and science education.[6] It is my impression, however, that despite the availability of creationist higher education, most radical creationists who pursue graduate study do so as closet fundamentalists at reputable 'secular' schools.

Hundreds of PhD graduates from all fields of science now identify themselves as creationists of the radical sort. (For an incomplete list, visit the Creation Ministries International website). Some of these have graduated from respected institutions. For example, palaeontologist Kurt Wise did his PhD work at Harvard under Stephen J. Gould, and geologist Steven Austin did his at Penn State University.[5] Many creationist PhD graduates are not actively working as research scientists in any capacity; but many radical creationists are practising scientists, who, if not employed by one of the many existing creationist institutions, may teach at universities alongside more scientifically orthodox colleagues and/or work in laboratory settings (physicist Russell Humphreys, for example, was employed at Sandia National Laboratories in New Mexico for many years among what he says was a significant community of professional creationists).[11] Radical creation scientists nowadays compete with conventional scientists for grants, and win them. They publish in, and review papers for standard professional journals. Some even have rather impressive publication records and CV's that are very much worth envying; the work of geophysicist John Baumgarder, for example, is known and respected internationally (Chandler 1997), and physicist Robert Gentry is the principal author of 12 papers in *Science* and *Nature* (plus numerous other publications) (Gentry 1967, 1968, 1970, 1971, 1974, 1978*a*, *b*, 1992; Gentry *et al.* 1973, 1974, 1976, 1982).

I have listed here just some of what I take to be the most important resources and accomplishments of radical creationism. The conclusion I draw from the remarkable extent of these resources, the short time in which they have accumulated, and the fact that radical creationism's adolescent growth spurt seems far from over, is that creationism is important enough to warrant serious scholarly attention as a cultural phenomenon. It should not inspire us to mock or intimidate or censor, and we should not merely dissect it as we would a tumor or gawk at it like insensitive children. We should instead find in it an occasion to ask hard questions: about human finitude, about human rationality (including our own), about the persuasive power of argument, about the role of naturalism in the sciences, about the religious and mythic and dogmatic characteristics of naturalism, about the ontology of values, about what it might be like to treat a creation scientist as a fellow traveller, and so on. Before we can do any of that, however, we must first strive to understand the creationist radicals on their own terms. To that task we now turn.

The various titles of 'radical' creationism

In what follows, I will analyse this most radical class of creationists as a whole by reflecting on the limits of various names that have been given to and/or taken up by them. I will conclude that none of these candidate titles do a very good job of characterizing radical creationists as a whole, and go on to recommend one of my own coinage.

So-called radical creationists have many misleading titles: anti-evolutionists, young-Earth creationists, Flood geologists, and biblical creationists among them. Radical creationists usually describe themselves well enough with such titles—thus subdividing radical creationism according to the diverse views that are to be found within it concerning geology, biology, the Bible, and the age of the universe—but these titles tend to mislead when applied to radical creationism as a whole. What makes them misleading is primarily the fact that none of them—not even 'biblical creationists,' despite its seeming appropriateness—are inclusive enough to refer to radical creationism in its entirety. Nor do any of them pick out what I think is the most important feature of radical creationism.

Anti-evolutionists

Critics of radical creationism often claim that it is 'anti-evolutionist,' and then beat the stuffing out of it by rehearsing some of the overwhelming body of evidence showing that some evolution has occurred. There are still species fixists within the radical creationist camp—especially in that fraction which is mostly innocent of both orthodox and creationist biological theory—but for the most part, radical creationists are quite comfortable with the fact of evolution. In fact, some believe in the power of evolution to an extent that would make Richard Dawkins blush.

Some radical creationists emphasize the importance of a distinction between micro- and macro-evolution, and insist that the former happens but the latter does not. Of those who affirm micro- but not macro-evolution, some come close to advocating species fixity. Many, however, think the 'micro' in microevolution is rather large (Marsh 1976). Radical creationists have entertained every taxonomic level short of the kingdom as marking the approximate limits of evolveability for the various 'kinds' of organisms they think God first presented to Adam. Some members of the Baraminology Study Group, cited above, argue that the famous horse and camel series are both real and developed through evolutionary processes in just the past few thousand years (Wood *et al.* 1999*a*; Cavanaugh *et al.* 2003). Such a view is clearly something other than anti-evolutionist.

Given the great differences of opinion among radical creationists concerning the extent and role of evolution, anti-evolutionists is a misleading name for them.

Young-Earth creationists

One extremely popular collection of names for what we are momentarily calling radical creationism emphasizes its relationship to time; consider young-Earth, young-age and young-universe creationism. However, wide differences of opinion exist within the radical camp about the age of the universe and its Earth. Many very prominent radical creationists do hold that the universe itself is around 6000 years old (Gentry 1992; Humphreys 1994; Vardiman *et al.* 2000; DeYoung 2005). Others are happy to suppose that the universe (and its Earth) is however old Big Bang cosmologists suggest (Brown 1981).

Nearly all radical creationists do agree that—whatever the age of the universe and its Earth—at least life on Earth is of recent origin (meaning thousands to hundreds of thousands of years). Even so, I will argue that even young-life creationism is less than best as a general term for the radical creationists, on grounds that the doctrine of youth rests on something more fundamental.

Flood geologists

Although it is not usually offered as a general term for radical creationism itself, Flood geology—according to which most of the multicellular-fossil-bearing portion of Earth's sedimentary rock record is the result of processes associated with Noah's Flood—is sometimes thought to be the approach to geological history preferred by all radical creationists. Flood geology is an extremely popular position on geological history among radical creationists, but it is far from the only one available; in fact, the whole spectrum of possible opinions on the geographical and stratigraphic scope of Noah's Flood can be found within the radical creationist camp.

At one end of the spectrum are those who claim that the Bible teaches and the rocks cry out that Noah's Flood was an utterly world-wrecking cataclysmic event, to which should be attributed the formation of the multicellular-fossil-bearing portion of the sedimentary rock record almost in its entirety (Whitcomb & Morris 1961; Oard 1990; Roth 1998). Advocates of this position claim that Noah's Flood covered the entire Earth at once, leaving no place to stand anywhere but on the Ark; they claim that it killed off every land animal Noah did not save, eroded mountains to their roots, redistributed the great land masses, perhaps even generated brand-new ocean floors around the world in a year's time thanks to being driven by catastrophic lithospheric subduction (Baumgardner 1994; Wise *et al.* 1994).

At the other end are some who argue that Noah's Flood—although catastrophic in a conventional sense—was a merely local or regional affair that might not even have left a trace in the geological record. Radical creationists such as these, like their Flood geologist brethren, also struggle to reinterpret geology to fit the short frame of time they allow for life on Earth; but the geological processes they invoke are local or regional rather than global, and—except for being faster—are otherwise rather like those that conventional geologists would also invoke. The number of theorists willing to reject any significant geological role for Noah's Flood seems to be on the rise at present among creationists who belong to the Seventh-day Adventist church.

Between these extremes can be found almost every position imaginable on the geographical and stratigraphic scope of Noah's Flood. The boundary that allegedly separates Flood deposits from post-Flood deposits is placed in the Cenozoic by some creationists; others place it in the Mesozoic, and still others in the Palaeozoic. The horizon that separates pre-Flood from Flood deposits is distributed just as widely. (The high level of disagreement among radical creationists on the stratigraphic extent of Noah's Flood has been made evident in an issue of the *Journal of Creation* (**10**(1), 1996) that was devoted entirely to discussion of the Flood/post-Flood boundary.) The fact that such diversity of opinion can be found among radical creationists concerning Noah's Flood, shows clearly that what unites them—if anything does—is something other than Flood geology.

'Biblical' creationists

Radical creationists and anti-creationists agree on at least one thing: that the Bible is the ultimate court of appeal in all matters of any importance for radical creationists. In fact, many creationist organizations are clear in their claims to be motivated primarily by the authority of the Bible.[5,6] Nevertheless, the importance of biblical authority for radical creationism is exaggerated.

Incredibly, the first body of data that the radical creationist massages to make it authorize an allegedly biblical model of natural history is biblical data. The following is just one example among many. Without an authoritative creationist tradition to declare otherwise, one would conclude that, according to biblical testimony, Noah's Flood was an extraordinarily tame affair geologically speaking—even if it did drown the planet. After all, most of the landmarks mentioned before the account of the Flood in Genesis 6 are still mentioned after the Flood in connection with Noah's descendants. To deal with this conflict between their 'biblical' account of Earth history and the biblical account, radical creationists who are also Flood geologists simply posit that Noah and his sons assigned pre-Flood names to the post-Flood world—just as my ancestors gave the names of Dutch provinces to the city of my birth when they migrated from the Netherlands. (This solution is very widespread in the oral tradition; I specifically recall hearing it endorsed by radical creationist palaeontologist Kurt Wise.) One conclusion to draw is that the Bible is not the final court of appeal for radical creationists, despite the near-consensus that says it is; we might instead suspect that tradition plays that role—a tradition that construes the Bible (or some other text) as a particular kind of scripture to be interpreted and applied in particular ways. We should further conclude from this observation that biblical literalism is not—contrary to popular opinion—the primary motivator of radical creationism; radical creationists as a whole are motivated and unified by something else.

Second, not all radical creationists think that the Bible (or any other book) is scripture in a sense that would warrant using it as the final court of appeals for questions about Earth history; some think of it instead as a very trustworthy history text that testifies to God's self-revelation in historical events. For these, the history behind the text is the final court of appeals (Giem 1996). Some Christians think that the early chapters of Genesis show clear marks of mythological character no matter how they regard the rest of the Bible. For such people, the doctrine that God created the world somehow can be as certain as it is for those who read the opening chapters of Genesis as sober history, and the problems that the natural sciences pose for such 'liberal' creationist belief can be just as great as they are for a more biblicist creationism. I retained a preference for radical creationist views about natural history for several years after concluding that the early chapters of Genesis are mythological. An inclination to read the early chapters of Genesis as mythology, then, need not exclude anyone from the ranks of the radical creationists. Once we understand what really motivates the radical creationists, even deep divisions over the nature and role of the Bible will not seem so surprising as they perhaps do at first.

However, I must issue a caveat before I describe what I think unifies and motivates radical creationism, for it is somewhat misleading of me to suggest that all creationists form a united group; the creationist house clearly is divided, and it would be naive to think otherwise. Creationism is a largely Protestant phenomenon (in its Christian manifestations), and it exhibits all of the diversity typical of Protestant denominationalism (Numbers 1993). Seventh-day Adventist creationists tend to do their own thing because of differences of doctrine and temperament, and because creationism has a rather unique trajectory and momentum among them and for other reasons. Some creationist institutions now require their employees to sign off on carefully worded doctrinal statements so as to exclude unacceptable sorts of creationists from their ranks.[3] Flood geologists sometimes level accusations of heresy against fellow radicals who prefer to invoke more conventional geological processes, and those who think catastrophic flooding fails as an all-purpose geological mechanism accuse Flood geologists in turn of naiveté. Similar accusations are made between young-Earth and old-Earth radicals. And, some so-called 'biblical literalists' might even refuse to fellowship with a creationist who openly touted a more 'liberal' view of the Bible.

I maintain, however, that, despite these divisions, radical creationism is a rather unified whole: Adventist creationists frequently do interact with the rest, Flood and non-Flood creationists sometimes collaborate on research projects and co-author papers, old-Earthers and young-Earthers attend conferences together, and probably all creationists at least entertain more 'liberal' understandings of scripture eventually. But most importantly, if we average the private motivations of individual radical creationists over lifetimes and across the creationist population as a whole, thereby allowing certain motivational differences to smooth themselves out, then we can see that when it comes right down to it, radical creationism is primarily motivated and unified by just one thing. And now that my caveat is in place—the caveat being that radical creationists do, of course, have their differences—I will describe what it is that I think for the most part motivates and unifies them.

Theodicy: the taproot of 'radical' creationism

Radical creationists believe in God. This would go without saying except for two accompanying points. First, they believe in God fervently; or at least, they very much want to believe in God with full confidence, even if some have their doubts. This desire probably issues partly from a need for meaning, and partly from a need to overcome fear (because for some creationists, believing properly is prerequisite to avoiding eternal punishment).

Second, radical creationists do not believe in just any God; the Gods of Baruch Spinoza and Paul Tillich are but idols of academia to them. Radical creationists believe in the (sometimes) loving, personal, omnipotent, omniscient Creator of popular tradition. And it is the strength of their belief—or their powerful need for strong belief—coupled with the particular Object of their faith, that compels radical creationists to reject the modern natural sciences. This can be explained as follows.

Many academic theologians and philosophers of religion, and all radical creationists, find it very hard to believe that God is a benevolent 'clockmaker' and at the same time hold to the most important conclusions of the conventional natural sciences. This is true for several reasons. First, by naturalizing explanations in biology that involve purpose, Darwinism significantly reduces the effectiveness of arguments from design for the existence of God in a context where they had once been at their most persuasive (Roberts 1988). Natural selection seems to leave a Creator little to do with biology (Dawkins 1986). Second, and more importantly here, Darwinism exacerbates the problem that evil poses for theism by suggesting that evils of all varieties might be God's efficient means of creating organisms and adapting them to their environments. Third, and most importantly here, the doctrine of deep geological time plus the observation that humans appear only recently in the fossil record suggest that death and suffering cannot be blamed on Earth's creatures—as curses that came with the sins of Eve and Adam, for example—but must be attributed to the will of the Creator, if a Creator exists (Baldwin 2000). Fourth, and significantly, the natural sciences are often thought to render value language meaningless—or at least to relativize it so thoroughly that it becomes nearly meaningless (Neville 1992*a*; Plantinga 1993; Rea 2002). Finally, deep time and the fossil record also suggest to some an incredible wastefulness and carelessness in the process of creation that seems incompatible with the omnipotence and omnibenevolence of God.

Of course, academic theologians, confronted by such problems as these, respond by pointing out the shortcomings of mechanistic naturalism and re-conceiving God (e.g. Tillich 1951; Neville 2006; see also Ostermann 2009; Roberts 2009). But, as noted, some evangelical Christians—and many others—are blocked from this response by the loss of meaning that seems to come with it. The sometimes non-personal Gods, grounded heavens, finite lives, and small meanings offered by many academic theologians simply don't fit the bill for those evangelicals who are accustomed to fellowshipping with the personal Creator of the entire cosmos in anticipation of immortality. Many evangelicals feel instinctively that with the triumph of the natural sciences (as advertised, anyway) comes the death of God and the loss of all they love. Having matured in environments where religious beliefs are taken in with mother's milk and uniformly presupposed in their surrounding communities, evangelical Christians often view the universe as an arena in which every sentient being is infinitely valuable, as a place in which every decision, every action, every thought has cosmic and eternal significance. From this mountaintop vista of traditional religious faith, the evangelical Christian can only imagine a world without a traditional, personal Creator as a desolate wasteland in which everything is dull and grey and empty and futile and cold; in which a child's love for its mother is like a computer's love for the assembly line that produced it; in which human pains, struggles, and accomplishments turn to dust as soon as we do and so were really nothing but dust before; in which judgements of right and wrong, beauty and ugliness—even truth and falsehood—are merely ecstatic outbursts or weapons in plays for socio-political power. When evangelicals survey this Valley of Death, they find that they cannot live there; they are even filled with the conviction that they do not live there, because God makes life meaningful and valuable and eternal.

At this point, our evangelical Christians may feel cornered by a pack of snarling natural sciences with bad intentions. If belief in a loving, personal God seems incompatible with belief in modern science, then there is no easy way out of a life-threatening situation. But, strengthened now by faith and emboldened by community, they turn to face their attacker and to defend their God, becoming radical creationists. Thereafter, instead of being overcome by the natural sciences, they struggle to overcome the natural in science, striving after a science that is compatible with their supernaturalism. Most importantly, they work to show that God is innocent of the charge of creating a world such as that made popular by the natural sciences: one in which those most brutal, promiscuous and conniving are rewarded by natural selection, in which death and suffering have marred life from its very beginning, in which life is only as meaningful as death.

What unites radical creationists is a common quest after a common goal: a plausible model of natural history in which death and suffering in the animal kingdom are un-natural because they are un-created and appear in the world only as consequences of creaturely error. According to the Bible as radical creationists read it, the world that God created was originally unmarked by death and suffering; these arrived later thanks to the sins of Adam and Eve (Genesis 3; Romans 5:12f; Baldwin 2000). The radical creationist's goal, then, is to defend the Bible at this point above all others. Of course, this involves a radical reworking of the whole of natural history, for if human sin is responsible for suffering even among non-human animals, then Adam and Eve lived in the Precambrian. And yet, because so many conceivable natural histories are compatible with the goal of thus rendering death itself the fault of human beings—natural histories in which Noah's Flood defaced the entire Earth or just flooded the Black Sea, in which species are fixed or indeterminately malleable, in which the universe has been around for billions of years or is only 6000 years old—radical creationists are a fairly cohesive group despite such deep disagreements.

Radical creationists, then, are concerned to 'justify the ways of God to men'; their primary task is one of natural theodicy production. This goal—this need—is what motivates and unifies them. It alone explains how so much unity can be found in the midst of such great diversity. Once we recognize this goal, we need no longer puzzle over such apparent anomalies as the geologist who has long thought the Bible is mostly un-trustworthy and pseudo-historical but is pursuing his education at a creationist graduate school just the same, or the creationist biologist who embraces evolution without limits because he thinks God created the world with a tendency to resurrect. We can also understand why, although they differ so radically about so much, they are mostly united in holding that life on Earth is young: it is because human history is short, and all the fossils have to fall within it if the bad state of the world is our fault. Perhaps most impressively, once we recognize that radical creationists are not really motivated by biblical literalism but rather by the desire to produce natural theodicies, we can also understand how so many can profess biblicism even while manifestly abusing the plain sense of the Bible to authorize their theories. All of this diversity can be accounted for by the fact that radical creationism is organized around and motivated by a research programme that aims to show God innocent of natural evils more than it is motivated by any particular doctrinal formulation or theoretical position.

Thus, because it explains so very much to note that creationists are engaged in the pursuit of natural theodicies, I suggest that what I have so far been calling radical creationism should hereafter be known as theodicic creationism. The advantages of this term are numerous: it has a clear meaning (as radical creationism does not); it is not merely a term of contrast (as radical is to orthodox); it is broad enough (as anti-evolutionism, Flood geology, and young-Earth creationism are not); and, finally, it gestures towards that which explains the unity behind the diversity among creationist radicals (as biblical creationism and young-life creationism do not).

The term does have its disadvantages. First, because the term theodicic creationism identifies what I think is the underlying, primary, long-term motivator of a movement and a group, it can be applied to the whole much more readily than to any of its parts; theodicic creationism is not comprised entirely of theodicic creationists. A variety of motivations exist within the theodicic creationist camp; my claim is that what gives that camp its character as a whole is its pursuit of a particular kind of natural theodicy. But this isn't to say that individual campers aren't in it to defend the Bible, pursue fame, or enjoy fellowship instead. Analogously, one could claim that science is primarily motivated by the pursuit of truths about the natural world without thereby implying that such pursuit is what motivates all scientists. So the term, theodicic, must be employed and read with caution. (Perhaps the term radical creationist can be retained to refer to individuals who belong to the theodicic creationist camp whose motivations are unknown, since they can't be placed within any of the other categories in current use unless one first conducts a doctrinal inventory.) The second, and, I think, primary disadvantage of the term, is that theodicic is a rather ugly neologism. But one gets used to that.

Conclusions

This paper argues that the wide differences of opinion that prevail among today's most radical class of creationists are entirely unsurprising in light of one fact: such creationists are united by a common quest after any theodicy of nature that plausibly renders death and suffering in the animal kingdom the direct consequences of human sin. It argues, furthermore, that this quest is itself motivated by their need to overcome the meaninglessness of living in a world like that envisioned by popular interpretations of the conventional natural sciences: a world without God. Unless these facts are understood about theodicic creationists, their behaviours will seem at best merely bizarre to conventional scientists, who will therefore likely respond in the most counter-productive of ways: with mockery, caricature, censure, neglect, and the like. What theodicic creationists deserve instead is sympathetic understanding, sincere engagement, and the freedom to evolve their tradition of inquiry in the only way that seems to work for anyone: by allowing the world to press back against what are almost always our initially stupid ideas about it (Dewey 1933). But if theodicic creationism is making too stinky a mess to be merely tolerated, if the need for a more parental style of intervention is felt, then would-be champions of orthodox science should begin by addressing the contemporary loss of meaning that they themselves have wrought—a loss felt so very deeply that some would rather attempt a radical overhaul of conventional natural history than be reconciled to it. An effective response to theodicic creationism requires nothing less than a world picture that affirms (or at least does not deny) that life is deeply meaningful. Only a satisfying scientific–philosophical–religious synthesis—one as satisfying as the Ptolemaic–Aristotelian–Christian system once was—is capable of meeting this need. Such a goal is well beyond the competency of natural scientists alone, and calls for an interdisciplinary effort that includes contributions by philosophers and students of religion.

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Notes

[1] *Adventist Today*. World Wide Web address: http://www.atoday.com/126.0.html

[2] *Answers in Genesis*. World Wide Web address: http://www.answersingenesis.org/

[3] *Baraminology Study Group*. World Wide Web address: http://www.bryancore.org/bsg/index.html

[4] *Creation in the Physics Lab*. World Wide Web address: http://www.answersingenesis.org/creation/v15/i3/physics.asp

[5] *Creation Ministries International*. World Wide Web address: http://www.creationontheweb.com/content/view/3873/

[6] *Creation Research Society*. World Wide Web address: http://www.creationresearch.org/

[7] *Creation Science Fellowship*. World Wide Web address: http://www.csfpittsburgh.org/

[8] *Fundamental Beliefs*. World Wide Web address: http://www.adventist.org/beliefs/fundamental/index.html

[9] *Geoscience Research Institute*. World Wide Web address: http://www.grisda.org/

[10] *Institute for Creation Research*. World Wide Web address: http://www.icr.edu/

[11] *SDA Department of Education*. World Wide Web address: http://education.gc.adventist.org/colleges.htm

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The history of the doctrine of creation; a Catholic perspective

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Abstract: The history of the emancipation of modern science can be traced in the history of the relationship between creation and evolution, but this is also an example of the growing importance of scholarly–theoretical issues within theology, especially in relation to the interpretation of the Bible. Three phases can be distinguished: (1) the time when teachings about creation were the dominant model; (2) the time when the scientific model of evolution clashed with the theological doctrine of creation; (3) a phase of open dialogue. The third phase began with the recognition of the scientific method by the encyclicals of Pope Pius XII in 1943 and 1950. However, only in the recent past, initiated by the second Vatican Council, was room made for a fruitful collaboration and the instigation of complementary scientific–theological models. The basic openness to dialogue and the recognition of the working methods of theology and science highlight extreme positions that, from their method of argumentation, must be called fundamentalist. 'Creationism' insists upon a literal–naive understanding of the Bible, which cannot be supported by scholarly–theological means, whereas the 'intelligent design movement', under the guise of empirical science, tries to present religiously motivated statements as empirical facts. Both groups are characterized by a closed world view and the use of arguments that do not follow from their premises. The present attempts at a scientific–theological synthesis are diverse and show that creation and evolution can be thought of together without inconsistency. For this dialogue to be successful, the open demonstration of one's own methods and the recognition of the theoretically accounted for methods of the dialogue partner are essential. This paper endeavours to demonstrate some of the theological methods relevant to the question of creation and evolution.

From a historical point of view, the relationship of modern science to faith and the scholarly research about faith (i.e. theology) is a history of emancipation. It is not, however, a relationship of absolute contrast.

Initially, the description of the heliocentric worldview by Nikolaus Copernicus in his main work *De revolutionibus orbium coelestium*, published in 1543, was uncontroversial, as his publisher, the Protestant theologian Andreas Osiander, stressed in his preface the hypothetical nature of the work. Therefore, Copernicus's ideas belonged in the realm of science and many contemporaries saw them mainly as an improvement of Ptolemy's astronomy. In 1514, Copernicus had been invited to the Lateran Council to participate in reforming the calendar, which he, however, declined. Modern historical research indicates that he was more afraid of being an object of ridicule than he was of the Inquisition (see Grün 2000, pp. 85–86). Only with the work of Kepler (1571–1630) did the heliocentric model gain in credibility, as he discarded the principle of perfect circular movements, which had been held from Pythagoras to Copernicus. The three great laws of motion, published in 1609 in the *Astronomia nova*, explained the tides as caused by the Moon, and made the Sun the true gravitational centre to the elliptic orbits of the planets. However, all this was neither denied nor actively opposed by the Church. What then was the issue in the quarrel with Giordano Bruno?

Giordano Bruno adopted the heliocentric model from Copernicus, and then went beyond it in that he deduced from knowledge of the cosmos the nature of God. He saw the eternity of cosmic space as a necessary analogy to God's eternal entity. Consequently, this meant for Bruno that finality must be only the derivate of eternity, and therefore, as God and creation are the same; the consequence is pantheism. Bruno also opposed the Aristotelian concept of substances: he described matter as possessing active properties and the soul as an expression of the omnipresence of God in all things. Thus, Bruno disputed the doctrine of the Trinity and of the two natures of Christ, which became points of indictment in his trial (see Blum 1994, column 735). Bruno's view no longer distinguished clearly between God and creation, and consequently did not leave room for God's redeeming work in Jesus Christ. Therefore, it was possibly Bruno's attack on the doctrine of redemption (which is central to Christian faith) that led to his condemnation, rather than his scientific views. The actual reaction against Bruno, of course, was completely incongruous from our modern point of view.

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Galileo Galilei and the lost chance of syntheses of interpretations

When Galileo Galilei argued in favour of the heliocentric model in his 'dialogue concerning the two chief world systems', published in 1632, he brought no radically new arguments to the Church authorities. However, it was new in its form of presentation, as Galilei claimed truth for his teachings, which was considered to be in contradiction to the claim of truth of the biblical revelation. 'In the 17th century, the issue was discussion about the basic question, whether scientific knowledge, which obviously contradicted the literal meaning of biblical statements, can claim to be truthful [in a realist way]' (Schneider & Sattler 1995, p. 194). Had Galilei, like Copernicus and Kepler before him, talked about only a hypothesis, it would probably never have come to a trial:

> 'Indeed, Galilei was unable to give empirical proof for Copernicus' world system. His reference to the moons of Jupiter was just an analogy and Galilei did not use the laws of motion, which could have offered a verification by calculation. It was not until the 19th century that optical proof was available by observing the phenomenon of parallaxes. As such, the church was indeed correct in a scientifically-theoretical sense to claim that Galileo Galilei could offer his statements just as a hypothesis (Gruber 2005, p. 32).

Church plaintiffs were also confronted with the problem of the very common literal interpretation of the Bible. This problem must be understood in the context of the continuing disputes of the Reformation, and was shared by Protestant and Catholic. The older, medieval and so-called 'fourfold sense of the scriptures' had been characterized by a greater diversity and liberty than the literal interpretation, which had become more prominent through the theological debate between Catholics and Protestants caused by the Reformation. The text of the creation stories and several of the Psalms were interpreted as statements that could be used in a theoretical and therefore scientific–literal sense.

Initially, notwithstanding a certain inflexibility of positions, there still were possibilities of reconciliation on both sides. In letters of 1613, Galilei laid down his conviction that there cannot be contradiction between the 'book of revelation' and the 'book of nature'. With this thought, the door to reinterpretation of the Bible had been opened. On the other hand, Cardinal Bellarmin, then prefect of the Holy Inquisition, noted that if there was definite proof of the Earth revolving around the Sun, then the Church should be careful with explanations of passages in the Bible that seemed to say the reverse. However, other plaintiffs jumped to the rash conclusion that the scientific side had no theological competence whatsoever, so that this interpretational loophole remained shut.

The argument of the verdict in the first trial against Galilei (in 1616), according to which the Earth does not revolve around the Sun but the other way round, soon proved to be scientifically wrong, thereby widening the rift between church and theology on the one hand and science on the other.

Charles Darwin, the Papal Biblical Commission and Leo XIII

In 1909, the Papal Biblical Commission published a declaration in which the early chapters of Genesis were interpreted as historical facts so as to proclaim certain creeds of the Catholic tradition as irrevocable (Denzinger & Hünermann (DH) 3512–3519). These were particularly the teaching of the unity of humankind (*unitas generis humani*), the special creation of humankind (*peculiaris creatio hominis*) and the formation of woman out of the first man (*formatio primae mulieris ex primo homine*). This was one of the last attempts to fight scientific challenges to the biblical creation stories by invoking Church authority. It was also one of the last documents that still insisted on a largely literal interpretation of the Bible, neglected the work of historical-critical biblical interpretation and endeavoured to curb the impact of this theological research.

In 1893, Pope Leo XIII had stressed the value of biblical interpretation and the liberty of research in his encyclical '*Providentissimus Deus*'. The main focus of the encyclical was on the infallibility of the Bible, which had to be protected from constantly changing biblical interpretation according to the prevailing zeitgeist. Therefore it was stressed that through inspiration, God himself is holy author and originator of the Bible (see Pope Leo XIII 1893–1894, DH 3288). Of course, the church was conscious that the Bible had always been interpreted according to the ideas and views of each epoch, and that therefore these interpretations themselves must be judged accordingly and could not be simply adopted: 'They [i.e. the church fathers and the following biblical interpreters] might have—depending on the views of their time—not always judged accurately about items where matters of natural history are raised, so that they have claimed all sort of things, which nowadays cannot be accepted fully' (Pope Leo XIII 1893–1894, DH 3289).

The debate must be viewed in light of historical developments. As a result of secularization after the French revolution, the disbandment of the Church State of the Vatican in 1870 and the social consequences of the industrial revolution (which included the pauperization of many people, movement of people from rural areas into cities, and the severing of family and religious roots), the 19th-century Catholic church was characterized by suspicion against a world that seemed to be hostile towards it.

In this situation, Darwin published his book *On the Origin of Species by Means of Natural Selection* (Darwin 1859). From the beginning, the reception of the book was not characterized by factual clarity but by trivial quarrel. In particular, the question of whether humans are descended from apes was discussed, although Darwin had touched on the descent of man in only one sentence at the end of *The Origin of Species*.

In 1860, the Synod of the Rhenian church province met in Cologne. According to the Catholic understanding this was not a very important event, but it became significant because of some statements made there. The main business was not the work of Darwin, but the controversial publications of the philosophers and theologians Georg Hermes (1775–1831) and Anton Günther (1783–1863). Whereas Günther pursued a scholarly and scientific renewal of Catholic theology, especially concerning creation, which he considered to be in danger from the monistic philosophy of German idealism, Hermes was especially concerned with the arguments for faith and stressed the compatibility of faith and reason. Both had tried to develop a new Christian dogma that would conform to modern philosophical ideas such as Kantianism and German idealism, and they also had revised the theology of creation. The whole of theology (i.e. also the theology of creation) was expected to make sense within the framework of modern philosophy and therefore was not allowed to resort solely to arguments of revelation. Additionally, at that time, the zoologist Ernst Haeckel and the physician Ludwig Büchner propagated Darwin's ideas, giving them an atheistic interpretation, and polemicized against the Christian faith. Darwin's theory of descent by modification thus became a topic of the Synod. The Synod stated that teaching about a Darwinian descent of man, which was the obvious and logical extension of Darwin's book about the origin of species, contradicted the Bible and Christian faith. 'The creation of the human body was meant explicitly because this act of creation—according to Christian views—could not arise from a former state of nature, since then the unity of the human body and soul was either torn apart or the soul was degraded into a material essence' (Rosenberger 1998, p. 394). These statements resulted in a line of argument that was used in later years. They must, however, be viewed in their context. The possibility of evolution of animals and plants was recognized relatively quickly, but not evolution of humans, who theologically are not part of the animal kingdom. These statements were not a general rejection of science, but they endeavoured to defend the teaching of redemption and the theological anthropology in its broadest sense and grounded in the creation of man in God's image.

The encyclical of Leo XIII explicitly stated: 'Between the theologian and the scientist, there will be no possibility of true disagreement as long as both restrict themselves to their respective field of knowledge' (Pope Leo XIII 1893–1894, DH 3287).

The continuing confrontation focused increasingly on the question of the human status. At the same time, a differentiation of the argument, beneficial to both sides, was achieved, which then resulted in a consensus in the 20th century.

From Pius XII to the Second Vatican Council

Two encyclicals by Pius XII are of special importance concerning creation and evolution: '*Divino afflante Spiritu*' (Pope Pius XII 1943) and '*Humani generis*' (Pope Pius XII 1950). The first encyclical did not address evolution; however, it explained the principle of openness towards the methods of historical–critical interpretation and thus allowed a new understanding of the creation story. The goal of theological interpretation was explicitly stated: 'They [i.e. the interpreters] shall not only point out those things, which belong to history, archaeology, philology and other such disciplines; but they shall—of course with proper mentioning of these things as long as they are relevant to exegesis—show especially, which are the theological concepts of the individual books or texts in relation to questions of faith or customs' (Pope Pius XII 1943, DH 3826). Thus, the theological meaning of the biblical books is of interest, rather than a scientific interpretation; nevertheless, other fields of knowledge, especially natural science, should be taken into consideration to find the theological meaning.

Consequently, the encyclical '*Humani generis*' named only the last remaining argument against the adoption of the theory of evolution for the formation of humans: The belief that souls are created immediately by God and must be embraced by faith. Faith, however, does not contradict the research on the origin of the human body from already existing, living matter. Concerning evolution, the encyclical stated that the teaching of the Church did not forbid 'that evolution according to the present state of human scientific endeavour and of holy theology is addressed in research and debate of scholars in both fields, namely thus that the reasons of both opinions, i.e. of protagonists as well as opponents, will be weighed and judged with the necessary earnest, moderation and prudence' (Pope Pius XII 1950, DH 3896). The encyclical stated that the concept of so-called monogenism (i.e. humans have one origin as an original pair of humans) must also be embraced, to retain the concept of the primordial or original sin. Concerning the first 11 chapters of Genesis, the encyclical stated that these are not historical accounts in the usual sense of the word, but 'nevertheless in some sense are historical, which must be explored and determined by the exegete' and that the language was 'simple and illustrative' (Pope Pius XII 1950, DH 3898). That is, on one side, theological reserve was retained and some statements of faith were defended explicitly (immortality of the soul and hereditary sin) but, on the other, liberties of scholarly or scientific research were stressed and the possibility was opened for new interpretations of the creation stories.

This opening can be seen especially in the work of the Jesuit and geologist Pierre Teilhard de Chardin, who transferred the dynamic dimension of the evolutionary worldview to the teaching about creation and Christ. According to de Chardin, evolution moves towards the spiritual, which reaches its goal in the personal, the human. The highest personal point is Christ as Lord and Redeemer of the world. As such, evolution has reached its climax with the *logos* becoming man (John 1: 1, 14) (see Schneider & Sattler 1995, p. 203). Perhaps, this calls for more theological explanation. The history of redemption and profane history or evolutionary history are not simply identical. Evolution of life, which of course still continues after Christ's death and resurrection, is interpreted regarding his acts, and will find its goal and fulfilment at the end of time with the return of Christ (de Chardin's Omega Point). The process of evolution is totally accepted and, at the same time, its significance is seen in the light of Christ. The Church accused Teilhard de Chardin because in his theology redemption loses the aspect of the history of salvation, which is subsumed behind the idea of an inevitable 'Christification' governed by natural laws. He was also forbidden to teach and publish. Only after the Second Vatican Council was the importance of his concept increasingly recognized, and today it is viewed as a positive example of openness and dialogue between the modern world and the Catholic Church.

The Second Vatican Council did not explicitly address evolutionary theory, but recognized very different forms of evolution: it mentioned cultural evolution (*Gaudium et Spes*; GS 5), stated that human work is a continuation of the evolution of creation (GS 34), and mentioned social (GS 44), scientific (GS 54) and economic evolution (GS 66). Reading between the lines, a factual recognition and acceptance of biological evolution can be inferred.

The present debate: creation or/and evolution

The theological question of 'why' and 'where from' and the scientific question of 'how' and 'what'

This distinction between theology as concentrating on the 'why' and 'where from' and science as endeavouring to explain the 'how' and 'what' is not an adequate solution in the case of conflicting interests. This is because, from the theological point of view, not only is God recognized as creator and the creation characterized as coming from nothing into being, but also the question of how God provides for the creation (the problem of theodicy) and what will become of the creation in future is relevant. Equally, scientific research on biological evolution is carried out both on the mechanisms of evolution, in the sense of mutation and selection, and also on the causes of these mechanisms. In both fields we try to find connections, to name causes and to give explanations for our observations. Theologians as well as scientists consider the existing world and pose questions to it. However, there is a great difference in how both fields deal with this world and the conclusions to be drawn from it. Whereas issues beyond the empirical can be neither the object of research nor arguments in science, the theologian is necessarily directed to sources of revelation beyond the empirical.

Already among the first witnesses of Christianity, who all were Jews, the question had arisen concerning the truth of revelation and how one can clearly distinguish between human and divine word. Christians understand the word of God to be a person: Jesus Christ. They regard his existence and message as the climax of the self-revelation of God. Therefore, the first criterion for revelation was the witnessing of the life, deeds and words of Jesus. Therefore, an Apostle in this sense was one who witnessed the resurrected Jesus and who was sent by him to preach the word of God (see Galatians 1: 15–17). Because, with the passing of time, the generation of direct witnesses died, people had to find ways to conserve and pass on these witness accounts unadulterated. It became more important to hand this tradition down through trustworthy people authorized by the witnesses. The criterion for trust in this tradition was the closeness to primary witnesses and therefore to the Christ event. Therefore, Paul opted for giving up the strict instructions of the Jewish laws (e.g. the circumcision) for the sake of handing down the Christian tradition (see Galatians 6: 15f), believing that cultural laws should not become an obstacle to embracing Christ's message. The community of those who believed in Christ became bearers of the tradition, and in their midst the bishops, and later especially the Bishop of Rome. In particular, the tradition was passed on and understood more deeply through the decisions of the great Church assemblies, the Councils.

The Bible was and is the most important authority in this process of tradition, as Christians believe that the texts of the Old and New Testament found in the Bible are the testimonies of the self-revelation of God; written down in the human words of the various witnesses (see 1 Thessalonians 2 : 13). The community of the faithful under the guidance of the bishops and the Pope, supported by theological research, preserves the authenticity of the tradition and provides for its continuing interpretation and dissemination. In particular philosophy, and other humanities and sciences, always have been (and are still) used to make this work of passing on the tradition possible, whether the use of Greek philosophy in explaining the trinity in the fourth century, or Aristotelian philosophy for St Thomas Aquinas.

During the Age of Enlightenment, reason became an ever more important guideline. However, from the beginning, believers had to follow the rule: What God reveals to humans about himself, does not contradict human reason, but rather can be understood through reason (see Philippians 3: 8–11). Whoever today talks about 'God's revelation' must submit to the historical and present verdict of the community of believers and must consider the tradition of understanding the whole of the Bible and the history of its interpretation. And last and not least, they must account for these 'revelations' by human reason. This is what the task of theology is: the rational formulation and explanation of the reliable testimonies of belief found in God's revelation, the Bible, which have come down to us by tradition.

This is not done just for its own sake (as an intellectual exercise), but for the salvation of humans. Thus the Second Vatican Council formulated in its constitutions about divine revelation: 'Through his revelation, God wanted to impart and communicate himself and the eternal decisions of his will about the salvation of humans' (*Dei verbum* 6).

The documents of the Bible have empirical causes, in as far as they have been written down in a historical process by humans and much that is contained in these documents can be verified by empirical methods (such as archaeology, history, philosophy, linguistic and literary research), but the originator of revelation is God, who ultimately is beyond the reach of humans and human understanding. Yet God himself decides to communicate with humans. These communications the theologian calls revelation. God 'speaks' to humans about himself, his nature, his plans, and his commands. For instance, in Exodus 3: 6, God told Moses that he is the God of his fathers, the God of Abraham, the God of Isaac and the God of Jacob. Moses then covered his face because he was afraid to look at God.

God is not part of this world but is before and above it in a hierarchical sense (God is transcendent), but he can act out of free decision within, with and for this world (God is also immanent), because the wellbeing of humans is his concern. For example, in Exodus 3: 7–8, it is described how God saw the suffering of his people in Egypt, and planned to protect them and guide them to a land where milk and honey flowed. This scene from the Old Testament shows that these things have happened in this world and can be verified empirically. On the other hand, there is much to say from a historical–philological point of view about the process by which these lines came down to us. The central meaning of these biblical verses, however, is, that God is the 'totally other' (i.e. transcendent). God addresses a human, acts for and on humans, and finally remains remote from human endeavour. He is the Lord of this world, its creator and keeper, and nevertheless remains completely free, the one to whom humans owe thanks and respect. Part of this respect is to deal critically and conscientiously with the word of God and not to talk carelessly of revelation. Authorities in dealing with revelation are the Bible and tradition, and the community of believers under the guidance of the bishops and the Pope within a discourse of human reason, as it is developed in theological reflection and in other humanities and sciences.

Scientists reject the notion of 'mother earth' as mythological and therefore not scientific or falsifiable. Matter, its causes, consequences and connections are their objects of investigation. This matter, from a theologian's point of view, is insignificant compared with God. In antiquity and more recently there have been many ideas about matter being eternal. Against this, the first Christian theologians emphasized the creation from nothing (*creatio ex nihilo*), derived from the 'otherness' of God compared with the material world, as did Athanasius in *De Incarnatione Verbi Dei* (Meijering 1989, chapter 2). At the beginning, there was just God and everything that is, came out of and from God. Theologically speaking: there is only something because God wants that there to be something, and everything exists only because God keeps it and provides for it to continue. As such, creation is not just a single act but continuing action of God. To recognize and believe in this continuing action of God is one thing. It is a completely different issue to research the truth of creation with the means of human reason. The two are not in opposition, as long as the different viewpoints and the completely different scope of intentions are kept in mind. This is the problem of creationism and intelligent design.

The fundamental problem: creationism and intelligent design

In the sense of (Christian) fundamentalism, creationism and intelligent design have to be viewed together, as both models or movements show similar deficiencies. The deficiency is found in the interpretational principles. Whereas the mistake of creationism is the attempt to prove an alleged history with ahistorical methods and empirical issues with biblical teachings that never were meant as empirical statements, intelligent design operates at the other end of the spectrum and tries to explain empirical facts (e.g. blood clotting) by means of non-empirical categories. Common to both is the basic problem of fundamentalism: a disconnected use of reason, models of thinking that fall short of their purpose and an ideologically restricted world view. In short: fundamentalism is a problem of thinking.

Creationism exists in different forms, more liberal and more extreme, but common to all is a literal or at least ahistorical understanding of the Bible. Although it has been demonstrated by scholarly research that the books of the Old and New Testament originated over several hundreds of years and then have merged in a long process into the present canonical form, the Bible is understood literally by Christian fundamentalists, and the relevant 'help-mates' of theology (i.e. archaeology, history or philology) are used in a way that does not conform to the rules of the scholarly or scientific community.

This pre-Enlightenment use of the Bible must necessarily lead to misinterpretation and fits neither to the life of modern humans nor to the present state of science and the humanities. An especially severe error, however, is the fact that the intention of biblical writers is misinterpreted. As neither the historical background nor the allegorical or metaphorical levels of meaning, to be deduced from philological and literary studies, are noticed, a very complex and differentiated message of revelation is reduced to human measure. The consequence is an image of God that conforms much more with the wishes of the reader rather than providing a challenging message. It is not the scholars of theology who misrepresent the Bible, a common accusation by fundamentalists; on the contrary, the image of God is shaped upon the mould of the fundamentalist's imagination.

There is a corresponding element in the intelligent design movement. This claims to follow scientific knowledge in large parts but then sidesteps to a different level of interpretation, when it claims that specific aspects of the complexity of development, which it terms irreducible complexity, and the continuation of life necessarily require an intelligent designer. To be more precise: whenever the knowledge of matter that can only be described by theories such as the Big Bang or the evidence for the evolution of species has the occasional 'gap', an explanation is sought, which can be found only in a purely transcendent intelligent designer. That is, at the moment when one level of argument no longer offers a complete and satisfactory solution, it is discarded for another, thereby neglecting the different laws and motives of the relevant level of argument.

For the fundamentalist believer who accepts a literal six day creation, the theory of evolution is an impossibility: as God surely tells the truth and this truth is found literally in the Bible, the theory of evolution must be false. The problem is solved by explaining the world as corresponding to the (fundamentalist) understanding of the Bible.

For adherents of intelligent design, science shows too many gaps to explain the world completely and therefore some 'element' (i.e. the actions of an intelligent designer) must fill these gaps. The scientific error of this attitude lies in the fact that this element is irreconcilable with the scientific argument, and therefore the construction as a whole does not follow from the premises and cannot be substantiated by arguments. The theological error is a rather humanized image of God: God becomes a God of the gaps and is not longer the other, to whom we can relate personally.

Opening of Catholic teaching for science

In a much regarded speech to the members of the Papal Academy of Sciences on 22 October 1996, Pope John Paul II spoke the later much quoted phrase: 'evolution is more than a hypothesis'. He referred to the encyclical 'Humani generis' by Pius XII, which I have discussed already.

Pope Pius XII deemed evolution to be appropriate for scientific and theological research, but also asked for caution where 'it is more like a hypothesis, even if it somehow can be strengthened by scientific evidence' (Pope Pius XII 1950, DH 3895). In contrast to this, has John Paul II now made a full recognition of the theory of evolution by the church? Certainly not, as this had not been the aim of the Pope's speech. He further added:

'A theory is a meta-scientific development, distinct from observations but homogeneous to these. It allows to put independent data and facts into context and to interpret them. The theory proves its veracity by being testable; it is constantly measured against the known facts. Where it can no longer account for the facts, it proves its boundaries and its unsuitability. Then we must think again' (Pope John Paul II 1996). That is, the Pope put the theory of evolution into the scientific context; this is where it was developed, and this is where it must stand the test, and be confirmed or falsified or improved.

Eight years earlier, the Pope addressed the relationship between religion and science explicitly in a letter to the former director of the Vatican Observatory, the Jesuit George Coyne:

> both religion and science must preserve their autonomy and their distinctiveness. Religion is not founded on science nor is science an extension of religion. Each should possess its own principles, its pattern of procedures, its diversities of interpretation and its own conclusions. Christianity possesses the source of its justification within itself and does not expect science to constitute its primary apologetic. Science must bear witness to its own worth. While each can and should support the other as distinct dimensions of a common human culture, neither ought to assume that it forms a necessary premise for the other. The unprecedented opportunity we have today is for a common interactive relationship in which each discipline retains its integrity and yet is radically open to the discoveries and insights of the other (Pope John Paul II 1992, pp. 155–156).

This is a clear recognition of and demand for autonomy of religion and science along with the simultaneous wish for dialogue and mutual support or debate.

The statement that the theory of evolution is more than a hypothesis simply means that research has developed further and new evidence has constantly been added, which now allow for this conclusion. A recognition or rejection of a theory by the church is possible only if questions of Christian faith are affected by it. Here John Paul II addressed the same aspect as Pius XII did 40 years earlier: the Christian view of humanity.

This view is characterized essentially by the idea that humans as persons possess not only intellect but as beings also possess the faculty to relate to others. This ability to relate to others has its foundation in the love of God.

> Consequently those theories of evolution are not compatible with the truth about humans, which—driven by some ideology—take the spiritual as just one facet of the powers of living matter or just as an epiphenomenon of this matter. These theories are also not able to argue for the personal dignity of humans. As a result, the theories of evolution which, because of the philosophies which inspire them, regard the spirit either as emerging from the forces of living matter, or as a simple epiphenomenon of that matter, are incompatible with the truth about man. They are therefore unable to serve as the basis for the dignity of the human person (Pope John Paul II 1996, No. 5, official English translation).

This aspect of the view of humans is a good example of the interaction of the two realms, religion and science, with simultaneous recognition of their autonomy. These statements can only be adequately taken in and discussed with mutual acceptance. Theologians must view the progress of science critically and openly where it has consequences for their field, and refer to it accordingly. Scientists must recognize the limitations of their argument in noticing the completely different intention of the religious statement, and accept that it is equally important for human culture. Both together must collaborate in developing and shaping this culture.

A recent example of this culture of co-operation and dialogue was the meeting of Pope Benedict XVI and his former students on the topic of 'creation and evolution', from 1 to 3 September 2006, in Castel Gandolfo (see Horn & Wiedenhofer 2007). In a final statement to the meeting, Pope Benedict XVI stressed that, on the one hand, we must adhere to the biblical belief in creation, which has led to a civilization of reason, and, on the other, we also must recognize the limitation that, notwithstanding all rationality in nature, a total insight into God's plan cannot be obtained.

The dialogue: creation in form of evolution

God is the creator and initiates the becoming

The view of God as creator, sustainer and provider of the world must be protected from too narrow a restriction to one or just a few aspects. The examples of creationism and intelligent design illustrate that God cannot be used only for explaining certain processes, but that we must constantly address the relationship between human freedom and the freedom of God. The eternal godly freedom is the origin of the relative freedom of the creation, but even this freedom of God has its own laws. Neither natural laws nor human autonomy is in contradiction to God's freedom. The contradiction appears only as soon as the relation of these two is corrupted and one of them taken as absolute. To clarify this relationship and the danger of taking one part as absolute, I would like to elaborate briefly on some traditional terms, as follows.

Creatio ex nihilo *and* creatio continua. This traditional distinction refers to the origin of all being (i.e. the creation from nothing) and the preservation of all that is (i.e. the continuing creation). It would be too short-sighted to equate *creatio continua* with evolution and to view *creatio ex nihilo* as God's own and original work, not accessible to scientific expertise. The danger lies in dividing the continuum of God's work into different categories to make room for scientific thinking. It is much better to argue from the idea of freedom: God creates the world in complete freedom and creates it in a manner that enables the world to become creative itself, albeit in a restricted fashion. This relationship is traditionally expressed in the following formula.

God acts in the world as primary cause (causa prima) *through secondary causes* (causa secunda). The term 'primary cause' is meant to express that all that happens does so only because God wants it to happen, or because it can be traced back to God's acting. As secondary cause, we consider nature and human action, for both of which a (relative) independence is granted by the term 'secondary cause'. Here too, it is crucial that the underlying freedom must always be thought of as the expression of a relationship, so that there is no clear distinction visible between the action of God and of men. The 'before' of God is a logical one and cannot be simply interpreted as temporal. The independence of nature and man (also in the sense of development or evolution) must be traced back (theo-)logically to the acting of God, but from a human perspective it is not clearly visible how much God is 'directly' at work. Only in faith can conclusions be drawn in prayers. As such, there is the question of the connection of the following terms.

Creation, providence and miracle. Here too, an oversimplified view could be expressed as follows: in the beginning, God created the world from nothing, but from then on preserved this creation and concerned himself about his creatures (= providence). Simultaneously, he not only cared routinely but also in extraordinary ways (= miracles). Such a view of causality must consequently fall into the danger of conflicting with natural causes. However, if these things are thought of rather as expressions of relationship, then there is a more differentiated and nuanced picture: God creates in love the world and the living beings, to stay related with them on a path of love, which eventually will lead them back again into the (final) community with God. The path of this loving relationship is traditionally called providence. Again, we have to note that this happens in freedom (on both sides). God in liberty provides freedom so that this path can occur within time in the form of open history. It is an improper restriction of this freedom to define providence as a hopeless predestination of future. The relationship of freedom explicitly includes that humans can perceive the acting God in the world (through faith). As such, the whole redeeming history is already to be termed a miracle. However, because humans are bound to time and space, they often need extraordinary moments and localities, so that the term 'miracle' usually is used for extraordinary events of (faithful) recognition of God. The overarching occurrence is the relationship in freedom.

Freedom of the creator and the freedom of the created. God is absolutely independent in his acts and in this sense absolutely free. As creator he is the free cause, who creates to freedom. God is the one who makes that world, and humans can make things from the material of that world. This making by humans is therefore directed to bring the divine founding action always newly into presence. Through proving themselves towards self and the whole creation worthy of having been created, freedom and salvation is possible for them as created being. In the idea of God creating man in his image is included the thought of development. Humans are becoming, progressing on the path towards the image of God, as how they were thought of by God. The freedom of God and the freedom of humans, the creating and constant acting of God with simultaneous autonomy of creation and created beings in the Christian view can be thought together only if the fact of incarnation is taken into account.

Incarnation as redemption of the creation and goal for evolution

In the light of religious experience, Christians look for the creative, redeeming and completing presence of God within today's world. Thereby such experience refers to the whole of reality as well as to the individual life. It is recognized that there is a difference between the factual, transient reality and the redeemed, completed reality. However, at the same time, we experience and trust that there is transcendence in form of events, which are given as a gift to us. The tension in this experience must be protected against misinterpretation, which would allow only the extreme ends of this field of tension: against a monism that excludes living relationship and tension, and against a dualism that 'over-stresses' tension and assumes two equal principles in discord.

Redemption in a Christian sense is possible especially because the transcendent God is immanent and thus transforms this creation, or, theologically speaking, redeems this creation. The crucified (Jesus Christ), who is also the resurrected and ascended, has transformed the creation for ever. Since the event of Easter, the creation has become new creation. This new creation is under the so-called eschatological proviso, so that redemption in the full sense is reached only when this creation is returned into the creator. The world, which was created in freedom, was not only in the beginning but is now constantly an object of the loving compassion of God, who has turned towards his creatures in Jesus Christ in a free and loving relationship, and in a historically singular way, to lead his creation to the redeemed and newly created reality of completeness. Evolution is therefore not only an expression of the freedom of this world or of humans and their culture but also a process that is inherent in the ways of God. Thus evolution can be neither a process that is excluded from the ways of God nor a process that is exclusively the doing of God. Comparable with what happens in the sacraments, it is a complex union of freedom inherent in God on the one side, and in humans or in the creation as a whole on the other.

Conclusion

The history of the emancipation of modern science can be traced in the history of the relationship between creation and evolution. However, on the other hand, this is also an example of the growing importance of scholarly–theoretical issues within theology, especially in relation to the interpretation of the Bible. Three phases can be distinguished: (1) the time when teachings about creation were the dominant model; (2) the time when the scientific model of evolution clashed with the theological doctrine of creation; (3) the present phase of dialogue and the mutual rapprochement or even recognition.

The verdicts against Giordano Bruno and Galileo Galilei were reached in the phase of predominance of the creation doctrine, and were not just a direct and simple consequence of stating a heliocentric worldview. In the case of Bruno his theological statements about the trinity and the doctrine of salvation were the decisive factor of his condemnation. However, in Galilei's case it was a problem of interpretation: truth only made sense as a theological statement, because ultimately only God could lay claim to truth. Galilei contradicted this idea and claimed for his empirically derived views also the term truth.

During the 18th and 19th centuries, the phase of antagonism between empirical science and ontological–metaphysical theology was intensified, and the pursuit of power and influence led to increasingly polemic debates. The adherence of the papal Biblical Commission to a literal interpretation of the Bible can only be understood in these conditions. Nevertheless, also in this period, people on both sides did attempt to establish a dialogue. The theological system of Teilhard de Chardin can be mentioned as an example.

The recognition of the scientific method and the opening for complementary research by the encyclicals of Pope Pius XII brought about a cautious change. Only in the recent past, initiated by the teachings of the Second Vatican Council, which were directed towards communication and discussion (especially in the document 'Gaudium et Spes'), was room made for a fruitful collaboration and the instigation of complementary scientific–theological models. The phase of dialogue began.

The basic openness to dialogue and the recognition of the working methods (methods to be accounted for theoretically) of theology and science highlight on both sides extreme positions that from their method of argumentation, must be called fundamentalist. 'Creationism' insists upon a literal–naive understanding of the Bible, which cannot be supported by scholarly–theological means, whereas the 'intelligent design movement', under the guise of empirical science, tries to present religiously motivated statements as empirical facts. Both groups are characterized by a closed world view and the use of arguments that do not follow from their premises.

The relationship of autonomy of the creation and, at the same time, constant relatedness of this creation to God the creator and keeper can be a metaphor also for the relationship between theology and science. The two are independent because they are based on different models of interpretation and they also differ in the leading aim of their questions; however, there are also common denominators, especially in the research object, the 'world'. Here it is crucial to point out in mutual dialogue the different structures of argumentation, models of interpretation and aims, so that the two fields can support each other but also be able to follow completely autonomous paths.

Rational argument remains the common denominator and allows dialogue at any time. The different interpretational structure allows coexistence without problems and shows that the often-cited conflict between creation and evolution is artificial and not a necessity.

Empirical facts are the foundation for scientific arguments, which must allow the drawing of logical conclusions. The theological statement rests basically on the message of revelation, which is reflected rationally by means of scholarly and scientific research. The acknowledgment and awareness of these differences allow for a fruitful dialogue concerning the common object of research (i.e. humans and the world); a dialogue that we should attempt for the benefit of humankind.

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An Anglican priest's perspective on the doctrine of creation in the church today

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Abstract: The Protestant understanding of creation in relation to science has been slightly different from that described for the Catholic churches and more diverse, as Protestants emphasize the authority of the Bible and private judgement. The conflict thesis of science and religion is rejected, but there were four skirmishes: over heliocentricity, the rise of geology, evolution and, today, the impact of creationism. The variety of belief among Protestants, and especially Anglicans, is expounded from non-realism, which denies the existence of God, to critical realism, in its liberal and conservative forms, which totally accept modern science, to 'naive' realism, which emphasizes the plain, or literal, reading of the Bible and rejects evolution and, often, geological time, and has given rise to 'creationism'. Representative examples of each are introduced.

As a Christian with an orthodox Anglican theology, there is much I totally agree with in the paper by Ostermann (2009), as I do with Pope John Paul II's speech to the members of the Papal Academy of Sciences on Evolution of 1996, Pope Benedict XVI's work on early Genesis published in the 1980s and, in part, Cardinal Schönborn's views in *Creation and Evolution* (Horn 2008), although he shows too much sympathy to the questionable ideas of German intelligent design proponents such as Junker & Scherer.

Despite the immense convergence that has taken place between Roman Catholicism and the 'Protestant' churches since the Second Vatican Council of nearly half a century ago, there are still differences between the two. The Roman Catholic church puts far more emphasis on the contemporary teaching office of the Church (i.e. the Vatican and the Pope), whereas mainstream Protestants and Anglicans are more independent. Even so, the relationship of science and Christianity and creation expounded by Ostermann is very similar to the Protestant mainstream, but clearly not 'creationist'.

However, there are greater differences between the various Protestant[1] churches, and these are even greater when the more fundamentalist evangelicals[2] are included. As befits the subject of geology and religion I shall confine my comments to the doctrine of creation, which comes out in the first chapter of the Bible and the first article of the Apostles' and Nicene Creeds. Today it is impossible to consider 'creation' without considering the various forms of 'creationism' that have swept the USA since its revival in 1961, and that are now spreading through the rest of the world (Numbers 2006; Roberts 2008).

Despite the fact that all Christians affirm the doctrine of creation as a basic belief there is great diversity on what that belief actually means. There is an even greater diversity on the understanding of creation in relation to science, where we are bedevilled by two related issues. The first is the continued acceptance of the conflict thesis of science and religion put forward by J. W. Draper (in relation to the Roman Catholics) (Draper 1923) and Andrew Dickson White in the late 19th century (White 1896). Despite this thesis being undermined over the last few decades, especially in the books edited by Lindberg & Numbers (1986, 2003), it still persists. The second concerns geological time and is the widespread claim that all Christians accepted Ussher's date of 4004 BC until Hutton and Lyell shattered that belief (Lewis & Knell 2002; Rudwick 2004; Roberts 2007). It is usually told with a strong Anglo-centric bias and little recognition is given to other geologists, British or not. This still bedevils historical treatments of geology in British and US textbooks, and in 'popular' science.

A brief history of science and Christianity

Hard on the heels of the Renaissance the Reformation was begun in 1517 by Luther. The ensuing controversy between Protestants and Catholics resulted in a hardening of theological ideas and a greater emphasis on the literal nature of the Bible by both. This was seen in the general acceptance of an Earth created in about 4000 BC, which reached its apogee in Ussher with his famous date. Although the ideas of warfare between science and religion were overstated, there were a succession of skirmishes.

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The first was over heliocentricity, culminating with the trial of Galileo, but by 1700 heliocentricity was almost universally accepted. With the rise of geology in the 18th century a literal interpretation of Genesis became untenable. White (1896, Chapter V) wrote of the conflict, which he considered to be greater in Britain than in mainland Europe, although that can be questioned. Despite a minority of Christians opposing geology, most educated Christians had little problem, although some of their schemes of accommodation seem rather forced (Roberts 2007; Lewis 2009). By the 1850s, biblical literalism had largely gone, although it survived for some revivalist chapels, traditionalists (Young 2009) and the Seventh-Day Adventists. After the publication of *The Origin of Species* (Darwin 1859) many Christians initially opposed evolution but soon adopted it (Moore 1979). In the 1920s, however, anti-evolutionism reared its head in the USA at the Scopes trial, but had little impact elsewhere. The last skirmish, which seems to be turning into warfare, is over creationism, which began in the USA in 1961 with the publication of *The Genesis Flood* (Whitcomb & Morris 1961), which has had a great impact first in the USA and now throughout the world (Numbers 2006; Moshier *et al.* 2009).

All of these skirmishes raise matters of science and of theology. I shall consider only the latter. As modern science developed many theological understandings could not remain unchanged. The basic understanding of *creatio ex nihilo* remained largely intact, except for more ‘liberal’ Christians. However, the understanding of geological time and prehistoric humans raised questions about the historicity of the Bible and as a result the doctrine of creation was modified by mainstream Christians or at times the science was rejected. With the discovery of primordial beasts living before humans, the picture that death came in at Adam’s fall became absurd. Christian thinkers have dealt with these issues in a variety of ways. Some have welcomed the science and found ways of retaining a ‘traditional’ theology, others have formulated a radically new theology, and yet others have rejected the science. Finally, over the last 30 years there has been much more engagement between science and Christian theology, and to that we turn.

Recently there has been a surge of interest in science and theology within all churches, whether Protestant or Catholic, liberal or conservative. A few decades ago it was possible to keep up with most publications on this subject. That is not the case today, as there is a deluge of publications from every possible scientific or theological perspective. Parallel to this has been a much greater interest in the doctrine of creation and a Christian attitude to environmental issues. As well as these, death, pain and suffering, the origin of humans and original sin raise problems for believers, and these are either grappled with seriously or the Gordian knot is cut by adopting a young-Earth creationist (YEC) approach, which simply claims that death and suffering came as a result of the transgression of Adam and Eve in the Garden of Eden and thus geological time and evolution must be wrong by definition.

Varieties of belief

Within the British and US Protestant churches there is an immense variety of understandings of the doctrine of creation, particularly within the mainstream denominations, which have both liberal and conservative or evangelical wings. I will subdivide them into three main groups, two of which may be divided again. These are:

(1) non-realism;

(2) critical realism ((a) liberal; (b) conservative);

(3) naive realism ((a) old-Earth creationism (evolution denied); (b) young-Earth creationism).

I have chosen this relatively unusual way of classifying Christian belief today as I consider it to be the best way of highlighting the spectrum of today’s Protestants, especially in the English-speaking world. Like any classification it has its limitations and, as we are dealing with human thought, these groups do not form watertight compartments. The various types of ‘realism’ give a good focus, as they centre on the nature of God, creation, and the meaning and content of theological language, which may or may not look to the Bible as revelation. At the extreme of non-realism, theological language is purely metaphor, which gives meaning to life, and in naive realism every biblical statement ‘naively’ and literally describes concrete phenomena.

Non-realism

Non-realism is very much a minority position in any of the churches, as its proponents argue that to be Christian one need not believe that God exists, and should not for philosophical and theological reasons. Its most well-known advocate is the Cambridge theologian Don Cupitt, who argued his case in *The Sea of Faith* (Cupitt 1984). Cupitt looks to Rorty’s anti-realism for a philosophical underpinning to his theology. Other significant writers are R. B. Braithwaite and the late novelist–philosopher, Iris Murdoch.

Non-realism has a limited appeal, and appeals only to those of a particular philosophical perspective.

Dawkins has waxed lyrical on 'atheist priests as Don Cupitt' and continued: '[B]ut if "religion" is allowed such a flabby elastic definition, what word is left for *real* religion, religion as the ordinary person in the pew or on the prayer-mat understands it today' (Dawkins 2003, p. 147). Non-realism cannot satisfy an atheist or agnostic, or the normal believer, who will think of God in (naive?) realist terms.

Critical realism

In its various forms this is probably the dominant thinking person's understanding within the mainstream churches. It combines a respect for and acceptance of all science with a robust view of God, which may vary from the panentheism of Arthur Peacocke to a traditional understanding of *creatio ex nihilo*. Philosophically, Protestants with this view look to Ray Bhaskar (1986) and W. H. Newton Smith (1981), and scientific critical realism, which emphasizes that scientific discourse is 'real' in what it describes, although it uses models and metaphors. This is in marked contrast to the work of Rorty and Feyerabend on the philosophy of science.

Two of the most significant British theologians from a liberal stance are the biochemist–priest Canon Arthur Peacocke (died 2006) and the former Oxford professor of theology Keith Ward; Anglican clergymen who have written prolifically. Peacocke was a biochemist at the universities of Birmingham, Oxford and Cambridge working on aspects of DNA. He became interested in science and religion in the 1950s, initially taking advice from a priest–physicist Grenville Yarnold (who happened to be my uncle). Peacocke was ordained in 1971 and began writing on theology and science. His perspective was that of a liberal Anglican and consequently valued the Bible rather than regarding it as the ultimate authority and revelation. To the critic he was weak both on the Bible and in his understanding of redemption in Christ. His theological method was far more reflecting on the natural world as understood by science rather than appealing to revelation.

On creation he rejected the doctrine of *creatio ex nihilo*, in contrast to all others described in this section and Ostermann (2009), preferring panentheism (literally 'God in all'). According to this, God is not solely transcendent and separate from the creation but involved in it, although not totally identified with creation as in pantheism. (Panentheism and pantheism are often confused.) Peacocke emphasized the immanence of God in creation rather than both immanence and transcendence. His theology had more in common with the process theology of theologians such as John Cobb and David Griffin (Cobb & Griffin 1976) than traditional Christian theism. Although Peacocke believed that God is closely involved in his creation and used his scientific understanding to expound this, he did not accept the miraculous because he regarded this as contrary to the nature of God. This agrees with much liberal Protestant theology over the last 150 years, but more conservative Protestants do accept the existence of miracles. Peacocke was a prolific writer and his mature thought is best read in *Theology for a Scientific Age* (Peacocke 1993) and, more briefly, *Paths from science towards God* (Peacocke 2001), the latter title summing up his method.

Canon Keith Ward was originally an atheist philosopher. His interest in science and religion stemmed from his time at Cambridge, where he was involved with seminars with Peacocke and Polkinghorne. Ward sees the future of religion in a liberal rather than a conservative faith, which is open to all religions, Christian or not. His many publications centre on the philosophy of religion rather than a theology based either on revelation or Christ. Ward summarized his work in *Pascal's Fire* (Ward 2006), which is an excellent introduction to this style of thinking. He argued that scientific explanations are incomplete, and that only a belief in a god, the mind behind it all, makes rational sense as 'a very elegant, economical and fruitful explanation of the existence of the universe'. Not surprisingly, Dawkins did not agree (Dawkins 2006, p. 179).

Somewhat more conservative, and more Christ-centred, are the many books by the Canon Sir John Polkinghorne, FRS, whose perspective is cosmology rather than geology or evolution. Polkinghorne was professor of mathematical physics at Cambridge before being ordained in 1981 and later became President of Queen's College, Cambridge. His theology is more 'traditionally orthodox' than that of either Ward or Peacocke, and the key to his understanding of God as Creator is to be found in the suffering (or self-emptying (*kenosis*)) of Christ on the Cross. This was discussed by Peter Bowler in his recent book *Monkey Trials and Gorilla Sermons* (Bowler 2007), and I cite him for his sensitive exposition:

> Here the thought of John Polkinghorne and John F. Haught (2000, 2004) becomes instructive, because they see that the central role played by suffering in the world may be just what we should expect if God had relinquished His control over nature in order to give His creatures a degree of freedom within their world. Unlike some other religions, Christianity can be presented as a religion in which God, far from sitting outside His creation, has actually entered into it and suffers along with the struggling creatures within it. Such a vision seems to make sense of the fact that the son of God himself suffered the consequences of human

selfishness and intolerance—and the Father did not intervene to prevent this supreme level of involvement and sacrifice. As Polkinghorne writes:

> In the lonely figure hanging in the darkness and dereliction of Calvary the Christian believes that he sees God opening his arms to embrace the bitterness of the strange world he has made. The God revealed in the vulnerability of the incarnation and the vulnerability of creation are one. He is the crucified God, whose paradoxical power is perfected in weakness, whose self chosen symbol is the King reigning from the gallows (Polkinghorne, 1989, p.58).

> This is powerful stuff, even for a nonbeliever like myself. Here is a totally different vision of the relationship between God, humanity and nature to that offered by the fundamentalists. This is not a God who punishes us eternally unless we accept His son's sacrifice as the only route back into His favor. It is a God who participates in the human drama and in the drama of creation, and if there is any kind of God who makes sense to the convinced Darwinian, this is probably it (Bowler 2007, 222–227).

I think I agree with Bowler.

Taking a similar line are the books by Alister McGrath, who has a PhD in biophysics and is now professor of theology at Oxford. McGrath is probably the most prolific evangelical theological writer in the Church of England today, but his evangelicalism is far removed from the evangelicalism associated with 'creationism', and his treatment of science is similar to that of Polkinghorne. Most of his writing has been on systematic and historical theology, and his *Christian Theology*, *An Introduction* (McGrath 2001) is a standard work. Unusually for one trained as a scientist, his *Christian Theology* makes scant reference to science. That deficiency was soon to be remedied as he published *Science and Religion; an Introduction* (McGrath 1998), followed in the next few years with his three-volume study *A Scientific Theology* (McGrath 2002–2003). The three volumes are entitled respectively, *Nature*, *Reality* and *Theory*, and deal at great depth with the relation of science to theology. However, this evangelical theology is further removed from young-Earth creationist approaches than it is from liberal theologies such as Arthur Peacocke's.

Several British scientists have ventured into theological writing, most notably the geneticist R. J. Berry, the Cambridge geophysicist Bob White and the biochemist Denis Alexander (who studied biochemistry under Peacocke at Oxford), all of whom are leading members of Christians in Science and evangelicals. Berry and White are members of Anglican churches. In his Gifford Lectures of 1997–1998, R. J. Berry presented the concurrence of biological evolution and an evangelical theology published as *God's Book of Works: The Nature and Theology of Nature* (Berry 2003). Alexander's works include *Rebuilding the Matrix* (Alexander 2001) and *Beyond Belief* (Alexander & White 2004). These three writers totally accept geological dating and evolution almost in its entirety, but White and Berry also claim that the biblical Adam lived about 10 000 years ago, which many do not find convincing. This is a similar theological problem to the one that Ostermann (2009) outlined over monogenism.

All of these writers seek to explain the doctrine of creation within a context of the accepted scientific understanding, and show the intellectual depth and range of recent writing on science and religion. My intention in this section has been to describe, rather than evaluate, contemporary British theological writing on creation.

'Naive' realism

By naive realism I mean that there is almost a direct one-to-one relationship between the words used by theologians and in the Bible and the actuality described, rather than the greater use of metaphor adopted by critical realists. Theologically, this is within the more conservative and 'fundamentalist' part of evangelicalism. Here, there is a great desire to understand the Bible in its 'plain and literal sense' and proponents consider that they are continuing the interpretations from the Reformation (Young 2009). In some senses they are, and this can be seen in some evangelical theology today, especially from the USA. This position is also growing rapidly in the UK and with the growth of evangelicalism in all parts of the world, including the 'new' evangelicals of mainland Europe.

All 'conservative' evangelicals have a very traditional doctrine of creation and emphasize *creatio ex nihilo*, as described by Copan & Craig (2004), although these two authors have much in common with McGrath, Berry and Alexander, except over evolution. However, many reject large parts of 'historical science'. Readers will be familiar with young-Earth creationists (YECs), who deny both evolution and geological time, but there are others who accept geological dating but not evolution: old-Earth creationists (OECs), who have remained with a pre-Darwinian understanding. Copan & Craig are examples of the latter. The reasons for the adoption of such positions, which seem nonsensical to most geologists and biologists, have similarities to the Catholic rejection of evolution a century and a half ago as described by Ostermann (2009). With the Bible being almost iconic for many evangelicals the concern is both the plain meaning of the Bible and the origins of humanity, and also the origin of suffering (Roberts 2008, p. 7).

Many call these evangelicals 'fundamentalist' (*evangelikal* in German) but the term is unhelpful and pejorative. 'Fundamentalism' is often used to label those evangelicals who insist both that the

Bible is inerrant and that Genesis is be taken literally. Commonly, this is regarded as a US phenomenon. It is correct to state that fundamentalism began in the USA in the late 19th century (Numbers 2006; Roberts 2008), but the movement is now worldwide. In 1900 many early fundamentalists accepted evolution, but following the Scopes trial of 1925 and the revival of young-Earth creationism in 1961, the movement has become belligerently anti-evolution and anti-geology. Probably most evangelicals in the USA are anti-evolution, as are increasing numbers in Britain and the rest of the world. These kind of opinions were scarcely present in Britain in 1970. To confuse matters, there is no simple demarcation between the conservative mainstream (such as McGrath and Berry), who are often evangelical, and those who are clearly 'creationists'. Thus in the USA, where nearly half the population claim to be evangelical, there is a range of outlook. At an evangelical liberal arts college such as Wheaton College (Moshier *et al.* 2009) most of the teaching staff (and all the science faculty) accept geological dating but not always evolution. However, about half the students go to college convinced that the Earth was created in 6 days, which presents a challenge in science teaching. (This I say from experience, as in 2001 I taught a geology course for Wheaton at their Black Hills Science Station.) Some other evangelical colleges, such as Liberty University and Cedarville College, insist that all staff are YECs and teach geology from that perspective. As a result, there is immense pressure for all evangelicals to adopt such views.

Until a few years ago, most in Britain were unaware of the growing problem of young-Earth creationism in churches and, increasingly, influencing education as with the Truthinscience initiative since 2006. YEC Christians hold the same central beliefs about God as creator, Jesus Christ, etc. as other more mainstream evangelicals and may seem indistinguishable from other evangelicals, but they insist that the Bible is inerrant and has to be interpreted literally. This kind of perspective is more prevalent in the USA but more and more evangelicals throughout the world are accepting young-Earth creationism. Thus in Britain, YECs, were comparatively rare 40 years ago, but are now dominant in student evangelical circles such as the University and Colleges Christian Fellowship (UCCF) and have made considerable inroads into the Church of England. It is tempting to dismiss these as anti-intellectual, but in Britain alone they probably have more influence and weight of numbers than the scientifically informed Christians I bracketed together as 'critical realists'. Despite having been 'involved' with YECs for nearly 40 years, I am unable to explain why people, including PhD scientists, adopt such a belief with such conviction and apparent rationality. It is difficult to itemize a few publications propounding this kind of view, as there are innumerable publications promoting intelligent design and young-Earth creationism and its compatibility with 'true' science. Although there are differences between these they do have much in common (see the website for Answers in Genesis, at http://www.answersingenesis.org). Their attempts to alter science teaching in the USA are well known and since 2006 Truthinscience has been attempting to introduce intelligent design into British schools, although in fact Truthinscience is clearly YEC, as is manifest in their alternative lessons on the fossil record.

There is a two-fold motivation for young-Earth creationism. The first is a view that regards the Bible as inerrant, which in its strongest and popular form claims that the Bible has no mistakes of any kind, including science and history. From early Genesis YECs conclude that the Earth can only be a few thousand years old and then strive to justify this scientifically. The second is the issue of suffering, which they consider to have started after the fall of Adam and Eve in Genesis 3. As Adam's sin caused the suffering, then no animal could have died before then, and thus the standard geological fare of trilobites and dinosaurs predating humans by millions of years simply must be wrong. This is supposed to justify the existence of suffering and death, and to put it slightly satirically: if death and suffering came from Adam's sin, then we must assume that God condemned millions of innocent plants, beasts and humans to death and suffering for the theft of a single apple. Yet this argument has great evangelistic appeal. To me it is moral absurdity. However, it must be said that the existence of suffering, whether through eating apples, or being written into the natural world, is one of the greatest challenges to belief in God.

Young-Earth creationism has come to prominence in the last few decades (Numbers 2006). It began to appear in Britain only in the late 1960s and elsewhere in Europe some years later. Many wrongly assume that it is only to be found in separatist evangelical churches but it has a wider influence. Within the Church of England, I consider that 5–10% of the 10 000 clergy are YECs, whereas in 1970 there were hardly any.[3] Third World evangelicals are dominantly YECs. Inroads have been made in mainland Europe within the growing evangelical churches. The cause of this sudden rise has been the burgeoning of evangelicals during recent decades, coupled with a new emphasis on biblical inerrancy, which in its hard form argues for literalism. There have been at least two popular books written by Anglican clergy arguing for young-Earth creationism, *Deluded by Darwinism* (Down 2007) and *Responding to the Challenge of Evolution* (Logan 2003), the first since the 1850s. Neither author has any undergraduate science: Logan was a journalist and Down a graduate from Cambridge. Their grasp of science, especially geology, is extremely poor, yet both books have received good reviews from the Christian press.

The influence is also seen in the training of clergy, as the most widely used textbook on systematic theology for evangelical seminary students in the USA, and increasingly in the UK, often in preference to McGrath, is *Systematic Theology* by the US theologian Wayne Grudem (Grudem 1994), who has a doctorate from Cambridge. His chapter on creation (pp. 263–414) devoted most space to issues of the age of the Earth and evolution. In this chapter, Grudem rejected evolution out of hand and was undecided on the age of the Earth although he was almost convinced by Davis Young's summary of standard geological arguments in his book *Creation and the Flood* (Young 1977). However, these were balanced by YEC arguments, which Grudem regarded as equally scientific. The net effect on clergy using this work is to raise serious doubts on the 'correctness' of modern geology and evolution. This will then be passed on from the pulpit to their congregations, who in turn will also doubt the 'correctness' of geology and be open to believing young-Earth creationism. All this links back to the paper by Young (2009), who discussed how Bavinck influenced Louis Berkhof (1873–1957). Grudem has stated that he regards *Systematic Theology* (Berkhof 1939) as 'a great treasure-house ... and ... probably the most useful one-volume systematic theology available' (Grudem 1994, p. 1224), and makes great use of it. Berkhof argued forcibly that Genesis must be taken literally. Thus we can see how Bavinck's doubts about geology were passed to Berkhof, then to Grudem and then to evangelical clergy today. In 2006 Grudem signed the evangelical petition questioning global warming, along with other US clergy many of whom were YECs. There is a strong linkage of young-Earth creationism, intelligent design and/or rejection of evolution with anti-global-warming (Mooney 2005; Roberts 2008), although evangelicals such as Sir John Houghton have done much to counteract this.

Young-Earth creationism and geology

During the last few decades young-Earth creationism has made its mark first in the USA and now throughout the world. Its basis is simple: the Bible should be taken literally and thus the Earth can only be a few thousand years old. That is a nightmare for any geologist. Young-Earth creationism has no historical roots in either the scriptural or anti-scriptural geologists of the early 19th century, or the apparently literalist 17th century theories of the Earth. Its roots, as described by Numbers (2006), are with the Seventh-Day Adventist sect in the late 19th century and the publication of *The Genesis Flood* (Whitcomb & Morris 1961). Young-Earth creationism is now worldwide and attracts much support from conservative Christians. Creationist organizations exist in most countries and one of the most effective is Answers in Genesis led by Ken Ham. In 2007 AIG opened its creation museum in Ohio. Other groups include the Institute of Creation Research (USA), the Biblical Creation Society (UK) and Wort und Wissen (Germany). Some Muslims have adopted young-Earth creationism, such as Harun Yahya (Adnan Oktar) of Turkey, and recently *The Atlas of Creation* (2007) was widely distributed.

For Genesis to be literally true, all geological dating must be wrong, and that is a major thrust of much YEC writing. Arguments include asserting that the use of fossils in relative age dating is a circular argument, radiometric age-dating rests on false assumptions, and many others. These can be found in many YEC books and are easily demolished by any moderately competent geologist, and failing that one can refer to the websites of Talk Origins (http://www.talkorigins.org) and the National Center for Science Education (http://www.natcenscied.org) headed by Eugenie Scott. Most YECs assert that all strata from the Cambrian to the Pleistocene were laid down in the year of the bibilical Flood, although some assert that the Flood ended at the end of the Mesozoic. They have two ways of explaining the fossil succession. The first is 'relative victim mobility', whereby the more nimble creatures escaped the deluge for longer and thus are in higher strata. The sloths seem to be an anomaly here. The other is 'differential gravitational sorting', whereby the heavier fossils sink to the bottom. Let the reader decide.

Intelligent design (ID) and geology

Intelligent design (Dembski & Ruse 2004) came to the fore in the mid-1990s with the publication of *Darwin's Black Box* (Behe 1996), which argued that some biochemical structures exhibit irreducible complexity. The leaders of ID attempt to avoid the issue of geological time, arguing that it is not relevant to the question of design and to attract YEC adherents. Since 2000 ID has become increasingly associated with young-Earth creationism, as happened in the Dover trial of 2005 and previous hearings in Kansas and Ohio. In Britain the group Truthinscience has attempted to encourage the teaching of ID in school science since September 2006; however, this group is actually made up of YECs and, as far as I can see, is using ID as a Trojan horse for young-Earth creationism. Some IDers, such as Behe, fully accept geological time, but remain silent on those who do not. Others claim to be unconvinced, such as the Lutheran philosopher Angus Menuge in the 2005 Kansas hearings. Yet others are convinced of young-Earth creationism as well, as are Paul Nelson of Access Research Network (ARN) and Marcus Ross, who has a PhD in vertebrate palaeontology and now teaches geology from a YEC perspective at Liberty University, founded by Jerry Falwell.

When it comes to geological time IDers tend to be very non-committal (Roberts 2004), but often claim that the Cambrian Explosion undermines 'Darwinian evolution'. This has been discussed in many places, with varying levels of inaccuracy. This vacillating approach can be seen clearly in the article 'The Cambrian Explosion: Biology's Big Bang' by S. C. Meyer, M. Ross, P. Nelson & P. Chien (http://www.theapologiaproject.org/Cambrian.pdf) (see also Campbell & Meyer 2004).

In this article, the authors wrote of standard geological time as fact, and gave the accepted dates of the base of the Cambrian. They stated: 'These studies also showed that the Cambrian explosion occurred within an exceedingly narrow window of geologic time, lasting no more than 5 million years. Geologically speaking, 5 million years represents a mere 0.11 percent of Earth's history' (Campbell & Meyer 2004, p. 326). However, at least two of these authors, Nelson and Ross, are self-confessed YECs and thus reject deep time. This seems rather devious, but it does sum up the whole problem for most scientists of ID and YECs, as they seem to say one thing and mean another. However, the rejection of both 'Darwinism' and punctuated equilibrium in the Meyer *et al.* paper was followed by the conclusion: 'In other words, intelligent design constitutes the best, most causally adequate, explanation of the specific features of the Cambrian explosion, and the features of this explosion in turn attest to the activity and power of a purposeful intelligence' (Campbell & Meyer 2004, p. 390).

Conclusion

A brief account like this can hardly do justice to the variety of understandings of the theology of creation today. There is a wide range of views, but a distinction must be made between those of academia and those of the pulpit and pew. Academics, except for the increasing number of creationists in university positions, tend to incorporate science into their theology. However, an increasing number of clergy, who may have studied theology at university, are becoming sceptical of science and more inclined to adopt a creationist perspective on creation. Thus within the Church of England, there is the whole range from young-Earth creationism to a virtual denial of the existence of God. The Anglican doctrine of creation is indefinable from such a diversity of opinion. From my stance as a practising Anglican priest, with ecumenical contacts and considerable contact with Christians in the USA, it is difficult to give a simple summary. Many within the churches take creation in the wide sense for granted and are not concerned with scientific issues. However, an increasing number are accepting young-Earth creationism or else intelligent design without understanding the (lack of) science behind them; this is partly in reaction to aggressive atheism of Dawkins and others, although this style of atheism came after young-Earth creationism became an issue in the early 1980s. The confusing variety of attitudes encourages me to play the orchestral introduction to Haydn's *The Creation.*

Author's perspective

I have attempted to give an 'objective' account rather than give my personal position. However, this is difficult for several reasons: I write from the perspective of an Anglican priest and have been personally involved in all these questions for about 40 years. My own membership of such groups as HOGG and Christians in Science, and transatlantic visits, including to an Intelligent Design conference in Wisconsin in 2000, have moulded my opinions. For those who wish to know, my theological orientation is similar to that of Polkinghorne and McGrath.

Notes

[1]I shall use the term Protestant for all churches that stem from the Reformation, although many Anglicans prefer not to consider themselves as Protestant.

[2]By evangelical I mean the growing part of the church that has roots in the German Pietism, the Wesleys and New Englanders such as Jonathan Edwards in the 18th century. Since 1730 evangelicals have formed a significant grouping among US and British Christians and are now worldwide (see Roberts 2008). Evangelical means a particular conservative and enthusiastic form of Protestantism. Bebbington summed up their beliefs as

conversionism (the importance of religious conversion), activism (the encouragement of an enthusiastic and active faith), biblicism (the emphasis on the absolute authority of the Bible) and crucicentrism (the heart of evangelical belief: the atoning death of Christ on the cross) (Bebbington 1989, pp. 2–17). However, in Germany 'evangelisch' simply means Protestant in the widest sense, and 'evangelikal' implies biblical literalism (i.e. fundamentalism to the English speaker).

[3]This is not based on a 'scientific' survey, but on my involvement in the Church of England for over thirty years. In the early 70s I never met a YEC priest, but now in most dioceses there are a small minority and my figure is based on those whom I know and a sampling by show of hands by a colleague for Evangelical clergy. The crucial fact is that it is now a small but significant presence. The significance of this becomes clearer from 1855 to 1970 there were virtually no YEC clergy in the Church of England.

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Index

Page numbers in *italic* denote figures. Page numbers in **bold** denote Tables.