A WHITMAN Learn About BOOK

OUR EARTH

What It Is

by FREDERICK H. POUGH

Whitman

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by **FREDERICK H. POUGH**

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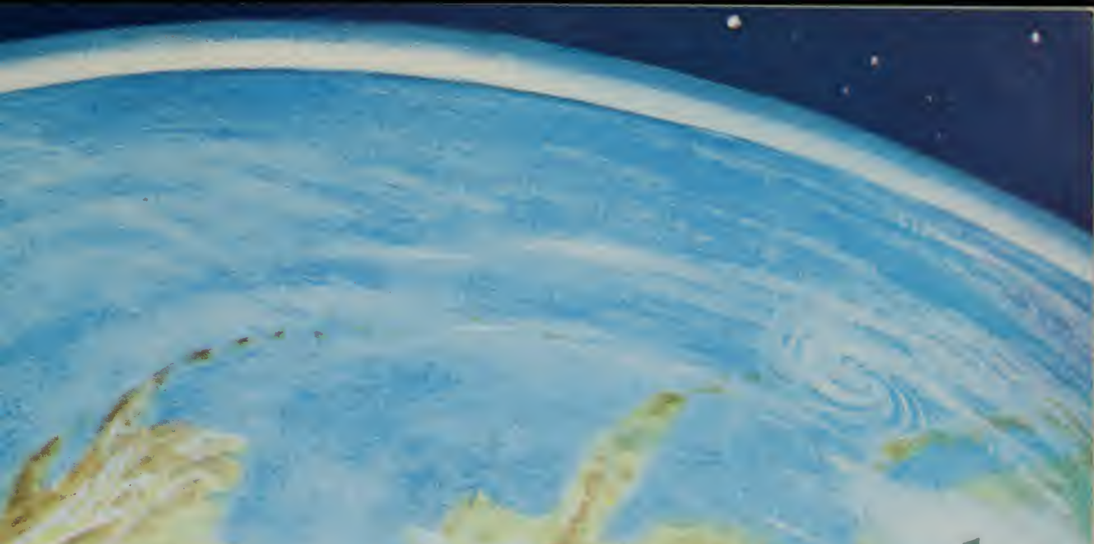


A Star Among Stars 1

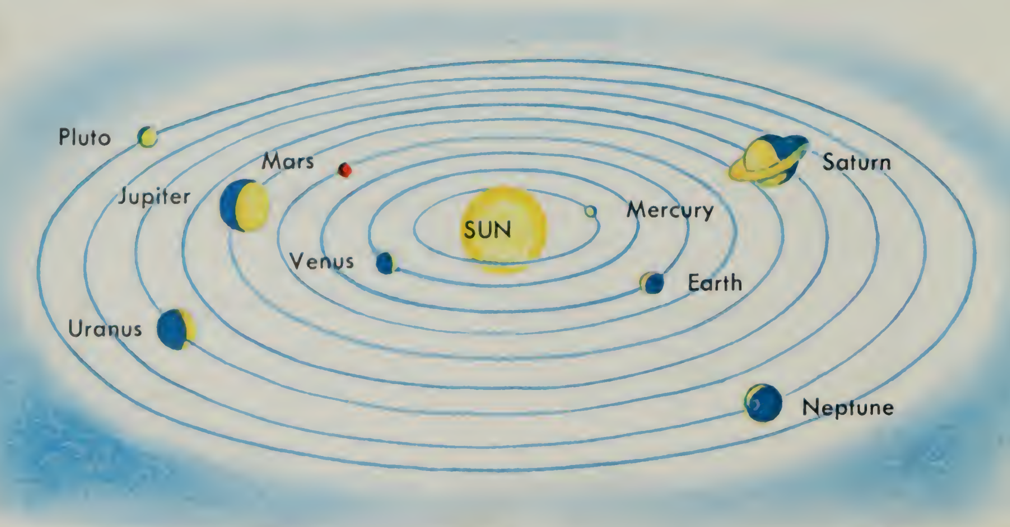
WHEN WE GO OUT ON A CLEAR EVENING to wish on the first star, we soon find ourselves looking up at dozens of pinpoints of light in the darkening sky. Our eyes become used to the darkness, and dim stars then seem to shine more brightly. The longer we look, the more we see. Finally, there seem to be thousands.

These shiny points of light are not all alike. Some are brighter than others because they are bigger or closer. Some really are brighter. And a few are not stars at all, but planets. They don't give off any light of their own. Instead, they glow with reflected light.

The star that is closest to us, and that we know the most about, is the one we call the sun. It is a glowing mass of hot gaseous elements. The sun seems big to us, but compared to the other stars it is really quite small. Nevertheless, it is our favorite size: big enough to give us warmth and light, yet not so big that it burns us up. It is the center of what is called our solar system: nine planets and their moons revolving around a central star.

If you were to look at the planets through a telescope, you would find that they look like solid shining balls, much like the moon. Like the moon they are lit only by the light of the sun. If they were not so close to the sun, they would be cold dark objects.

Mercury, the planet closest to the sun, shines as brightly as any star. It revolves around the sun at a distance of 37 million miles. Pluto, a very distant planet that was found only in 1930, is 4 billion miles away. We are about 93 million miles away. If our world were closer to the sun, like Mercury, it would be too hot for life to exist. If it were farther away, like Pluto, it would probably not receive enough light and heat. So, you can see that we are at a nice comfortable distance from the white-hot center of our solar system!



Stars like the sun don't move much among themselves. We always see them in the same patterns in the sky. We call these patterns constellations. Centuries ago men gave names to these constellations, names that we still use. The planets, though, move along regular paths called orbits. Each night finds them in different parts of these paths. We may call Venus either the evening star or the morning star, depending upon where it is in its orbit.

The planets, in order of increasing distance from the sun, are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. We can remember the order by using a memory aid, an old sentence that goes: MEN VERY EASILY MAKE JUGS SERVE USEFUL NEEDS. After 1930 another word was added: PROMPTLY!

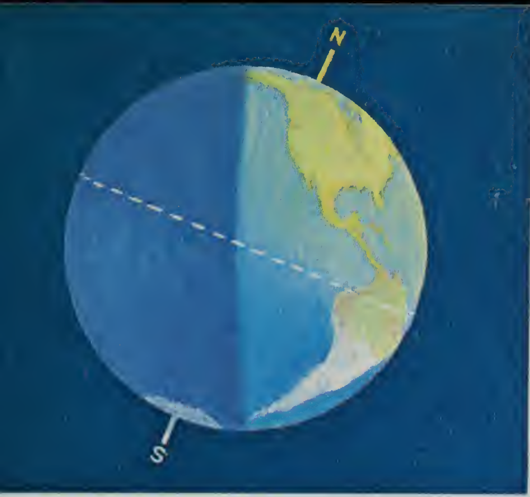
2 A Long Look at Our World

EVEN THE NEAREST PLANETS are too far away for us to see clearly. Nevertheless, we look at them through our telescopes and seek the meanings of what little we can see in terms of what we know about our planet, the Earth.

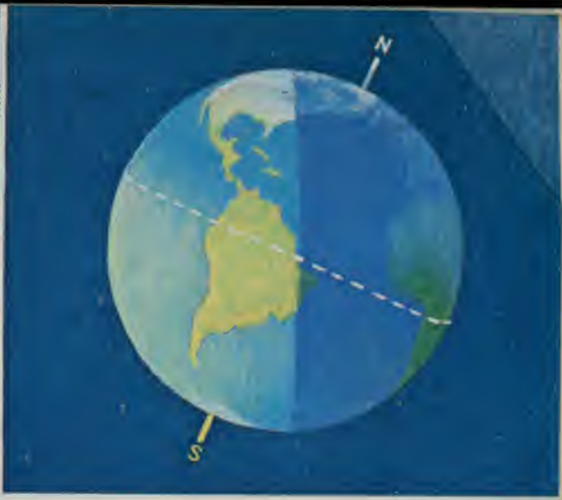
We know that all the planets came from sun material. Thus, their make-up should be about the same as ours. They must have rocks like ours. Possibly they have water and air. If they do, then the surface features of these planets, the mountains and valleys, must have developed in about the same way as those of the Earth.

From the Earth we look at the moon and see a bright white ball. We know that it has a dead, unchanging surface. There are jagged peaks, smooth deserts, and volcanic or meteorite craters. We are fairly sure it hasn't much atmosphere.

One day we will land on the moon and look back at the Earth. What a wonderful sight we will see! The Earth, for one thing, will be very colorful. The blueness of the oceans that cover two thirds of its surface will be set off by white polar caps and green, red, and brown continents.



North's Summer



North's Winter

From the moon we will see that land areas lie mainly on the northern half of the planet. Below the center, the equator, we will see tag ends of continents, the tapering tip of South America, and the narrower part of Africa. Australia will look like a big island. Only the knowledge that Antarctica is land will help us distinguish South Pole ice from North Pole ice.

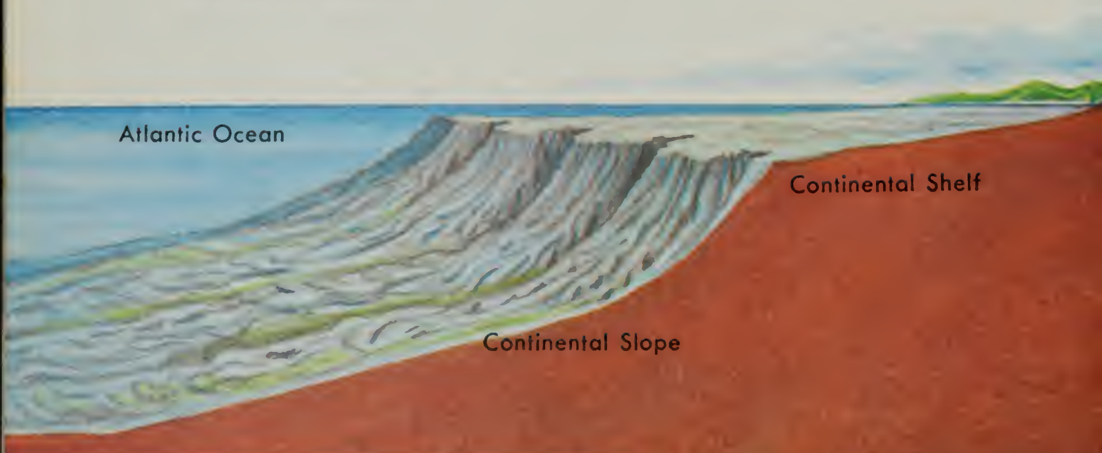
Clouds will be seen drifting across the continents as storms form and move eastward across the Earth. Snowy whiteness will spread southward in the North's winter and shrink back again in spring, closely followed by a wave of green. New colors will come in the fall as the North chills and the South grows warm.

From what we will see of the Earth from the moon, and knowing what it means, we shall be better able to understand the seasonal changes on Mars. We shall also have a better idea of what to expect when we get there.

3 The Face of a Continent

THE HIGH AND LOW PLACES of any one continent, the name we give to a large land mass, are not very different from those of any other continent. When we look at the different regions of North America, we see pretty much the same kinds of things we would see in South America or Asia. There are mountains and valleys, lakes, rivers, plateaus, and plains. Relief, which is another name for the surface features of a continent, always develops in much the same way. That being the case, let's take a look at North America.

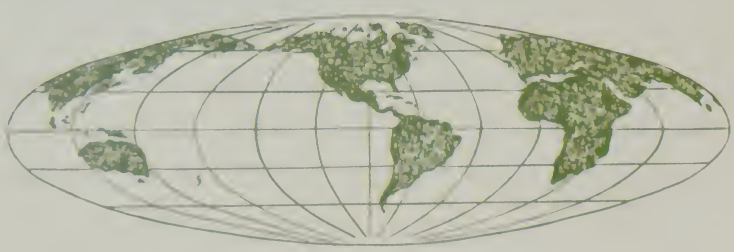
Eastern North America really begins far out under the sea. About a hundred miles east of our Atlantic coast is an underwater cliff standing high above the sea floor. This cliff is called the continental slope. It is the edge of the continental shelf, a sort of platform on which our continent stands.



Once the land reaches up out of the water, it forms a coastal plain. Beyond this, following the eastern edge of the continent, is an old worn-down range of mountains, the Appalachians. A river valley, the Delaware Water Gap, opens the way through these mountains. If we look at it closely, we see that the rock layers below the hills are all crumpled up, matching the long rolling hills above. Past them, in Ohio, river valleys show that the rocks are flattening out again, forming a vast plain. The Mississippi River and its branches cut a few gentle valleys in this plain, but we find ourselves way out in Colorado and Wyoming before there is a sudden change in scenery.

The Rocky Mountains form a new kind of country. Mountains, broken by high plateaus, followed by more mountains, can be found all the way to the Pacific. These are newer mountains than the Appalachians. They are higher and steeper. The second highest mountain in the United States, Mount Whitney, stands near the California-Nevada border. It is only a short way from Death Valley, the lowest place on the continent.

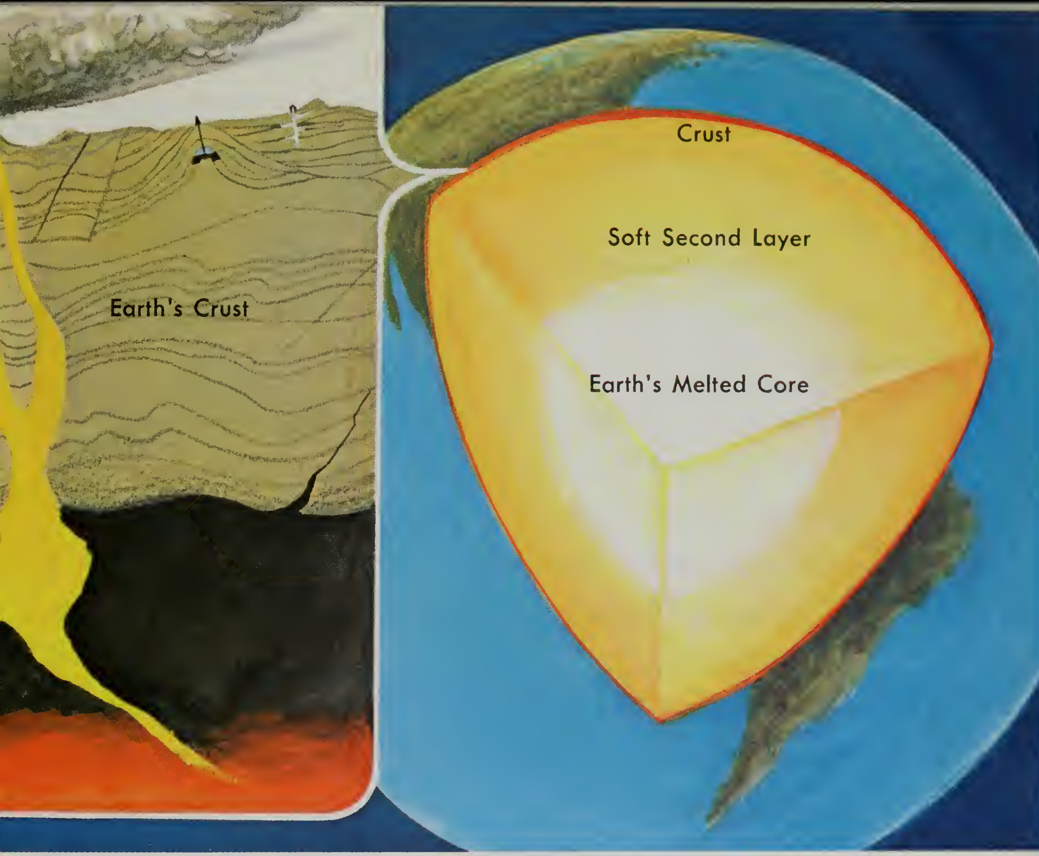
Everywhere that rocks are bent and broken we have breathtaking scenery. We can almost say that scenery and underlying rock structure go hand in hand!



4 What Lies Below Us ?

THE DEEPEST OIL WELL we have ever drilled goes down only about five miles. Our deepest mine is a lot less than that. We really cannot say that, from actual experience, we know very much about what lies beneath our feet. Still, we do know a number of things.

We know that the Earth has an outside layer, a solid crust of rock that averages about twenty miles in thick-



ness. In some places it is less than that, and in other places it may go down as much as sixty miles.

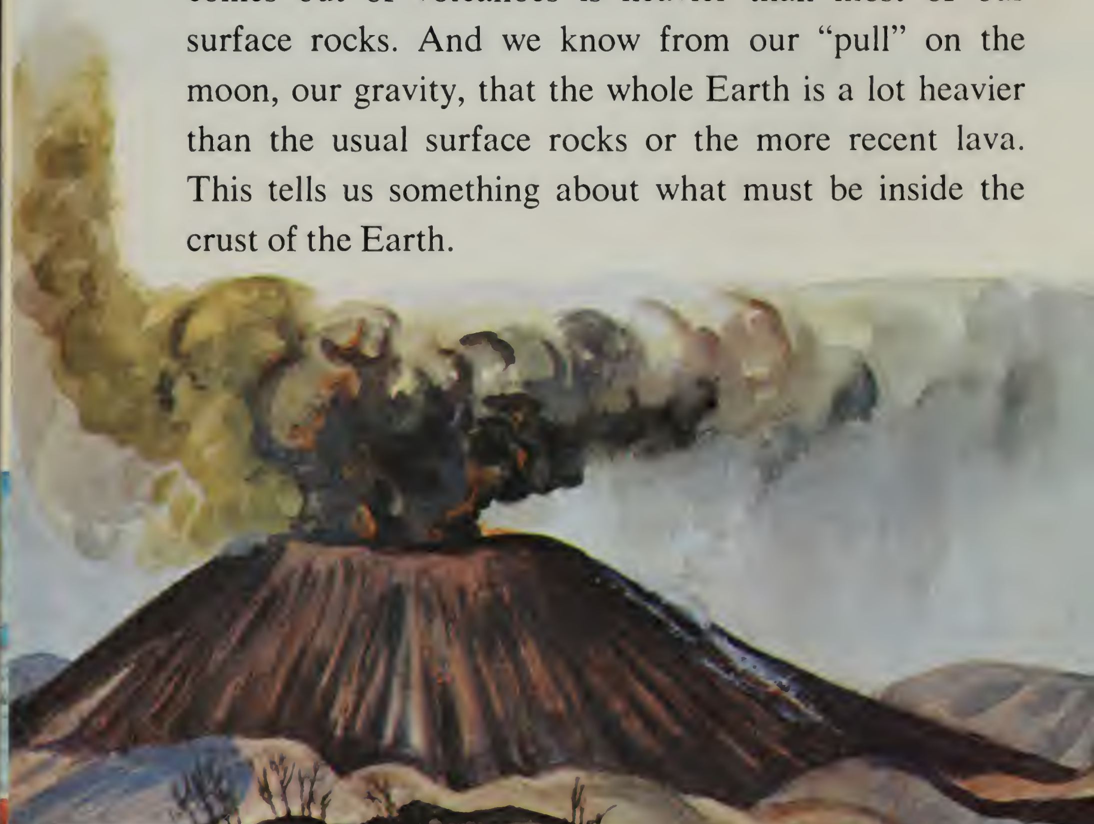
Beneath the crust there is some sort of a break and the next rock seems to be heavier, soft, and bendable. This heavy rock goes on down for more than two thousand miles, getting heavier and heavier—and probably hotter and hotter. At last we reach the core of the Earth.

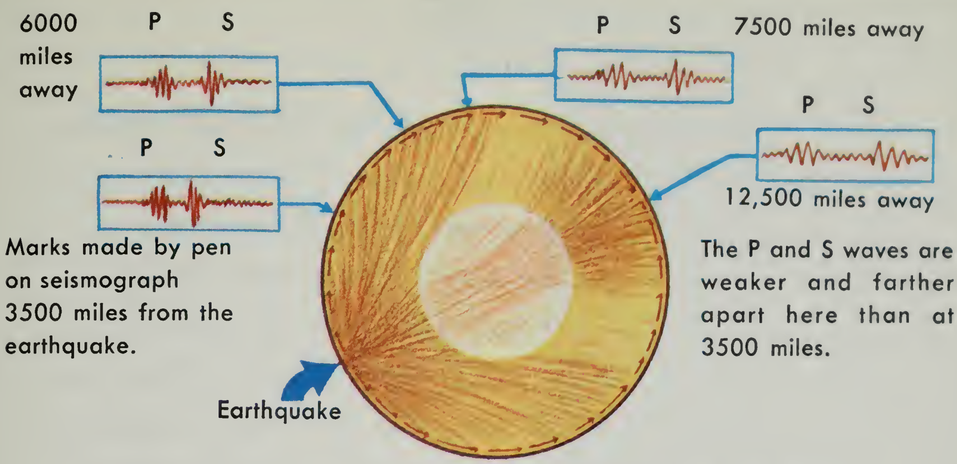
We think the Earth's core is made up of metal, mostly iron and nickel, like the meteorites that sometimes break through the Earth's atmosphere and fall to the ground. Some of these meteorites are all iron and nickel—parts, we think, of a planet that broke up or of one that never completely formed.

You might well ask: How can we know so much about an Earth into which we cannot see? The Earth gives us clues.

Active volcanoes show us that deep inside the Earth is molten, melted, rock. Deep mines show us that temperatures go up as we go down into the Earth's crust. Knowing these things, we make mathematical calculations, and we find that we get volcano temperatures at about fifty miles down.

Further, we know that the lava, molten rock, that comes out of volcanoes is heavier than most of our surface rocks. And we know from our "pull" on the moon, our gravity, that the whole Earth is a lot heavier than the usual surface rocks or the more recent lava. This tells us something about what must be inside the crust of the Earth.

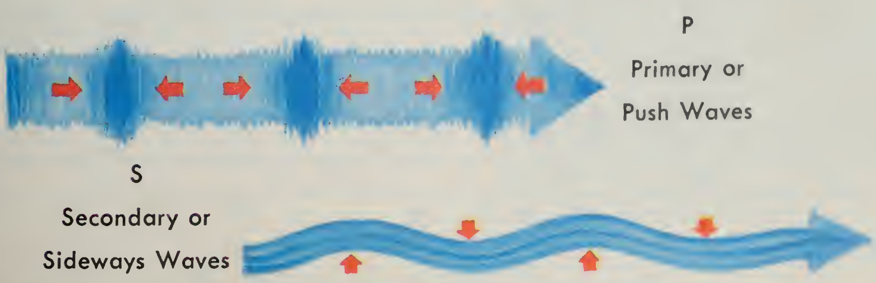




Some earthquake waves pass through the Earth, some pass around it at the surface. P waves are stronger than S waves.

We get further clues about the mysterious center of the Earth in the form of earthquakes. When there is an earthquake anywhere on Earth we know about it from instruments called seismographs. If there is an earthquake in Tokyo, for instance, some of the shock waves pass right through the middle of the Earth and show up on seismographs in this country, while others pass around the Earth at the surface.

We know that earthquakes cause two kinds of shock waves that pass through the Earth: waves which move straight ahead with jerky little pushes, and waves that move ahead, but with a side-to-side movement. The push waves, primary waves, are called P waves. The sideways moving waves, secondary waves, are called S waves.



We know how fast these shock waves travel, and that they go faster when they go deeper. The straight ahead push waves nearly always pass right through the center of the Earth and are recorded on the other side. But if the sideways pushing waves have to go too deep, they may never reach the far side of the earth because the liquid core of the earth cannot pass along a sideways movement. From these waves, we know that the center of the Earth is heavier than the outside and that it is partly liquid.

Volcanoes, mines, gravity, and earthquakes—these are the clues the Earth gives us. Checked against each other, they give us a pretty good picture of what lies below us.

5 The Rusting Rocks

THE EARTH'S CRUST is not its topmost layer. Outside the crust is a layer of water that spreads in a thin sheet over nearly three fourths of the earth's surface. And above this is still another layer, rising nearly a hundred miles above the rocks and water, our atmosphere.

There is more to the atmosphere than just the air we breathe. As we go higher in the sky, the density of the atmosphere changes. The air becomes lighter, "thinner." It is harder to breathe, harder to exercise, high on a mountaintop than down in a valley because there is less oxygen to take into our lungs with each breath.

The air at the surface of the Earth is made up of a mixture of gases. Nitrogen, a gas that our bodies can't use, makes up almost four fifths of the air. The oxygen we do need is less than a fifth. The rest is made up of rare gases, carbon dioxide, and water vapor.

Scientists are lifted by giant plastic balloons high into the upper part of the atmosphere. There they learn about space and the effects of flight on man.

Water vapor in the air is not always the same. Air can be either dry or humid. When the humidity is high, water vapor leaves the air and settles on the Earth as rain or dew. Rain water carries dissolved air down into the rocks of the Earth's crust.

This air-filled water acts upon the rock. Grains of the rock are oxydized, rusted. Some of the rock dissolves and is carried along as the water sinks deeper into the Earth's crust. But some of the surface rock, turned into the soft, rusty, claylike grains that we call "soil," remains aboveground.

The destruction of fresh rock by water and oxygen is a process we call weathering. It can't happen on the moon, since there is little atmosphere there. It happens only here on the Earth. The soil formed by weathering is important; without it there would be no life on Earth. For plants grow in the soil—and animals and men live on plants.

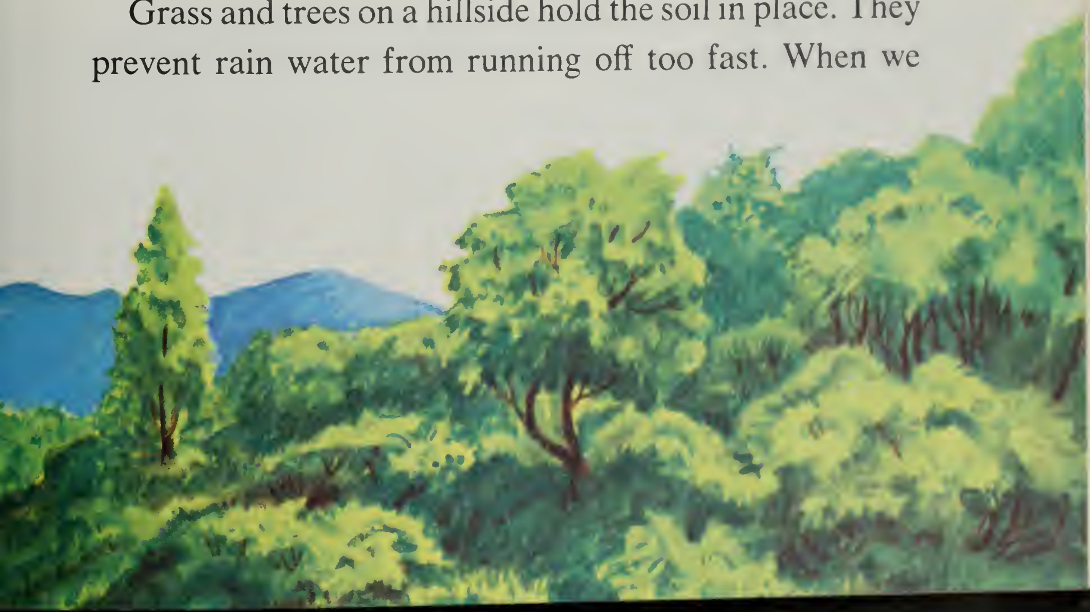
The Trash Removers

6

Only in recent years have we become worried about saving our precious soil. For too many years we paid no attention to its loss. We allowed trees to be logged recklessly on our mountain slopes, permitting heavy rains to wash the mountains clean. We lost forever rich soils that had been formed by millions of years of weathering.

Italy once had tree-covered mountains. The Romans and their followers cut all the trees without thought for the future. Today most Italian mountains are bare. As the population of the United States grows, we shall find it harder to raise enough food and timber for our people. It is time to think about conserving our productive soils.

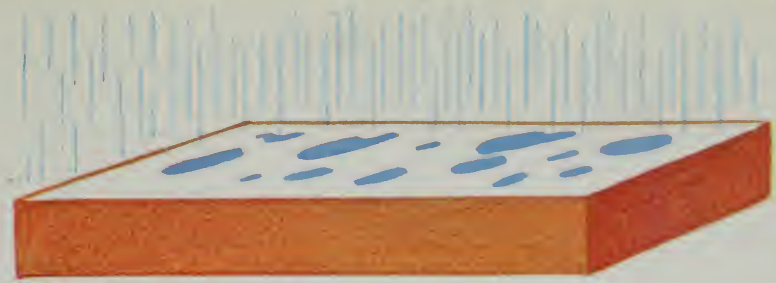
Grass and trees on a hillside hold the soil in place. They prevent rain water from running off too fast. When we



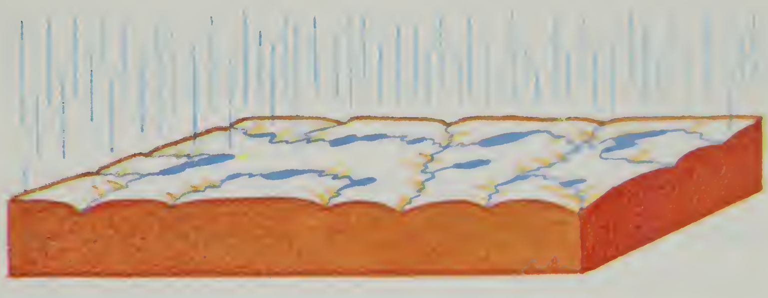
cut all the trees, or plow grassy slopes, streams bite into the soil. A certain amount of wear is normal. It is bad only when it is speeded up by our own recklessness.

Erosion, the wearing-away process, has been going on as long as the Earth has been solid. It started as soon as rocks began to weather, making hills and mountains, plains and river valleys. We can find all stages of the erosion process, somewhere on this continent. When the wearing away process goes on at its normal rate, new soil develops as fast as older soil is carried off.

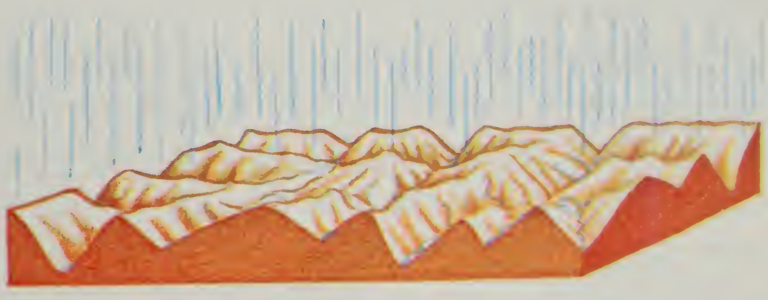
The most important soil remover is running water. Water always tends to find a lower level. It runs from high places to low places, and when it reaches the ocean it stops. When it runs fast it can carry gravel, sand, or mud along. When it runs slowly it can carry only what it may have dissolved from the rocks.



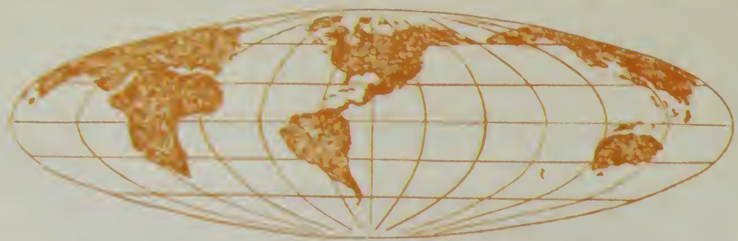
We can see what happens when water flows if we imagine a flat mud plain suddenly lifted high in the air. Rain water would first lie all about the plain in puddles.



Then the big puddles would join and find slightly lower places to which they would run. The moving water would soon cut gullies in the mud.



As the gullies grew, the puddles would be drained. In time our plain would no longer be a flat muddy area. It would be a region of ridges and gullies.



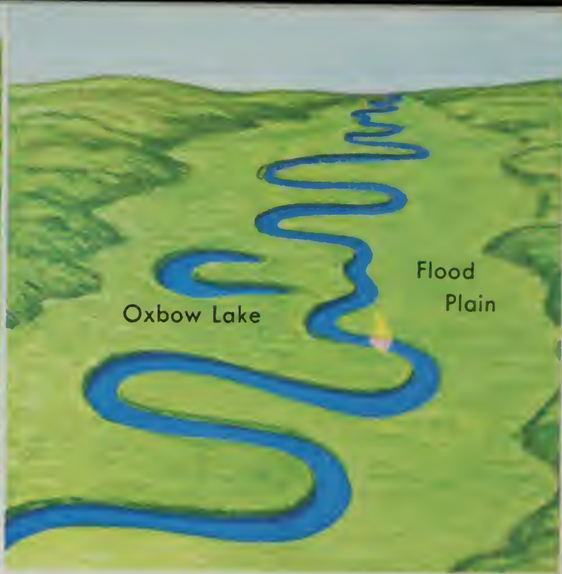
7 A River Grows and Grows

THE DEEPENING GULLIES in our mud plain will become a river system in time. The valleys will grow in a series of stages that we speak of as being young, mature, and old. A river's age is known by its appearance. And its appearance, in turn, depends on how fast it flows and how rapidly it is cutting its valley deeper.

A young river is one that is still vigorously plucking at its bed. It is likely to be quite muddy at times, flowing swiftly over rapids and waterfalls. The sides of the river bed are steep, forming deep V-shaped valleys or canyons. Since our river is young, it is flowing through high country, starting the erosion of a plateau that will one day be a land of mountains.

The Grand Canyon is a fine example of what a young river can do. Eventually the Colorado River and its branches will make a mountain wonderland of the Colorado Plateau.

Young River



Mature River

As long as the bed of a river is high above sea level, the water runs toward the ocean as directly and as quickly as it can. Once it has deepened its bed nearly to sea level, the river will flow more slowly. A rock that falls from one side will cause the current to push toward the other bank. From there, the current will swing back, but not before it has loosened a bit of sand from the wall. Soon the current will swing back and forth, back and forth, wearing away the sides of the river bed as fast as it wears away the bottom. The valley will become broader and the hills on either side will be lower and more gentle.

In time, the plateau cut deeply by the rushing young river will change into a hilly landscape of broad river plains and wide valleys. The rapids and waterfalls will be gone, and in place of rocks the stream bed will be blocked by sand bars and gravel banks. The last of the lakes will be filled or drained. When all of this has happened, our river will be mature.

Finally, thousands of years later, the river will wind slowly back and forth across a broad flood plain in great curves, among hills that have become almost flat. New lakes, called oxbow lakes, may have formed at cutoff curves of the river. The river may be free of mud, but brown from decaying plants, like the water in a swamp. Old age has now claimed the river.

The old stage of a river's life is first noticed near its mouth. Gradually it spreads up toward the river's source. Little new can now happen to our old and sluggish stream —until the land is lifted again.

8 Enemies of Rock

WATER IS NOT THE ATMOSPHERE'S only tool for the removal of soil that protects fresh rock from attack by the air. For in many places there is little rain, and yet the weathering process goes on; wind then becomes a major enemy of rock.

With too little moisture for plant growth, the rocks in desert areas never get the protection they need to stop dangerous erosion. The rocks in these places are heated to high temperatures during the day. Then suddenly, when the sun goes down, they cool rapidly and as they cool grains of the rock break away. But these grains do not remain on top of the rock, to collect there and one day form enough soil to permit plants to grow and protect the rock. Instead, they are carried away by high winds—winds which help in the erosion process. For the winds carry the grains of rock at high speeds, hurling them against exposed rock in a kind of sandblasting process. In this way the pinnacles we know to be typical of deserts are formed.

Ice and snow make a sort of desert, too, for no plants can grow if all the water is frozen. Freezing and thawing crack off big pieces of rock from mountains, but they are too big to be blown about by the wind. In frozen places ice, rather than wind, wears away rock. It flows slowly from high places to low in glaciers, moving rivers of ice that carry bits of rock to scrape away at the ground below. There are two kinds of glaciers.

Mountain glaciers lie in valleys and wind their way downwards until the ice melts. Glaciers widen V-shaped valleys into U-shaped valleys. Side valleys are undercut so that streams come into the main valley as waterfalls.

At one time the Earth had a cooler climate than it now has. We know of many valleys that were shaped by glaciers. The Yosemite valley was once glacier filled. And the Norwegian fiords were deepened by glaciers to well below sea level.

Continental glaciers cover land in broad sheets, and they too wear away the land beneath them. An ice sheet

once covered much of Canada and the northern part of the United States. It reached as far south as the Ohio and Missouri Rivers and down into what is now New York City. As it moved it left piles of sand, gravel, and rocks behind, piled into mounds called moraines. Long Island, Block Island, Nantucket, and Cape Cod were left as such moraines at the glacier's farthest front.

9 Rivers: Nature's Movers

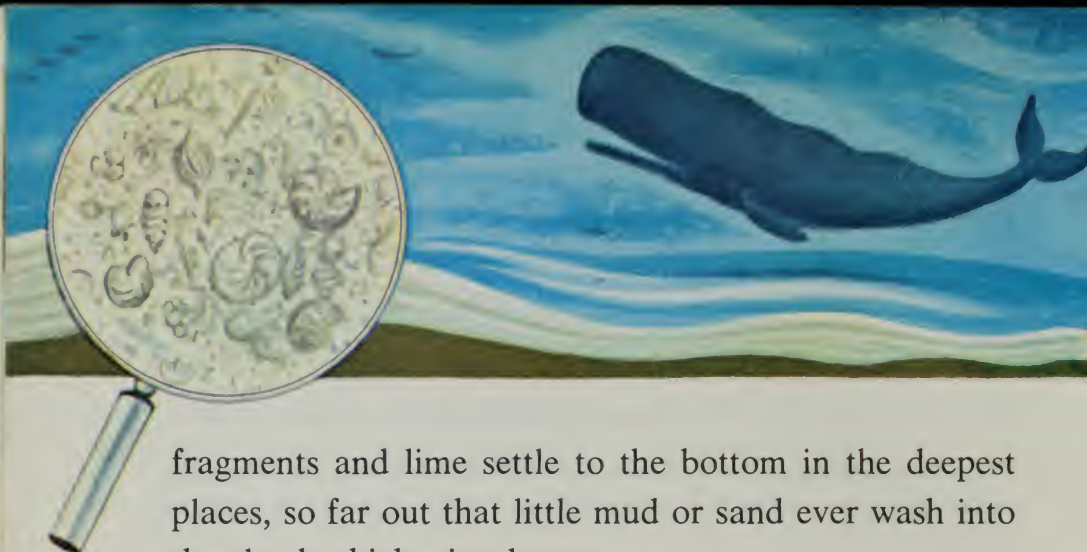
RIVERS CARRY SEDIMENT, grains of earth or rock that are either fine or coarse. In normal times, the river may carry only mud. But when the river floods, when the water moves swiftly, larger grains of sediment are carried along. The boulders we see in the bed of a young stream are moved along when there is a great flood. When the water lessens or the slope of the river bed flattens, the river slows down in its headlong rush for a lower level. The larger sedimentary grains of the fast-flowing river then settle to the river bottom. But the finest grains of earth travel far. The muddy waters of the Amazon can be seen for a hundred miles at sea!

Eventually, even the Amazon must come to an end, and the last and finest clay sinks to the ocean bottom. All that is left is whatever may have dissolved in the water. And when sea water evaporates even this will be left behind, adding to the saltiness of the ocean. The seas are getting more and more salty every day.

Swiftly rushing mountain streams move heavy sediments in the mountains. As the river slows down it drops heavy sediments first and then lighter and lighter sediments. Some sediments are dropped near the river's mouth. The finest can be carried out to sea.

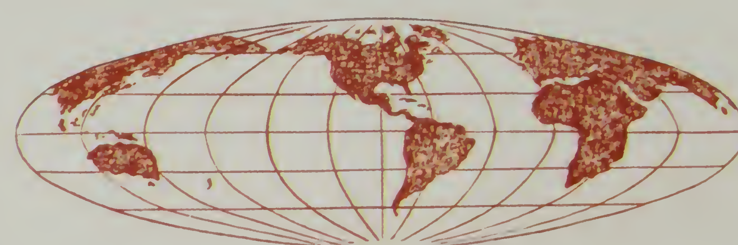
The sediment dropped by a stream wherever the water lost some of its speed can be traced the length of a river, from its headwaters to its end far out at sea. The gravel collected far upstream. The sand was swept along to quieter places near the seashore, there to build up sand bars and beaches. The finer sediment filled shallow bays with the mud flats in which we look for clams. And some of the finest sedimentary material was carried on out to sea.

Last of all we find the deposits of sediment that come from dissolved chemicals. A chemical reaction far out at sea sometimes separates lime from ocean water. Shell



fragments and lime settle to the bottom in the deepest places, so far out that little mud or sand ever wash into the slowly thickening layers.

Oysters, clams, and other shell-forming animals take lime for their shells from sea water. When they die they may become buried in layers of soft lime that thicken by a fraction of an inch in a century.



10 The Sedimentary Rocks

SINCE RIVERS SORT the different kinds of sediment, leaving each size in a different spot, we don't find a whole mixture of sizes in a single sand bar or mud flat. The particles in any one place are alike in size and nature—all sand, all mud, or all pebbles. Were they pressed together into rocks, they would be rocks with like grains. And in time that is exactly what happens.

Early layers of sediment are squeezed under the weight of later ones. The later ones may be finer or coarser, as sea level rises or falls, but all are pressed closer and closer together. Some of the elements in the grains dissolve and separate out again somewhere else in the bed. Finally the loose sand grains and mud particles are all stuck together, and what was once loose, soft sediment becomes tightly packed—hard rock.

The Earth is very old. It takes a long time for a river to carry enough sediment to add another inch to the sediment layer on the floor of the sea at the river's mouth. Yet we find hundreds of feet of mud and sand that have turned into rock, layer after layer after layer!

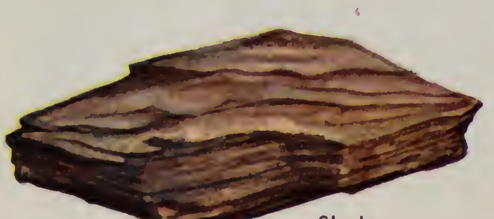
The Different Kinds of Rock in the United States

There are certain things about such layered rocks that we can always recognize, so that we say: These are sedimentary rocks. We say this often, because much of what is dry land was sea floor at one time. It has been lifted up and rivers have begun to wear it away in turn. We can see layers of sediment that are being worn away for a second time.

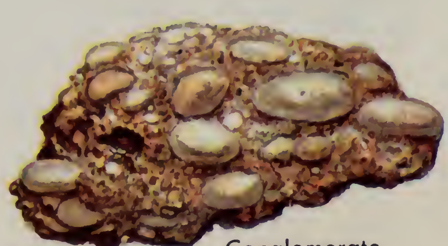
The sedimentary rocks are named for the particles of which they are made. Sand beds harden into sandstone. Lime beds become limestone. Clay becomes shale, and pebble masses turn into conglomerates. The different kinds are easy to recognize when we know that we are in a part of the country that has sedimentary rock under its hills and valleys. A geological map shows just what kind of rocks occur in each part of the country.

Sandstone

Limestone



Shale



Conglomerate

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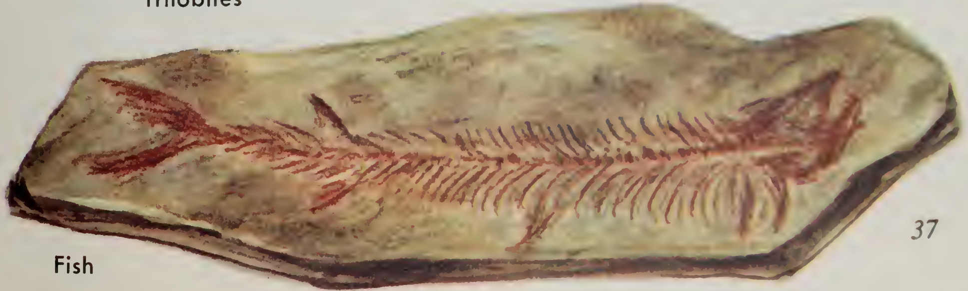
THE PRINT OF A STONY SEA SHELL that we find on the top of a hill many miles from the ocean tells us that the hill has a foundation of sedimentary rock. To a specialist, who calls such a hardened print a fossil, it means much more. From it he can tell us how long ago it was that the rocks under the hill were soft sediments on a sea floor. He will tell us in years, so many years that it is hard to imagine what he means. He may tell us that the rocks under the hill were just a collection of grains on the floor of an ocean 100 million—or even 300 million—years ago. All we can say is that was a long long time ago!

Fossils

Trilobites

Sea Plants



Fish

The fossil expert, the paleontologist, knows a lot about the Earth. He knows how it became the place it now is. He knows when life seems to have appeared. He knows how it developed from simple forms in the beginning into the complicated animals we find on the Earth today.

He has found that in the oldest sedimentary rocks, those we see near the bottom of the Grand Canyon, for instance, there aren't very many kinds of sea animals. Those he does find are simple. As he climbs the walls of the canyon, he comes to layer after layer of rock, and in some he finds more fossils. Each time they are different from fossils in lower rocks, and some are more complicated.

Today, man is the most important form of life. The animals to which he is related, mammals, have been the leading kinds of life for the past 80 or 100 million years. Before the mammals there was an era of about 130 million years when reptiles were the important animals. Some, the big dinosaurs we hear so much about, were enormous. But there were little dinosaurs, too, no bigger than some of the lizards that still live about us.

Dinosaurs took a long time to develop from simpler animals that lived in the sea. For a long time, 300 million years, the main forms of life were all in the water. Geologists have studied this time, called the Paleozoic era, through series of rocks. They have found one layer of sediment on top of another, one collection of fossil shells after another, each group a little different from the one beneath it. We call such a continuous series an era.

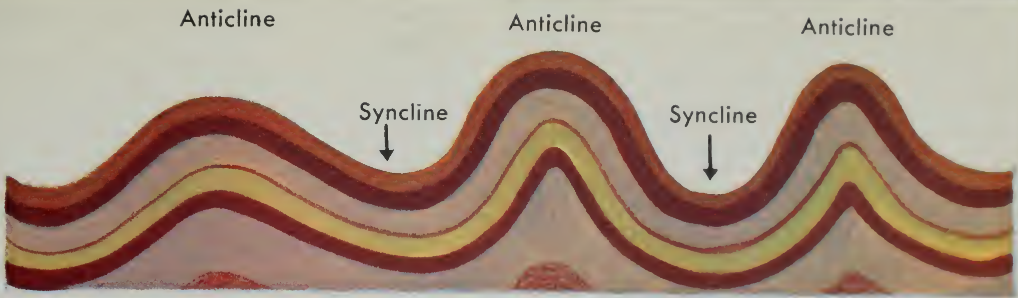
At the end of each era there seems to have been a time when there weren't many seas on the continents, when few sedimentary layers were forming. These are bad gaps in our fossil ladder. We call the gaps revolutions. These were times when all the land was high, mountains were formed—and we have missing pages, missing links, in our book of life history.

12

Crumpled Pages

SEDIMENTARY ROCKS form in horizontal layers, one on top of another. But we don't always see the layers that way. We see them arched and broken in mountainous regions.

Since these sedimentary rocks formed beneath the sea, we know they must have lifted after they formed. They rose out of the water and became dry land. But they didn't all rise to the same height. Parts of the rock bed, bent and twisted, pushed up higher than other parts and the once-flat layer of rock became a wavy surface. The up-arching waves are called anticlines, and the down-arching waves are called synclines. Sometimes the rocky



The Earth's surface once was crumpled and pushed together.

After thousands of years of weathering, this is the way it looks today.

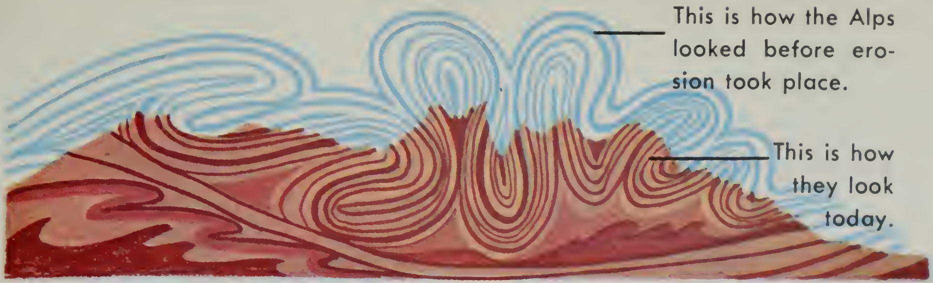
beds pushed together sideways, crumpling into a whole series of these anticlines and synclines.

The waved sedimentary rock layers are made up of different kinds of rock, some soft and some hard. After a time, the soft rock began to weather, wearing away much faster than the hard rock. And so valleys were formed from the soft rock, and the hard rock became mountain ranges.

The Appalachians, a whole chain of mountains running from New England to Georgia, were formed this way a long time ago. Some scientists think the Earth shrank, causing its "skin" to wrinkle. The Rocky Mountains formed in much the same way many years later.

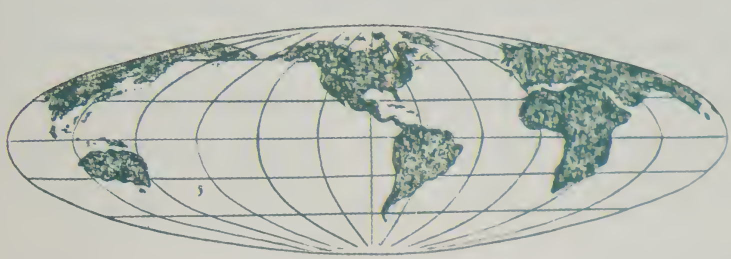
At times the moving crust put so much strong, sudden pressure on surface rocks that they didn't just bend, but broke and slipped past each other. A place in a rock bed where we can see that the layers broke and slipped up or down is called a fault. In Utah and Nevada there are lots of small mountain masses where great blocks of sedimentary rocks have been broken and tilted about, all standing above the general ground level. Again, these are the harder layers of the rock bed. The softer layers wore away centuries ago.

Block mountains in the Southwest before and after erosion took place.



When the crustal movement of the Earth is unusually strong, the folding may become very complicated. This happened in the Alps at one time, and parts of the crust pushed northward nearly a hundred miles. The rock beds that form those mountains were folded and bent in every direction.

Such topsy turvy folding affects the sedimentary rocks. It changes them into a new class called the metamorphic rocks.



13 Squeezing Out New Rocks

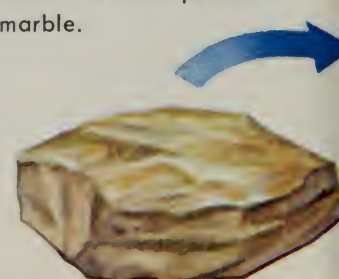
SEDIMENTARY ROCKS, squeezed and folded down into the Earth's crust, get hot. The grains of sediment, minerals, were formed by weathering in coldness and dampness. As they washed down into the sea, they had plenty of room to move about. Now, suddenly, they find themselves pressed tightly together, far beneath the surface of the Earth where the temperature is very high. Some of the newly weathered minerals can't stand up under this pressure and heat. Slowly they change into other minerals. We call this process metamorphism, and we say the new rocks are metamorphic rocks.

The metamorphic rocks aren't like the original rocks from which the grains of sediment originally came. The original unweathered rock was made up of a mixture of minerals. With the weathering process, the minerals were sorted out. Metamorphic rocks are made up of layers that are mainly one or another substance, just as they were when they were beds of sediment. The grains, though, may have changed into different minerals. Some grains change more than others, depending on the minerals.

Sandstone can't change very much. It was formed of grains of sand, quartz, one of the minerals found in granite. Quartz doesn't really weather, but just breaks

Sedimentary sandstone metamorphoses to quartzite.

Limestone metamorphoses to marble.

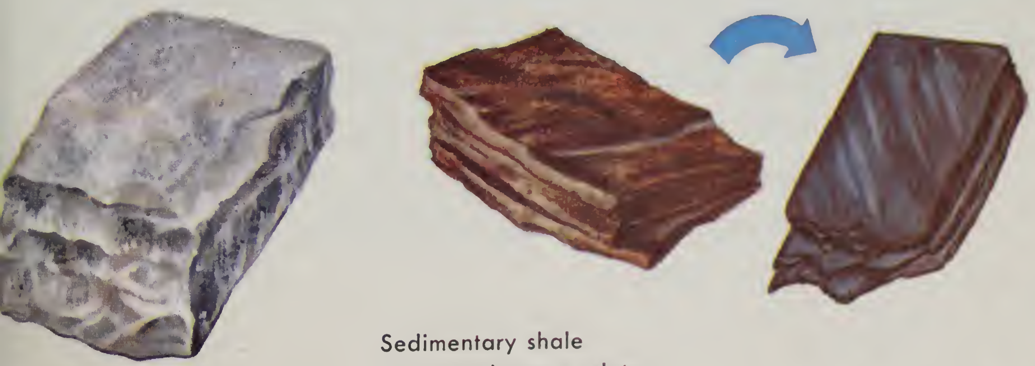


up into tiny grains of sand. The grains become sandstone when they harden into rock, and then quartzite when they metamorphose. The only real difference between sandstone and quartzite is its solidness. Sandstone grains can separate, but quartzite is one of the hardest rocks we can find.

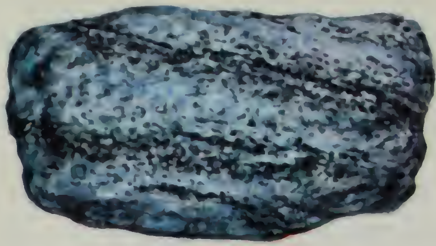
Limestone is like sandstone; it can't change very much as it metamorphoses. Instead, the grains of limestone become larger and more pure until at last we have marble.

Shale is rock made up of clay particles. On weathering, clay forms from mica and feldspar, which are also granite minerals. As the clay is heated and squeezed, it turns back into mica or feldspar again.

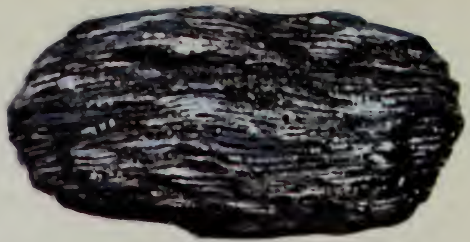
If the metamorphic rock contains quartz, feldspar, and mica, it will look like granite—but with a difference; the flat minerals like mica will be arranged in bands instead of mixed together with the other minerals as they would



Sedimentary shale metamorphoses to slate.



Gneiss

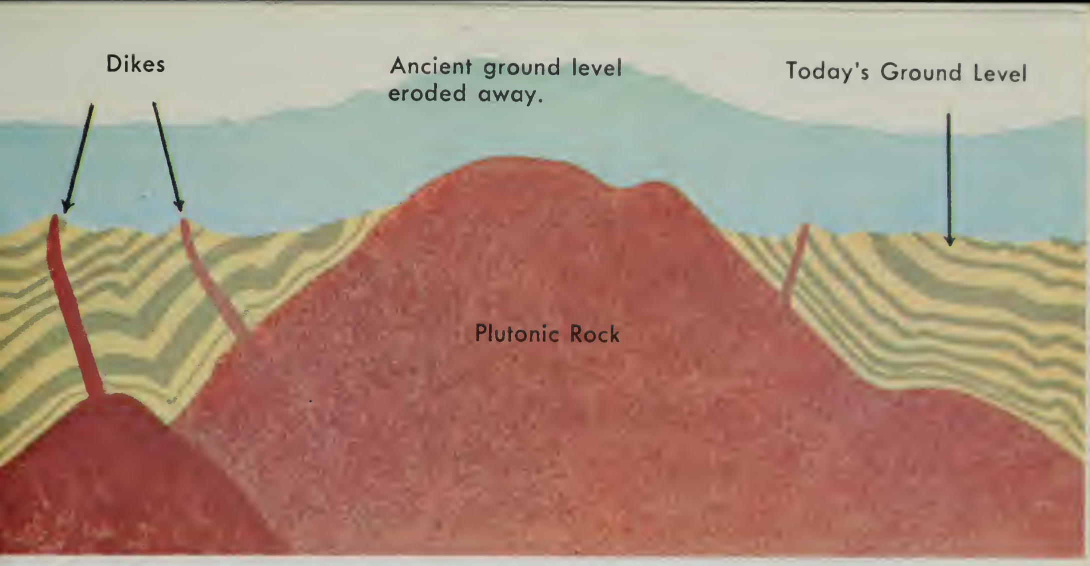


Schist

be in the original unweathered granite. We call a banded granite a *gneiss,* a word that is pronounced as if it were spelled "nice." If the metamorphic rock is made up mostly of mica, the spacing between the bands will be very small and it will split easily along these bands into thin slabs; this kind of metamorphosed rock is known as a *schist.*

14 The Melting Rocks

THERE AREN'T ANY PLACES LEFT where we can see any of the rocks that once formed the original crust of the Earth. This has all been weathered, transported, deposited, and metamorphosed many many times. Even the very oldest granites, like those of northeast Canada, are metamorphic rocks.



Some of the ancient sedimentary layers were pushed down deep into the Earth. There they melted, forming what is called magma. Magma, melted rock, squeezes up into the Earth's crust wherever it can, and then cools and hardens back into solid rock. Its elements combine to make the mineral grains we find in granite: mica, feldspar, and quartz.

Magma works its way up into a mountain's base. The top of the mountain will be the metamorphic rock of the Earth's crust. As this weathers away, we see the mountain's root, magma which has hardened into granite. We call this rock plutonic rock, because like Pluto of the myths, it came from the depths of the Earth. We know that it is plutonic rock because, as a result of its slow cooling, it looks different from the rocks that cooled more quickly, When in pushing up into the Earth's crust, the magma happens to break through and spill out onto the surface, it forms a volcano. We call the spilled magma lava. Since lava cools quickly after it reaches the surface, the elements in it don't have time to move around and group together in clusters; instead, they "freeze" quickly into many small grains.

Down within the crust of the Earth, though, mineral grains can "grow" in the slowly cooling magma. They continue to grow until the magma is solid. Sometimes the magma forms a solid sheet which we call a dike. When the mineral grains grow very large, we call it a pegmatite dike and it has granite minerals. If we want a bit of one of the granite minerals for a close-up look at it, we go to a pegmatite dike to get it. But we may also find lots more there than just mica, feldspar, and quartz. We may find minerals of tungsten, tin, or that useful rare metal, beryllium.

Near granite we may also find rich deposits of other

minerals, to give us gold, silver, lead, copper, or mercury. These may have combined with one or more elements, or may have come out of the rocks in an almost pure state. We look for the places to dig out, mine, whatever it is we need.

Earth's Building Blocks 15

CHEMICAL ELEMENTS, substances like oxygen, aluminum, silicon, and iron, are the building blocks of the Earth. There are 102 of these elements in the Earth's crust. Some of the 102 elements are radioactive, and can change into something else.

Usually the elements are found in combinations of two or more. Two elements put together in a laboratory are called a chemical compound; but when they are found already combined in their natural state, they are called *minerals*. There are lots of element combinations, minerals, in the Earth's crust. Mineralogists, men who study minerals, have counted some two thousand of them. Of these, only about two hundred are common. All the rest

A drop of dried salt water magnified.

are pretty rare and some have only been found in one place, where nature happened to set the scene so that some unusual element combinations could take place.

The smallest bit of an element is an atom. The atoms of most minerals join together in regular arrangements. Some of the minerals may have formed in magma. Some may have formed in solutions that came from magma, or from rain water that weathered surface rocks and then seeped down into the Earth. The atoms themselves are too small to see. But we know that they are there, arranged in the mineral grains in the way that they must.

To make our study of minerals a little easier, we make groups of the compounds. Metals that are combined with sulphur are called sulphides. The same metals combined with carbon dioxide are called carbonates. Metals that teamed up with silicon oxide are called silicates.

Some of the 102 elements are more common than others. Silicon, for instance, is very common. So are oxygen, aluminum, iron, and calcium. Beryllium, tungsten and thallium are rare. Most of the minerals that make up most of the rocks contain the more common elements.

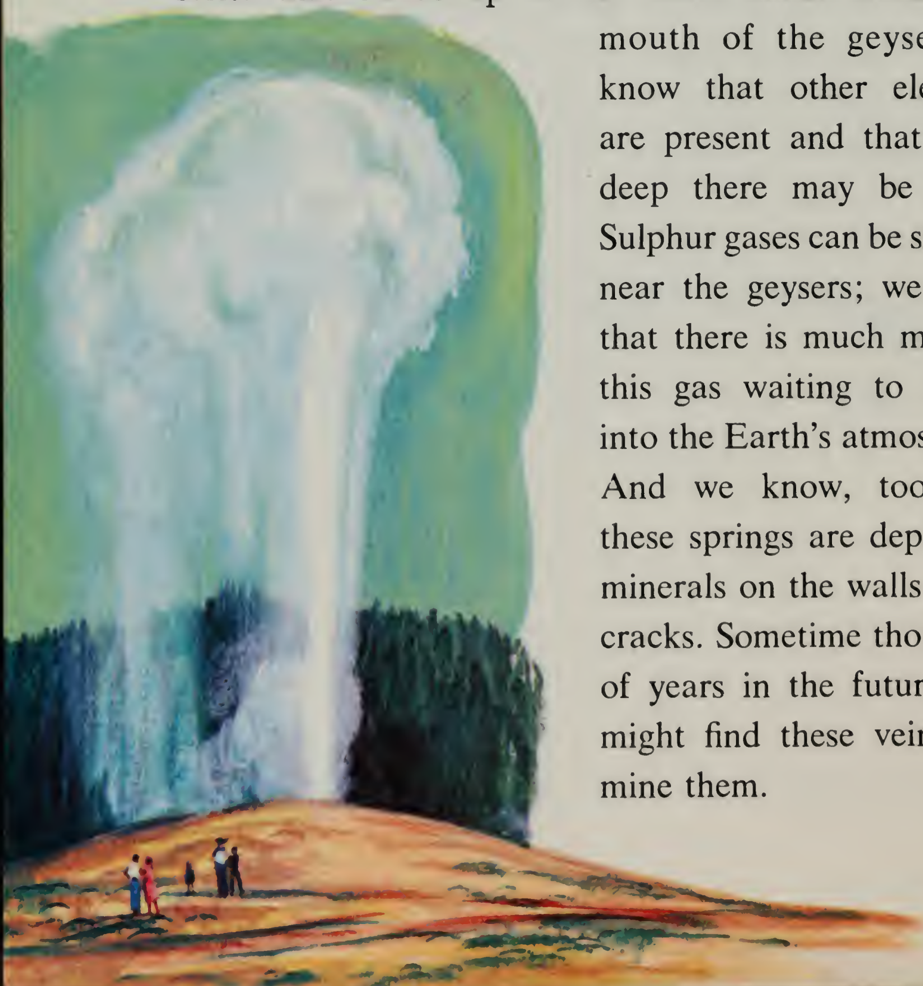
Quartz, made up of silicon and oxygen, is the most common mineral of all. When its atoms can get together in great numbers, in an open space, they take shape as a crystal. All crystals of quartz are the same: six-sided. Some, though, may be stretched out more than others. Another mineral, salt, which is sodium and chlorine, forms cubes when it can grow without being pushed out of shape by other crystals.

There are six different crystal groups. Often we can tell a mineral from its crystal, for each adapts one of the six basic shapes into its own special angles. Some people collect mineral crystals, for many are beautiful.

Down into the Crust 16

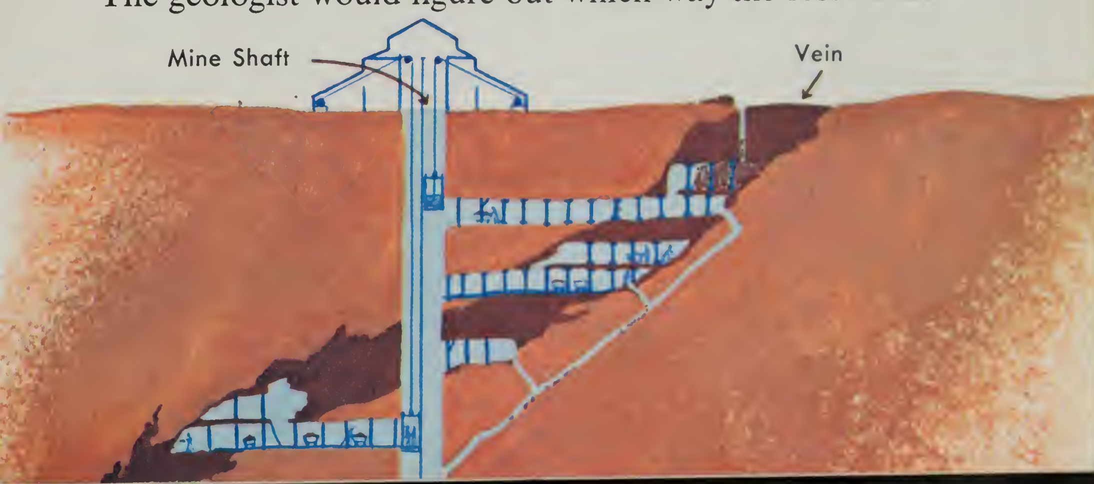
MINERAL-FORMING SOLUTIONS are still seeping up out of magmas, spouting hot water out of the Earth where there are breaks in the crust. Here and there in the United States are places where people go to bathe in this warm mineral water, places like Hot Springs, Arkansas. And in Iceland this hot water is even used to heat houses! We can tell a lot about what goes on far beneath the Earth's surface from these spouting springs, called geysers.

The water is hot. We know that it comes from deep within the Earth and that it must be very hot down there. Because the water contains dissolved minerals, we know that these minerals are still being formed beneath the Earth's crust. From the crust of a stone called geyserite that builds up as the water cools around the mouth of the geyser, we know that other elements are present and that down deep there may be more. Sulphur gases can be smelled near the geysers; we know that there is much more of this gas waiting to escape into the Earth's atmosphere. And we know, too, that these springs are depositing minerals on the walls of the cracks. Sometime thousands of years in the future men might find these veins and mine them.



Lots of things can be dissolved in very hot water, more than in cool. As the water rises it cools. The minerals separate out of the cooling water and collect on the walls of the crack. If we happen to find such a crack, centuries later when the top of a mountain has weathered away, we find the walls of the crack lined with mineral crystals. It may be filled with a single mineral, or with a mixture of minerals. If it is filled with many minerals we will find the less soluble minerals in the deepest parts of the crack because they were the first to separate out of the cooling water. Higher in the crack, closer to the surface, we will find the more soluble minerals, the last to separate out of the water. Filled cracks like this are called veins, and miners work their way into the veins to bring out the ores that collected there.

If you should happen to find such a vein, you would need a geologist to tell you if it was valuable and how to follow it. Movement of the Earth's crust may have cut off the vein and shifted it in some unexpected direction. The geologist would figure out which way the rest of the



vein had moved and tell your miners where to tunnel to find it again. There wouldn't have to be much gold in your mineral vein to make it worth mining. But there would have to be quite a lot of a less valuable metal such as lead, and the lead would have to be mined in large quantities.

All mines are not the shaft and tunnel kind. There are what are called open-pit mines, big open mines with many levels on which power shovels work at digging out the ore. The ore in such a mine may be very poor, mostly granite with a little copper in it. There may be as little as fifteen pounds of copper to a ton of rock. But a lot of rock can be dug from such a mine in the course of a day—perhaps as much as thirty thousand tons. These mines sometimes last longer and give more metal than some of the rich vein mines.

Veins often shift as they go down, and so mining may become very expensive. And then, too, as the miners go down they find that the rocks get hotter and hotter, and that the weight of the rocks is harder and harder to hold up with mine timbers, logs and props. If the miners are not forced to stop work by rising costs, they may get all the ore from a mine. Then we say that it is exhausted.

17 Signs of an Ever-Young World

THE HEAT IN THE DEEPEST MINES, some two miles down, is only a sign of what we would find still deeper. There are places on the Earth where molten rock from deep within the Earth is being squeezed out on the surface. These leaks are what we call volcanoes.

Today volcanoes are arranged in pretty definite lines on the Earth's surface: around the Pacific Ocean, in the West Indies, along the Mediterranean, and along a ridge near the middle of each ocean.

In earlier times, volcanoes were to be found in other places. Lava poured out to make a big, flat plain in Washington and Oregon: the Columbia River Plateau. There are lava plateaus in India and Brazil, too. That lava must have come from cracks and flowed easily, to have spread

so far and in such a thin sheet.

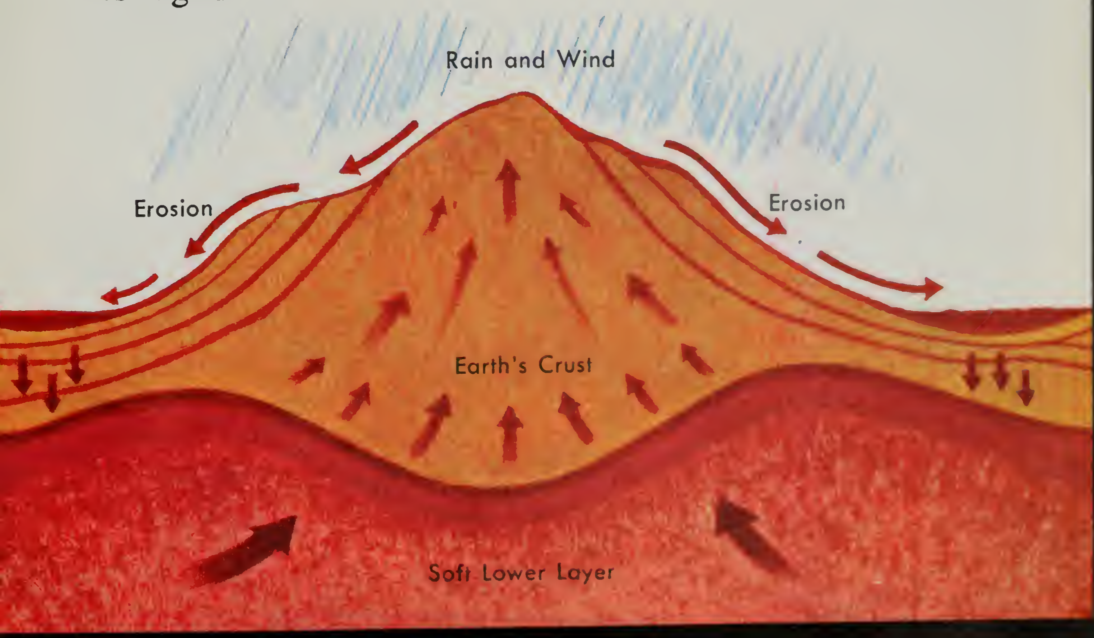
Usually lava piles up around its opening in the crust, making a cone. The slope of the cone depends on the behavior of the lava. If the lava explodes, letting off a lot of steam, it will pile up in a steep cone of lava and loose rocks. Fujiyama is a big, beautiful cone that you would recognize as a volcano right away. It has been erupting for a long time, off and on. Other volcanoes may be small and erupt only once, like Parícutin, the Mexican volcano that sprouted in a farmer's cornfield.

If the lava is very liquid, it may flow out of the Earth without any explosions. Then it will pile up in a big mound like the volcanoes of the Hawaiian Islands, which rise nearly six miles above the ocean floor. We can see that even very thin lava can build up into quite a rock pile if it keeps escaping long enough.

Volcanoes are just one sign that the Earth is still very much a "live" planet. There are a number of other signs as well. We see those signs in our atmosphere, in our mountains, and in the waters of the Earth.

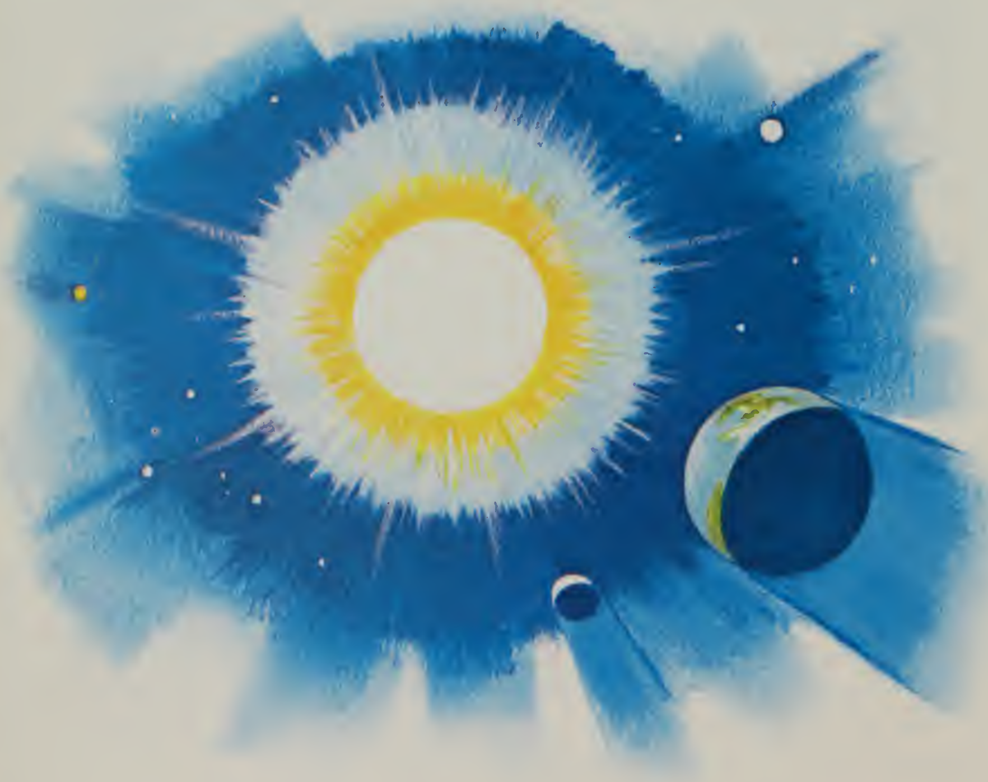
Much of the life of our planet we owe to its atmosphere. By wearing away the high places and moving them to the low places, the atmosphere paves the way for new high places to form.

And the new high places do form! Picture one of the Earth's mountain ranges. It formed when crustal movement squeezed together a huge lump of rock. This rock, half "floating" on heavier, softer, deeper rock, formed a mountain range. The lump bulged downward as well as upward, much as ice does in water. When the lighter crustal rock of the mountaintops is removed by erosion, the whole lump may push upward, so that the mountains rise again.



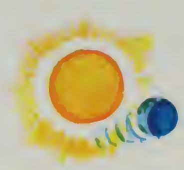
Picture the waters of the Earth, rain and rivers, constantly at work. With our mountains always ready to renew themselves, it takes a long, long time for water to do its work of leveling. But level it does. Finally the lower parts of the Earth's crust sink beneath the thickening deposits of sediment. Eventually the sand and clay may remelt and return to the surface again as lava.

The Earth is infinitely old, if we measure it only in terms of years. But it is forever being renewed, and in being renewed offers proof to us that—as planets go—it is still young.

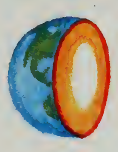


It's Fun to Know

. . . that the Earth weighs 6,600 billion billion tons and is thought to be from 2 to 3 billion years old.

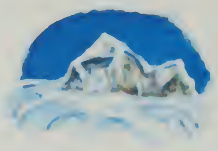


. . . that the Earth whirls around the sun at a speed of 66,700 miles per hour.



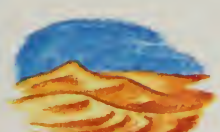
. . . that if you wanted to take a trip around the world at the equator you would travel 24,902.39 miles, but that if you could take a short cut straight through the Earth you would travel only 7,926.68 miles.

. . . that the highest peak on Earth is Mount Everest, in Asia, which is 29,028 feet high; and that the highest point in the United States, and on the North American continent, is Mount McKinley, Alaska, which is 20,320 feet high.



. . . that the lowest land on Earth is along the shore of the Dead Sea, Palestine, 1,292 feet below sea level; and that the deepest point on the ocean floor is in the Pacific, south of the Island of Guam, called the Challenger Deep which reaches down to a depth of 35,640 feet.

. . . that the longest river on Earth is the Nile, Africa, which is 4,000 miles long.



. . . that the biggest desert on Earth is the Sahara, Africa, which covers an area of 3 million square miles.

THE AUTHOR

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Dr. Pough is the author of many scientific articles and of the geological sections of several dictionaries and encyclopedias. He is also the author of several books. His home is in Brooklyn, New York.

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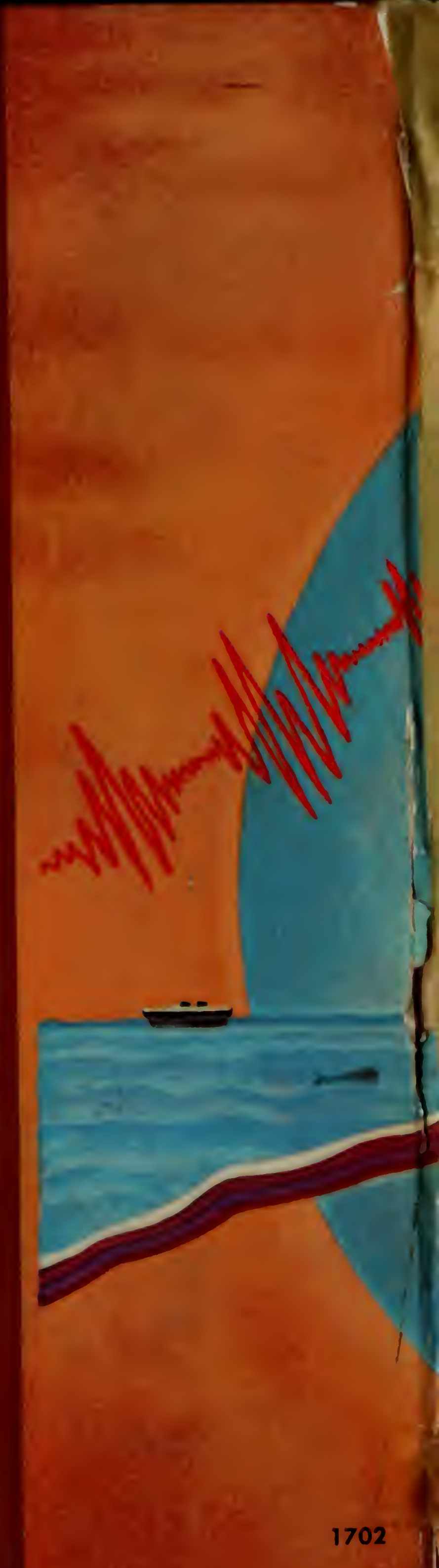

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