The quarterly journal of science.

London:John Churchill and Sons,1864-1879.
http://www.biodiversitylibrary.org/bibliography/14370

v.5 (1868): http://www.biodiversitylibrary.org/item/50396
Page(s): Page 166, Page 167, Page 168, Page 169, Page 170, Page 171, Page 172, Page 173, Page 174, Page 175, Page 176, Page 177, Page 178, Page 179, Page 180, Page 181, Page 182, Page 183, Page 184, Text, Text, Page 185

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MAP
OF THE
NORTH WEST COAST
OF
SAMLAND.

Fig. I.

Cape Brüsterort
Brüsterort
Rosenort
Washtrieden-berg
Kleinkuhren
Grosskuhren
Warnicken
Georgswalde
Rauschen
Sassau
Wangen
Neukuhren
Loppehnen
Rantau
Gr. Dirschkeim
Marscheiten
Kreislacken
Gr. Hubnicken
Kraxtepellen
Palmnicken
Sorgenau
Lesnicken
Nodems
Rothenen
Baltic Sea

Fig II.

Sea level
Eastern boundary of the synclinal
North western boundary of the synclinal
Boundary between the two different deposits of the Glauconitic Sand
Line drawn through the middle of the synclinal formed by the lower Tertiary strata
Sea level
Drawn by G. Zaddach

Fig III. Sections of the coast near

1 Sassau. 2 Georgswalde 3 Grosskuhren 4 Kreislacken 5 Gr. Hubnicken 6 Kraxtepellen

Fig IV. Diagram of the coast near Warnicken.

Sea level
A. B. C. D. E.

- ε Upper-Diluvium
- δ γ Sand of Lower Diluvium
- β Marl of Lower Diluvium
- α Gravel and erratic blocks
- 9 5 Brown-coal
- 7 Micaceous Sand
- 4 Striped Sand
- 6 3 2 Clay or sand mixed with clay
- 8 1 Quartz sand and coal sand

Glauconitic Sand
- e d e) Green and d) White Marl
- c Green Sand
- b a b) Quicksand and a) Amber-earth

M & N Hanhart. lith

of manufacturing artificial stone may, with certain modifications, be found capable of being adapted. It is now used extensively in England and all over the Continent, as well as in America, where amongst other buildings it has been extensively used in the decorative portions of Cranston's Hotel in New York. It is being employed in the construction of a glass roof over the beautiful Indian Court at the new India Offices in London, and a great quantity of ornamental work has been sent out by the Patent Concrete Stone Company for public buildings under construction in Calcutta. They have received orders also from China; and large quantities of the silicate of soda and chloride of calcium have from time to time been shipped for different parts of India, with the view of manufacturing artificial stone on the spot where it was required to be employed.

IV. AMBER; ITS ORIGIN AND HISTORY, AS ILLUSTRATED BY THE GEOLOGY OF SAMLAND.

By Dr. G. Zaddach, Professor in the University of Königsberg, and Director of the University Museum.

The Natural History of Amber still presents its many problems, although for the last century numerous investigators have endeavoured to solve them. One of the few places at which some of these questions may be elucidated is Samland, which has for ages been celebrated for its richness in Amber, and which even now possesses in deep-seated deposits an inexhaustible store of this valuable fossil. I therefore undertook, some years ago, the geological examination of this district in the employment of the 'Physikalisch-ökonomische Gesellschaft' of Königsberg, and I have lately published the results of my survey in a detailed essay, accompanied by several maps, in the 'Schriften' of that body. A short summary of these results will, I hope, be of some interest to the readers of this Journal.

By the name Samland is distinguished that part of the Province of Prussia which is bounded on the west by the Baltic; on the north by the same sea, the Kurische Nehrung, and the Kurische Haff; on the east, by an arm of the Pregel (the Deime); and on the south, by the Pregel itself and the Frische Haff. The north-west part of this region, which constitutes the promontory of Brüsterort, is hilly, from 100 to 150 feet in height on the average, but reaching in many places to the height of 200 feet, and in some even to 300 feet. On the other hand it becomes flat towards the north-east and east, and gradually sinks down towards the south-eastern angle, where, upon a peninsula lying between the sea and

the Frische Haff, are situated the seaport and the fortress of Pillau. This surface-contour of the country corresponds also with the form of the coast, the eastern portion of the north coast and the southern portion of the west coast being for the most part flat, and exhibiting only Quaternary formations: Diluvium, and Alluvium. The coast of the elevated north-western portion of the country, on the contrary, forms steep cliffs both on the north and on the west, and exhibits a section from 100 to 190 feet in height. In this manner an excellent insight into the geological structure is afforded, showing that in many places, under a proportionally slight thickness of Diluvium, Tertiary beds are conspicuous at a height of from 80 to 125 feet above the sea-level. They are not continuous, but are interrupted at several places, the gaps being filled up with newer formations, such as marl and sand. Sometimes also dislocations are seen in the older deposits, while the Tertiary beds are broken through and displaced by the pressure of the overlying masses.

Fig. I. in the accompanying quarto plate shows the north-western part of the coast of Samland on a scale of 1 : 100,000. Below it is drawn a view of the profile of the same part of the coast, where the vertical scale is 36 times that of the horizontal. The notches reaching from the surface to the sea-level signify ravines, which at various places intersect the coast, and down which streams flowed to the sea. The heights are given in Prussian duodecimal feet. The places where the Tertiary formation is preserved are shaded both upon the map and section: the white portions are therefore those where only Postpliocene or Diluvial masses exist. Of the formations which belong to the recent period, there occurs on this coast only blown sand, or Dunes, and these in so slight a degree as to require no attention.

Where the Tertiary formation crops out it always comprises two different deposits; the underlying consisting of thick beds of Glauconitic Sand, which sometimes attains a height of 65 feet above the sea-level (Figs. II., III., *A*), and upon which are the beds of the Brown-coal formation, from 60 to 100 feet thick (*B*).

The Glauconitic Sand is not everywhere similarly composed. It is necessary to distinguish a northern deposit, which occurs on the whole of the north coast, and on the northern part of the west coast, as far as the village of Kreislacken; and a southern deposit, which extends from Kreislacken to the village of Kraxtepellen, so far as the formations can generally be followed on the coast.

The northern deposit (Fig. III., 1, 2, 3, *A*) is very simply constituted. The upper part, from 40 to 60 feet thick, presents a bright-green sand (*c*), which is composed of rather large quartz-grains and bright-green knob-like granules of Glauconite. In the north-western corner of Samland, namely, near the villages of Grosskuhren, Kleinkuhren, and Rosenort, the lower beds of this

"Green Sand" are cemented by hydrated oxide of iron into a coarse sandstone, which is important on account of its containing remains of numerous animals, which have not been preserved in the loose sand. Under the "Green Sand" lies a deposit, consisting of finer quartz-grains and a larger quantity of Glauconite, besides containing clay and Mica, which increase in quantity the deeper the deposit is penetrated. The Glauconite gives it, in the dry state, a greyish-green colour, which becomes nearly black when the rock is moist. Generally, also, the following beds can be distinguished in this deposit. The uppermost, from 5 to 8 feet thick, is called a "Quicksand" (Fig. III. *b*), because it contains a large quantity of water, which has been arrested in its descent by the underlying clayey stratum; next follows the so-called "Blue Earth," or "Amber-earth," which is from 3 to 4 feet thick, and more firm, dry, fine-grained, and argillaceous than the "Quicksand." The still more deeply seated deposit is called the "Wilde Erde," because it contains no Amber. It has been explored only here and there to the depth of from 10 to 18 feet; and generally there has been no inducement to penetrate farther. It is also unknown how deep this formation continues and what underlies it.

The Amber occupies only a narrow zone in the whole formation; in this indeed, it occurs abundantly, but is not equally distributed. For each square foot of the surface of the bed, that is, one cubic foot of sand, from $\frac{1}{2}$ lb. to 1 lb. of Amber may be reckoned as about the average. The pieces are of various sizes, those weighing as much as half-a-pound being seldom found; and larger lumps of one or more pounds weight are extremely rare. Their surfaces are dull and worn, and their edges and angles are also somewhat rounded, but not to a sufficient extent to obliterate the various forms which they originally received as the liquid resin of a tree, such as pins, drops, and plates, which were formed between the bark and the wood, or between the yearly rings of growth of the stem. Frequently, also, fine impressions of the parts of the plants which produced them can be distinguished on their surfaces. It follows, therefore, that the pieces of Amber were for some time, but not for very long, rolled about by the water previous to their deposition.

With the Amber also occurs fossil wood, but generally only in small pieces, which were probably half-decayed when they were deposited. The complete stem of a tree has never yet been found in the Amber-earth, and solid pieces of a foot or more in length are very rare. Such pieces of wood as still have Amber attached to them are of especial interest; and there are even some so completely penetrated with Amber-resin that they appear to consist not so much of wood-fibres as of Amber-filaments. In the "Amber-earth" and in the lower part of the "Quicksand," there also occur pieces of compact clay and marl, which contain numerous fossils, the same

as those which are found in the overlying ferruginous sandstone. Mr. C. Mayer, of Zurich, determined thirty-five species of these fossils in the year 1860.* Among them the most abundant are an oyster (*Ostrea ventilabrum*, Goldf.), a small cockle (*Cardium vulgatissimum*, Mayer), *Pectunculus polyodontus*, Phil., *Natica Nysti*, D'Orb., *Morchia Nysti*, Gal, besides two species of *Spatangus* (*S. Sambiensis*, Beyr., and *S. bigibbus*, Beyr.), a small *Echinus* and a *Scutella* (*S. Germanica*, Beyr.); as well as a Crab related to the living *Carcinus moenas*; finally, there occurred in the greatest abundance species of *Eschara* and *Cellepora*.

The conclusion which Mr. Mayer has drawn from his examination is that the "Glauconitic Sand" of Samland is of the same age as the Glauconitic Sand of Egeln near Magdeburg, and of Lethen in Belgium, and therefore belongs to the Eocene or Lower Oligocene division of the Tertiary formation.

From the circumstances previously mentioned it follows that the Amber in the "Amber-earth" by no means lies in its original bed, that is, not in the soil of the old forest in which the Amber-pines grew; but that the whole deposit of the "Glauconitic Sand," so far as we have hitherto considered it, is a marine formation; and that the Amber was washed into it by the sea in which the crabs, sea-urchins, and oysters lived. From the habits of these animals, and from the form of the pieces of Amber, it may be inferred that the deposition of the latter occurred not very far from the shore; and from the condition of the Amber, that its deposition took place in a proportionately short time, and that considerable stores of it must have been collected in neighbouring localities. In the beds above and below the "Amber-earth" only a few isolated pieces of Amber occur.

The southern deposit of the "Glauconitic Sand," which commences near the village of Kreislacken on the west coast (Fig. III., 4, 5, 6*A*), behaves somewhat differently. Here the distance between the base of the "Amber-earth" and the upper margin of the "Green Sand" is less than anywhere else, namely, scarcely 30 feet, notwithstanding that the "Amber-earth" is 8 feet thick. Towards the south, however, the latter not only descends lower, but also increases in thickness, so that in a distance of half a German mile, near the village of Kraxtepellen, the thickness of the formation has increased to more than 50 feet, and that of the "Amber-earth" to more than 20 feet. This is caused by the coming in here of five different beds above one another from south to north. The Amber-earth is here composed of two different layers (Fig. III., 6, a^1, a^2), each of which is covered with a bed of quicksand, and the lower of which is dis-

* 'Die Faunula des marinen Sandsteines in Kleinkuhren bei Königsberg.' Vierteljahresschrift der naturforchenden Gesellschaft in Zurich. Jahrg. 1861, p. 109.

tinguished by its very coarse quartz grains. Above them lies a bed of "Green Sand" (*c*), then follows a bed composed of a very fine micaceous sand, from 10 to 25 feet thick, containing quite as small granules of glauconite, and much clay, being near the latter rich in sulphate of iron. This bed bears amongst the Amber-diggers the name of the "White Wall" (*d*), because when it is dry it soon becomes covered with a sheet of sulphate of iron. Upon it, finally, there reposes (still in the southern part) a bed of coarse quartz sand, 3 feet thick, which is particularly rich in large granules of Glauconite (*e*). Of all these beds only the upper "Amber-earth" and the "Green Sand" can be compared with the corresponding beds of the northern deposit, the remainder being peculiar to this southern formation. The latter is also further distinguished by containing no fossils with the exception of shark's teeth, which occur everywhere in the "Amber-earth," and by the greater abundance of pieces of Amber in the beds overlying the Amber-earth, namely, in the so-called "White Wall," than in the "Green Sand" of the northern deposit. We have evidently here, therefore, the northern margin of a deposit, which filled up a basin of its own,—immediately connected, it is true, with the great sea-bed in which the northern deposit was accumulated,—but which was formed by the action of particular currents. All this is clearly and sufficiently explained if we assume that these southern deposits have been formed at the mouth of a stream. The following observations will confirm this hypothesis.

In order to advance the solution of the various disputed questions relating to the birth-place of Amber, I directed my attention particularly to those minerals which are found in the beds of the "Glauconitic Sand" in the form of pebbles; and it has been my good fortune to obtain such a series of these pebbles as throws considerable light on the problems in question. In the "Amber-earth" of the northern deposit are found somewhat abundantly pieces of a compact stone, from the size of a hazel-nut to that of a walnut, which is evidently the parent-rock of the "Green Sand," as it is composed of exactly similar granules of Quartz and Glauconite bound together by a marly cement. These fragments, however, vary amongst themselves, in the quartz grains being sometimes larger and at others smaller, and the cementing marl being sometimes more and sometimes less abundant. With them also are associated small portions of marl which contain only granules of Glauconite.

In the "Amber-earth" of the southern deposit, however, occur fragments of that Cretaceous rock which is so abundant as pebbles in the Diluvial deposits of Northern Germany, and which is known sometimes as hard chalk, or as chalk-marl, or again as earthy ("*todter*") limestone. It is characterized by its richness in such fossils as *Belemnitella mucronata* (Schl.) d'Orb., *Ostrea vesicularis*,

Lam., and *Terebratula carnea*, von Buch.; and it is composed of very small granules of Quartz, minute flakes of Mica, and little grains of Glauconite, cemented together by a matrix of marl. It has therefore exactly the same constituents as the above-mentioned pebbles, and corresponds to them so precisely that both of them are evidently only variations of one and the same rock. This marly sandstone, however, is still found upon the neighbouring Island of Bornholm,* and belongs to the Greensand of the Cretaceous formation, which also includes in its lower beds coarser glauconitic sand and glauconitic marl. It is therefore proved that the Tertiary "Glauconitic Sand" of Samland has been formed out of the Greensand of the Cretaceous formation, the younger beds of which constitute a part of the Danish Island. The marly sandstone is evidently the parent-rock of the deposit which I have already distinguished by the name of the "White Wall," and which is particularly characteristic of the southern deposit of the Samland formation.

We can determine, however, still more exactly the route over which the materials of the northern deposit were brought there, because in the "Amber-earth" small pebbles of Silurian limestone occur in some abundance. This fact is itself sufficient to prove that the "Green Sand" came from a region where the Cretaceous formation reposed on old Silurian rocks. Moreover, two large stones, which were once found in the "Green Sand" near Warnicken, contained fossils, namely, *Beyrichia Buchiana*, Jones, *Chonetes striatella*, Dalm., and *Rhynchonella nucula*, Murch., and resembled partly rocks of the Island of Gothland and partly those of the Island of Oesel, so that it is in the highest degree probable that they were derived from the land which connected these two islands during the Tertiary period. And as the Silurian pebbles and the "Green Sand" came together to Samland, so it follows that, at that period, the Greensand of the Cretaceous formation extended from Bornholm towards the north, through Gothland to Oesel, and occupied a great part of the area which is now filled by the southern half of the Baltic Sea. The Cretaceous rocks then formed, evidently, a broad coast-land round the old continent of Northern Europe, which consisted of the crystalline rocks of Scandinavia and Finland, and of Silurian and Devonian strata. They also extended from Scandinavia over the area which is now occupied by the northern part of the Baltic and its bays, as also so far as Courland and Esthonia far away towards the east. The northern and northeastern part of that coast-land which lay north of the existing Samland must have been formed out of the oldest beds of the Cretaceous formation,—the loose Greensand and glauconitic Marl;

* For a recent account of the Geology of this Island see K. v. Seebach's 'Beiträge zur Geologie der Insel Bornholm.' Zeitschr. deutsch. Geol. Gesell. vol. xvii., p. 338.—Trans.

because upon the Danish Islands the deposits of that formation still form zones which follow one another in the order of their age from the north-east to the south-west. Add to all this that Cretaceous beds now crop out in the East of Prussia on the banks of the Niemen near Grodno, and that in the south Cretaceous beds to the thickness of 300 feet were bored through, in sinking a well near Thorn on the Vistula, and scarcely a doubt can then remain that the Tertiary deposits were accumulated in a sea-bed, which was formed by a great depression of the strata belonging to the Cretaceous formation.

The discovery of the parentage of the "Glauconitic Sand" also furnishes us with that of the Amber of Samland. The trees which yielded the Amber-resin must have grown upon the Greensand beds of the Cretaceous formation. Even as in North America at the present day the *Taxodium distichum* especially delights in the low and frequently inundated marsh-lands lying along the lower portion of the Mississippi, so during the Tertiary period may the Amber-trees have flourished best on the boggy coast which then surrounded the great continent of Northern Europe.

We can still more exactly draw the boundaries which then existed between sea and land, and with the assistance of a few hypotheses we can picture to ourselves the conditions under which the Amber was deposited.

We know not, indeed, how far in Prussia the beds of the "Glauconitic Sand" extend, as they are exposed only on the coast of Samland; but as we know that the beds of the Brown-coal formation were deposited immediately upon them, we can conclude, from the expansion which these beds possess in Prussia, what were the general boundaries of the old Tertiary sea, namely, that the whole of West Prussia, a neighbouring portion of Pomerania, and the western half of East Prussia, extending to about the thirty-ninth degree of longitude (from Ferro), formed the bed of a bay connected in the south-west with the great Tertiary sea, which covered the larger part of Northern Germany. The northern boundary of this bay left Samland at some distance, and was continued westward with some irregularity to Rückshöft, which lies at the foot of the peninsula of Hela, and where thick Brown-coal beds crop out on the coast of the Baltic. The bay was, as we have seen, a basin in the Cretaceous formation, and was bordered by widely expanded flat coasts, which mark the last upheaval of the district. Numberless rivulets with small discharge emptied themselves into the bay, and carried solid matter into it; but a larger stream from the north-west, which flowed through the southern portion of the Cretaceous land, also discharged itself here.

We have no knowledge of the oldest deposits which were formed in the bay; we can only conclude from the corresponding form-

ations in Belgium, where the Tertiary strata likewise repose on the Cretaceous beds, that the "Glauconitic Sand," which contains the Amber, may have been preceded by other deposits. In the meantime the coasts continued covered with luxuriant plant-growths—with that flora, in fact, the most delicate structures of which are still preserved to us in the clear Amber. If we consider that the temperature was then much higher than it is now, that the land descended from the highest North towards the South, and was there washed by a Middle-European sea, the temperature of which was, perhaps, elevated by a warm current, we shall then find it explained how this flora contains certain northern forms associated with plants of a temperate climate, and with others whose nearest allies now live in much more southern regions. Thus, Camphor-trees (*Cinnamomum polymorphum*, Heer) occur with Willows, Birches, Beeches, and numerous Oaks; amongst the Conifers the most abundant tree was a *Thuja*, very similar to the *Thuja occidentalis* now living in America, next to which abounded *Widdringtonia*, Pines, and Firs in great variety, and amongst them the Amber-pine. Many thousands of the last might already have perished, and while the wood decayed, the resin, with which the stem and branches were stored, might have accumulated in large quantities in bogs and lakes in the soil of the forest. In order to explain, however, that this accumulation of Amber could be suddenly broken up, floated away, and scattered, I assume that the coast of the district was at that time on the point of sinking. This supposition will appear less arbitrary when we see, as we shall presently, that alternate upheavals and depressions of the country may be positively proved to have occurred in the immediately succeeding period. If at that time the coast sank but slowly, nevertheless in the lapse of a few centuries, or even in a shorter time, a great portion of the flat coast-terraces might have been covered by the sea. The forest-earth was washed up by the waves, and the Amber carried into the sea. The greater portion being probably still attached to the wood, it could float about in the water for some time before it sank. The forest of the inundated coast was also destroyed; but the stems of the trees which floated out into the open sea were scattered about, only those pieces of wood which lay in the earth with the Amber sinking with it to the bottom. Thus perished the greater portion of the Amber forests; but it is not necessary to assume that they were all destroyed, as it is much more probable that in the higher districts of the country there still remained many forests which also were rich in Amber-trees.

The deposition of the "Green Sand" lasted for a long time afterwards, and pieces of Amber still continued to be washed into the sea; but it was only in the neighbourhood of the streams that

it was now deposited in greater quantity, probably because they flowed through either uninjured forests, or soil rich in Amber, in the higher parts of the country. What finally put an end to the deposition of the "Green Sand" it is difficult even to conjecture. Probably the land was so deeply depressed that the lowest beds of the Cretaceous formation,—the looser Greensand and sandstone,—were covered by the sea, and consequently protected from the action of rain.

Immediately upon the "Glauconitic Sand" lie the beds of the true Browncoal-formation. They very clearly form three deposits or stages (Fig. III., B^1, B^2, B^3), of which the two lower are certainly the most closely connected. The lower stage (distinguished by 1 in Fig. III.) is principally formed of "Quartz-sand," which generally contains no admixture. It is everywhere much more coarse-grained than the other varieties of sand belonging to the Browncoal-formation, but it is nevertheless found composed of particularly large grains in certain layers in the southern portion of Samland. At some places it alone (Fig. III., 1, B^1) constitutes the lower stage of the formation, which is everywhere of the same thickness, namely, from 24 to 25 feet; at other places the lower stage includes also a bed of clay (Fig. III., 2, 3, B^1). In order, however, to be able to explain the expansion of this clay, we must glance at the stratification of certain older beds which we have not yet discussed.

The beds of which we have hitherto spoken,—both the "Glauconitic Sand" and the "Quartz-sand,"—do not lie horizontally; but in proceeding from east to west along the north coast, they may easily be observed to sink gradually from the village of Sassau, then to proceed horizontally near Georgswalde, and to rise again from Warnicken towards Grosskuhren. They form therefore a trough-shaped synclinal, which is, however, very flat, as it possesses only a depth of from 40 to 50 feet in a length of nearly two miles. This trough is also seen again on the west coast; and numerous observations and measurements prove that it stretches from north-east to south-west through the western part of Samland, and in this direction becomes considerably widened and deepened. While its north-western margin is turned from the village of Grosskuhren on the north coast towards the west-south-west as far as the estate called Gross Dirschkeim, the eastern border appears to be extended from the village of Sassau in a southerly direction; but the site of the latter is not known exactly, as it passes through the midst of the country. The deepest point of the trough is near the village of Rothenen on the west coast, for while its base is 42 feet above the sea-level near Georgswalde, at the former locality it lies 10 feet below it. According to this the "Amber-earth" would occur near Rothenen at a depth of from 60 to 80 feet below the sea, but

hitherto it has been proved here quite as little as at other localities on the north coast, where it exists at a considerable depth.

The trough has evidently been formed by the upheaval of its two sides, and it can easily be shown when this commenced, and that it continued slowly. This is taught us by the clay-bed (Fig. III., 2, 3.—2), already mentioned as occurring in the "Quartz-sand" of the lower deposit, and as possessing a thickness of from 8 to 10 feet. It has exactly the same extension as the trough; it does not, however, belong to its infilling, but lies under it, forming a part of its base. Together with the "Quartzsand" it possesses the same thickness as the latter assumes, where it alone forms the lower division of the formation. It therefore follows that the upheaval of the sides began at a time when from 15 to 17 feet of "Quartzsand" had been deposited, and that while it continued, "Quartzsand" was thenceforward deposited only in the upheaved area; the resulting trough, however, was immediately covered with the mud, which is now hardened into a clay-bed. Where the clay is mixed with sand, it is not the "Quartzsand," but the fine Micaceous sand, which, as we shall see, forms the principal constituent of the infilling of the trough. This clay-bed, which I shall call the lower, because two others follow above it, belongs therefore, according to its situation, to the lower stage of the formation; according to its origin, however, it belongs to the middle stage, and thus it connects in the most intimate manner the two divisions, one with the other.

The materials which fill the trough (Figs. II., III., *B* 2) are of three kinds; namely—Clay, Sand, and Browncoal; but the first and the last occur only here and there, and the Sand (Fig. III.—4) must be considered the most important deposit in this series. It is composed of fine quartz-grains with an admixture of numerous small flakes of Mica and small bright-green granules of Glauconite. At the same time it contains many pieces of coal, partly as powder or small particles, and partly as large tree-stems. The first form the layers and nests, which give to a section of the sand a brownish striped appearance. I have, therefore, called this deposit the "Striped Sand," and it is absolutely peculiar to the Prussian Browncoal-formation as a glauconitic Micaceous sand. It is, however, on that account particularly remarkable, because it contains Amber, which occurs, not indeed so abundantly, nor yet in one precise layer, as in the Amber-earth, but still in tolerable richness as nests in the brown stripes, and with small pieces of coal. As this Amber comes from a much dryer stratum than the blue "Amber-earth," it may be distinguished both by its external appearance and its greater solidity; and it is on that account more highly valued than that from the latter deposit, which, if it dries in the open air, becomes cracked and shivered.

Under the "Striped Sand" lies, here and there, a clay-bed (Fig. III., 2, 6-3), which I call the Middle; it contains the remains of an extinct Flora, changed into coal,—some large portions of stems, flattened branches and stalks in greater abundance, and many leaves. As at other places, here also it may be observed that the last belong in great part to deciduous plants, while the wood is almost entirely that of conifers. This Browncoal-flora differs from the older Amber-flora; either the latter had perished as a shore-flora, and we have in the former the plant-growths of more northern and more elevated districts, or — what is more probable — the climate and flora of northern Europe had already altered. This flora, indeed, contained many species of plants which at the present day are quite foreign to the region; but it was, nevertheless, very similar to the existing Flora. Poplars, Alders (*Alnus*), Buckthorn (*Rhamnus*), Ash (*Fraxinus*), and, among the Conifers, *Taxodium dubium* and *Sequoia Langsdorfii* formed the principal components of the forests of that period; with them, however, occurred also a *Gardenia* with pea-like fruit, a Fig, and species of the genera *Sapindus*, *Diospyros*, and *Banksia*. The clay in which these plant-remains lie sometimes passes immediately into Brown-coal (Fig. III., 6. 5); generally, however, the latter occurs higher, above the "Striped Sand," and forms the uppermost member of the whole series (Fig. III., 2. 5, 9).

It is very remarkable that exactly in the same area which the southern deposit of the "Glauconitic Sand" occupies, the lower division of the Browncoal-formation appears to be differently composed. Instead of the simple clay-bed which lies above or in the "Quartzsand" on the north shore, we find here three deposits of clay and argillaceous sand (Fig. III., 4 and 6—2′, 2″, 2‴), so that the "Quartzsand" forms only thin layers between them. No one can doubt that these clayey deposits owe their origin to the same source as the older argillaceous sand which we have previously distinguished by the name of the "White Wall." More than this, we can even determine exactly the area over which the current of the river made itself perceptible in the Tertiary sea. For on the portion of the coast belonging to the village of Gross Hubnicken occurs a district, 2,700 paces broad, which contains generally the same beds as the districts lying to the north and the south, with this difference, that the argillaceous portions are absent (Fig. III., 5). Instead of the three clayey beds of the lower stage we find striped sand deposited in the "Quartzsand" of this area (Fig. III., 4); and we cannot explain this otherwise than by the supposition that the current was here so strong that it carried on the argillaceous ingredients, and sorted out, as it were, the striped sand. At the same time this furnishes us with the proof that all the clayey beds of the lower stage belong to the "Striped Sand," and that, therefore, not

only it, but all the infilling of the trough, with the Amber which it contains, was also brought there by the same river which during an earlier period had floated similar materials from the land into the sea. Thus the deposit of the "Glauconitic Sand," which appears to be connected with the Green Sand, is bound up in a wonderful manner with the overlying Browncoal-formation.

The deposits of the middle division of the Browncoal-formation have no important relations, for altogether they attain a thickness of only 22 feet, and even thus are unrepresented in one-half of the trough. The beds of the third division of the formation (Figs. II., III., *B* 3) are thicker and more wide-spread; they extend over the whole area of the Lower Stage, and repose partly upon the "Quartzsand" of that division, and partly upon the beds of the second stage. The succession of its various strata is also nearly the same as in the Middle Stage. At the base lies a clay-bed (Fig. III.—6), which passes upward into a clayey "Micaceous Sand" (7). Both contain plant-remains: pieces of wood and leaves of Conifers. As the clay and coal diminish in quantity, the "Micaceous Sand" becomes brighter, and at last white. It does not, however, contain Glauconite, and is thus distinguished from the "Striped Sand." Its upper layer is in great part composed of a Quartzsand, the grains being more equal and smaller than in the "Quartzsand" of the Lower Stage; but it can nevertheless only be looked upon as an alteration of the same. It is coloured grey or black by a great quantity of coal-dust, and is therefore appropriately called "Coal-sand" (Fig. III.—8). In it or in the uppermost layer of the "Micaceous Sand" sometimes occur, finally, true beds of Brown-coal (Fig. III.—9), from 6 to 8 feet thick, which are sometimes sandy, but at others consist of bituminized wood, and then contain a great quantity of gigantic trunks of trees. These upper Browncoals are those which are found also in other remote districts of the Province of Prussia covered by newer formations, for instance, near Braunsberg on the Passarje, near Schwetz on the Vistula, near Rückshöft on the Baltic, &c.

From what has now been stated it will be easy to carry on the history of Samland through the Tertiary period. When in the place of the "Glauconitic Sand," the deposition of the "Quartzsand" commenced, the relations of sea and land were not changed. As the "Quartzsand" in the southern districts is much coarser than in the northern, and as it forms in the latter area numerous intercalated beds between other strata, which do not occur in the former, we can infer that it was carried into the Bay from the great sea in the south-west. After the deposition of this Sand, and of the clayey ingredients which the river washed into the Bay, had continued undisturbed for some time, began the gradual

upheaval of the country lying east and north-west of the Bay. And the Bay itself, which had been so extended by an earlier depression, was now confined to the small flat trough whose most northerly portion we have now learnt to know. As it arose, however, it was filled up with the mud which the river carried into it, for the barriers which had formerly stopped its deposits were now destroyed by the upheaval of the coast. With the sand, which it derived from a variety of the Cretaceous Sandstone, poor in Glauconite, it took up also, out of the lakes and marshes through which it flowed, the Amber which was deposited there, and carried it into the trough, as well as numerous fragments of such plants as a river would bear away from an old forest. That the wood occupies as Browncoal chiefly the uppermost place in the series of deposits can perhaps be explained only by supposing that it floated about on the surface of the water until the trough under it was filled up, and it was pressed downward into the Sand.

About this time the coarse Quartzsand on both margins of the trough lay dry; but, as it is covered by the beds of the uppermost division of the Browncoal-formation, it is clear that a depression again followed the upheaval of the country, during which the deposits of the argillaceous "Micaceous Sand," of the "Coal-sand," and of the Browncoal, were accumulated. The "Micaceous Sand" of the upper division contains, however, no Glauconite, and as we are unacquainted with its origin, the influence of the river on these beds is also unknown, and the mode of their formation cannot be pursued any farther with certainty. No doubt the forests of an extensive shore-line again perished, and furnished the wood to the Browncoal-beds. Finally, the Prussian Bay of the North-German Tertiary sea was filled up, and while numerous deposits were formed in other parts of this sea, Prussia was laid dry by an upheaval of the rocks, and thus ended for a time the history of the country, but only to commence again after many centuries, when a harsher period of destruction succeeded to the clemency of the Tertiary Epoch.

This new period in the history of Samland began with the depression of the continent of Northern Europe. This region, which had endured since the oldest period of the earth's formation, was depressed first of all in the north-east, then in the south; and the Polar sea was enlarged as gradually, the valleys and deeper portions of the land being overflowed towards the south. The climate and all the conditions of the country were thus completely changed. The mountains projecting out of the sea were covered with glaciers, which extended down to the water. Icebergs and ice-flakes laden with the *débris* of rocks and with blocks of stone were detached from these glaciers and drifted towards the

south; here they stranded upon the overflowed land, which was formed of Silurian and Cretaceous strata. The latter, with its many soft and marly beds, offered the least resistance to the water and the ice, and was therefore the most deeply eroded and destroyed. The clayey material, being more easily suspended in the water, was carried away by the sea and deposited as mud. The harder portions were mixed with the crushed components of the northern rocks, and were also widely distributed as sand by the water and the ice.

Without doubt there remained also at this period considerable deposits of Amber upon the Greensand beds of the Cretaceous formation, where the remains of the old forest soils existed, or the marshes and lakes which long ago had dried up or been filled with earth. With the soil, these also were now broken up, and with them the Amber was scattered in every direction. It can thus be explained why Amber-nests are found in the Diluvial deposits over all the German Plain, and why Amber also occurs in many other countries in Northern Europe, for instance, in Sweden, on the coast of the North Sea, &c. After the partial destruction of the Cretaceous beds, however, the Tertiary formation of Samland was laid bare to the fury of the waves and the pressure of the icebergs; it was destroyed in many places, and at last overflowed and covered with mud and sand.

The high coast of Samland presents an excellent opportunity for observing the nature and mode of the erosion of the Tertiary rocks by the Diluvial sea; and even the small coast-section (Fig. II.) enables us to perceive how here and there the upper beds only have been denuded, while at other places all the strata have been eroded down to the present sea-level, and even deeper. The narrow limits which have been assigned to this article, render it impossible for me to discuss very closely these relations, and I must therefore confine myself to the following remarks.

Of the deposits which were thrown down by the Diluvial sea, two divisions, having clear boundary lines, are usually distinguished, namely, the Older Diluvium and the Newer. The Older Diluvium (Figs. III., IV., α to δ) is deposited on the Tertiary strata to the thickness of from 10 to 40 feet; but where the latter have been denuded down to the sea-level, it may be seen reaching a height of 150 feet. Marl (which was deposited by the sea as mud), sand, large pebbles, and boulders are the principal components of the Older Diluvium. The sand, which has numerous varieties, distinguishable partly by colour and partly by the size of the grains, is characterized throughout Samland by always being rich in Glauconite, which was no doubt derived from the Greensand beds of the Cretaceous formation. The Newer Diluvium (Figs. III., IV., ε) consists of yellow sand and yellow loam; it is but slightly developed

in north-western Samland, and forms a covering of from 5 to 20 feet in thickness, spread regularly over all older deposits.

The destruction of the Tertiary strata had commenced before they were overflowed, no doubt by means of the masses of ice which were driven against the deeper beds. On thawing, the ice deposited the débris and stones with which it was laden. This explains the great gravel-bed which often lies imbedded in marl, near the remains of the Tertiary strata (as in Fig. IV., near A and E α). Often, however, surrounded by Diluvial masses, occur large blocks derived from the uppermost beds of the Browncoal-formation; they fell down by the destruction of the middle beds, and remain lying in the mud. Thus were large blocks of the older rocks washed away. In Fig. II. we see such removals, both in the east near Neukuhren and Wangen, as also westward near Georgswalde and Warnicken, —isolated remnants of the older beds being still seen projecting from their foundations. In Fig. IV., also, is exhibited on a larger scale the last-named coast district, where near A is seen one such remnant, and near E the step-like fractured margin of the Tertiary beds. These denudations, however, were also sometimes accompanied by dislocations, which were caused by the pressure of the masses of mud and sand which were thrown on the older beds. One such dislocation is shown in Fig. II. in the district of Rauschen; and near Rosenort on the west coast we have the remarkable case of the older Glauconitic beds being upheaved, and not only covered by Diluvial masses, but having also the same beneath them,—where they appear to have been thrust by lateral pressure.

In the deeper erosions occur marl and sand, not in a regular succession of beds, but thrust without order into each other, or heaped up against one another. Such a mode of arrangement cannot be explained in deposits from water; but they may nevertheless have arisen in two ways. At one time the ice-islands of the diluvial sea abundantly destroyed again the deposits which they had themselves formed, and the gaps which thus arose were filled up with other material. Still more generally it happened that the half-floating mud was forced upwards, by the weight of the sand which was heaped up on it, to such points where this pressure was accidentally slighter; by these means the mud penetrated into the overlying sand, as may be seen in Fig. IV. near B; or the sand beds were heaved up and thus fractured, as the sand beds D have been heaved up through the marl. All these changes took place slowly and in slightly agitated water. The proof of that is found in the circumstance that the broken and transported masses of the older beds are often found very near the places where they were detached; and great deposits of Tertiary sand are found with the ordinary Diluvial sand in the Diluvium, having been derived from the denuded portions of the Browncoal-formation.

After the deposition of the Older Diluvium the land was raised up above the water, and lay dry for a long time. At that time, probably, numerous hills were formed as Dunes, for they can be proved in some cases; and thus by means of wind and water the land probably obtained its present features; but it was once more overflowed. The depression this time seems to have progressed faster and to a greater depth than before, so that the ice-islands drifting towards the south but slightly eroded the surface; and, on their melting, only the blocks which they had transported were deposited; and these are imbedded abundantly in the associated sand and loam.

After this the land once again emerged out of the water; and thus it is that through alternate upheavals and depressions it has gradually risen to the height which it now possesses; but the waves of the sea still continue the work of destruction which they commenced thousands of years ago, and yearly lessen the area of the country. If, however, other countries can only complain of the damage which the sea has inflicted on their coasts, it here amply repairs the loss it has caused. When lashed by storms, it tears up the Amber out of the deep-lying beds of Amber-earth; by the help of sea-weeds torn up at the same time from the bed of the sea the Amber is heaved upwards, and carried on the surface of the water; and when the storm abates and the sea becomes calm, it carries the Amber, together with pieces of older Browncoal and fresh marine plants, on to the beach, where a hundred hands are waiting to intercept it with nets. That is the "Amber-drawing," a trying occupation, which demands a strong and hardy frame, for the cold winter storms yield the richest booty. But many pieces of Amber, nevertheless, do not reach the shore, for the largest and heaviest pieces have already sunk to the bottom, and lie between the large boulders which cover the sea-bed. Therefore, in calm weather and with clear water, the inhabitants of the coast go in boats, and turning the stones with hooks fastened on long poles, endeavour to discover the Amber in the interspaces, and to draw it up with small nets. This is called "Striking for Amber."* For a long time people were contented with what Amber they could recover by these means from the sea; and these modes of acquisition still furnish the greatest quantity of the Amber which is obtained from Samland for commerce. For the last ten years, however, on all points of the coast where the Amber-earth does not lie too deep beneath the sea-level, endeavours have been made to lay it bare and to obtain the Amber immediately from it. The circumstance that it is overlain by a bed of very loose sand, which contains a large quantity of water, has hitherto impeded the attempts to open out the Amber-earth by subterranean mining-works. And to make this possible,

* "Bernstein stechen."

and therefore to render accessible the stores of Amber which lie hidden in the interior of the country, will be the next progress in the acquisition of these, in so many respects, remarkable fossils.

For the benefit of such students as desire to inform themselves more fully concerning the natural history of Amber, we append a list of the principal books and papers which have at various times been published on the subject; and we also venture to illustrate the paper of our contributor with a plate, which will convey some idea of the organic remains usually found in this fossil resin. For the accuracy of the list of works, therefore, as well as for the second plate, the Editors of this Journal are responsible. The specimens figured in that plate belong to the National Collection in the British Museum; and for the facts relating to the Insects embodied in the annexed explanation of it, we are indebted to the kind and able assistance of Mr. Frederick Smith, of the Entomological Department of that Museum.—Editors.

EXPLANATION OF THE QUARTO PLATE.

Fig. I. shows the north-western part of the coast of Samland.

Fig. II. is a section of the same line of coast.

In both figures the tinted portions distinguish those places where the Tertiary beds crop out above the sea-level. The white portions are those where Quaternary or Postpliocene deposits only are visible. The principal divisions of the Tertiary rocks are distinguished by different lines. *A* signifies the deposit of the "Glauconitic Sand"; B^1 the Lower Stage, B^2 the Middle Stage, and B^3 the Upper Stage, of the Browncoal-formation. The boundaries of the Synclinal Trough, which the Second Stage fills up, are shown by dotted lines.

Fig. III. exhibits vertical sections on a larger scale through three points on the north coast and three on the west. Here *A* distinguishes the deposit of the "Glauconitic Sand"; *a*, the "Amber-earth"; *b*, the associated "Quicksand"; *c*, the "Green Sand"; *d*, the so-called "White Wall"; *e*, the "Green Wall." *B* is the true Brown-coal formation; also 1, the "Quartz-sand"; 2, the intercalated clay-beds, which are represented on the west coast by three members, 2′, 2″, 2‴; 3, the Middle Clay-bed; 4, the "Striped Sand"; 5, the Lower Brown-coal; 6, the Upper Clay-bed; 7, "Micaceous Sand"; 8, "Coal Sand"; and 9, the Upper Brown-coal. *C*, Diluvial deposits:—α, coarse sand, gravel, and large boulders; β, Marl; γ, ordinary sand; δ, redeposited Tertiary sand;—all these (α to δ) belong to the Older Diluvium; ε is the Younger Diluvium.

Fig. IV. shows on a much larger scale than Fig. II. a small part of the coast near Warnicken, where the Tertiary beds are in great part denuded and replaced by Diluvium, exhibiting also the position of the Diluvial masses. The letters and numbers upon it have the same signification as in Fig. III.

EXPLANATION OF THE PLATE OF ORGANIC REMAINS FOUND IN AMBER.

Fig. 1.—A Dipterous Insect belonging to the European genus *Leptis*. Three times the Natural Size.

Fig. 2.—A Dipterous Insect belonging to the European genus *Echinomyia*. Enlarged one-half.

Fig. 3.—A species of the Blind Travelling Ants (*Formicidæ*) of Africa, being either *Anomma rubella* or a closely-allied species. Twice the Natural Size.

Fig. 4.—A species of the spined *Formicidæ* belonging to the South American and African genus *Polyrhachis.* Twice the Natural Size.

Fig. 5.—A Dipterous Insect belonging to a new genus of *Muscidæ*, allied to the European genus *Tachinus.* Twice the Natural Size.

Fig. 6.—A Clicking Beetle belonging to the European genus *Cardiophorus.* Twice the Natural Size.

Fig. 7.—A species of Heteromerous Beetle belonging to the family *Cistelidæ*, and allied to the genus *Statira*, in which, as in the fossil, the eyes coalesce. Three times the Natural Size.

Fig. 8.—A species of the tropical family of Beetles, termed *Eumolpidæ*, and probably belonging to the genus *Calasposoma.* Twice the Natural Size.

Fig. 9.—A species of *Termes* (White Ants). Twice the Natural Size.

Fig. 10.—Front view of a Spider belonging to the family *Attidæ.* Magnified four diameters.

Fig. 11.—An oblique Dicotyledonous Leaf. Natural Size.

In the above Explanation, the term "European genus" is not used as signifying that the genus is now *confined* to Europe, but only to show that it is still represented on the Continent.

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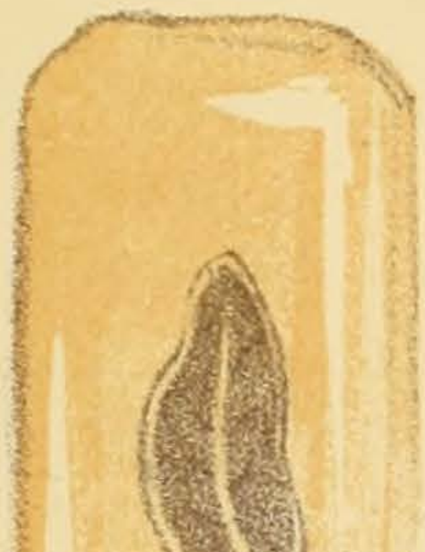

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