the boundary between the Pleistocene and Pliocene deposits. This error was soon afterwards justly corrected by Suzuki and later more effectually by Tokunaga.

Of more importance to the discussion is the boundary between the Narita and Tokyo Series, which was once exposed very favourably in the sand ditches along the Owu line at Tabata. The marked difference of lithological characters between the two consecutive beds above and below the boundary-line made the unconformity very striking.

At that time I was inclined to take it as an evidence of time-interval between two deposits; the new discovery of the shell-sand, which is the main subject of the present article, however, entirely deprived me of any confidence in this previous supposition. As mentioned above, we see now at Tabata, on one side the regular downward succession of sandy gravel bed and sand-bed which locally passes to argillaceous sand, arenaceous clay, and the shell-sand with the characteristic transitional fauna between the Oji and Narita fauna, and on the other hand likewise quite a regular succession of the deposits of the Tokyo Series, namely, in ascending order (A) the principal shell-bed of Oji and Shinagawa, (B) sand and clay beds of an estuarine formation. These estuarine deposits of the Tokyo Series lie on the same level as, and in close proximity to, the sand-bed which is the direct continuation of the shell-sand above mentioned. The detailed local researches of Mr. Yamakawa and myself have clearly revealed the total absence of any indication of a stratigraphical break between them. We are therefore obliged to conclude that the variation of sediments is only a local phenomenon and that their deposition took place side by side at the same time. Consequently, the apparent unconformity between the Narita and Tokyo Series must also be regarded as only of minor geological importance.

NOTICES OF MEMOIRS.

On the Value of the Fossil Floras of the Arctic Regions as Evidence of Geological Climates.[1]

By Professor A. G. Nathorst, Hon. Sc.D. Camb., of Stockholm.

Translated from the French original[2] by E. A. Newell Arber, M.A., F.G.S.

AMONG the problems which are constantly called to mind during geological explorations in the Arctic regions, that of the climates of the past naturally demands special attention. The contrast between the present and the past is there more striking than in any other region. Beneath the snow and ice bordering the Arctic sea, one marvels to find, for example, large corals in beds belonging to the

[1] A paper read before the Eleventh International Geological Congress on August 25, 1910. "Sur la valeur des flores fossiles des régions arctiques comme preuve des climats géologiques," Stockholm, 1910. Also in Compt. Rend. Eleventh Intern. Geol. Congr., Stockholm, 1911.

[2] The English translation has been revised by Professor Nathorst, and references added.

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Carboniferous System, or again the remains of Saurians, Ammonites, or Nautiloids, in those of Triassic age. But when one bears in mind the extreme richness of the Invertebrate fauna of the Arctic seas to-day, when one remembers the colossal whales which find their subsistence in these waters, one may be inclined to ask if it has not been an error to conclude, from the occurrence of the fossils above mentioned, that the climate was formerly more genial than it is to-day. Should we not be under-estimating the creative power of life if we imagine that, among the Saurians, the Ammonites, and the Nautiloids, no species has been able to develop which was adapted to life in the Arctic seas? If the Reindeer and the Musk-ox were extinct, who would imagine that these beasts were able to flourish on the scanty vegetation of the high parallels north of 80° of latitude? And who would suppose that such monsters as the Mammoth and the Woolly Rhinoceros could find sufficient nourishment in the poor vegetation of the Tundras or the Coniferous forests? Such examples teach prudence; there is certainly no question which requires so much caution as the problem of deducing from the faunas of the past the climatic conditions under which they flourished.

This remark applies with equal force to the floras. Although to-day the Cycads only occur in warm regions, it would be an error to conclude that the Cycadophyta of the past have always flourished under similar conditions. On the contrary, we must admit that during the Mesozoic period, when these plants were abundant, it would no doubt have been possible to find several species which had adapted themselves to an Alpine climate if such a one had then existed. And if, since then, the differentiation of climates has begun to make itself felt, it would be again a case of overlooking the creative power of life, if we assumed that none of the species of Cycadophytes were able to adapt themselves to a temperate climate in the Polar regions. Again we meet with difficulties, even when we study the plants of the Tertiary period, which are assigned to genera still living. Our Common Juniper (*Juniperus communis*, Linn.), which exists in Northern Europe as far north as the North Cape, exceeds by 20 to 25 degrees of latitude, in the Eastern Hemisphere, the northern limit, not only of the other species of the genus, but also the whole family of the Cupressineæ. Now, if one imagined that the Common Juniper was extinct, one would naturally draw conclusions relative to the fossil remains from the distribution of the other species. And one would consequently suppose that it lived under a climate much warmer than is actually the case. One would scarcely imagine that we were concerned with a plant adapted not only to temperate, but also to Arctic, climates. (One finds the Juniper, on the western side of Greenland, up to the 64th parallel.)

These examples counsel prudence, and the matter should be treated with judgment and circumspection. But, even if it is necessary to make reservations, when one seeks to determine from the fossil plants the nature of former climates in the Arctic regions, at least one cannot doubt that they were distinctly warmer than that of the present day. The difficulty of explaining these former climates, especially when one has to take into consideration the length of the winter

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night, is without doubt the reason which has led some scientists to evade the question, instead of seeking to solve it. It is indeed a case of evading the question when it is boldly asserted that the plant-remains, on which Heer[1] has based his theories of ancient Arctic climates, have been drifted by marine currents to the places where they have been found.

It is not to be disputed that plant debris may be transported in water for a very great distance without being damaged, provided that they are carried at a sufficient depth to escape the influence of the movements of the surface layers of the water. When Agassiz was engaged in dredging on the American coasts, he found that the bottom of the sea—sometimes to a depth of nearly 3,000 metres—was covered with plant debris, such as wood, branches, leaves, seeds, and fruits, in all stages of decay. Also, in certain places, these remains were still fairly abundant at a distance of 1,100 – 1,200 kilometres from the shore. This distance corresponds to about 10 degrees of latitude. It is thus proved that the remains of plants may be transported for very considerable distances. But this is true only of marine deposits. If we are concerned with freshwater sediments, the example given has no bearing on the case.

One might, however, reasonably suppose that a river, flowing in the direction of the meridian from south to north, might have carried from the southern regions leaves and other fragments of vegetation which became buried in some deposit of the stream itself, or of a lake, which it traversed, or of its delta. This is a possibility which must not be neglected, but on the other hand it must not be treated as though it were an ascertained fact, since we do not know how far it applies to the case in point.

The fact is, it is puerile to attempt to draw conclusions as to the ancient climates of the Arctic regions, before the nature of the deposits in which the fossil plants have been found has been ascertained. It is especially important that an attempt should be made to answer the question, did the plants once flourish in the neighbourhood of the deposits in which they are found, or were they transported from far-away lands? It is this question which an attempt will here be made to solve, by furnishing a concise résumé of the principal beds containing fossil plants in the Arctic regions.

In Bear Island,[2] and in Ellesmere Land,[3] beds extremely rich in plant-remains are met with belonging to the Devonian system. The fossil plants of Bear Island occur in the series of beds which also include several seams of coal. Beneath the coal, which is composed essentially of the bark and trunks of *Bothrodendron*, one finds, as elsewhere, bituminous schists containing roots, and from this one can show that the plants of which we speak flourished, at least in part, in situ. This is likewise proved by the actual nature of the plants, as much in the older beds with *Archæopteris fimbriata*, Nath.,

[1] O. Heer, *Flora fossilis arctica*, vols. i–vii, 1868–83.

[2] A. G. Nathorst, "Zur Oberdevonischen Flora der Bären Insel": Kongl. Svenska Vet.-Akad. Handl., vol. xxxi, No. 3, 1902.

[3] Id., "Die Oberdevonische Flora des Ellesmere Landes": Rep. 2nd Norweg. Arctic Exped. in the Fram, vol. i; Christiania, 1904.

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as in the more recent with *Pseudobornia ursina*, Nath. The latter species has been found with large stems or rhizomes, as well as very small ones, only a few millimetres in diameter, to which extremely delicate, almost membranous, leaves are still attached. It is hence quite certain that there is here no question of the plants having come from distant regions. The materials have not been sorted out. One sees a medley of branches, small and large, and the perfection of the preservation of their delicate leaves demonstrate conclusively that they have not undergone transportation from afar. The same applies to *Archæopteris fimbriata*. The beds of coal, the clay with rootlets, and the very nature of the plants themselves, all point to the same conclusion, namely, that we have here a flora which flourished in part on the very spot where it is now found.

As I have already pointed out in my description of the Devonian flora of Ellesmere Land, one arrives at the same conclusions here also, and it is unnecessary to enter into further details.

In the Arctic regions, Culm deposits, yielding fossil plants, are known from Spitzbergen,[1] from the north-east of Greenland,[2] and probably from the south of Melville Island, in the Arctic Archipelago of America.

We will here concern ourselves only with Spitzbergen, although it may be mentioned in passing that the flora of the Culm discovered by the Danish expedition in North-East Greenland, in latitude 81° North, consists of nearly the same species as that of Spitzbergen. The latter flora has been observed in many localities up to 79° of latitude. It is characterized by the presence of *Stigmaria*. with appendicular organs radiating in all directions, still in continuity and penetrating the clay beneath. We are thus able, in several places, to observe the presence of *Stigmaria* in situ, which furnishes undeniable evidence of the fact that the plants lived in the place where we now find them. The stems of *Lepidodendron* found in the same place have a diameter of at least 40 cm. It would be superfluous to give other examples, for one can scarcely doubt that the plants of the Culm have flourished in the very place in which they are now found, or in its vicinity.

On the other hand, the observations which relate to the Triassic plants of Spitzbergen and Eastern Greenland are somewhat different. The latter ones belong to the Rhætic Series and include several species of *Pterophyllum*, *Podozamites*, *Cladophlebis*,[3] etc. In Spitzbergen one finds them as far north as 78°.[4] Neither there nor in Eastern Greenland, where one meets with them between the 70th and 71st parallel, are they associated with beds of coal, but the manner in which they occur in Greenland indicates that in no case have they

[1] A. G. Nathorst, "Zur Paläozoischen Flora der Arctischen Zone": Kongl. Svenska Vet.-Akad. Handl., vol. xxvi, No. 4, 1894.

[2] Id., "Contributions to the Carboniferous Flora of North-Eastern Greenland": Meddelelser om Grönland, vol. lxiii; Copenhagen, 1911.

[3] N. Hartz, "Planteforsteninger fra Cap Stewart i Östgronland": Meddelelser om Grönland, vol. xix; Copenhagen, 1896.

[4] A. G. Nathorst, "Zur Mesozoischen Flora Spitzbergens": Kongl. Svenska Vet.-Akad. Handl., vol. xxx, No. 1; Stockholm, 1897.

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travelled from very distant localities. One has not with certainty observed any marine petrifactions associated with the plants, but it has not yet been clearly determined whether the Triassic beds with fossil plants of Spitzbergen are of marine or of freshwater origin.

The most ancient Jurassic sediments of Spitzbergen are marine, and belong to the Sequanian stage. There was consequently a long interruption in sedimentation after the formation of the Rhætic beds.[1] The upper part of the Jurassic formation (Portlandian) furnishes a series of plant-bearing sandstones, seams of coal, and beds of undoubted freshwater origin, containing *Unio* and *Lioplax polaris*. The fossil plant-remains belong to two different floras, one, the more ancient, being characterized by the presence of *Ginkgo digitata*, Brongn., sp.; the other, the more recent, by *Elatides curvifolia*, Dkr., sp. The two floras are associated with beds of coal, and one may here also put forward the view that the plants originally flourished in the place where they are now found. One of the coal-seams at Cape Boheman furnishes a great abundance of *Podozamites* and *Pityophyllum*; sometimes the surface of the schists is as completely covered with the leaves of *Ginkgo digitata*, as the soil beneath a living *Ginkgo* tree may be in autumn. Since branches and seeds of the same plant are also associated, it is natural to suppose that a Ginkgo forest occurred not far away from this spot. The same observation applies to *Elatides curvifolia* of the more recent flora, which occurs locally in the freshwater beds containing *Unio* and *Lioplax*. Floras of the same age and composition are also known from King Karl's Land, the islands of New Siberia,[2] from Northern Siberia, and Arctic Alaska.

The Neocomian Series of King Karl's Land is overlain by sheets of basalt, often amygdaloidal, and containing chalcedony and agates. Fragments of silicified woods, large and small, also occur here, and these, without doubt, owe their mineralization to the volcanic phenomena. Some of these trunks are fairly large, and I have myself measured one, which, although incomplete, was 70–80 cm. in diameter, and showed 210 annular rings. Some of these remains consist of the lower portion of the trunk and the primary ramifications of the roots.

The microscopic examination of these specimens, undertaken by Dr. W. Gothan,[3] has shown that the annual rings of the fossil stems from King Karl's Land were much more accentuated than those of stems found in the corresponding beds of the European continent, which indicates that the trees lived in a region where the difference between the seasons was extremely pronounced. They cannot therefore have been transported from the south by marine currents, and as the trunks found in the corresponding beds of Spitzbergen[4] show the

[1] A. G. Nathorst, "Beiträge zur Geologie der Bären Insel, Spitzbergens, und des König Karl Landes": Bull. Geol. Inst. Upsala, vol. x, 1910.

[2] Id., "Über Trias und Jurapflanzen von der Insel Kotelny": Mém. Akad. Imp. Sci. St. Pétersbourg, ser. VIII, vol. xxi, No. 2, 1907.

[3] W. Gothan, "Die fossilen Hölzer von König Karls Land": Kongl. Svenska Vet.-Akad. Handl., vol. xlii, No. 10, 1907.

[4] Id., "Die fossilen Holzreste von Spitzbergen": Kongl. Svenska Vet.-Akad. Handl., vol. xlv, No. 8, 1910.

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same peculiarity, it is quite safe to conclude that we are here concerned with large trees, which have actually flourished in these latitudes, and which have not been transported from more southern regions.[1]

The Cretaceous System, as we know it, is represented in Western Greenland, between the parallels of 69° and 71°, by an important series of beds containing fossil plants belonging to the Urgonian, Cenomanian, and Senonian, the two first mentioned containing coal-seams. I have been able to show, as the result of the studies which I made in Greenland in 1883, that beds, full of roots, underlie those containing fossil plants at Unartoarsuk, as well as at Igdlokunguak. Without doubt the Urgonian flora, like the Cenomanian flora, is a relic of vegetation which once flourished in the same regions where we now find the fossils. But, on the contrary, the Senonian flora, or flora of Patoot, is in part contained in marine beds, containing *Inoceramus*, etc., and thus it may have been transported from some distance. The Urgonian flora, or flora of Kome, is composed of Ferns, Cycadophytes, and Conifers, while the Cenomanian or Atane flora, in addition to arborescent Ferns (*Dicksonia*) and Cycadophytes (*Pseudocycas*),[2] is particularly rich in the leaves of Dicotyledonous trees, among which are found those of planes, tulip-trees, and bread fruits, the last mentioned closely resembling those of the bread fruit-tree (*Artocarpus incisa*)[3] of the islands of the Southern seas.

In the limited space at my disposal, I have had to be content with a brief summary of the strata containing fossil floras of Palæozoic and Mesozoic age. But, from what has been said, it is clear that we have every reason to regard the floras of the Devonian, Culm, Jurassic, and Cretaceous of the Arctic regions as being composed of plants which flourished in these very regions. It has not been definitely proved that the Triassic flora has been transported from more Southern regions by marine currents, but there is still some uncertainty on this point.

In relation to the present problems, the Tertiary floras are undoubtedly the most important, and for this reason I will enter into the subject in some detail. But the materials are so wonderfully rich

[1] It may be mentioned here that a silicified *Dadoxylon* from the Carboniferous deposits of Spitzbergen described by Dr. Gothan (loc. cit.) does not show any annual rings at all, precisely as is the case with the corresponding Palæozoic stems of Europe. As observed to me by Mr. Th. Halle, this is a most curious circumstance, since the darkness during the long winter night in those regions—provided that the position of the North Pole was the same as now—ought to have caused an interruption of the growth, even if the climate was a warm and genial one. As the specimen, however, was not found in situ it is possible that it originates from some marine deposit into which the wood had been brought by ocean currents from more southern latitudes. But also a *Dadoxylon* from the Triassic of Spitzbergen shows only slight indications of annual rings (Gothan, loc. cit.).

[2] A. G. Nathorst, "Paläobotanische Mitteilungen, 1 und 2. *Pseudocycas*, eine neue Cycadophytengattung aus den Cenomanen Kreideablagerungen Grönlands": Kongl. Svenska Vet.-Akad. Handl., vol. lxii, No. 5, 1907.

[3] Id., "Über die Reste eines Brotfructbaumes, *Artocarpus Dicksoni*, n.sp., aus den Cenomanen Kreideablagerungen Grönlands": Kongl. Svenska Vet.-Akad. Handl., vol. xxiv, No. 1, 1890.

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that I shall have to restrict myself to giving some examples indicating the nature of the beds containing the Tertiary plants in Spitzbergen, Iceland, and Greenland. More especially, I shall recall that they are found at 79° of North latitude in Spitzbergen; on the east coast of Greenland between 74° and 75°, and on the west coast between 69° and 73°; at Lady Franklin Bay, in Grinnell Land (81° 42″); in Ellesmere Land between 77° and 78°; on the River Mackenzie at 65°; in Alaska south of 60° (and therefore outside the Polar Circle); and lastly in the islands of New Siberia (75°). Iceland, it is true, is outside the Polar Circle, but nevertheless its Tertiary flora may be included in this consideration.

The Tertiary formations of Spitzbergen, which have a thickness of perhaps 1,200 metres or thereabouts, contain fossil plants and seams of coal, both in the upper and lower beds, though the middle portion is marine. As an example of the deposits with fossil plants from the base of this formation the shales called the 'Taxodium Shales', at Cape Staratschin, may be mentioned. These are fine-grained black soft shales, which form the roof of a small bed of coal. In the shales the leafy branches, the flowers, the seeds, and the ovuliferous scales of the Swamp Cypress (*Taxodium distichum miocenum*), the leafy branches of *Sequoia Nordenskiöldi*, Hr., and *Librocedrus Sabiniana*, Hr., are particularly common. There are also associated a large number of remains of Gramineæ, Cyperaceæ, several species of Pines and Firs, a *Potamogeton*, and the leaves of various Dicotyledonous trees. Thus, as Heer has shown, one is dealing here with freshwater sediments, in the neighbourhood of which it is evident that the Swamp Cypresses have formed forests, as in the swamps in the southern portion of the United States to-day. This conclusion is also confirmed by the occurrence of the remains of rather numerous insects, among which there are a score of Coleopterids, two of which are hydrophilous Coleopterids (*Hydrobius* and *Laccophilus*).

These beds with fossil plants, at the base of the Tertiary formations of Spitzbergen, are overlain by thick marine sediments. In their upper portion, the latter show indications of a retreat of the ocean and a recurrence of freshwater conditions. It is possible that the leaves found in the lower part of the higher horizon containing fossil plants have been transported from afar by a river, and deposited near its mouth, but as regards the upper portion, deposition must have taken place in vast swamps, on which the majority of the plants actually lived. In these beds one notices thin seams of coal, a great quantity of leafy branches, and also cones of *Sequoia Langsdorfii*, Brongn. (which resembles the Red Wood of California, *Sequoia sempervirens*, Endl.) and the Swamp Cypress (*Taxodium distichum miocenum*). Here and there a large Horsetail (*Equisetites Nordenskiöldi*, Nath.) occurs in such abundance that one would imagine that it formed small forests. There are also associated rhizomes, with their roots and tubercles still attached. I may mention in passing that *Equisetum arcticum*, Heer, occurs in the same manner in the lower zone of the plant-bearing beds. There also occurs a great abundance of *Osmunda spitzbergensis*, Nath., and on the same horizon nodules of clay ironstone, entirely filled with leaves and stems of the

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latter plant, in which the tissues have been so completely mineralized that one can study the microscopic structure as minutely as in the living *Osmunda*. One sees in the carbonaceous petrified layers rootlets and spores of ferns, as well as fragments of branches, etc. This might justly be called a mineralized peat. Among the Dicotyledonous trees, the leaves of which occur in great quantity, one finds leaves of all dimensions belonging to the more common species. I have examples, among others, of the leaves of *Ulmiphyllum asperrimum*, Nath., varying from 1–17 cm. in length. All the observations indicate that we have here a deposit formed by the delta of a stream, passing through a marsh, on which grew trees requiring humidity, while the remains of other plants which lived at some distance away have been transported, either by the wind or by water, and become mingled with those of the marsh.

The beds of this horizon, discovered at Cape Lyell, are remarkable for the enormous quantity of leafy branches of *Sequoia Langsdorfii*, leaves of *Grewia crenata*, Hr., and of *Acer arcticum*, Hr., the fruits of the last mentioned also occurring. A bed full of rootlets was also met with, showing that the plants flourished on the spot where they are now found. Among the marsh plants an *Alisma* occurs. Among the Dicotyledonous trees of this horizon are Poplars (*Populus*), Willows (*Salix*), Alders (*Alnus*), Birches (*Betula*), Hornbeams (*Carpinus*), Hazels (*Corylus*), Beeches (*Fagus*), Oaks (*Quercus*), Elms (*Ulmus*), Planes (*Platanus*), Magnolias (*Magnolia*), Limes (*Tilea*), and Maples (*Acer*), etc. We can thus show that during the Tertiary period all these plants have flourished at 78° or 79° of latitude. In Grinnell Land we find, even at nearly 82°, the Swamp Cypresses, the Spruces, Pines, Firs, Poplars, Birches, Elms, Limes, etc.

In Iceland the Tertiary flora may be studied in the volcanic tuffs or in the alluvium formed from them, and at Brjàmslaekur, for instance, in a deposit which may be compared with a laminated peat. Thus, as Heer had suggested, and Thoroddsen has proved, we here meet with formations laid down above sea-level, which are overlain by thick basaltic beds. A glance at the specimens from Brjàmslaekur serves to show that we have here to deal with freshwater deposits. M. Östrup's[1] microscopic examination of the Diatoms, found in the same beds as the fossil plants, confirms this conclusion, for they are freshwater species.

Among the beds furnishing Tertiary plants, so abundant in Greenland, I will only mention that at Harön, near Waigattet. Here the plants occur either in a true basaltic tuff or in an altered tufa or a sediment formed from it, and overlain with basalts.

The investigation of two beds, which I made in 1883, has proved that they cannot be other than formations laid down above sea-level. In one of these deposits the fossil flora consisted almost exclusively of leaves of the Maple (*Acer*), crowded like those which cover the ground in autumn, and among these leaves large samaras, like those of

[1] E. Östrup, "Diatoméerne i nogle islandske Surtarbrandlag," pt. i: Meddel. fra Dansk Geol. Forening, No. 3; Copenhagen, 1896. Pt. ii, ibid., No. 6, 1900.

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A. otopteryx, Gp., occur. In another bed the tuff was formed of cinders and small lapilli, and the way in which the vegetable fragments were embedded leads one to suppose that the branches, leaves, and fruits of the trees were broken off by a shower of cinders and lapilli. A medley of silicified branches of different sizes occurs, and among them are the cones of the Spruce, the nuts of the Walnut (*Juglans*), and the Hickory (*Carya*), with the leaves of *Ginkgo*, etc. In the finer tuffs we likewise find the leaves of the Walnut, the leaves and fruits of an Ash (*Fraxinus macrophylla*, Hr.), and the leaves of species common in the Tertiary flora of Greenland, such as the Plane, Oak, Chestnut, Beech, etc.

The presence of the leaves of *Potamogeton*, associated with a freshwater mussel (*Unio*), indicates that the deposits were of freshwater origin. Some of the branches of the trees are silicified and exhibit, under the microscope, an extremely well-preserved structure. M. J. Schuster, who has undertaken a preliminary examination of these remains, concludes that they all belong to one species, which was probably either an arborescent member of the Leguminoseæ or of the Rosaceæ. It is clear that we have here to deal with fragments of vegetation broken off by a shower of ashes and entombed in them, though some fragments may have been transported into a freshwater basin containing mussels and aquatic plants.

The Tertiary plants discovered by the Norwegian Expedition to Ellesmere Land deserve special mention on account of their state of preservation. They consist almost entirely of branches of *Sequoia Langsdorfii*, contained in a bituminous laminated clay, from which I have been able to remove them by a process of washing, with the result that they are now isolated like dried specimens in a herbarium.

I must here bring to a close my review of the ancient plant-bearing beds of the Arctic regions. We may conclude that, in the greater number of cases, it is evident that the plants really grew in the regions in question. Although we know of fossil plants in some marine deposits, as for instance in the Senonian of Greenland, and perhaps also in the Trias of Spitzbergen, these are exceptions which lack importance, since other deposits, of a closely corresponding age, are of freshwater origin. While it may be admitted that, even in Spitzbergen, part of the Tertiary flora may have been transported from a more or less distant country by a river, yet other deposits, on approximately the same horizon, indicate that the greater number of the species, and among them the most important types, have actually flourished in the region itself.

Taking into account the facts which I have enumerated, it is evident that the fossil floras of the Arctic should be still regarded as the foundation of every discussion of the former climates of this region. How are these favourable climates to be explained? That is a question to which we are not able to reply at the present moment, and of which the solution belongs to the future.

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