34. NOTES on a COLLECTION of ROCKS and FOSSILS from FRANZ JOSEF LAND, made by the JACKSON-HARMSWORTH EXPEDITION during 1894–1896.

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[PLATES XXXVII–XLI.]

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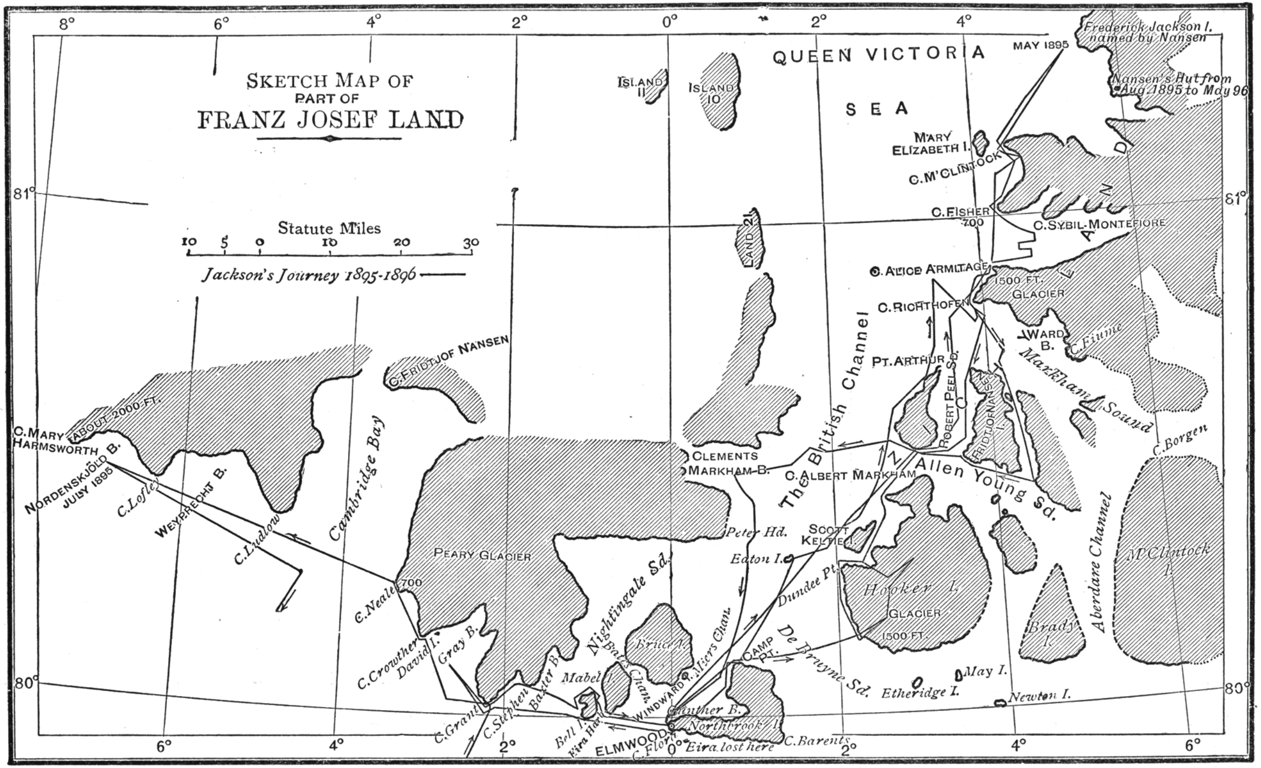
I. INTRODUCTION.

THE steamship *Windward*, which has now paid two visits to Franz Josef Land, brought back last year (1896) a series of rocks and fossils, collected by the Jackson-Harmsworth Expedition. This collection, by far the most important which has reached this country from Franz Josef Land, was forwarded to the Geological Survey, and at the request of the Director-General, Sir Archibald Geikie, we have undertaken its examination. Although the full results of the geological observations recorded by Dr. Kœttlitz cannot be made known until the return of the expedition, it has been thought desirable that a preliminary account of the district, based on the specimens already received, should be published.

II. PREVIOUS WORK ON THE GEOLOGY OF FRANZ JOSEF LAND.

The geological literature relating to Franz Josef Land, though small in amount, is sufficient to prove that those portions of the district which have as yet been visited possess a comparatively simple geological structure. Scattered observations have now been made over more than two degrees of latitude by Payer, Leigh Smith, Jackson, and Nansen, and everywhere the features observed appear to be essentially of the same character. It is a region of plateau-basalts comparable, not only in its main features, but also in many of its minor details, to portions of the western coast of Scotland. Vast flows of basaltic lava, associated in all probability with intrusive sills of the same type of rock, form the greater portion of the district. Sometimes the basalt descends to the level of the sea, and sometimes, as at Cape Flora, rests on some 600 feet of nearly horizontal strata of Jurassic age. It may be safely predicted that if the capping of snow and ice which conceals so large a portion of the district were cleared away, the geological aspect and physical features of Northbrook Island would be very similar

Fig. 1.—*Sketch-Map of part of Franz Josef Land, by Frederick G. Jackson.*
(Showing discoveries and journeys, up to 1896, of the Jackson-Harmsworth Expedition.)



to the northern part of the Isle of Skye, where basaltic lavas and intrusive sills are associated with nearly horizontal strata of Jurassic age.[1]

The geological observations made by the members of the Austro-Hungarian Polar Expedition under the command of Lieuts. Payer and Weyprecht were necessarily of a limited character. Payer calls attention to the plateau-like aspect of the land in the neighbourhood of Cape Tegethoff, the southern promontory of Hall Island, and to the fact that the plateau terminates with steep precipitous rocks.[2] He refers also to the occurrence of dolerite (the general term applied to the rocks by Prof. Tschermak) on Koldewey and Schönau Islands, that of the latter being remarkable for its beautiful columnar structure. He states generally that dolerite is the prevailing rock, but refers also to the occurrence of sandstones and of a shale containing white mica and plant-remains. There is no means of correlating the latter rocks with the beds discovered by Dr. Kœttlitz, of the Jackson-Harmsworth Expedition. The common occurrence of silicified wood is also noticed by Payer, and wood of this character is abundant in the present collection. The ship *Tegethoff* was abandoned, and only a few specimens appear to have been brought back. In his general remarks on the geology of Franz Josef Land, Payer clearly recognizes that it forms a part of an extensive volcanic province, stretching westward through Spitsbergen, Jan Mayen, and Iceland to Greenland.

The voyages of Mr. Leigh Smith in the *Eira* furnish additional information of importance as to the geology of Franz Josef Land. From the account of the first voyage in 1880 given by Mr. (now Sir) Clements R. Markham[3] we learn that May Island, the first land reached, is 200 feet in height, and formed of basalt. Cape Barents, the south-eastern promontory of Northbrook Island, is formed of 'columnar basalt like the Giants' Causeway.' It is stated that while the ship was in Eira Harbour Mr. Grant walked along the shore to the eastward, presumably on Mabel Island, and afterwards ascended with a party to the summit of the hill overhanging the harbour (Bell Island?), which proved to be 1040 feet above the sea. 'On the slope of this hill a good deal of petrified wood was collected, and some other fossils.' It is further stated that 'the lowest rocks belong to the Oxford Clay, and are represented in the collection brought home in the *Eira* by two belemnites. Above the Oxford Clay the rock is of the Cretaceous period to which the fossil coniferous wood belongs, including one very perfect cone. There are also slabs with impressions of plants. Over all these has been an overflow of basalt and lava, forming a cap, as on the island of Disco.' In the discussion which followed

[1] See 'The Tertiary Basalt-plateaux of North-western Europe,' by Sir A. Geikie, Quart. Journ. Geol. Soc. vol. lii. (1896) p. 331.

[2] 'New Lands within the Arctic Circle.' See also Proc. Roy. Geogr. Soc. vol. xix. (1874) p. 17.

[3] Proc. Roy. Geogr. Soc. n. s. vol. iii. (1881) p. 129.

the reading of the paper, Mr. Etheridge referred to the widespread distribution of the basalts, which he regarded as being probably of the same age as those of the Giants' Causeway.

During the second voyage of the *Eira* in 1881, which unfortunately terminated in the loss of the ship, a raised beach, 90 feet above sea-level, was found in Gray Bay, and cliffs of columnar basalt, 800 feet in height, were observed at the same locality.[1] Fossil wood was found on David Island.

Dr. Nansen's book, 'Farthest North,' contains many references to the geology of the parts of Franz Josef Land visited by him. The first rock touched in his memorable journey towards the south is described as a coarse-grained basalt,[2] and he refers to the occurrence of basalt on the western coasts of Karl Alexander Land and Frederick Jackson Island; also at Capes McClintock, Fisher, and Richthofen. In justice to Mr. Jackson it should be remembered that he had visited most of these localities in 1895, and had observed the occurrence of basalt.

In many places the rock exhibited the characteristic columnar structure in the most perfect manner. While staying with Jackson at Cape Flora, Dr. Nansen examined the geological structure of the neighbourhood of that cape, the points of interest being shown to him by Dr. Kœttlitz, the doctor and geologist of the English expedition. The basalt appears at a height of 500 or 600 feet, and below this is a soft clay containing lumps of an argillaceous sandstone, in which fossils occur. At first Dr. Nansen held the view that the stratified deposits belonged to a late beach-formation, but Dr. Kœttlitz showed him that these deposits actually passed underneath the basalt. Dr. Nansen also observed thin strata of basalt in the clay, below the main mass. The fossils were mainly ammonites and belemnites, and these convinced him that they belonged to the Jurassic period. The main mass of basalt was coarser in grain than ordinary basalt, and resembled the so-called 'diabases' of Spitsbergen.

Dr. Nansen points out that the situation of the basalt on Northbrook Island is different from that which had been observed farther north. Here it was found at a height of 500 or 600 feet, whereas north of lat. 81°, at Capes Fisher, McClintock, Clements Markham, and many other localities, it descended to the sea-level. He regards the basalt as in great part of Jurassic age.

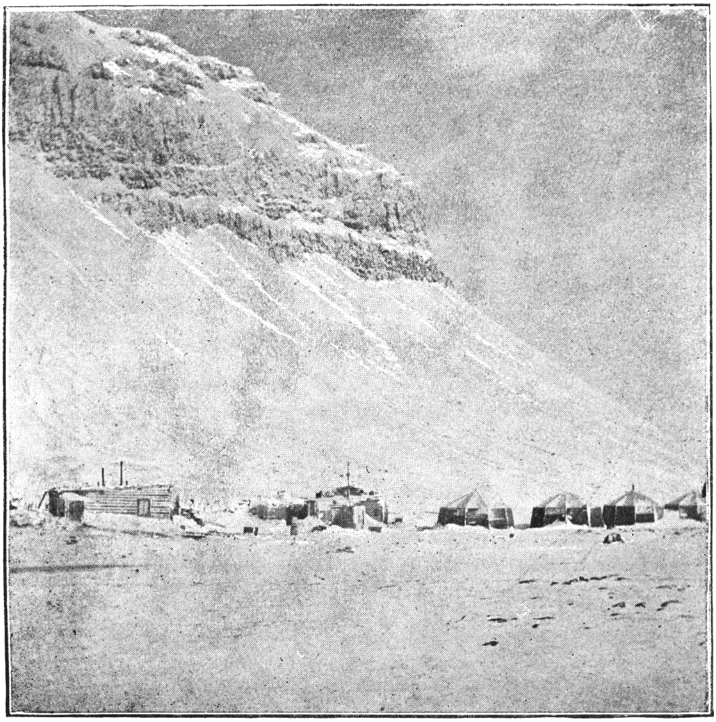
Mr. Jackson and Dr. Kœttlitz discovered innumerable fragments of rock, containing plant-remains, resting on a mass of basalt which, at a height of more than 700 feet above the sea, projected through the glacier on the north of Cape Flora. Dr. Nansen was taken to this spot by Dr. Kœttlitz, and they brought away a number of specimens, some of which were submitted to Dr. Nathorst, and

[1] See the account of the voyage by C. R. Markham, Proc. Roy. Geogr. Soc. n. s. vol. v. (1883) p. 204.

[2] Vol. ii. p. 306. In his diary the rock is called a granite, but in a footnote he adds that it was a coarse-grained basalt.

determined by him to be of Upper Jurassic age. The fact of these fossils having been found on the basalt also influenced Dr. Nansen in referring this rock, in part at least, to the Jurassic period. Evidences of recent changes in the relative level of land and sea are referred to in Dr. Nansen's book. Thus, Mr. Jackson's hut is

Fig. 2.—*Elmwood, Cape Flora.*



[From a photograph.—This view shows the exposure of basalts above, and the huts of the Expedition below the talus-heaps, which are here covered by snow.]

built on an old beach 40 to 50 feet above sea-level, and other beaches were found at still greater elevations. Raised beaches were also observed farther north, in the neighbourhood of the hut in which Dr. Nansen wintered.

A number of geological specimens were sent home by Mr. Jackson and his party when the *Windward* returned in 1895, and a short note on some of these was appended by our colleague, Mr. G. Sharman, and one of us to Mr. Montefiore Brice's report of the expedition.[1] The much larger series of specimens, of both rocks and

[1] Geogr. Journ. vol. vi. (1895) p. 518.

fossils, which has now been received, throws additional light on the geological structure of the Franz Josef Land archipelago. Although the cliffs are so largely hidden by talus-heaps and snow, that exposures of rock are few and far between, yet the specimens now collected by Mr. Jackson's party have all been so carefully labelled and localized that it has been possible to piece them together, so as to present what we believe to be a correct idea of the geology of some of the southern parts of Franz Josef Land. We have received much help from Mr. H. Fisher, the botanist of the expedition, who is now in England: his admirable coloured sketches and verbal descriptions doing much to aid us in realizing the actual conditions under which the specimens were found. Moreover, Mr. Fisher's patience in answering our innumerable and perplexing queries has helped us out of many difficulties, and we take this opportunity of tendering him our warmest thanks. We are also under obligation to Dr. G. J. Hinde for many hints, but especially for his Note on the radiolarian chert from the iceberg. We have moreover received help and many kind suggestions from our colleagues, Mr. Clement Reid, Mr. G. Sharman, and Mr. W. W. Watts, and we desire to thank all these friends, and to acknowledge our indebtedness to them.

III. The Basalts of Franz Josef Land.

The basaltic rocks which form so important a feature in the geology of Franz Josef Land are well represented in the Jackson-Harmsworth collection by specimens from Cape Flora and Hooker Island. All these belong to one type, although the specimens may be massive, vesicular, or amygdaloidal; but another and a distinct type is represented by one or two specimens obtained from the under-surface of an iceberg found, tilted up, in De Bruyne Sound, between Northbrook and Hooker Islands.

The common type will first be described. It is represented by specimens collected *in situ*, and from the talus which so commonly conceals the lower portions of the cliffs. As there is no essential difference between the specimens collected under these different conditions, they will be grouped together for purposes of description. In the fresh condition the rocks are very dark, almost black, and of medium grain. They weather in the manner characteristic of basaltic rocks, and sometimes break up into spheroids. Examined with a lens, the felspars are often seen to be of a yellowish colour, and the appearance of the rock under these circumstances is such as to suggest at first sight that olivine is an important constituent. This, however, is not the case; olivine does occur occasionally, but never in sufficient quantity to affect the macroscopic character of the rock.

A special feature of almost all the rocks of the common type is the tendency of some of the felspars to be somewhat larger than the others, and to occur in groups, thus producing a kind of glomero-porphyritic structure. A few specimens may be fairly termed 'porphyritic basalts,' but the porphyritic structure is never strongly marked in the hand-specimens, and is frequently not noticeable.

Vesicular and amygdaloidal rocks are extremely common at Cape Flora. This is a point of some interest, when considered in connexion with Payer's remark that 'amygdaloidal varieties, so common in Greenland, were never found in Franz Josef Land.'[1] The cavities have been filled with various substances, such as calcite, analcime, natrolite, chacedony, quartz, and palagonite.

Under the microscope the constituents are seen to be plagioclase, augite, magnetite, olivine, interstitial matter, and various secondary products. The plagioclase occurs in forms giving lath-shaped sections, and also as aggregates of somewhat larger individuals, which mutually interfere with each other, and are more equally developed in the different directions. A broad type of albite-lamellation is common to both modes of occurrence, and the individuals of the larger aggregates often show, in addition, a zonal structure and twinning on the pericline-plan. The lath-shaped sections in a common type of rock measure about ·5 mm. in length by ·1 mm. in breadth; whereas the individuals which compose the larger aggregates may measure as much as 1 or 2 mm. in their longest diameters. There is a certain amount of variation in the dimensions of the felspars in different specimens, but the above figures will give an idea of the scale on which they are commonly developed in those varieties which contain comparatively little interstitial matter.

When the powder of the rock, freed from the fine dust by washing, is placed in a diffusion-column of cadmium borotungstate, the felspars form a fairly well-defined band, the centre of which corresponds to a specific gravity of 2·7. There is no great amount of scattering, and a fragment of labradorite floats in the centre of the band. The felspar, therefore, agrees on the average with labradorite, but the optical characters of the zoned individuals, and the slight scattering of the grains in the diffusion-column, indicate deviations on both sides of the average. The central portions of the zoned individuals are more basic than the marginal portions, but the transition is not always continuous; so that in the life-history of individual crystals there has occasionally been a recurrence of the conditions which gave rise to the deposition of more basic material. The larger individuals frequently contain inclusions of brown glass, with or without bubbles. These inclusions are as a rule limited to the central portions.

Augite is abundant in all the rocks, and forms, with felspar, the greater portion of the mass in the majority of cases. Generally only one type of augite is present. In thin sections this is pale brown, more rarely yellowish green, sometimes almost colourless. It is usually without any trace of crystalline form, and occurs as grains or patches, which are often penetrated by the lath-shaped sections of plagioclase. As a rule, several individuals having

[1] 'New Lands within the Arctic Circle,' German ed. p. 267.

different orientations occur in juxtaposition, so that the ophitic structure, though present, is not so marked as it is in many of the holocrystalline dolerites from Iceland, the Færöe Islands, and the West of Scotland. It resembles in character and mode of occurrence the augite of the Tynemouth and related dykes in the North of England.[1]

One rock-specimen, obtained from the underside of an iceberg found, tilted up, off Eira Cottage, which otherwise belongs to the common type, contains more or less idiomorphic phenocrysts (see Pl. XXXVII, fig. 3) of pale greenish augite, with peripheral inclusions, in addition to the ordinary augite above described. A few grains of this mineral were isolated, and the presence of chromium established. It is therefore, as was suspected from its appearance under the microscope, a chrome-diopside; and the fact is of some interest from the point of view of correlation, because Scharizer has proved the occurrence of this mineral under similar conditions in the basalts of Jan Mayen.[2] It will be shown subsequently that the basalts of Franz Josef Land have other points of resemblance with those of Jan Mayen.

The iron-ore occurs as grains, crystalline aggregates, and skeleton-crystals. It is strongly magnetic, and is often present in sufficient quantity to make the rock magnetic. The felspar and augite are as a rule remarkably free from inclusions of this mineral, which certainly does not in these rocks belong to the earlier phases of consolidation, as it does in so many rocks of intermediate composition. In many cases it is found only as skeleton-crystals in the interstitial matter (Pl. XXXVII, fig. 4), and in some the iron-oxides have remained wholly undifferentiated in a deep brown glass.

Olivine is by no means constantly present, and rarely occurs in sufficient quantity to give a marked character to the rocks. It occurs as grains, and occasionally as more or less idiomorphic crystals. When fresh it is colourless in the thin sections; but it is sometimes represented only by green, or more rarely by brown, alteration-products. The occurrence of olivine in sparsely-scattered grains or crystals seems to be a special character of this class of basalts. Its absence from any particular section does not prove that it is entirely absent from the rock, for if several sections be prepared from one specimen it may be found in some and not in others.

In addition to the mineralogical constituents above described, the rocks invariably contain a certain amount of interstitial matter, which assumes different forms in different cases. It may occur as a brown glass comparatively free from microlites, as palagonite arising from the alteration of this brown glass, or as a fine-grained matted aggregate of microlites of augite, magnetite, and felspar, with which some colourless base may possibly be associated. Transitions from the condition of brown glass to the microlitic type may sometimes be observed, and under these circumstances the gradual bleaching of the glass by the separation of ferriferous

[1] 'Petrological Notes on the North-of-England Dykes,' Quart. Journ. Geol. Soc. vol. xl. (1884) p. 209. See pl. xii. fig. 6.

[2] 'Ueber Mineralien u. Gesteine von Jan Mayen,' Jahrb. d. k.-k. geol. Reichsanst. vol. xxxiv. (1884) p. 707.

constituents is clearly shown. The amount of interstitial matter varies considerably in different specimens. It is very small in amount in the massive varieties, but in some of the vesicular forms it becomes an important constituent.

The most interesting type of interstitial matter is the palagonitic. Palagonite is especially abundant in the amygdaloidal varieties, where it occurs not only wedged in between the crystalline constituents, but also as the infilling material of some of the amygdaloids. It is a soft black or greenish-black substance, which can be readily scratched with the finger-nail and cut with a knife. The powder has a soft unctuous feel when rubbed between the fingers. Heated in a closed tube it gives off a large amount of water. It is readily acted upon by hydrochloric acid, and fragments leave behind a white siliceous pseudomorph. Under the microscope, in very thin sections, it is usually seen to be of a deep brown colour; but occasionally it contains green zones arranged parallel with the boundaries of the space which it occupies. In its general appearance, and in the presence of this zonal structure, it resembles the palagonite from deep-sea deposits described by Messrs. Murray & Renard.[1] When viewed with crossed nicols the palagonite is seen to be doubly-refracting. It appears to be formed of minute interlacing fibres or scales of a brown or, more rarely, of a green colour. The double refraction of the deep-brown palagonite enables us at once to distinguish it from the isotropic paler brown glass with which it is sometimes associated, and out of which it has been formed by hydration. The following analysis of this substance was made. Analyses of palagonite and of the closely-related 'hullite' are quoted for comparison :—

	I.	II.	III.	IV.	V.
SiO_2	35·48	41·26	44·73	46·76	39·44
Al_2O_3	8·30	8·60	16·26	17·71	10·35
Fe_2O_3	12·30	25·32	14·57	1·73	20·72
FeO	14·60	...	...	10·92	3·70
MnO	...	...	2·89	0·44	trace
CaO	1·04	5·59	1·88	11·56	4·48
MgO	7·10	4·84	2·23	10·37	7·47
Na_2O	3·92	1·06	4·50	1·83	...
K_2O	trace	·54	4·02	0·17	...
H_2O or loss on ignition	16·80	12·79	9·56	...	13·62
	99·54	100·00	100·64	101·49	99·78

I. From amygdules in basalt at Cape Flora, Franz Josef Land (Teall).

II. Palagonite from Palagonia, Sicily. The insoluble residue (10·99 %) is deducted and the remainder calculated to 100. Quoted from Zirkel, 'Lehrbuch der Petrographie,' 2nd ed. vol. iii. (1894) p. 689.

III. Palagonite from South Pacific. Analysis by Sipöcz, *Challenger* 'Report on Deep-Sea Deposits,' p. 307.

IV. Basic glass from the centre of the mass from which the palagonite (III) was obtained.

V. 'Hullite' from Carnmoney Hill, near Belfast. Analysis by Hardman. Quoted from Sollas & McHenry, 'On a Volcanic Neck of Tertiary Age in Co. Galway,' Trans. Roy. Irish Acad. vol. xxx. (1896) p. 734.

[1] 'Report on Deep-Sea Deposits,' *Chall.* Exp., p 304.

The published analyses of palagonite differ considerably from each other, and the one which must now be added to the list does not entirely agree with any one of them. It is often stated that the iron present is wholly in the condition of ferric oxide. If this be taken as an essential character the present substance is certainly not palagonite, for most of the iron is in the ferrous condition. The discovery of so large an amount of ferrous oxide was quite unexpected, and a second determination was made with special care. The results in both cases were identical. It may, therefore, be taken as certain that the present substance, which so closely resembles palagonite in its microscopic character, mode of occurrence, and relation to basic glass, is rich in ferrous oxide. As the other analyses differ widely in some respects, no great harm will be done by extending the use of the term so as to include this substance.

The 'hullite' of Hardman has been shown by Profs. Cole[1] and Sollas[2] to occur, like the palagonite of Cape Flora, as interstitial matter, and as the infilling of amygdaloids. Mr. Hardman's analysis shows that the two substances have decided chemical affinities. Both are remarkable on account of the large amount of iron. Under these circumstances it became important to compare them as regards specific gravity. Mr. Hardman gives the specific gravity of hullite as 1·76, and Prof. Sollas confirms this somewhat extraordinary result. Five small pieces of palagonite were taken from two amygdules occurring in a specimen collected from the talus near Cape Flora, and placed in a solution of methylene iodide. After twenty-four hours' immersion it was found that two sank, one remained suspended, and two floated in a liquid of specific gravity 2·433; four sank and one remained suspended when the specific gravity of the liquid was lowered to 2·409. The specific gravity is therefore not constant, but it is somewhat greater than 2·4.

On comparing the analysis of the Cape Flora palagonite with that of Palagonia it will be noted that there is a close agreement so far as the total amount of iron is concerned, but an important difference as regards its state of oxidation. There are further important differences as regards the total amount of lime and the relative proportions of lime and magnesia.

The two analyses quoted from the *Challenger* Report are especially interesting. One represents the palagonitic crust, and the other the nucleus out of which it has been formed. They indicate, as the authors point out, that the change is accompanied by hydration, elimination of lime and magnesia, oxidation of the ferrous iron, and addition of alkalies.

More interesting results will be obtained if, instead of considering the palagonite of Cape Flora in relation to more or less allied substances from other localities, we consider it in relation to the rock in which it occurs. This is a basalt with a specific gravity

[1] 'On Hullite,' Rep. Belfast Nat. Field Club 1894–95, p. 1.

[2] 'On a Volcanic Neck of Tertiary Age in Co. Galway,' Sollas & McHenry, Trans. Roy. Irish Acad. vol. xxx. (1895) p. 739.

of about 2·9. The palagonite has arisen from the hydration of the glass formed by the consolidation of the mother-liquor out of which the other constituents, mainly labradorite and augite, have crystallized. If we assume that the only chemical change which has taken place is that of hydration, then the percentage composition of the mother-liquor would be as follows:—

SiO_2	42·88
Al_2O_3	10·03
Fe_2O_3	14·86
FeO	17·65
CaO	1·26
MgO	8·58
Na_2O	4·74
	100·00

In view of the researches of Lemberg[1] and the observations of Murray & Renard the above assumption is not warranted. Alkalies may have been added, and lime and magnesia removed. There is, however, no reason to believe that the relative amounts of alumina and iron have been appreciably changed, and we are therefore able to draw the important conclusion that in a magma of the type to which these basalts belong—that is, a basic magma poor in alkalies—progressive crystallization leads to the formation of a mother-liquor poor in silica and alumina and rich in iron. It is possible that the relative amounts of lime and magnesia have not been seriously modified by the hydration, and if so we see that crystallization may, at any rate in its earlier stages, tend to increase the relative amount of magnesia. The partial separation of the lime, alumina, and silica from the iron and magnesia is of course effected by the crystallization of basic felspars, which in this class of rocks precede the augites and sometimes even the olivine.[2]

This concentration of the iron, and to a certain extent magnesia, in the mother-liquor of basic magmas does not appear to have attracted the attention which it deserves. It shows that progressive crystallization in these magmas sometimes leads to a result, the opposite of that observed in the case of intermediate magmas in which ferriferous compounds separate out during the early phases of consolidation.[3] The synthetic experiments of Messrs. Fouqué & Lévy[4] indicate that the formation of magnetite is not limited to one period in the history of the consolidation of silicate-solutions, and the

[1] Lemberg examined the effect of water and solutions of alkaline carbonates on volcanic glasses. He says:—'Fassen wir alles zusammen, so werden basische Gläser (Palagonitglas, Tachylyt) schon durch reines Wasser hydratisirt; durch Alkalicarbonate werden auch sauere Gläser sehr rasch umgewandelt; dabei wird Wasser aufgenommen, Alkali gegen andere starke Basen ausgetauscht, Kieselsäure zum Theil ausgeschieden' ('Zur Kenntniss der Bildung und Umwandlung von Silicaten,' Zeitschr. Deutsch. geol. Gesellsch. vol. xxxv. 1883, p. 557).

[2] See W. W. Watts, 'Guide to the Collections of Rocks and Fossils in the Museum of Science and Art, Dublin,' 1895, p. 78.

[3] 'On some Quartz-felsites and Augite-granites from the Cheviot District,' Geol. Mag. 1885, p. 106.

[4] 'Synthèse des Minéraux et des Roches,' Paris, 1882.

same fact has been established by Vogt in his work on slags. The last-mentioned author has made a special study of the conditions under which magnetite is formed and has established the fact that in basic slags in some cases magnetite precedes olivine, in other cases it crystallizes simultaneously with olivine, and in yet others it is formed after olivine.[1]

If we take the analysis quoted above, *minus* the water and alkali, as representing the composition of the mother-liquor formed after the separation of labradorite and augite, it is clear that we have still the material necessary to form olivine, magnetite, and spinel (hercynite).

In view of the evidence thus furnished of the concentration of iron, one is tempted to speculate as to the results that might follow if the process were carried still further. Magnetite forms the matrix of the cumberlandites of Rhode Island and Taberg, in which olivine and felspar occur as phenocrysts.[2] It is found as interstitial matter in the ultrabasic 'schlieren' in the banded gabbros of Druim an Eidhne.[3] Magnetite and a green spinel (hercynite?) are intimately associated in the pyroxenites from Scourie. Metallic iron associated with graphite occurs as interstitial matter in certain basalts in Greenland.[4]

Can it be that in some, at least, of these cases we see the extreme results of the process indicated above?

We have now described the principal constituents of the common type of basalt. The different specimens vary somewhat as to the relative proportions of the several constituents, and still more striking differences are due to the presence or absence of amygdaloids. The massive varieties are of medium grain, and contain comparatively little palagonite or other form of interstitial matter; the amygdaloidal varieties are usually of somewhat finer grain, and contain a considerable amount of palagonite. The mutual relations of the constituents are illustrated in Pl. XXXVII, figs. 1, 2, 3, & 4. The labradorite formed first, and the larger individuals sometimes contain glass-inclusions in their central portions. The separation of labradorite probably left the mother-liquor poorer in alumina, lime, and soda, and this facilitated the formation of augite. The common augite occurs in irregular grains and patches which are often penetrated by the felspars. The chrome-diopside belongs to an earlier phase of consolidation. Magnetite has formed at different stages, but it is commonly associated with the interstitial matter, and in many specimens the felspar and augite are almost entirely free from inclusions of this mineral. The bulk of the magnetite belongs to a

[1] 'Beiträge zur Kenntniss der Gesetze der Mineralbildung in Schmelzmassen,' Archiv for Math. og Naturvidensk. Kristiania.

[2] See 'Lithological Studies,' by M. E. Wadsworth, Mem. Mus. Comp. Zool. Harvard, vol. xi.

[3] 'On the Banded Structure of some Tertiary Gabbros in the Isle of Skye,' Geikie & Teall, Quart. Journ. Geol. Soc. vol. l. (1894) p. 645.

[4] 'On the Existence of Nickel-iron . . . in the Basalt of North Greenland,' K. J. V. Steenstrup, Min. Mag. vol. vi. (1886) p. 1.

comparatively late period in the history of consolidation. Its distribution in the rock is in accordance with the view that progressive crystallization has tended to concentrate the iron-oxides in the mother-liquor. In some specimens there is no recognizable magnetite, the whole of the iron-oxide, except that which occurs in the augite, remaining undifferentiated in the brown glass. Microscopic sections of the amygdaloidal varieties show the connexion between the interstitial palagonite and that which partially or wholly fills the vesicular cavities. There is perfect continuity between the two kinds. In cases of partial infilling the central portion of the cavity is occupied by calcite (Pl. XXXVII, fig. 2).

Many specimens of more or less decomposed basalt from the talus at Cape Flora contain beautiful, radiating, fibrous aggregates of natrolite, and the same mineral occurs in a more compact form in concentric concretions filling large, irregular cavities. It is found also in joints in rotten basalt. Analcime occurs in detached crystals, sometimes measuring more than 1 cm. in diameter, and also as aggregates of smaller crystals. The analcime of these rocks appears to be wholly of secondary origin, and does not occur as in the monchiquites and analcime-basalts.[1]

Agates are also represented in the collection, and one large specimen of chalcedony and quartz which was evidently formed in a hollow cavity measures about 20 × 12 × 10 cms.

Calcite is abundant in the altered varieties, and frequently forms the infilling material of the amygdules, occurring either alone or in association with palagonite.

The specimens of basalt on which the above description is based were mainly collected near Cape Flora. The collection includes a few from Hooker Island which belong to the same type, but which are all massive.

Two or three points still remain uncertain with reference to the basaltic formations of Franz Josef Land. Judging from analogy with other districts of similar character, we should expect to find both lava-flows and intrusive sills. Tuffs and agglomerates are rare in regions of plateau-basalt, but they occasionally occur as necks and as beds interstratified between successive lava-flows. Then again old river-gravels and lake-deposits are sometimes found between the different outpourings of basalt.[2] Have we evidence of similar phenomena in Franz Josef Land? Unfortunately there is no petrographical character by which sills can be in all cases distinguished from lavas in the Brito-Arctic province. The sills are usually coarser in grain, columnar, holocrystalline, and ophitic in structure, but none of these characters can be relied upon as distinctive. Lavas are often amygdaloidal, but amygdaloids are not uncommon in sills and dykes.

[1] 'On the Monchiquites or Analcite Group of Igneous Rocks,' L. V. Pirsson, Journ. Geol. Chicago, vol. iv. (1896) p. 679.

[2] See Sir A. Geikie's paper on the 'Tertiary Basalt-plateaux of N.W. Europe,' Quart. Journ. Geol. Soc. vol. lii. (1896) p. 331. Future observers in Franz Josef Land would do well to study this paper.

We cannot, therefore, separate the specimens into two groups, lavas and intrusive sills. Nansen speaks of basalt interstratified with the underlying sediments, and the collection that we are describing contains specimens of amygdaloidal basalt 'from lowest rock (6 feet deep) having 3 feet layer of sandstone above it.' They were collected from the watercourse running down the talus. It is a well-known fact that the basalts of the West of Scotland are often intercalated between Jurassic strata,[1] and this fact led the early observers to conclude that they were of Jurassic age; but it is now universally admitted that this intercalation is the result of intrusion along planes of bedding, and that the basalts in question are post-Cretaceous.

The existence of tuffs cannot be positively asserted from the evidence before us, but there are one or two specimens of highly altered rocks which may be tuffs. The evidence that pauses occurred during the formation of the plateau-basalts is of a more satisfactory character. This is furnished by a specimen of a conglomeratic rock, mainly composed of basaltic débris and containing rounded pebbles, 'found in dolerite some 50 feet above lowest rock' near Cape Flora.

We are indebted to Mr. Fisher for the following table, giving the lowest level at which the main mass of basalt could be seen at several localities; the base, however, was often hidden by talus:—

	feet.
Cape Flora	600
Cape Gertrude	700
Cape Stephen	650
Tween Rocks	450 at one place, 200 at another.
Cape Grant	400 to 500
Cape Crowther	700 on one side, and sea-level on the other.
Cape Neale	500

IV. Distribution of Basalts of similar Type.

We will now conclude this account of the ordinary basalts with some remarks on the general distribution of rocks of the same type. Specimens brought home by Payer were described by Prof. Tschermak. He says, 'It [the dolerite] is a medium-grained, dark yellowish-green, crystalline, massive rock. Plagioclase forms the principal mass, although it only exceeds the augite by a small amount. The crystals of plagioclase are frequently 1 mm., sometimes 3 mm. long. They consist sometimes of thin and sometimes of thick lamellæ. The augite is greenish grey, shows no crystalline outlines, but forms grains which are often 1 mm. in diameter. Inclusions of the other minerals are frequent, and also gas-pores. Olivine forms grains which are smaller than the augite and only seldom show crystalline faces. These grains are frequently surrounded with a border of a yellowish-brown mineral (eisenchlorit). The titaniferous iron-ore occurs in long plates or fills the space

[1] Sir A. Geikie, *op. cit.* p. 375.

between the other minerals.' The resemblance of this rock to the dolerites of Spitsbergen is pointed out, and it is also stated that 'amygdaloidal varieties, so common in Greenland, were never found in Franz Josef Land; while the rocks in the south were aphanitic and thus like true basalts, those in the north were coarse-grained and nepheline-bearing.'[1] From this description we may conclude that the rocks brought home by Payer from the eastern portion of the archipelago resemble the massive olivine-bearing varieties of the Jackson-Harmsworth collection. Prof. Tschermak makes no mention of the occurrence of palagonitic material as interstitial matter, but he refers to an iron-chlorite which he regards as arising from the alteration of olivine. It is possible that this substance may in part represent the palagonite so common in the rocks from Cape Flora. He speaks of the 'titaniferous iron-ore' as 'sometimes filling the space between the other minerals.' The magnetite in the specimen that we examined contained only traces of titanic acid, and in none of our rocks does it actually occur as interstitial matter. It either crystallizes out during the later stages, or else remains undifferentiated in the residual glass. Specimens from the northern part of the archipelago have not as yet been examined in detail, but both Payer and Nansen agree that more coarsely crystalline varieties occur in this region. It would be interesting to know the exact nature of the evidence on which nepheline has been stated to occur.

The more or less allied rocks of Spitsbergen have been described by A. E. Nordenskiöld[2] as hyperite, and by Drasche[3] as diabase. They frequently occur as sills in rocks of very variable age. Both authors appear to regard them as contemporaneous with the strata in which they are found, and Drasche comments on the remarkable nature of the fact that rocks so uniform in character should be associated with strata of all ages from pre-Carboniferous to Tertiary. The remarkable nature of this fact disappears if we regard the rocks as intrusive sills.

A curious difference of opinion has arisen between Bäckström[4] and Nathorst[5] as to these Spitsbergen rocks. At the conclusion of his paper on the liparites of Iceland, Bäckström calls attention to the widespread distribution of basalts in the Arctic province which 'extends on the one side to Spitsbergen and Franz Josef Land, on the other to Greenland, and in the south to Scotland.' Nathorst, in commenting upon this statement, points out that basalt has not been found in Spitsbergen, but that post-Triassic diabases occur both as dykes and sheets (Decken). Whether the Spitsbergen rocks should be termed basalts or diabases is a matter of comparatively slight

[1] 'New Lands within the Arctic Circle,' German ed. p. 267.

[2] 'Sketch of the Geology of Spitsbergen,' Stockholm, 1867.

[3] 'Petrographisch-geologische Beobachtungen an der Westküste Spitzbergens,' Tscherm. Min. Mitth. 1874, p. 261.

[4] 'Beiträge sur Kenntniss der islandischen Liparite,' Geol. Fören. Stockholm Förhandl. vol. xiii. (1891) p. 671.

[5] 'Einiges über die Basalte des arktischen Gebietes,' *ibid.* vol. xiv. (1892) p. 69.

importance; it is certain, however, from Drasche's description that some of them are substantially identical with rocks described as basalt from other portions of the Brito-Arctic province. It is often not clearly recognized by Continental authors that the basalts and dolerites of this province are more closely allied in composition and structure to the pre-Tertiary diabases of the Continent than they are to the Tertiary basalts of the same region. We may safely conclude that the so-called 'diabases' of Spitsbergen described by Drasche are of the same general character, and approximately of the same age, as the basalts of Franz Josef Land.

The rocks of Jan Mayen have been described by Reusch [1] and Scharizer.[2] The descriptions of these authors show that rocks closely allied to those of Franz Josef Land occur on this island. Thus Reusch speaks of the occurrence in one of the specimens examined by him of hollow cavities 'encompassed by a zone of glass,' and Scharizer records the presence of a chrome-diopside. In the British Isles the rocks which most closely resemble the vesicular basalts of Cape Flora are those of Carnmoney Hill, near Belfast, and of Bunowen Tower, in County Galway.[3] Both these rocks are ophitic dolerites which contain brown glass or its hydrated alteration-product (hullite). The rocks of the Tynemouth and related dykes [2] also resemble the basalts of Franz Josef Land, but the interstitial matter which also occurs in some of the amygdules is always devitrified.

It is evident, therefore, that the basalts of Cape Flora and Hooker Island are similar to types widely distributed in the Brito-Arctic volcanic province. They differ from the more common holocrystalline ophitic dolerites in containing a small quantity of interstitial matter. The general result of this examination is to confirm the conclusions of Payer, Etheridge, and others that Franz Josef Land belongs geologically to an extensive region of plateau-basalts, including such widely separated localities as Jan Mayen, Iceland, Greenland, the Færöe Islands, the West of Scotland and the North of Ireland.

The second type of basalt is represented by some small angular fragments obtained from the underside of an iceberg in De Bruyne Sound. It differs from the common type above described, both in macroscopic and microscopic characters, and is, therefore, considered by itself. The rock is dark grey in colour, compact, and of so fine a grain that extremely thin sections and high powers are required to reveal its true character. The specific gravity is 2·977. The principal constituents are granules and microlites of augite (·008 mm. and ·008 × ·04 mm.), microlites of felspar (·004 × ·04), and crystals or grains of magnetite (·008 × ·02).[4] It is possible that a

[1] 'Det Norske Nordhavs-Expedition, 1876–1878,' Christiania, 1882, p. 27.

[2] 'Ueber Mineralien u. Gesteine von Jan Mayen,' Jahrb. d. k.-k. geol. Reichsanst. vol. xxxiv. (1884) p. 707.

[3] See papers, already quoted, by Profs. Cole and Sollas.

[4] The figures are merely intended to give an idea of the scale on which the different constituents are developed.

small quantity of colourless interstitial matter (? analcime) may be present. The rock contains a few scattered felspars, somewhat larger than the microlites, and also grains of quartz and patches of calcite. A special feature is the occurrence of aureoles of slender augite-microlites round some of the patches of quartz and calcite (Pl. XXXVII, fig. 5). These microlites are larger than those of the main mass of the rock, and show a rough tendency to a radial arrangement with reference to the nucleus.

The occurrence in basaltic rocks of quartz-grains surrounded by aureoles rich in augite-microlites has been frequently described,[1] and a discussion has arisen as to whether the quartz is indigenous or exotic. In this case the aureoles surrounding quartz are precisely similar to those surrounding calcite.

The microscopic section also shows many groupings of augite-microlites similar to those surrounding the grains of quartz and calcite, but without a central nucleus. This may be, and doubtless is in some cases, due to the fact that the section does not pass through the centre, but the occurrences appear to be too frequent to be entirely explained in this way. This type of basalt appears to be rare in the volcanic province to which Franz Josef Land belongs. We are unable to refer to any rocks from this province with which it can be said to be closely allied.

V. Fossils and Sedimentary Rocks of Franz Josef Land.

The greater number of the fossils have been collected in the immediate neighbourhood of Elmwood, the depôt of the Jackson-Harmsworth party, and around Cape Flora; but others have been obtained farther afield, during some of the longer expeditions. Each of the localities, with the fossils there found, will be first noticed, and their relations to each other afterwards considered.

The little settlement of Elmwood is on the south side of Cape Flora, on the island of Northbrook; it is placed on a raised beach at an elevation of about 40 to 50 feet above the sea. Behind the settlement are extensive talus-heaps, above which steep cliffs rise to a height of about 1100 feet above the sea, and this is capped by 100 feet of ice. The lower 500 or 600 feet appears to be chiefly clay, interstratified with shales and bands of ironstone, lignite, etc., and almost hidden by the talus, while the upper 500 is basalt.

1. North of Cape Flora.

The highest fossiliferous bed said to be *in situ*, of which the collection has representatives, is that discovered by Dr. Kœttlitz on the north side of Cape Flora, where a bed of shale, broken into innumerable fragments and containing impressions of plants, was found lying across a mass of dolerite, protruding through the west side of a glacier at a height of about 700 feet above the

[1] 'On a Group of Volcanic Rocks from the Tewan Mountains, New Mexico, and on the Occurrence of Primary Quartz in certain Basalts,' J. P. Iddings, Bull. U.S. Geol. Surv. no. 66, 1890.

sea. This plant-bed therefore would seem to be included in the thickness of the basalt. A number of specimens were collected at this point by Dr. Kœttlitz and subsequently by Dr. Nansen. The last-named gentleman submitted his collection to Dr. Nathorst, the well-known Scandinavian authority on fossil plants, and a very interesting account of them is given in Dr. Nansen's 'Farthest North,' [1] together with some woodcuts of certain of the specimens. According to Dr. Nathorst the most abundant remains were needles and seeds of coniferous plants, which he refers to *Pinus* and *Taxites*; but the most interesting among his specimens are leaves of the genus *Ginkgo*, only one species of which is now living, in Japan. This genus, however, is very characteristic of certain Oolitic deposits in Europe, and several species have been found in the Jurassic, Cretaceous, and Tertiary strata of Spitsbergen, Greenland, and Eastern Siberia. One of the forms from Franz Josef Land is believed by Dr. Nathorst to be a new species, for which he proposes the name of *Ginkgo polaris*. It is said to be a near ally of *G. flabellata* from the Jurassic of Siberia, and is not unlike the *G. digitata* from British Oolitic strata.

A few ferns were included in Dr. Nansen's collection, and these are said to represent four types, but to be too imperfect for specific determination. One of these is referred to the genus *Cladophlebis*; two others are said to suggest the genera *Thyrsopteris* and *Onychiopsis*, while the fourth seems closely allied to the *Asplenium petruschinense* described by Heer from Jurassic strata in Siberia.

PLANTS IDENTIFIED BY DR. NATHORST.

Pinus like *Nordenskioldi*, but probably another species.
,, species with narrow needles.
,, seeds, resembling those of *Maakiana*.
Taxites nearest to *T. gramineus*, Heer.
Fieldenia (= *Torellia*) sp.
Ginkgo polaris, Nath.
,, sp.
Czekanowskia.
Cladophlebis.
Thyrsopteris ?
Onychiopsis ?
Asplenium, near to *A. petruschinense*.

A goodly number of examples of these plant-impressions collected by Dr. Kœttlitz have been sent home, and although small and fragmentary, as indeed were all the specimens found at this locality, they represent most of the forms mentioned by Dr. Nathorst. There are many of the winged seeds of *Pinus*, varying in form, and possibly representing more than one of the species alluded to in the above list (Pl. XXXVIII, figs. 6–8). With these are numerous pine-needles, both broad and narrow, as well as a portion of a branch and a small cone. A few fragments may belong to the genus *Fieldenia* [*Torellia*] (Pl. XXXVIII, fig. 11). The peculiar form *Ginkgo* is represented by many specimens, some of which are

[1] Vol. ii. p. 484.

referred to Dr. Nathorst's new species, *G. polaris* (Pl. XXXVIII, figs. 1–3); but there are others rather larger, with more slender divisions to the leaves, and with seven or eight ribs on each blade, which are very like *G. siberica*, Heer (figs. 4 & 5), if they are not identical with that species.

Ferns are represented by several specimens which, although small, are well preserved, and in some the venation of the pinnules is particularly well shown. There is some variation in the form of the pinnules of these specimens, but this is not greater than might be expected in different individual plants, or perhaps even in parts of the same frond. The only genus mentioned by Dr. Nathorst to which these could belong is *Thyrsopteris*, and there is much resemblance between the present specimens and *Th. Murrayana* and *Th. Maakiana*[1] (Pl. XXXVIII, figs. 13 & 14), which occur in the Jurassic rocks of Eastern Siberia and of England.

The pinnules of these ferns also bear much resemblance to the figures of *Adiantites amurensis* as given by Heer,[2] but it seems to me best, for the present, to leave them in the genus *Thyrsopteris*. In none of these forms, however, is the venation so clearly shown as it is in some of these Franz Josef Land specimens, and in the latter also the bifurcation of the veins in the pinnules seems to be more regular and definite.

Dr. Nathorst found no cycads among his specimens; there are, however, in our series one or two long lanceolate leaves, not quite perfect, which so closely resemble some of those that have been called *Podozamites lanceolatus* that they are provisionally referred to that species (Pl. XXXVIII, fig. 12).

We have a few examples of long, slender, regularly-tapering leaves (?), with few strongly-marked longitudinal ridges; these are broken across in such a way as to resemble a jointed stem, and remind one of a slender *Equisetum* (Pl. XXXVIII, fig. 10). The true affinities of these specimens are not clear, but they bear some resemblance to *Baiera* and *Czekanowskia*.

With regard to the probable geological age of these plants, we could not do better than quote the opinion of Dr. Nathorst; but, as we are not permitted to do so, we can only refer our readers to 'Farthest North' (p. 487), and say that on the whole this flora resembles that of the Upper Jurassic beds of Spitsbergen, and indicates a cool climate, but one much more genial than that which obtains in Franz Josef Land at the present day.

2. East of Elmwood.

The second set of specimens to be noticed are labelled 'East of Elmwood and above Sharp's Rock.' These are specimens of some thin beds of shale which were found exposed *in situ* just below the basalt, but in which no fossils were found. Taken in descending order, these are:—

[1] Heer, 'Flora Fossilis Arctica,' vol. iv. Beiträge zur Juraflora Ost-Sibiriens, etc. pl. i.

[2] *Ibid.* pl. xxi. fig. 6.

(i) Black shale 4 inches thick, from just below the basalt. There is no appearance of this shale having been heated to any extent by contact with the basalt.

(ii) Black material like the preceding, but broken into fine particles and powder, $1\frac{1}{2}$ inch thick.

(iii) Greenish-grey shale, 3 inches thick.

(iv) A lighter-coloured brownish clay-shale, the thickness of which is not recorded.

3. Elmwood.

In a watercourse at the back of Elmwood the rock is uncovered at a point about 50 feet below the basalt, and from this exposure of 'clay sandstone' a small, well-preserved ammonite was obtained (Pl. XXXIX, fig. 5).

Unfortunately this ammonite is the only specimen which was found in place at this spot, but in the same watercourse below the exposure of rock, and apparently fallen from the rocks above, a number of other specimens were collected, chiefly in blocks of clay-ironstone. Among these are ammonites identical with that found in place, as well as others which are referable to *A. macrocephalus* and *A. modiolaris*.

The number of species found at this locality is not great, and they will now be considered in detail.

AMMONITES (CADOCERAS) TCHEFKINI ?, d'Orb. (Pl. XXXIX, figs. 4–6.)

To this species is referred provisionally the one ammonite (fig. 5) found *in situ* 50 feet below the basalt at Elmwood, as well as several other specimens found in the watercourse below this exposure and two others from the side of the glacier at the western end of Cape Flora.

The ammonite found *in situ* is about 22 mm. in diameter, and 7 mm. thick; the umbilicus is 6 mm. in diameter. The ribs are sharply defined and regular in thickness, having no enlargements or tubercles; they pass outwards from the umbilicus, and in most cases bifurcate about the middle of the side, then with a definite flexure forwards pass over the back, which is narrow but not sharp. Most of the other specimens above noted agree so closely with the one just described as to need no further mention, but one of them (fig. 4) is nearly twice the size (35 mm.) and shows that the forward flexure of the ribs becomes less marked as the shell grows larger. The outer part of this specimen is crushed, so that its form is uncertain.

On comparing these ammonites with young examples of *A. Tchefkini* from Russia their agreement is found to be so close that, for the present, they are referred to that species: but at the same time there are small points of difference which leave some doubt. None of the Franz Josef Land specimens are large enough to show signs of the lateral expansion which characterizes the adult *A. Tchefkini*, but the largest of them retains the same character of the ribs on the outer whorls that it has on the inner whorls—that is to say, the ribs merely bifurcate, and consequently those around the umbilicus are of the same size as those near the back. Now, in all the larger specimens of *A. Tchefkini* available for comparison, the ribs around the umbilicus are distinctly larger than those on the back, and only one third or perhaps one fourth as numerous. The figures of *A. Tchefkini* given by De Verneuil[1] and Nikitin[2] show this same character.

In the Museum of Practical Geology there are several specimens from the Kellaways Rock of Chippenham which come very near to the Arctic ammonites, and these have been regarded as a variety of *A. Mariæ.*

Ammonites (Cadoceras) modiolaris, Luid. (Pl. XXXIX, figs. 7–10.)

The specimens from this locality referred to the above species are two fragments of whorls, which show the lobes and saddles very clearly, and in form and markings agree closely with examples of *A. modiolaris* from the Kellaways Rock (figs. 7 & 8). A cast from the umbilicus of one of these fossils also agrees with this species, and there is a similar cast from the talus of the western end of Cape Flora which just fits the umbilicus of one of the Kellaways Rock specimens in the Museum of Practical Geology.

One specimen from the talus near Elmwood (Pl. XXXIX, fig. 9), embedded in ironstone and partly crushed, so as to give the appearance of a sharp back, has a much wider umbilicus than is usual in *A. modiolaris*; but as this agrees with the figures given by Prof. S. Nikitin of a specimen from Elatma,[3] which is regarded as *A. modiolaris*, the Cape Flora specimen is likewise referred to this species.

Another specimen, from below where the rock was found *in situ*, is more compressed, and in this respect somewhat resembles *A. Elatmæ*[4]; but, while the ribs are quite as strong as in the latter species, there is no evidence of the large tubercles around the umbilicus.

A better-preserved example of this variety was obtained from the side of the glacier at the west point of Cape Flora (Pl. XXXIX, fig. 10).

Ammonites (Macrocephalites) macrocephalus, Schloth. (Pl. XXXIX, figs. 1–3.)

The specimens from the present locality referred to this species are not good, but a much better example is that received in the earlier consignment and noted by Mr. G. Sharman in the Geographical Journal,[5] a further examination of which has convinced us that it is the true *A. macrocephalus* (fig. 1). In these specimens the ribs pass directly outward from the small umbilicus, and, after

[1] 'Géologie de la Russie d'Europe,' vol. ii. (1845) pl. xxxv.
[2] Mém. Acad. Imp. Sci. St. Pétersb. ser. 7, vol. xxviii. (1881) no. 5, pl. iii.
[3] Nouv. Mém. Soc. Imp. Nat. Moscou, vol. xv. (1885) pl. xi. fig. 48.
[4] Nikitin, *op. cit.* vol. xiv. (1881) pl. xi. fig. 21.
[5] Vol. vi. (1895) p. 518.

bifurcating, run over the back without any forward flexure; they agree with British and Continental examples of this species, and attention may be especially directed to Prof. Nikitin's[1] figures of specimens from Kellaways beds near Elatma, in Central Russia.

Another specimen found upon the talus-heap, which includes about half the shell, has rather more rounded whorls; but, as it resembles some of the inflated forms which have been referred to *A. macrocephalus*, it is provisionally allowed to remain here (Pl. XXXIX, fig. 3).

BELEMNITES PANDERI, d'Orb. (Pl. XXXIX, figs. 11–14.)

Fragments of several belemnites have been collected at No. 3 locality, but only a few of them can be determined with any certainty; on comparing them, however, with better fragments from the talus, there is no doubt as to their being the same species. These belemnites belong to the group in which the radiation, seen on the cross-section of the guard, is excentric, as in the well-known *B. lateralis*. In the specimen now under consideration the guard is not flattened dorso-ventrally, as in the last-named species, but to a slight extent laterally, and there is a distinct though not very deep ventral groove near the apex, and extending a short distance along the guard. The most perfect specimen (Pl. XXXIX, fig. 11) was found on the talus at the western end of Cape Flora: it is only about 2 inches long, and shows nothing of the alveolar cavity. Other examples retaining this cavity show that it is excentric (fig. 12).

A comparison of these belemnites with a series from Russia, in the possession of Mr. Lamplugh and named by Prof. Alexis Pavlow, left no doubt as to their agreement with examples of *B. Panderi*, a species which has been recorded from the Middle Kellaways and passes upward to the Kimeridge Clay.[2]

PECTEN *cf.* DEMISSUS.

The mould of a small *Pecten* evidently indicates a shell closely allied to, if not identical with, the common Oolitic *Pecten demissus*, which is one of the species recognized in the Upper Jurassic rocks of Spitsbergen.

GORGONIA (?). (Pl. XXXIX, fig. 15.)

On one of the ironstone-blocks is to be seen a long cylindrical body, about 1 mm. in diameter and 70 mm. long, the nature of which is by no means clear. Only part of this now remains, and it seems to be entirely replaced by iron pyrites. Externally it is almost smooth, with a few transverse, very fine lines. This fossil calls to mind the rod of the living *Pennatula* and that of the *Graphularia* from the London Clay; but it is not now a continuous rod: there are regular intervals here and there, reminding one of the interrupted condition of the stem in the genus *Isis* and its

[1] Nouv. Mém. Soc. Imp. Nat. Moscou, vol. xv. (1885) pl. viii. fig. 44.

[2] S. Nikitin, 'Ueber die Beziehungen zwischen der russischen u. der westeuropäischen Juraformation,' Neues Jahrb. vol. ii. (1886) p. 205.

allies. These intervals may, however, be due to breakage before being embedded in the rock.

PHOSPHATIC NODULES. (Pl. XXXVII, fig. 6.)

Rounded and ovoid nodules of a pale brown colour externally, but black or dark brown internally, occur with these fossils, and apparently at almost all the horizons from which fossils have been collected; mostly they seem to have been free in the clay, but sometimes they are included in the clay-ironstone. These nodules vary much in size, some being less than an inch in diameter, others 3 or 4 inches in length and perhaps 2 inches in diameter. Thin sections under the microscope show for the most part a mass of fine débris with nothing definable; but some specimens show in parts small masses of minute oval bodies, with a long diameter of 1 mm., which agree in form and size with the small coprolites described by Mr. A. Strahan[1] from the Phosphatic Chalk of Taplow, and indeed there can be little doubt that they are the droppings of some small animal. And further, upon closer examination with the microscope, these minute ovoid bodies may be seen pressed closer and closer together, until at last they form one mass; but in most cases the separate pellets may be still distinguished. A number of these nodules have been tested, and in all cases they proved to be rich in tricalcic phosphate.

The following forms have been identified from this horizon at locality No. 3:—

Ammonites (*Macrocephalites*) *macrocephalus*.
 „ (*Cadoceras*) *Tchefkini*?
 „ „ *modiolaris*.
 „ „ „ var.
Belemnites Panderi.
Pecten cf. *demissus*.
Gorgonia?
Phosphatic nodules.

Precisely similar forms have been found in the talus at other points near Elmwood, and on the side of a glacier-slope at the western point of Cape Flora.

This series of fossils, although small, is of the greatest interest, inasmuch as it contains ammonites which give no uncertain indication of the horizon to which they must be referred. *Ammonites modiolaris* is distinctly a Kellaways Rock form, although extending into the true Oxford Clay. The occurrence with this of *A. macrocephalus*, which not only occurs in the lowest Oxford Clay and Kellaways Rock, but is perhaps the most characteristic ammonite of the Cornbrash, shows very clearly that beds of lowest Oxfordian age occur at Cape Flora at a height of about 400 or 500 feet above the sea, and doubtless correspond to some extent with the '*macrocephalus*-beds' which are now known to have so vast an extent throughout the northern hemisphere, if, indeed, they do not also occur in Australia (see references on p. 515).

[1] Quart. Journ. Geol. Soc. vol. xlvii. (1891) p. 356.

4. Windy Gully.

The next exposure of rock to be noticed is that which was found at the southern end of Windy Gully, a valley north-east of Elmwood, running nearly north and south. Near the southern end of this valley there is a projecting shoulder of rock, and on this, at a height above the sea of about 300 feet,[1] a number of fossils were obtained, nearly all of them being in hard concretions or in phosphatic nodules. Dr. Kœttlitz is satisfied that they were *in situ*; but even if not actually in place, they could only have been weathered out of the rock on which they rested.

These beds seem to be lower in the series than those of No. 3, unless the strata are less horizontal than we understand them to be, and they have yielded a different set of fossils; the most striking of these are some ammonites which are believed to be varieties of *A. Ishmæ*, a species described by Keyserling from Ishma in Petchora Land.

AMMONITES (MACROCEPHALITES) ISHMÆ, Keys., var. ARCTICUS. (Pl. XL.)

Several examples of this ammonite were found, but they vary somewhat in form. The most typical specimen is also the most perfect (Pl. XL, fig. 1); it is about $2\frac{3}{4}$ inches in diameter, and its greatest thickness measures $1\frac{1}{2}$ inch. The ribs, which are sharply defined, pass outwards, with a distinct inclination forwards. At a distance from the umbilicus of about one-third the height of the whorl, the ribs bifurcate, and then pass over the back. Occasionally there is a single rib interposed. The umbilicus is very small, less indeed than is usually the case in *A. macrocephalus*, although it is equally small in some specimens that have been referred to the latter species. In nearly all the above points our specimen resembles *A. macrocephalus*, but on closer examination it is found that the whorls do not increase so rapidly, and as at the same time they are more involute, the outer whorls are much more encroached upon by the whorl which precedes it; so that while in *A. macrocephalus* the last whorl is encroached upon for less than half its height, in the present form the encroachment is always more than half the height, thus indicating a different mode of growth. And further, the sides of this species are less inflated around the umbilicus, and more so towards the back, so that the entire shell has a different aspect.

If this specimen be compared with Keyserling's figure of *A. Ishmæ* from Petchora Land,[2] it will be seen that in most of those points in which our specimen differs from *A. macrocephalus* it approaches *A. Ishmæ*; but at the same time the inner whorl of *Ishmæ* does not encroach so much upon the outer one as is the case in the Arctic specimen. This encroachment of the whorls, involving, as it does, a different growth of the shell, may perhaps be thought sufficient for the establishment of a new species, and if so

[1] [Dr. Kœttlitz says 'over 400 feet.']

[2] 'Reise in das Petschora-Land,' 1846, p. 331, pl. xx. figs. 8 & 9.

the name of *A. arcticus* may be used; but it has seemed better for the present to include this form in the species *A. Ishmæ*, and call it a variety—*arcticus*.

Among the ammonites collected from this locality there are two others which agree with the one described, but are less perfect; besides these are two which, agreeing with the type in all main particulars, differ in being more inflated, and one of them has coarser ribs (Pl. XL, fig. 2). Still another specimen, showing all the characters of the type, has the outer whorl nearly smooth, although it is a rather smaller shell (Pl. XL, fig. 3). The specimen above described (fig. 1), however, shows the beginning of this smooth outer whorl, but it must have been a considerably larger individual.

Belemnites sp.

A number of portions of belemnites were found at this locality, but none of them are perfect enough for specific determination. Two of these are phragmocones of some large species, contained in nodules. Another specimen gives evidence of a long slender form, apparently circular in section and concentrically radiated. This belemnite is preserved in a block of ironstone, and possibly belongs to another bed.

The remainder of the specimens are much decomposed: some of them seem to have been compressed laterally and to show a deep ventral groove. One specimen is a short form, with the alveolar cavity seemingly reaching to near the apex.

Although it is tolerably clear that these *Belemnites* represent at least three species, yet there is no evidence of an excentric form which could be referred to *B. Panderi*.

Phosphatic nodules occur. (See remarks on p. 499.)

List of Fossils from Windy Gully.

Ammonites (*Macrocephalites*) *Ishmæ*, var. *arcticus*.
" " " inflated variety.
" " " smooth variety.
Belemnites. 3 species.
Phosphatic nodules.

Although it is clear, from their relative height above the sea, that these fossils occupy a lower horizon than the bed with *A. macrocephalus* and *A. modiolaris*, yet the fossils themselves give no evidence that such is the case, and it is quite possible that they may belong to the Lower Oxfordian. It seems likely, however, that being 150, or perhaps 250 feet, lower in the series of beds, and the fossils of a different type, they represent a somewhat lower horizon and may perhaps be more nearly of the age of the Cornbrash.

5. West of Elmwood.

At a spot about 500 yards west of Elmwood, and some 30 or 40 feet above the sea, 'sandy shale' was found *in situ*, and from this were collected a number of fragmentary fossils which had been washed out from the rock. These fossils are mostly either pieces of belemnites or parts of a large species of *Avicula*, but there is one fragment of an ammonite allied to *A. Gowerianus*, which is as yet undetermined.

BELEMNITES sp.

Most of the fragments of belemnites from this locality are so much broken and decomposed that it is hopeless to think of specific determination, nevertheless there are a few points which may be noticed. There are evidently two if not three forms, but none of them can be referred to *B. Panderi*, as they do not show the marked excentric radiation of the transverse section characteristic of that species. One form is compressed, with a well-marked groove near the apex and a slightly excentric radiation.

A second form is similar, but much more compressed, and there seems to have been a deep groove extending from the apex some distance up the guard.

The third form is cylindrical, concentrically radiated, and with a comparatively acute apex.

Some of these belemnites may be the same as those from locality 4.

AVICULA sp. cf. INÆQUIVALVIS. (Pl. XL, fig. 4.)

There are several of these large aviculas, but all are more or less crushed and broken; some of them, probably on account of breakage, look more equilateral than others, and at first sight remind one of *Pecten*; but the large wing on one side shows that they do not belong to that genus.

The best-preserved specimen (fig. 4) in its present condition is 1¾ inch in length; but, with the exception of the umbo and a piece of the hinge, all the margins are broken away, and, judging from other fragments, the species must have reached 3 or 4 inches in diameter. One valve is moderately convex, while the opposite valve is concave. Strong ribs radiate from the umbo to the margin; between these are finer ribs, and a third still smaller series are to be seen between each of these, giving the shell much the appearance of a well-marked *A. inæquivalvis*, but in that species the ribs are not nearly so strong. The concave valve is less distinctly marked than the other. The hinge is long, and the posterior wing is much larger than the anterior. Some of the specimens appear to be more equilateral than others, but this is believed to be due to crushing, and as all have similar markings they are regarded as one species.

The small height above the sea at which this exposure of rock is situated, to the west of Elmwood, shows that it occupies a position at about 250 feet below the bed with *Ammonites Ishmæ* var. *arcticus* at Windy Gully, but the specimens give no idea of their age.

6. Cape Gertrude.

Cape Gertrude, which is some 2 or 3 miles east of Cape Flora, rises to a height of about 1100 feet above the sea. Mr. Fisher, who has carefully examined this locality, says that the uppermost 100 feet is basalt, columnar above, but more irregular underneath. From the base of this basalt to the sea-level the face of the cliff is almost wholly hidden by talus; but at one place the débris has been cleared away, apparently by ice or rock falling from above, exposing a series of sedimentary beds more than 200 feet high by about 100 feet wide, the highest part being between 300 and 400 feet above the sea. Dr. Kœttlitz, with Mr. Fisher, measured the section thus exposed, and they found as many as seventy beds of sand, flaggy sandstone, pebbly sand, shales, lignite, etc., varying in thickness from 3 inches to 25 feet. The extraordinary number of thin beds of diverse character shown in this section points to rapidly-varying conditions of deposition, and possibly to oscillations of level; while the beds of lignite indicate, to some extent at least, a freshwater origin.

With the exception of this lignite, and some wood found embedded in the lower part of the basalt, no fossils have been obtained from this section, and consequently the beds cannot be correlated with those at Cape Flora. The lignite-seams at the latter locality, and the few indications there seen of the nature of the beds, appear to indicate many rapid alternations of thin beds, similar to these at Cape Gertrude; and, judging from this and the height of the beds above the sea, it is likely that the Cape Gertrude section corresponds to part of the Jurassic series present at Cape Flora.

Much interest attaches to the discovery above mentioned of the masses of wood in the lower part of the basalt; for Mr. Fisher says that it is of precisely the same character as the silicified wood which has been found so abundantly on the talus at Cape Flora and also at Cape Gertrude; but this is the one place where it has been found *in situ*, and is the only clue that we at present possess as to its place of origin.

7. Cape Stephen.

We have now to travel some 20 miles west of Cape Flora to Cape Stephen. At this point, and also between here and Cape Grant, a hard calcareous sandstone was met with, near the sea-level and under the raised beach. This bed, which is *in situ*, contains an abundance of carbonized plant-remains, but they are not well preserved, and in none of them can the details of structure be seen. Consequently their determination cannot be settled with that degree of certainty which could be wished. Although the stems of Equisetaceæ and some other forms are not unlike species with which we are familiar in the Yorkshire Lower Oolites, yet these Arctic specimens seem to agree best with the flora described by Prof. Schmalhausen from Petchora and Tunguska.[1]

[1] Mém. Acad. Imp. St. Pétersb. ser. 7, vol. xxvii. (1880) No. 4.

PHYLLOTHECA (EQUISETITES) *cf.* COLUMNARIS, Phil. (Pl. XLI, figs. 1–3.)

Several striated and jointed stems, such as we have long known under the name of *Equisetum columnare* in the Yorkshire beds, occur in these sandy deposits at Cape Stephen. These stems vary from $\frac{1}{4}$ to perhaps $1\frac{1}{2}$ inch in diameter. In two instances, what looks like an outer sheath of a joint is preserved, showing at one end the oval spaces to which the whorl of spikelets or perhaps branches was attached. There is also one portion of a 'disc' with the spikelets still attached.

RHIPTOZAMITES ? *cf.* GŒPPERTI, Schmalh. (Pl. XLI, figs. 6 & 7.)

The cycadaceous leaves of various shapes and sizes from Northern Siberia which are referred by Prof. Schmalhausen to the above genus and species seem to find their counterparts among the plant-remains on these slabs from Cape Stephen. Some of these leaves are slender and lanceolate, others broader and more oval, but each leaf, as far as can be seen, has fine ribs running nearly parallel from end to end. A portion of what may be a large oval woody leaf of this form, in its present broken condition, measures nearly 2 inches in width.

ANOMOZAMITES ? (Pl. XLI, fig. 8.)

A fragment of what appears to have been a large leaf of a Cycad allied to *Anomozamites* shows what seems to be a broad midrib and on one side three unequally divided portions of the leaf, thus resembling the genus *Anomozamites*; it is introduced here for the sake of calling attention to the possible presence of this genus, but the specimen is not sufficient for certain identification.

ZAMIOPTERIS ? *cf.* GLOSSOPTEROIDES, Schmalh. (Pl. XLI, figs. 4 & 5.)

There are a number of more or less fragmentary leaves to be seen on these slabs, which, while varying in size, agree in being broadly lanceolate and in having a venation which passes obliquely outwards from the middle line forward to the periphery, but without a definite midrib. The venation of these leaves certainly appears coarser than those shown in the figures given by Schmalhausen, but as it is possible that this may be due to their bad state of preservation, I have provisionally referred them to *Zamiopteris*.[1]

ASPLENIUM *cf.* WHITBIENSE, Brongn. (Pl. XLI, fig. 9.)

A portion of the frond of a fern with pinnulæ short and pointed, with entire margins and with a base attached by its whole width, is believed to represent this species, which, besides its original home, the Yorkshire Oolites, is said to occur in the north of Siberia. The venation of the Franz Josef Land specimen is entirely obliterated, and consequently the determination can be regarded as only doubtfully correct.

[1] [Compare also with *Gangamopteris*. See Seward, Quart. Journ. Geol. Soc. vol. liii. (1897) p. 324.]

List of Fossils from Cape Stephen.

Phyllotheca cf. *columnaris*, Phil.
Rhiptozamites? cf. *Gœpperti.*
Anomozamites?
Zamiopteris cf. *glossopteroides.*
Asplenium cf. *whitbiense.*
Bituminous shale.

The striking resemblance between this series of plant-remains from near Cape Stephen, and those described and figured by Prof. Schmalhausen from Lower Tunguska, can only lead to the inference that they are approximately of the same age. This Tunguska flora was at one time supposed to be Palæozoic, but Prof. Schmalhausen afterwards regarded it as of Oolitic age, and even referred it to the Great Oolite.[1]

There is no stratigraphical evidence available which might indicate the position of these plant-beds at Cape Stephen, and the distance between them and Cape Flora prevents any correlation with the strata there exposed, as we know nothing of the possibilities of change of dip or faulting which may occur in the 20 miles which intervene. At the same time it may be remembered that the probable north-easterly dip of the beds in Franz Josef Land would, if correct, bring these beds some little distance below horizon No. 5 at Cape Flora, where indeed beds of Lower Oolite age might be expected to occur.

Bituminous paper-shales occur in close relation with these sandstone plant-beds, at the locality between Cape Stephen and Cape Grant sometimes called 'Tween Rocks,' but it is not known whether they are merely in restricted patches or occur as regular beds. This shale contains a large amount of combustible matter, and burns with a good flame.

Near the spot at Tween Rocks where the plant-bed was found, a bed of coaly lignite was discovered at a height of about 100 feet[2] above the sea; this, Mr. Fisher tells us, was undoubtedly *in situ.* A stream of water had cut a channel for itself in the almost perpendicular cliff and had exposed this stratum, a good-sized block of which has been sent home, but is now split into many pieces, a consequence, probably, of its having been frozen. This coal burns with a good flame, and was recognized by the discoverers as a possible supply of fuel; it is not merely a lignitized tree-stem, but is composed of crushed and compacted vegetable matter. One point of interest about this coal is that in parts macrospores can be seen with a lens, reminding

[1] [Mr. Seward, in the August number of this Journal (vol. liii. 1897, p. 325), says that the rocks described by Schmalhausen are probably of Permian age (see Zeiller, Bull. Soc. géol. France, ser. 3, vol. xxiv. 1896, p. 466). If this be so, then the series of plant-remains from Cape Stephen, which are so similar to those from the Tunguska deposits, may prove to be of the same age. But an Oolitic facies in the case of Permo-Carboniferous plants is so remarkable that, in the absence of some characteristic form, such as the *Sigillaria* described by Mr. Seward from the South African beds, it would hardly be safe to regard these Cape Stephen plant-beds as of Permian age.]

[2] Dr. Kœttlitz says that this bed is 300 feet above the sea.

one of the 'spore coal' so commonly met with in 'Coal Measure' coal; and on examination with the microscope this portion of the lignite was found to be largely made up of micro- and macrospores.

This coal-seam, so far as we can judge, occurs about 100 feet above the sandstone which has yielded the plant-remains, and it may be that it belongs to beds of about the same period. A similar lignite or coal was found on the moraine at Cape Richthofen, but it is not certain that it contains macrospores.

There is still a specimen from Cape Stephen which has to be noticed; but, as it was obtained from the talus at 300 feet above the sea, it is evident that it must have been derived from a bed situated at that or some greater elevation. The specimen is a slab about 10 inches square and $1\frac{1}{2}$ inch thick, wholly composed of layers of plant-remains completely silicified; it is black throughout, but one surface is weathered white. The greater part of the plants are strap-like leaves from 4 to 9 mm. wide, and the longest piece measures about 110 mm., but none are perfect at the ends; the broadest leaf has 11 longitudinal ridges. They remind one of *Baiera* and *Podozamites*, but there is no evidence of their mode of attachment, and their true affinities are uncertain.

On this slab there is a fan-like leaf which is believed to be an undivided *Ginkgo*-leaf, like that of *G. integriuscula* from Jurassic beds in Spitsbergen,[1] but it has a still closer resemblance to *G. reniformis*, Heer, from Tertiary beds on the Lena.[2] As the identity of this *Ginkgo* is not established, it can only be taken as an indication of the possibility of the specimen being of Tertiary age, and the other plants on the slab do not seem to militate against this; the piece of a conifer-branch close to the *Ginkgo* might be of almost any age. It is quite possible, on the other hand, that this slab has been derived from a bed representing at Cape Stephen the Upper Jurassic plant-bed of Cape Flora. Finally, it may be that this silicified slab is of the same age as the silicified wood which is so abundant in Franz Josef Land; but the age of the wood has yet to be settled.

8. Cape Crowther.

Cape Crowther, which is some 12 miles north-west of Cape Grant, has been visited, but the only specimens that we have received from that locality are a piece of the ubiquitous silicified wood, a mass of silicified plant-remains, and some black-banded chert containing vegetable tissue. These fossils were not found in place, but were picked up from the highest raised beach.

9. Cape Neale.

About 6 miles still farther north-west is Cape Neale, the most westerly point from which we have received specimens. On the

[1] Heer, 'Flora Fossilis Arctica,' vol. iv. (1877) pt. i. p. 44 & pl. x. figs. 7–9.
[2] *Ibid.* vol. v. (1878) pt. ii. p. 32 & pl. viii. figs. 24–25.

summit of this headland, which reaches a height of 700 feet, there is a level plateau free from snow, and from here we have received some silicified wood which is stated to be part of a large block found protruding from the soil. With this wood were some black flinty specimens containing plant-remains, and likewise fragments of what looks like siliceous sinter. The upper 250 feet of Cape Neale is formed by basalt, and it was on this that the fossil wood was found.

10. Hooker Island.

Hooker Island, which lies about 20 miles north-east of Northbrook, has been visited by Mr. Jackson with some of his party, and on the higher raised beach, as Mr. Fisher tells us, several small flints and cherty specimens were obtained from the 'soil,' which soil is formed of disintegrated basalt. The flints and cherty specimens all seem to contain traces of vegetable tissue, but this is very indistinct.

11. Cape Richthofen.

During Mr. Jackson's journey to the north a number of specimens were collected and labelled 80° 51′ N. and 53° 40′ E., which, according to the map, seems to be at or near Cape Richthofen The specimens were found on the top of a lateral moraine which is said to be 300 feet high and 500 yards wide, but the height above the sea is not stated. The specimens are fragments of basalt, rotten vesicular basalt, brown sandstone, cherty nodules, lignite, friable sandy shale with plant-remains, and a small mass of compressed vegetable remains. About some of these a few words may be said, but it is unfortunate that they were not *in situ*.

One of the nodules (No. 345) is a grey-and-white cherty flint, which under the microscope is seen to be chalcedonic and contains some indistinct foraminifera which remind one of *Rotalia*, but they are not sufficient for determination and give no clue as to age. The latter remark may be also applied to the large sponge-spicules seen in a second cherty nodule, which look like one of the 'glass-rope' sponges.

Two of the pieces of lignite are really pieces of tree-stems or branches retaining the outward form, but they are so much altered and in so friable a condition that their microscopic structure has largely been obliterated. It is not quite certain what the wood is, but an appearance which may represent spiral fibres and single rows of discs points to the possibility of its being allied to the yew-tree.

Some of the lignite seems to be composed of fragmentary vegetable matter, and is not unlike that from near Cape Stephen, which contains the macro- and microspores.

There are several pieces of a sandy shale which is exceedingly friable and almost black with carbonized vegetable remains; but these are so altered that at present nothing distinct has been made out, and the nature of the plants is uncertain.

The compressed mass of plant-remains is very recent-looking;

it is mixed with a little muddy matrix, and readily breaks up on soaking in water; when this is done the mass separates into small pieces, perhaps $\frac{1}{8}$ inch wide and, say, 1 inch or less in length, flat, and as thin as paper. With these are other fragments, broader, but, like the first, so much altered that nothing can be made out of them. Mr. Clement Reid, who is so familiar with Pleistocene plants, has seen these, and feels sure that they are not so recent as Pleistocene, but thinks that they are probably of Tertiary age.

Raised Beaches.

The occurrence of raised beaches in many places in Franz Josef Land is well established. One was noticed by Mr. Leigh Smith at Gray Bay, west of Cape Grant, 90 feet above sea-level. Mr. Jackson's hut at Elmwood is on an old sea-beach 40 to 50 feet above the sea, while there are others at higher and lower levels. The bones of a whale (probably *Balæna mysticetus*) are mentioned as being found near Mr. Jackson's hut. Similar raised beaches occur on Frederick Jackson Island, showing that the movement of upheaval is not confined to the southern parts of Franz Josef Land, where most observations have been made. At the northern end of Günther's Bay raised beaches were observed by Dr. Kœttlitz, and from the lower one pebbles of basalt and specimens of *Saxicava arctica* were collected; similar beaches were also seen by the Jackson-Harmsworth party at Cape Crowther, at Cape Stephen, at Hooker Island, and at Windy Gully; from the latter, *Trophon antiquus, Tr. gracilis, Mya arenaria*, and *Balanus concavus* were obtained.

Silicified Wood.

The common occurrence of silicified wood has been noticed by all who have visited Franz Josef Land. Lieut. Payer alludes to it; Mr. Leigh Smith and Mr. Grant collected specimens; the first consignment of fossils from the Jackson-Harmsworth expedition contained some fine specimens; Dr. Nansen also notices it; and the present series of specimens from the Jackson-Harmsworth party includes many examples, some of which are large and formed part of a tree-stem.

This silicified wood is widely distributed in the Franz Josef archipelago, for Lieut. Payer's specimens must have been from the eastern islands, while we have evidence of it from Capes Flora, Crowther, Neale, and Gertrude. Mr. Leigh Smith's specimens seem to have been found on Mabel Island. In nearly every case this wood has been found on the talus-heaps, and the only place where it has been found *in situ* is at Cape Gertrude, where Dr. Kœttlitz and Mr. Child discovered a mass of it embedded in the lower part of the basalt at a height of more than 700 feet above the sea. On the plateau at the summit of Cape Neale, which is 700 feet above the sea, a large silicified tree-trunk was found projecting from the soil, and therefore above the 250 feet of basalt which there caps the Cape.

It is difficult to assign any age to this wood. It is possible that a Tertiary basalt overwhelmed forests of pines growing at that time, and that the same kind of trees subsequently grew on the surface of the sheets of basalt. Or it may be that some already existing plant-beds were invaded by the intruding basalt, in which case the moving mass might in some instances have passed over, and in others passed under, the plant-bed; or there may have been more than one such bed.

It is well-nigh certain that this silicified wood is not earlier than Upper Jurassic, for it almost certainly occupies a position above the Oxfordian fossil-bed; but of this we have no positive proof, seeing that the beds exposed at Cape Gertrude have yielded no fossils to indicate their age. It is quite possible, therefore, that some of this silicified wood may be of Upper Jurassic, Cretaceous, or Tertiary age. On the whole, it seems most in accordance with the known facts to regard it as of approximately the same age as the basalts, which are probably of Tertiary date.

Judging from the report of Mr. Leigh Smith's visit to Franz Josef Land,[1] and Mr. Etheridge's remarks in the discussion,[2] it was thought that the pine-cone, the silicified wood, and the plant-impressions there mentioned were all from one horizon; but no evidence was brought forward proving that such was the case. Mr. Carruthers, who examined the pine-cone, was of opinion that it was of Cretaceous age; and the presence of Cretaceous rocks in Franz Josef Land rests upon that opinion. It is by no means clear, however, that the silicified wood is Cretaceous, even if the evidence of the pine-cone be accepted; but there now seems to be some doubt as to the age of the cone.

The manner in which this silicified wood is preserved merits attention; in some cases the replacement by silica has been so brought about that the form of the finest tissues is extremely well preserved, and, being of a dark brown colour, sections under the microscope show their structure even better than recent wood (Pl. XLI, fig. 11). The large longitudinal cells of the woody tissue are clearly defined, as are also the medullary rays which cross them, but the feature which is the most striking and at the same time the most characteristic is the well-marked series of discs (dotted tissue) which are typical of coniferous wood, and are in this instance large, and arranged in single and double rows in the cells. Transverse sections show the usual annual rings.

There is much difference in the degree in which the finer tissues of this fossil wood are preserved, some examples, like that above described, seeming to have every feature of the original structure retained, while in others this is nearly or quite obliterated. Some sections of black flinty fragments which have been examined have traces of tissue so faint as to leave doubt concerning its vegetable origin; and there are many intermediate stages between the two extremes. It may be mentioned also that silicified masses

[1] Proc. Roy. Geogr. Soc. n. s. vol. iii. (1881) p. 135.
[2] *Ibid.* p. 147.

of vegetable matter other than wood have been collected, but these may not be of the same geological age. One such block, from the talus at Cape Stephen, on which there is a leaf of *Ginkgo* and a piece of a pine-branch, has already been noticed (p. 506).

The preservation of this wood in close relation to the basalt is of much interest, for it is not only in Franz Josef Land that there is this association, but it has been noticed in many other places. Under very similar conditions wood has been found interstratified with the basalts of Greenland; the same conditions are present in the Western Islands of Scotland, where *Pinus eiggensis*, sometimes silicified and sometimes preserved in carbonate of iron, occurs under the Scuir of Eigg, as described by Hugh Miller in the 'Cruise of the *Betsy*'; and coniferous wood was found by Sir A. Geikie under the basalt in the Island of Canna.[1]

The common occurrence of silicified wood on the shores of Lough Neagh, Ireland, is well known, and is stated to be derived from clays which are there found under the basalt.[2] Silicified wood has also been met with in the basalt of the Giants' Causeway.

It would be interesting to know whether similar conditions have existed in other places where silicified wood has been so abundantly found, such as near Cairo, in Antigua, in Arizona, in Tasmania, etc. In some of these localities volcanic conditions do obtain, but further information as to the precise relation of the silicified wood to the volcanic rocks is desirable.

In addition to the specimens above described the collection contains material from the surface of a floe, 48 miles south of Bell Island, and from the under-surface of an iceberg found, tilted up, off Eira Cottage.

That from the floe is a brown mud composed of extremely fine, brownish, amorphous particles, with which a few diatoms are associated. A partial analysis gave the following result:—

SiO_2	49·88
TiO_2	·28
Al_2O_3	18·06
Fe_2O_3	9·14
CaO	3·00
MgO	2·20
Loss on ignition	13·88
	96·44

The material from the iceberg is a greenish sand, containing shells and fragments of *Mya truncata*, *Balanus concavus*, *Balanus porcatus*, and *Saxicava arctica*; also some small subangular pebbles. The sand is principally composed of quartz and felspar, but contains also hypersthene, zircon, iron-ores, rutile, tourmaline, and garnet.

[1] Quart. Journ. Geol. Soc. vol. lii. (1896) p. 362.

[2] See W. W. Watts, 'Guide to the Collections of Rocks and Fossils in the Museum of Science and Art, Dublin,' 1895, p. 69.

The subangular pebbles are formed of basalt, sandstone, and black radiolarian chert. A section of the chert has been examined by Dr. G. J. Hinde, F.R.S., who has kindly furnished us with the following description:—

'The thin section of the small rolled pebble of light-coloured chert from Franz Josef Land is seen under the microscope to be filled with casts of radiolaria. The structure of these organisms, as is usually the case, is now entirely obliterated, and they appear as minute transparent bodies with circular, oval, or discoidal outlines in the cherty matrix. Most of them are smooth, but a few have projecting spines. They range from 0·06 to 0·19 mm. in diameter; in general, the forms are relatively smaller than those usually met with in chert. Judging from their outlines, several genera are represented in the section; the most numerous are the simple round and oval forms belonging to *Cenosphæra* and *Cenellipsis*, and the rarer spined ones may be probably referred to *Xiphostylus* and *Dorysphæra*. Though the horizon of the rock from which this pebble comes cannot be positively determined from these imperfectly preserved radiolaria, it is not improbably of Palæozoic age. The character of the chert itself is precisely similar to that of the radiolarian chert of the Palæozoic rocks of Devon, Cornwall, and the South of Scotland.'

It is a curious circumstance that among the few specimens brought from Joinville Island in the Antarctic region, south of the Falkland Isles, was one of radiolarian chert; thus this rock has been found, though not *in situ*, in the most northerly and most southerly lands yet visited.

Rocks showing cone-in-cone structure are very abundant near Cape Flora, and have been found at several localities. Numerous specimens have been collected, but unfortunately not one of them was found in place, so that the exact horizon from which they come cannot be determined. As they are found all round the Cape, and sometimes high up on the talus, it is probable that they form a band or bands situated not far below the basalt.

The rock is an argillaceous limestone, and the carbonate, which has produced the structure by its attempts to crystallize under unfavourable circumstances, is rich in lime and poor in iron and magnesia.[1]

VI. The Relations of the various Fossiliferous Horizons.

In order to give some idea of the relations of the various beds of fossils above noticed, and of their probable place in the geological sequence, a vertical section (fig. 4) has been made of the strata at Cape Flora, relying upon the various heights above the sea, at which the different beds are said to occur, for the position of these

[1] See G. A. J. Cole, 'On some Examples of Cone-in-cone Structure,' Min. Mag. vol. x. (1892) p. 136.

beds in the section; but it must be remembered that the figures supplied to us are only approximately accurate, and are liable to correction by further measurements.

The sedimentary strata in the south of Franz Josef Land are believed to be regularly horizontal, with only a slight dip to the north-east, and consequently within the area of Cape Flora it is unlikely that there will be any serious variation in the height of the same bed at different parts of the cliffs.

Cape Flora is said to be 1100 feet high; the upper 500 feet is basalt, while the lower 600 feet is made up of sedimentary rocks, covered for the most part by talus. The base of the basalt is thus placed at 600 feet above the sea, and the positions of some of the beds, as we shall see, are reckoned by their distance below the basalt. Thin beds of basalt are said to occur in the clay-beds, but as the exact position of these is not stated they are left out of the section; and for the same reason the seams of coaly lignite, noticed in these clay-beds, are omitted.

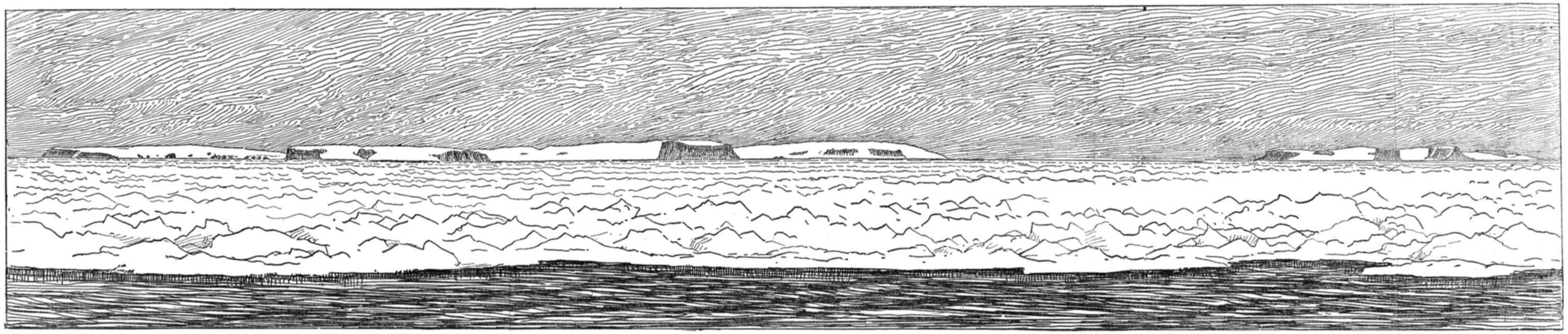
There is one horizon, however, the age and position of which are definitely known: it is that which occurs at the back of Elmwood, at about 50 feet below the base of the basalt. At this spot a bed (No. 3) was found *in situ*, and from it a small ammonite was obtained, which is probably *Ammonites Tchefkini*. In the watercourse below this exposure similar ammonites were found, together with *A. modiolaris* and *A. macrocephalus* (see p. 496). These suffice to settle the age as Lower Oxfordian and probably the equivalent of our own Kellaways Rock; and although only one ammonite was really found *in situ*, yet it is sufficiently certain that the others, if not from the same place, came from beds but little lower in the series. Similar fossils to these occur in the talus at many places around Cape Flora, showing that the same beds in all probability occur all round the Cape.

The belemnites which were collected during the *Eira* Expedition by Mr. Grant, apparently on Mabel Island and said to be of Oxford Clay age, probably belong to this horizon.

How much of the beds above and below the *Ammonites macrocephalus*-horizon is to be included in the Lower Oxfordian one cannot say, no distinctive fossils having been found. The thin bands of shale (No. 2) which occur just above the *A. macrocephalus*-horizon and close under the basalt have yielded no fossils.

On the north side of Cape Flora, at a height of about 700 feet, the bed with plant-remains (No. 1) occurs; it is said to be *in situ*, and overlying a mass of basalt projecting through a glacier. This locality is about a mile north-west of Elmwood—that is, on the supposed strike of the beds; it is therefore included in the section at the height given. It is difficult to decide whether this plant-bed should be included in the Oxfordian or not. Dr. Nathorst's opinion, that it is of Upper Oolite age, carries great weight; but if this be correct, then there would seem to be only 150 feet of strata between the Lower Oxfordian and the Upper Oolite. More-

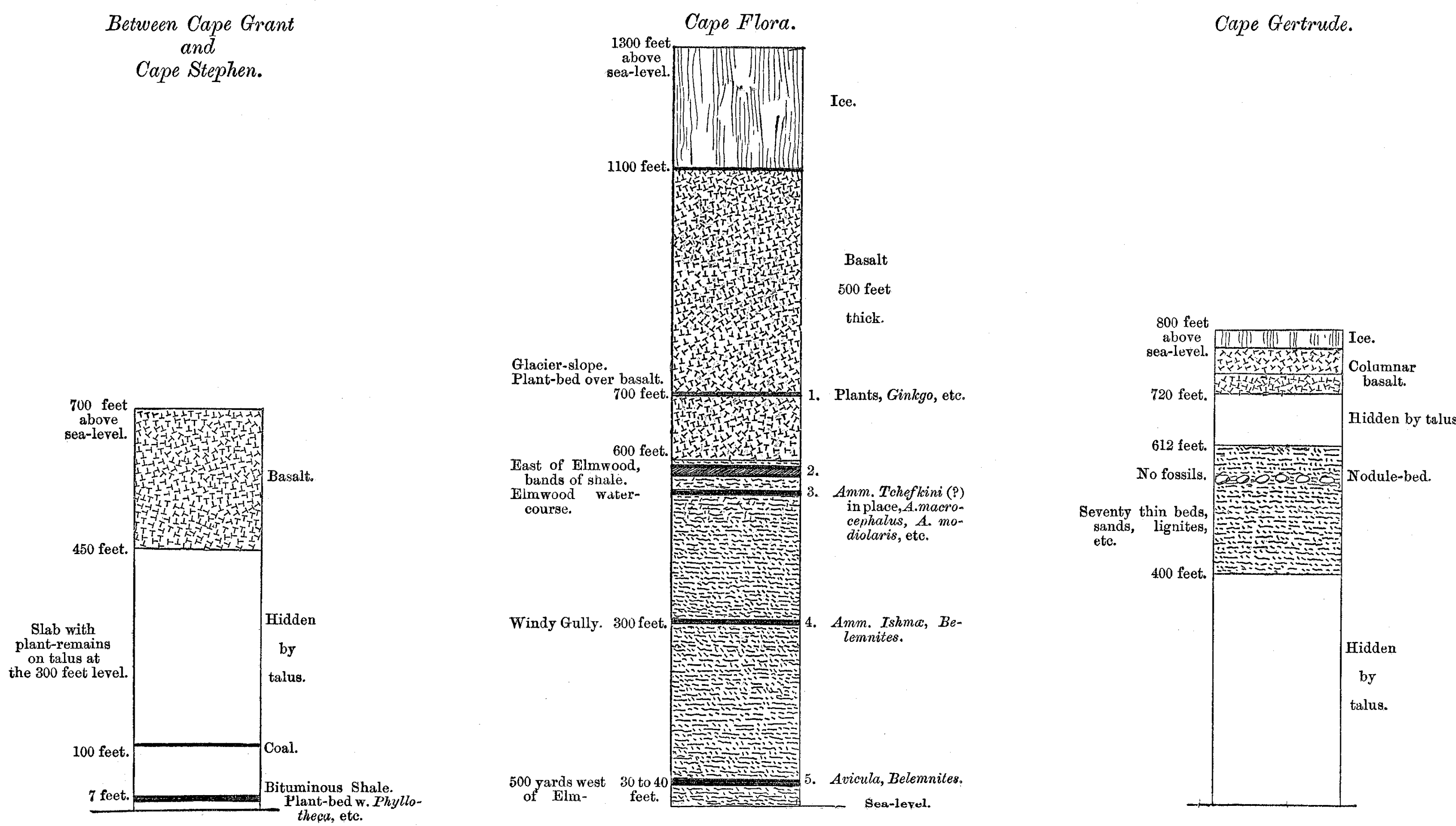
Fig. 3.—General View of the western part of Franz Josef Land. (*From a sketch by Mr. Fisher.*)



Cape Crowther. Cape Grant. Tween Rocks. Cape Stephen. Mabel Island. Bell Island.

[Ice-pack extends from the distant cliffs to the sea in the foreground. The dark masses are basalt-crags.]

Fig. 4.—Vertical sections, compiled from data supplied, showing the probable stratigraphical succession in Franz Josef Land.



over, if the basalt is intrusive, then the two beds (1 and 3) may originally have been nearer together than they are now. We must await further evidence before this point can be fairly discussed; in the meantime these plant-bearing shales are the highest fossiliferous horizon that has yet been found in place in Franz Josef Land.

The specimens of *Ammonites Ishmæ* discovered at Windy Gully, at 300 feet above the sea,[1] are believed by Dr. Kœttlitz to have been in place—that is to say, he is of opinion that they belonged to the bed on which they were found. This horizon, therefore, is placed in the section at 300 feet above the sea, and is thus 250 feet below the *Ammonites modiolaris*-bed, but this distance may be too great. The ammonites and belemnites of this bed are not of the same species as those found in the *Ammonites macrocephalus*- and *A. modiolaris*-horizon; and it is quite possible that we may have in this *A. Ishmæ*-bed a representative of another formation, perhaps of the age of the Cornbrash.

The lowest horizon seen at Cape Flora is the bed exposed at about 30 to 40 feet above the sea, a little to the west of Elmwood (No. 5). Except for the fact that this bed is situated some 250 feet lower in the series than the place where *A. Ishmæ* was found, there is nothing to give a clue to its geological horizon. The large *Avicula* has not been identified, and the belemnites, although resembling those found with *Ammonites Ishmæ,* are not perfect enough for identification.

The numerous thin beds (No. 6) at Cape Gertrude, that occur at a height of from 200 to 400 feet above the sea, having yielded no fossils to indicate their age, cannot be correlated with the section at Cape Flora, and it is only their elevation above the sea that points to a possible correspondence with the *Ammonites macrocephalus*- and *A. modiolaris*-series.

We now come to what seems to be the lowest horizon from which fossils have been collected in Franz Josef Land—namely, the plant-bearing sandstone at Cape Stephen (No. 7), which was also found exposed farther south-west, towards Cape Grant. As this locality is more than 20 miles west of Cape Flora and the structure of the intervening islands is not known, it is hazardous to attempt to correlate the beds at the two places. But, at the same time, if the strata of the south of Franz Josef Land are uniform in their north-easterly dip, then, as this plant-bed is near the sea-level at Cape Stephen, we should expect to find it or its equivalent at some distance below the sea at Cape Flora; and the possibly Lower Oolite age of the plants points to a similar position in the series. On the other hand, as already pointed out (p. 505), these beds may be of much greater antiquity.

The presence of a plant-bed at the top of these Oolitic strata of Franz Josef Land, and the occurrence of lignite-beds in many places below, show that estuarine, if not indeed freshwater, con-

[1] See footnote, p. 500.

ditions must have prevailed during a large part of the time when they were being deposited; but, on the other hand, the horizons with *Ammonites* and *Belemnites* point to times when marine depositions intervened.

Strata of Oolitic age have been met with in Spitsbergen by Prof. Nordenskiöld,[1] and the presence of *Ammonites triplicatus* would seem to indicate that they belong to higher beds than have been recognized in Franz Josef Land, unless indeed they correspond with the upper plant-bed of Cape Flora.

More recently two species of Jurassic ammonites have been recognized from Spitsbergen by Dr. Fraas,[2] namely *Ammonites triplicatus* and *A. cordatus*, from which one can only conclude that beds are present which in Britain would be called Upper Oxfordian.

Numerous Jurassic fossils were collected by Prof. Nordenskiöld in Novaya Zemlya and have been described by Prof. Tullberg.[3] Among these *Ammonites alternans* is found, thus indicating the presence of beds of Kimeridgian age in that country.

The question of the age of the silicified wood has already been alluded to (p. 509), and little further can be said. The occurrence of this wood below the basalt and near to probable Jurassic deposits shows that some of it may perhaps be of Jurassic age; but it may equally well be of Cretaceous or Tertiary date. Even if future discoveries confirm the supposed Cretaceous age of the pine-cone from Bell Island, this will not necessarily prove the silicified wood to be of the same age.

The possibility of Tertiary beds being present is shown by the silicified slab from Cape Stephen, the *Ginkgo* seeming to be the same as *G. reniformis*, which is from beds believed to be of Tertiary age.

The plant-remains found near Cape Richthofen may likewise be of Tertiary age, as already mentioned (p. 507), but the evidence is so slender that it must be taken rather as a suggestion of something to be looked for in the more northern parts of Franz Josef Land than as a proof of the presence of beds of so late a date. The fact that beds with abundant plant-remains of Tertiary age have been found in Spitsbergen shows that similar deposits may be expected here. It will be remembered that the specimens from Cape Richthofen were found upon a high lateral moraine, and therefore presumably were derived from beds directly above this moraine, or it may be were brought from a distance; in either case it is quite possible that they may yet be found *in situ*. The plant-remains themselves have a very recent look, but it is hardly likely that they can be more recent than the Glacial Period; indeed, Mr. Clement Reid's opinion (p. 508) goes far to show that they are of neither recent nor Pleistocene age, but must be referred to the

[1] 'Sketch of the Geology of Spitsbergen,' 1867, p. 27.

[2] Neues Jahrb. 1872, p. 203. See also Raymond & Dollfus, 'Géol. Spitsbergen,' Feuille des Jeunes Naturalistes, 1897, Nos. 286, 287, 288.

[3] 'Verstein. Nowaya Semlya,' Bihang till Svenska Vetenskap. Akad. Handl. vol. vi. (1880) pt. ii.

Tertiary period. These plants, however, are so poorly preserved, and their place of origin is so uncertain, that we can only hope for additional specimens which may throw light upon this interesting but obscure question.

VII. Conclusion.

In conclusion, we may perhaps be allowed to sketch out briefly the salient features in the geological history of Franz Josef Land, so far as this can be done in the light of our present knowledge. Passing over the plant-bed at Cape Stephen, the age of which is uncertain, the first event of which we have any record is the deposition of a series of shales and sandstones containing plant-remains, beds of lignite, and other evidences of littoral or estuarine conditions. Intimately associated with these shallow-water deposits are some purely marine beds, the age of which is placed beyond all doubt by the occurrence of such well-characterized zonal fossils as *Ammonites macrocephalus* and *A. modiolaris*.

Owing mainly to the brilliant researches of Neumayr,[1] it is now generally recognized that the Jurassic sea reached its greatest extension in the present land-areas during the Callovian and Oxfordian periods. Hydrocratic and geocratic movements alternated during Jurassic times, with a decided balance in favour of the former, and a recession of the coast-line towards the north. Even in the North of Scotland we find no decided evidence of the proximity of land during the Oxfordian period, although the lower portions of the Jurassic formation are represented by littoral and estuarine deposits.[2]

Under these circumstances the discovery of *A. macrocephalus*-beds in Franz Josef Land in association with plant-bearing strata is of special interest. It extends the range of this ammonite several degrees towards the north, and shows, in all probability, that during the period of its existence a coast-line lay somewhere in this direction. Marine deposits of Callovian and Oxfordian age are now known to range from Sutherland to Cutch and from Franz Josef Land to the North of Africa; and *A. macrocephalus* is one of the most widely distributed of all Jurassic ammonites.[3] The soft Jurassic sediments were subsequently covered up and preserved from destruction by vast flows of basaltic lava; and it is not a little remarkable that rocks of the same general period have been preserved in the same way in districts so far removed from Franz

[1] 'Die geographische Verbreitung der Juraformation,' Denkschr. d. k. Akad. d. Wiss. Wien, vol. l. (1885) pp. 57–142.

[2] J. W. Judd, 'The Secondary Rocks of Scotland,' Quart. Journ. Geol. Soc. vol. xxix. (1873) p. 164, & vol. xxxiv. (1878) p. 726.

[3] It not only occurs in Central and Southern Europe, Northern Russia, and Franz Josef Land, but also in Cutch (Waagen, Pal. Indica, ser. ix. vol. i. 1873) and Bolivia (Steinmann, Neues Jahrb., Beilage-Band i. 1881, p. 239). It has also been recorded from Western Australia (Moore, Quart. Journ. Geol. Soc. vol. xxvi. 1870, p. 226), but Neumayr throws doubt on the identification (*op. cit.* p. 118).

Josef Land as the North-west of Scotland[1] and Abyssinia.[2] We have already pointed out that Dr. Nansen refers the basalt in part to the Jurassic period; but in view of the fact that the basalts of the West of Scotland were at one time supposed to be of the same age, for reasons similar to those relied upon by him, this conclusion cannot be regarded as definitely established. At the same time it is important to notice that, if we except the North of Ireland, the Upper Cretaceous period is unrepresented, or but feebly represented, by sedimentary deposits in regions like the Deccan of India and the high plateaux of Abyssinia, where basalts are extensively developed. It is therefore quite possible that the vast outpourings of basic lavas which have given a special character to extensive areas of the earth's surface[3] may have commenced in pre-Tertiary times.

The present configuration of the archipelago of Franz Josef Land (see fig. 3, facing p. 512) conclusively proves that it is formed of the fragments of an old plateau. The land frequently ends off in high cliffs, capped with sheets of basalt which must have extended far beyond their present limits. When one compares the topography of this district with that of the Færöes and the West of Scotland, one is inclined, notwithstanding the immense tracts of water which now separate these localities, to ask whether they may not at one time have been continuous, and whether the northern portion of the North Atlantic, as suggested by Suess,[4] may not be of comparatively recent origin.

But whatever answer may be given to this question, it is clear that at the close of the volcanic period the various islands of Franz Josef Land were united and formed part of an extensive tract of land. This land was subsequently broken up, partly, in all probability, by the sinking of certain areas along lines of fault, and partly by denudation.

The final stages in the history of the district are represented by the raised beaches, which prove that this region, like so many other portions of the extreme north, has quite recently been under the influence of a geocratic movement.

EXPLANATION OF PLATES XXXVII.-XLI.

Plate XXXVII.

Fig. 1. Basalt from talus, Cape Flora. × 20. The figure shows labradorite, ophitic augite, and interstitial matter, with which some magnetite is

[1] J. W. Judd, 'The Secondary Rocks of Scotland,' Second Paper, Quart. Journ. Geol. Soc. vol. xxx. (1874) p. 220.

[2] Aubry, 'Observations géologiques sur les Pays Danakils, etc.,' Bull. Soc. géol. France, ser. 3, vol. xiv. (1886) p. 201.

[3] The Deccan traps cover an area of about 200,000 square miles, 'Geology of India,' 2nd ed. 1893, p. 256.

[4] 'Are Great Ocean-Depths Permanent?' Natural Science, vol. ii. (1893) p. 185.

associated. The magnetite cannot be distinguished from the interstitial matter in the figure. [F. 318.]

Fig. 2. Amygdaloidal basalt from the talus, Cape Flora. × 10. Labradorite, augite, palagonite, and calcite. In this case no magnetite can be recognized under the microscope; the whole of the iron-oxide appears to have remained undifferentiated. The interstitial matter occurs also as the infilling material of an irregular cavity, the centre of which is occupied by calcite. [F. 321.]

Fig. 3. Olivine-basalt with chrome-diopside. × 10. From the under-surface of an iceberg off Eira Cottage. The chrome-diopside occurs as a phenocryst with a zone of inclusions near the margin. The large black inclusion is of a greenish undetermined substance—not magnetite. Olivine is not seen in the figure. [F. 324.]

Fig. 4. Another portion of the same section. × 20. The interstitial matter in this rock has been devitrified during consolidation, and is crowded with grains and skeleton-crystals of magnetite, which can be recognized in the figure. [F. 324.]

Fig. 5. Quartz-bearing basalt. × 50. From the under-surface of an iceberg, found tilted up in De Bruyne Sound. Calcite surrounded by a zone of augite-microlites. The clear patch near the outer margin of the zone is also formed of calcite. The main mass of the rock is formed of microlites of felspar, augite, and magnetite. [F. 343.]

Fig. 6. Phosphatic nodule from Windy Gully, Cape Flora. × 16. [F. 336.]

[The numbers in square brackets refer to the collection in the Museum of Practical Geology.]

Plate XXXVIII.

Fossil plants from the north side of Cape Flora, Northbrook Island, Franz Josef Land, 700 feet above the sea.

Fig. 1. *Ginkgo polaris?*
2. ,, ,,
3. ,, sp.
4. ,, *siberica?*
5. ,, ,, ?
6, 7 & 8. Pine-seeds.
9. ,, cone.
10. *Baiera?*
11. *Fieldenia?*
12. *Podozamites?*
13 & 14. *Thyrsopteris* sp.

Plate XXXIX.

Figs. 2, 3, 5, 7, 8 & 15 are of specimens from the watercourse in the talus at the back of Elmwood, Northbrook Island, No. 5 being found *in situ*. Figs. 4, 6, 10, 11, 12, 13 & 14 are of specimens from the western end of Cape Flora. Figs. 1 & 9 from Cape Flora.

Figs. 1 & 2. *Ammonites* (*Macrocephalites*) *macrocephalus*.
3. ,, ,, ,, var.
4 & 6. *Ammonites* (*Cadoceras*) *Tchefkini?*
5. ,, ,, ,, Found in place 50 feet below the basalt.
7, 8 & 9. *Ammonites* (*Cadoceras*) *modiolaris*.
10. ,, ,, ,, flattened variety.
11, 12 & 13. *Belemnites Panderi*.
14. ,, ,, Piece of large specimen.
15. *Gorgonia?*

Plate XL.

Figs. 1–3. Ammonites from Windy Gully, east of Elmwood, Northbrook Island, found on a shoulder of rock 300 feet above sea-level, believed to be in place.

Fig. 1. *Ammonites* (*Macrocephalites*) *Ishmæ*, var. *arcticus*.
2. " " " inflated variety with coarser ribs.
3. " " " The exterior of this shell is almost devoid of ribs.
4. *Avicula* sp., from west of Elmwood, 30 or 40 feet above sea-level, and believed to be in place. The outline shows the probable size. Other fragments indicate still larger shells.

Plate XLI.

Figs. 1–9. Plants collected from beds *in situ* near the sea-level, at a spot called 'Tween Rocks' between Cape Grant and Cape Stephen.

Figs. 1–3. *Phyllotheca* like *Equisetum columnare*, Phil.
4 & 5. *Zamiopteris?* like *glossopteroides*. Margins imperfect.
6 & 7. *Rhiptozamites?* near to *Gœpperti*.
8. *Anomozamites?*
9. *Asplenium* cf. *whitbiense*.
10. Portion of silicified slab of plant-remains from Cape Stephen, 300 feet up the talus, containing strap-like leaves with (a) *Ginkgo reniformis?* and (b) *Pinites*.
11. Magnified section of silicified wood from Northbrook Island, showing the discs of coniferous wood.

Discussion.

Dr. J. W. Gregory was glad that the Authors confirmed Mr. Etheridge's determination of the beds as Oxfordian—a conclusion based on the collections made by Mr. Leigh Smith. The simplicity of the series around Elmwood was probably due to its occurrence in the heart of a great plateau-area; whereas in Western Spitsbergen the series was more varied, owing to its having been formed on the oscillating border of the land-area. Hence it is probable that the outlying islands of the Franz Josef archipelago, such as Oscar Land and Petermann Land, will yield a richer series of deposits.

The main interest of the stratigraphical portion of the paper was centred in the history of the Arctic Jurassic sea; but the speaker thought that Neumayr's fascinating theory, to which reference had been made, was now quite untenable. The relations of the Jurassic series in Franz Josef Land to those of the Northern Petchora basin were very significant. He understood that *Belemnites Panderi* was typically Kimmeridgian and Sequanian. He thought that all Fellows of the Society would be grateful to Mr. Harmsworth for his munificent generosity, and to the Authors for their very careful and thorough study of the material collected.

Mr. W. W. Watts enquired as to whether it was absolutely certain that the basalts were other than of Tertiary age. In

Spitsbergen, Ireland, and Scotland exactly similar lavas were of Tertiary age.

Mr. G. C. Crick agreed with the Authors as to the age of the cephalopoda exhibited, and with regard to Dr. Gregory's question respecting the occurrence of *Belemnites Panderi* with the ammonites referred by the Authors to *A. macrocephalus* and *A. modiolaris*, suggested that possibly beds of a somewhat higher horizon than that indicated by the Authors were also present.

The President, Prof. H. G. Seeley, Dr. G. J. Hinde, Mr. A. Montefiore Brice, and Prof. Lawson also spoke.

The Authors, in reply, said that they did not suggest that the basalts were of Jurassic age. They thought that these were probably related to the Jurassic rocks in the same way as in the north of Skye. They were quite aware of the probable occurrence of faults in the district, but could not give any direct evidence on this point.

With regard to the Upper Jurassic age of the higher plant-bearing beds, they were pleased to be able to support the view of Dr. Nathorst. They thought that the range of *Belemnites Panderi* would prove greater than was supposed.

In conclusion, they desired to express their appreciation of the careful way in which the specimens had been collected and labelled—a result doubtless in large measure due to the energy and organizing skill of the Hon. Secretary of the Expedition, Mr. Montefiore Brice.

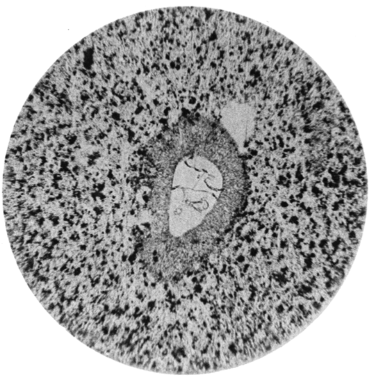
1.

2.

3.

4.

5.



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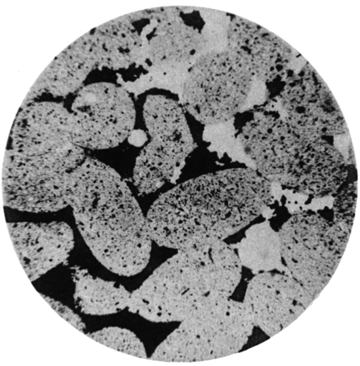
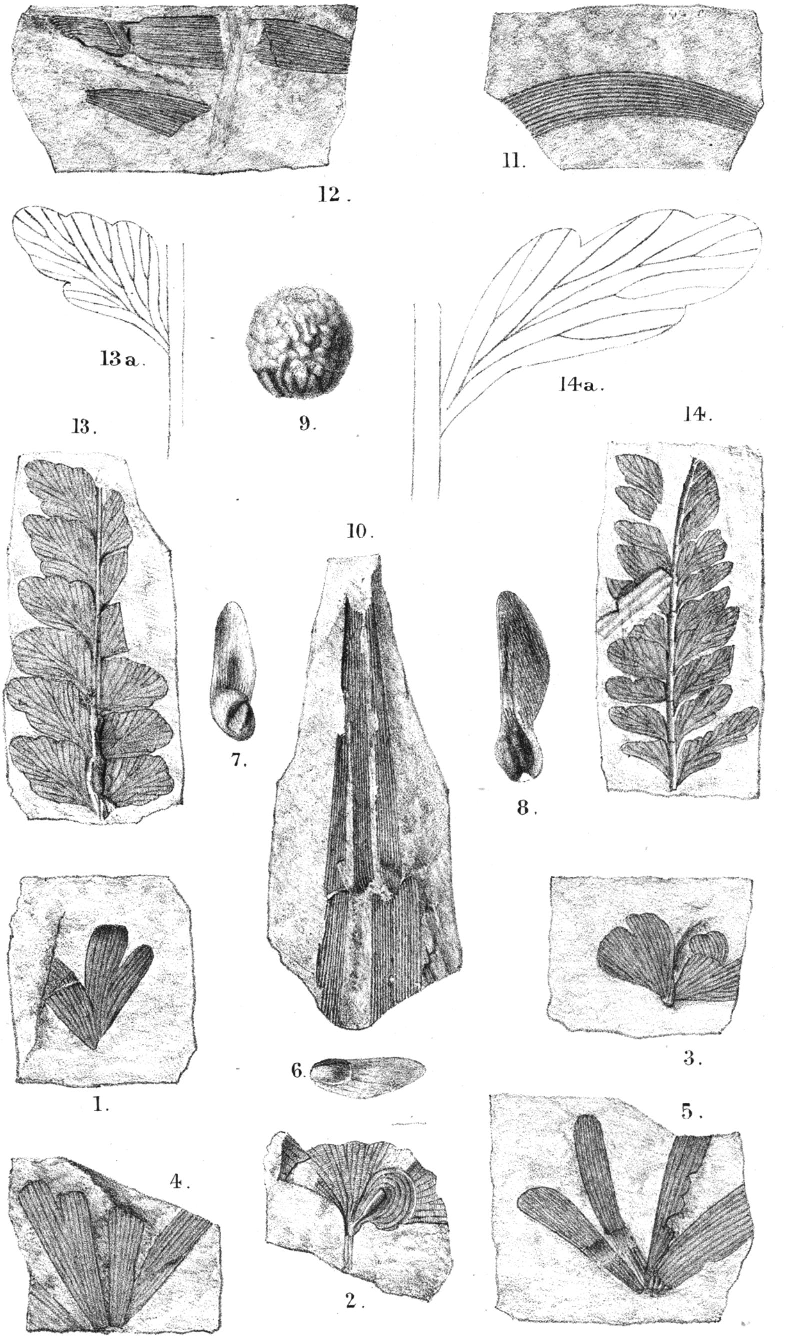


Rocks from Franz Josef Land.



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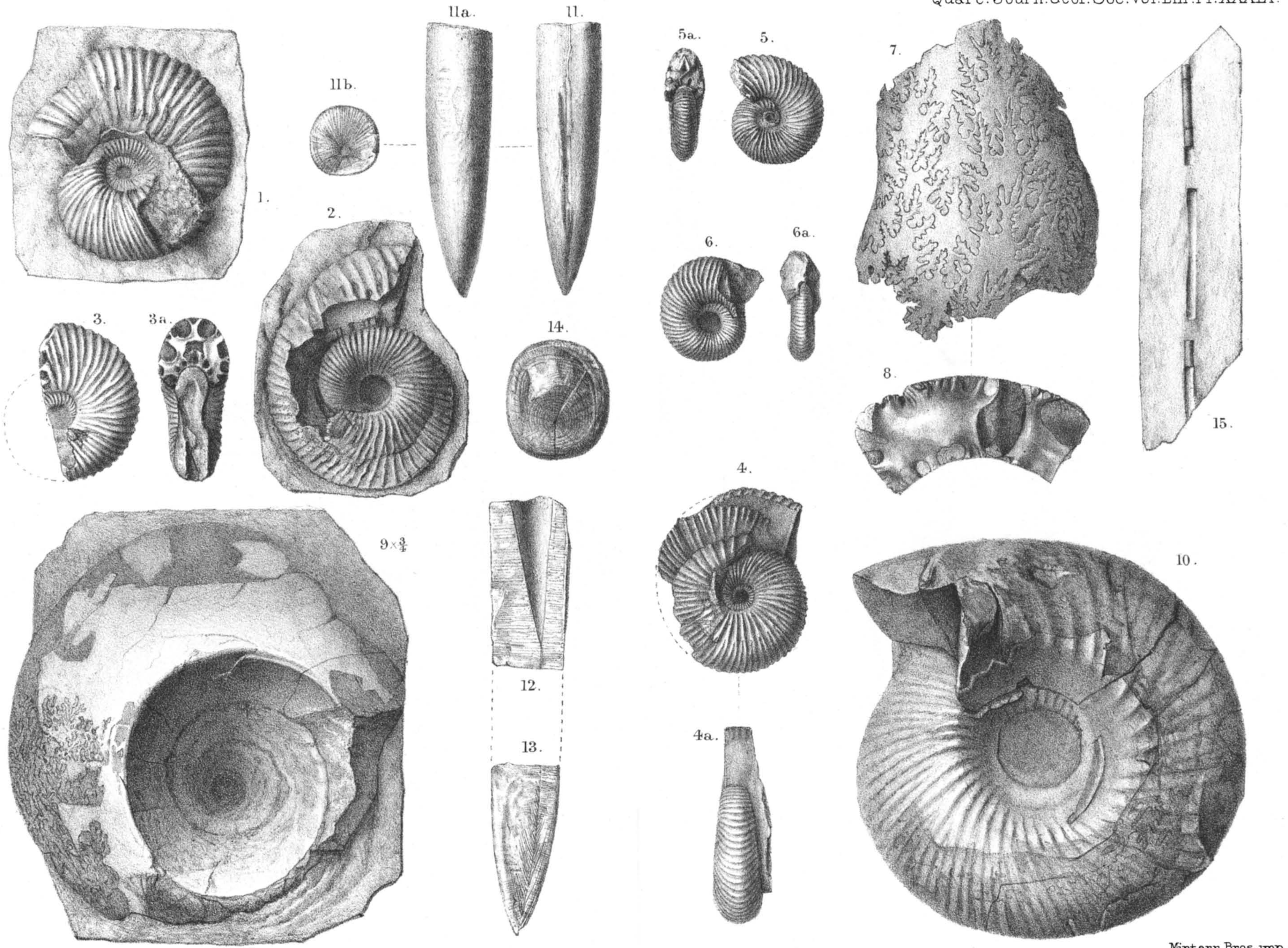
FRANZ JOSEF LAND FOSSIL PLANTS.



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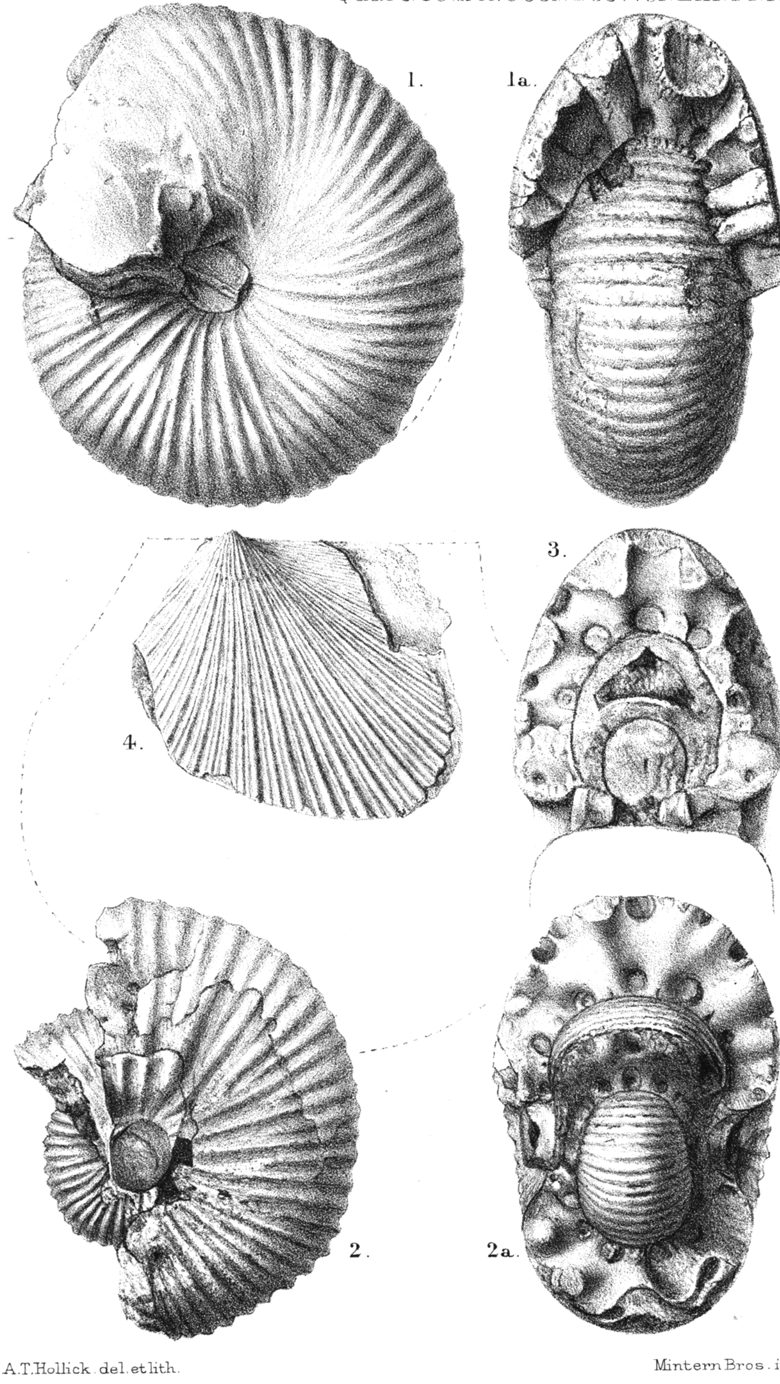

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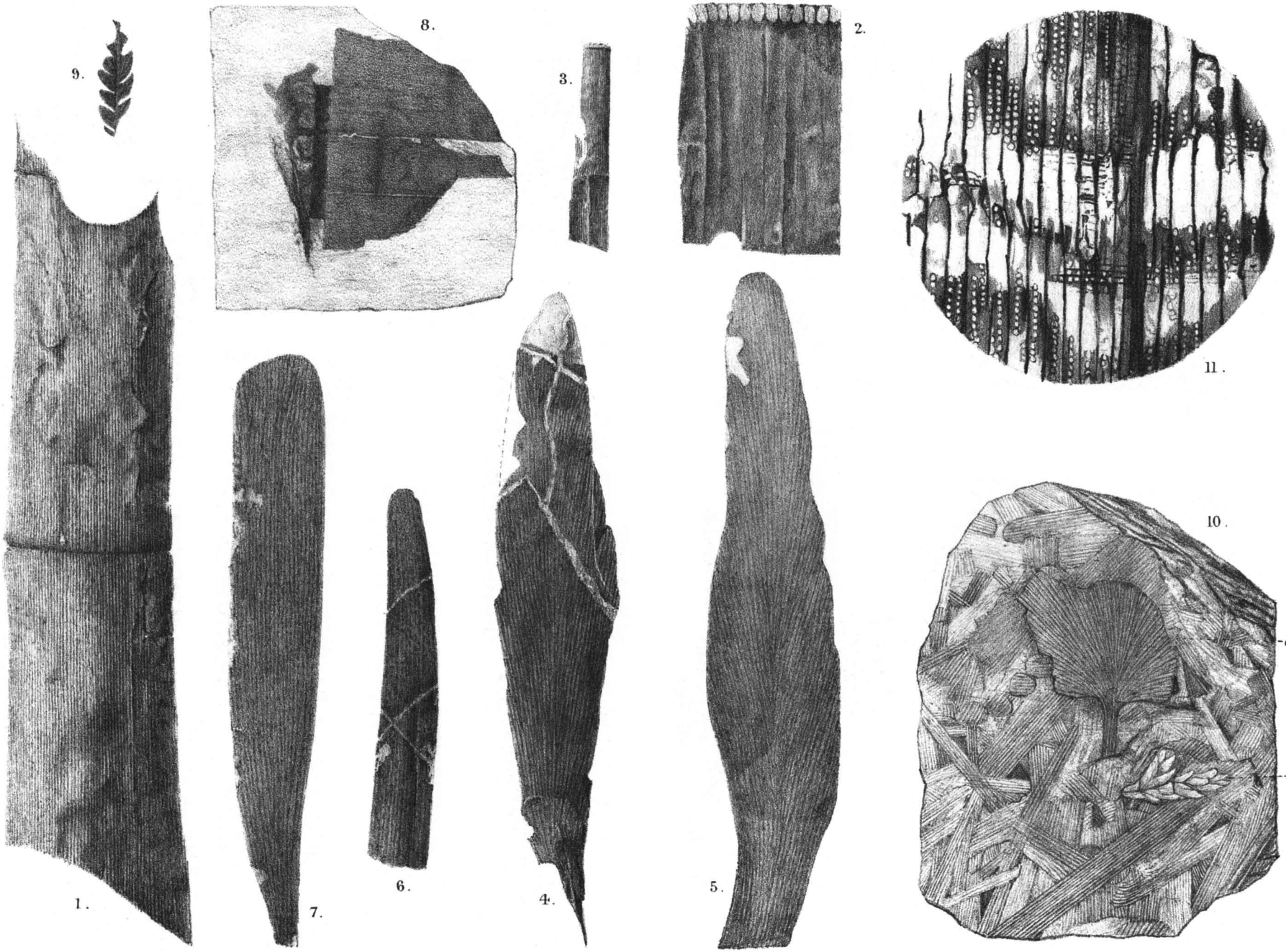

FRANZ JOSEF LAND, FOSSIL PLANTS.