II. *The Cretaceous Plant-bearing Rocks of Western Greenland.*

By A. C. Seward, *F.R.S.*, *Sc.D.*

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(Plates 4–12.)

Contents.

I.—INTRODUCTION.

In the summer of 1921, with the assistance of a grant from the Royal Society and the Cambridge Worts Fund, I spent rather more than two months in Western Greenland. It was mainly through the kind offices of my friend Prof. Ostenfeld, of Copenhagen, that the necessary permission to visit the Danish Colony was obtained. Mr. R. E. Holttum, who is now Assistant Director of the Botanic Garden, Singapore, acted as my Research Assistant, and did more than his share of the hard work. We left Copenhagen on June 18 and arrived at Godthaab at midnight on June 28; at Egedesminde, which we reached on July 2, we left the steamer and crossed Disko Bay in a motor-boat to Godhavn, on Disko Island. At Godhavn we were received by Mr. Morten Porsild, the Director of the Danish Arctic Station.* Two motor-boat expeditions were made from Godhavn—the first along the south-east coast of Disko Island as far as Ritenbenk's coal mine; and the second, in the course of which we travelled more than 500 miles, along the south-west coast of Disko Island to Hare Island, Upernivik Island and the Nûgssuak Peninsula, where several exposures of Cretaceous strata were examined. All arrangements were made for us by Mr. Porsild, whom it is impossible adequately to thank for his invaluable help and uniform kindness; his son, Mr. Erling Porsild, accompanied

* For an account of the Arctic Station, see 'Nature,' November 3, 1921, and Seward (22), p. 14.

us as interpreter, and by his intimate knowledge of the country and of the local flora rendered very valuable service.

A general account of the present vegetation has been published by Mr. HOLTTUM.* Specimens of the recent plants which we collected, supplemented by gifts from Mr. PORSILD's herbarium, have been deposited in the herbaria of Kew, the British Museum, and the Cambridge Botany School. In a popular account of the expedition, published in 1922,† acknowledgment was made of the assistance received from botanists in the determination of the non-vascular plants.

All the specimens figured in this paper and many others have been handed over to the Keeper of the Geological Department of the British Museum. In the Explanation of the Plates and in the legends to the Text-figures the registered numbers of the specimens in the British Museum are given in parentheses. A small collection of Cretaceous shells and the remainder of the fossil plants have been deposited in the Sedgwick Museum and the Botany School, Cambridge. Specimens of igneous and sedimentary rocks were divided between the Mineralogical Department of the British Museum and the Sedgwick Museum.

To the Director for Greenland, Mr. DAUGAARD JENSEN, I am greatly indebted for the loan of his motor-boat after a serious mishap to the boat belonging to the Arctic Station. Throughout the expedition we received much assistance and not a little hospitality from the Danish officials. I am indebted to Prof. BÖGGILD, Dr. RAVN and Mr. MATHIESEN, of the Copenhagen Museum, also to Prof. HALLE and Mr. FLORIN, of Stockholm, for affording me facilities for examining the rich collections of Greenland fossils. Mr. HOLTTUM not only assisted me in the field, but also, after our return, at Cambridge. My son-in-law, Mr. J. WALTON, undertook the description of some petrified coniferous stems and helped me substantially in many other ways. I have received much assistance from Mr. T. M. HARRIS, of Christ's College.

To Mr. RAMSBOTTOM, of the British Museum, I am indebted for some notes on microscopical preparations of Fungi made from material collected on Disko Island. Dr. RASTALL, of Cambridge, and Mr. CAMPBELL SMITH, of the British Museum, kindly made an examination of samples of sedimentary rocks. Mr. ELBORN, the late Senior Assistant in the Cambridge Botany School, lightened my task by making preparations of carbonised cuticles. I also wish to thank the Staff of the Botanical Department of the British Museum, particularly Mr. R. GOOD, and the Staff of the Kew Herbarium.

II.—NOTES ON THE GEOLOGY OF GREENLAND, WITH SPECIAL REFERENCE TO LOCALITIES WHERE FOSSIL PLANTS WERE COLLECTED.

THE greater part of Greenland consists of a mountainous plateau of Archæan rocks penetrated by long and often tortuous fjords—a sector, as SUESS‡ describes it, cut out of

* HOLTTUM (22).

† SEWARD (22), p. vii.

‡ SUESS (21), t. II, pp. 416, 491.

the ancient continent of Atlantis. In the course of ages there have been partial marine transgressions, some of which have left impressive evidence of climatic conditions very different from those of to-day, notably the evidence of the Silurian coral reefs on the coast of Washington Land* (lat. 80° N.), which form part of the legacy of the great marine transgression in the Palæozoic era over north-west Greenland. A summary of the geological features was contributed by Prof. BÖGGILD† to the 'Handbuch der regional Geologie'; and, in addition to sources mentioned in this paper, other geological descriptions will be found in the volumes of the 'Meddelelser om Grønland.'

The region with which we are more immediately concerned is shown on the accompanying map, based on that by HAMMER and STEENSTRUP.‡ Our most northerly objective was Upernivik Island, where there is a patch of fresh-water Cretaceous sediments at the south-west corner abutting on the high Archæan mountains which form the main mass of the island. From Kûk,§ on the north coast of the Nûgssuak peninsula, Cretaceous rocks are exposed, almost without a break, to within a short distance of the western end of the peninsula, resting at some localities on the denuded hummocks of an old Archæan land-surface. Similarly on the south coast, from Alianaitsunguak to Naujat, many hundred feet of Cretaceous and occasionally Tertiary strata in regular sequence are exposed at several places in the ravines and cliffs. For the most part the sedimentary rocks contain only plants, and are often barren. A few marine shells were collected at Atâ and Pâtût. The slightly inclined sediments are overlain by the protective basaltic lavas and beds of ash.|| At some localities, *e.g.*, Godhavn on Disko Island, and at the western end of the Nûgssuak peninsula, the Tertiary volcanic series rests unconformably on Archæan gneiss, but at the great majority of the places visited a considerable thickness of sedimentary strata is intercalated between the gneiss and basalt. At Hare Island, where there are no Cretaceous rocks, we collected a few Tertiary plants. On the east coast of Greenland,¶ approximately on the same latitude, Tertiary volcanic rocks occur similar to those on the west.

Fossil plants, probably of Lower Carboniferous age, were recorded by NATHORST** from the north-east coast, between lat. 80° N. and lat. 81° N. in 1911. A Rhætic flora was described by Dr. HARTZ†† from Cape Stewart, Jameson's Land, in 1896, and supplemented in 1902.‡‡ I am greatly indebted to Dr. HARTZ for generously placing in my hands for description a large additional collection from this eastern locality. The examination has now been completed by Mr. T. M. HARRIS. A few specimens of Tertiary plants collected by PAYER and COPELAND on Sabine Island (lat. 74° 30′ N.) were identified by

* KOCH (20).

† BÖGGILD (17).

‡ STEENSTRUP (83).

§ I have followed the spelling of place-names adopted in the official book, 'Grønland' (2 vols.), Copenhagen, 1921.

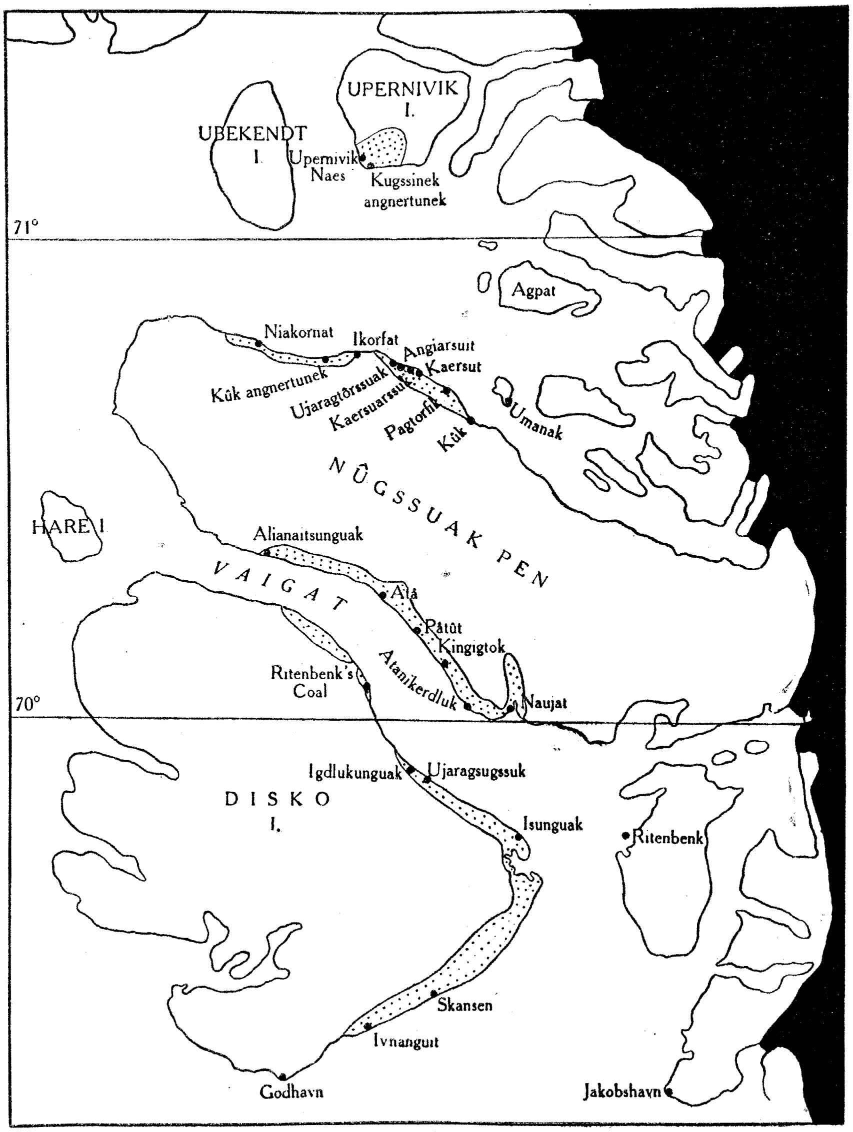
|| A generalised geological section is reproduced by SUESS (21), t. III, p. 1525, from RIKLI and A. HEIM (11).

¶ SCORESBY, W., junr. (23), p. 408; NORDENSKIÖLD (09); NATHORST (01); KOCH (23).

** NATHORST (11).

†† HARTZ (96); NATHORST (01).

‡‡ HARTZ (02).



MAP I.—Sketch-map of the Region of West Greenland where Cretaceous Plants were Collected, based on the geological map of K. I. V. Steenstrup and on the maps issued with 'Grønland i Tohundredaaret for Hans Egedes Landing' (*Copenhagen*, 1921).

The black portion on the right shows the edge of the Inland Ice and some of the Glaciers debouching into the Fjords. For the sake of clearness the Ice-cap of Disko Island and the ice in the interior of the Nûgssuak Peninsula are omitted. The position of the Cretaceous strata is indicated by the small black dots.

List of Localities.

Alianaitsunguak, S.W. coast, Nûgssuak Peninsula (= N.P.).
Angiarsuit, N. coast, N.P.
Atâ, S.W. coast, N.P.
Atanikerdluk, S. coast, N.P.
Igdlukunguak, E. coast, Disko Island (= D.I.).
Ikorfat, N. coast, N.P.
Isunguak, E. coast, D.I.
Ivnanguit, S. coast, D.I.
Kaersuarssuk, N. coast, N.P.
Kaersut, N. coast, N.P.
Kingigtok, S.W. coast, N.P.
Kugssinek angnertunek, S. coast, Upernivik Island.
Kûk, N. coast, N.P.
Kûk angnertunek, N. coast, N.P.
Naujat, S. coast, N.P.
Niakornat, N. coast, N.P.
Pagtorfik, N. coast, N.P.
Pâtût, S.W. coast, N.P.
Ritenbenk's coal, E. coast, D.I.
Skansen, S. coast, D.I.
Ujaragtôrssuak, N. coast, N.P.
Ujaragsugssuk, E. coast, D.I.
Upernivik Naes, Upernivik Island.

HEER* as species previously recorded from the west coast. Other specimens from the same locality, including a well-preserved leaf of *Ginkgo*, are in the Copenhagen Museum and will be described by Mr. MATHIESEN. NATHORST† gave a short list of Tertiary plants collected by him at Sabine Island in a paper on the Geology of the north-east of Greenland, which is illustrated by a geological map.

Our knowledge of the Cretaceous and Tertiary rocks of Western Greenland is still very incomplete. It is customary to adopt HEER'S classification of the Cretaceous strata, based on fossil plants, into three series—the Kome series at the base, succeeded by the Atane and Patoot series. My hurried examination of the strata and a more careful comparison of the plants lead me to doubt the validity of this threefold division. I am at least convinced that a more thorough examination of the sections should be undertaken.

Upernivik Island.—At Upernivik Naes, near to the south-west corner, plants were collected at a height of about 500 feet in two valleys; in the valley north of the small Settlement, *Pseudocycas* was found associated with abundant *Platanus* leaves, *Ginkgoites*, and twigs of Conifers in a bed of shale below sandstones penetrated obliquely by a basalt dyke. The plant-bed is seen at the bottom of fig. A, Plate 4, where Mr. HOLTTUM is standing.‡ This is no doubt the locality for *Pseudocycas* recorded by STEENSTRUP.§ Leaves of *Ginkgoites* and a few *Platanus* leaves were obtained at about 500 feet above sea-level in the valley south of the Settlement. About four miles south of Upernivik Naes, at Kugssinek angnertunek (the locality spoken of by STEENSTRUP as Kook angnertunek), some Ferns were obtained in the shale close to an obliquely vertical dyke,|| and at a height of 380 feet in a valley on the far side of the nearest slope shown in fig. B, Plate 4, Mr. HOLTTUM found specimens of *Pseudocycas*. The mountains on the extreme right, beyond the moraine which slopes to the beach, are composed of Archæan rocks.

At Upernivik Naes and at Kugssinek angnertunek thick unstratified beds of shale were seen containing abundant roots or rhizomes; precisely similar shales were met with at several places on the Nûgssuak peninsula. For this characteristic rock I have suggested the name Rhizome bed.¶ STEENSTRUP estimated the thickness of the Cretaceous strata on Upernivik Island at 2,700 feet at least; they consist of shales and sandstones, which are often ripple-marked and false-bedded, and carbonaceous layers.

Kûk (=*Kook* or *Kome*).—This locality, where the Cretaceous strata are first exposed on the north side of the peninsula, is historically interesting, as it was here that fossil plants were first collected, more than a century ago. Sandstones, shales and coal-bearing layers rest on rounded hummocks of gneiss. Dr. RASTALL kindly examined samples of a loose sandstone from Kûk (fig. C, Plate 4), which he describes as consisting

* HEER (74^3), p. 4.

† NATHORST (01).

‡ About half-an-inch above the letter A on the photograph.

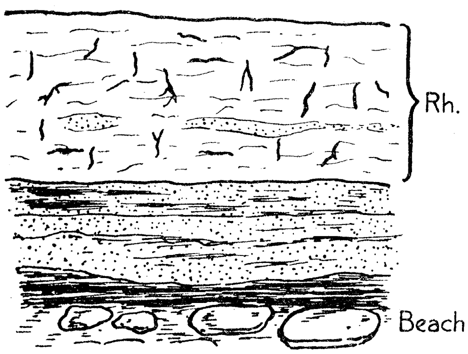
§ STEENSTRUP in HEER (83), p. 233.

|| For a photograph of the locality, see SEWARD (22), Plate XXIV.

¶ SEWARD (25), p. 233.

of grains of all sizes, shapes, and degrees of rounding, probably derived from the inter stitia quartz of a granite or gneiss. The heavy residue after panning and separation was small in amount and consisted chiefly of augite and hornblende, with a black iron-ore, presumably ilmenite, associated with small flakes of muscovite and crystals of zircon and rutile. He concludes that much of the heavier material was furnished by the disintegration of basaltic rocks.

As WHITE and SCHUCHERT* state, the sedimentary beds extend without any essential change to a height of 1,500 feet above sea-level. We ascended several ravines, but failed to find many fossils. On the west side of a glacier valley near a deserted Settlement the Cretaceous rocks lie on a foundation of disintegrated gneiss. The greater part of the cliff shown in fig. D, Plate 4, at sea-level, consists of weathered gneiss, and above it are seen sandstones and black shales. About half a mile west of the cliff (fig. D), at the end on the second ravine west of the ruined houses, there is a good section of cream-coloured sandstones and black shales (fig. C), where numerous leaves of *Sciadopitytes Crameri* were found in the lowest bed of shale. A Rhizome bed of argillaceous sandstone, similar to that on Upernivik Island, was seen at a higher level. It was probably at the head of this ravine that the members of the German expedition† obtained their fossils.



TEXT-FIG. 1.—Section of the cliff on the beach, Pagtorfik, showing the Rhizome bed, *Rh.* (6 to 7 feet), of arenaceous shale, with irregular bedding and partings of sandstone resting on carbonaceous sandstone, sandstone, shale, and thin layers of coal.

Pagtorfik.—The Cretaceous beds are exposed at sea-level in association with hummocks of gneiss. On this part of the coast there is a well-defined Pleistocene raised beach, reaching a height of 150 feet. Lists of shells from this locality are given by NORDENSKIÖLD‡ and by WHITE and SCHUCHERT. From a bed near the base of the sedimentary series we collected *Gleichenites*, twigs of Conifers, and other plants; and at a higher level we found a Rhizome bed (text-fig. 1) identical with that at Kûk.

Kaersuarssuk.—From an anchorage below the manager's house we walked across the delta to the Government coal-mine, where two seams of coal are worked from the face of the cliff almost at sea-level. No underclay was noticed below the coal. Near the entrance to the mine the sedimentary rocks are disturbed and metamorphosed by a large weathered dyke, which has been fully described by A. HEIM.§ To the west of the dyke is a fault, and it was on the west side of this that we collected *Gleichenites* and other plants, at 4 or 5 feet above sea-level. Other specimens were obtained from apparently the same bed, at a height of 700 to 800 feet, between Kaersuarssuk and Kaersut, to the

* WHITE and SCHUCHERT (98).
† DRYGALSKI (97), vol. II, p. 358.
‡ NORDENSKIÖLD (72), p. 411.
§ HEIM (11). See also PHALEN (03).

east of the mine. Below the *Gleichenites* bed and separated from it by a few feet was a layer containing leaves of *Sciadopitytes*: between the two was a Rhizome bed.

Angiarsuit.—In their account of the Cretaceous strata WHITE and SCHUCHERT* describe a section on the coast a short distance west of Ujaragtôrssuak, the locality spoken of by NORDENSKIÖLD as Angiarsuit. The American authors speak of three localities in a distance of "about 300 yards," A, B, C; but their section, which we followed, extends almost a mile along the coast. Near their locality A, where ripple-marked and false-bedded sandstones, with a basal conglomerate, rest on weathered hummocks of a finely crystalline rock, which is probably basalt, we found only leaves of *Sciadopitytes Crameri* and fragments of a *Tæniopteris.* Near A we found a typical Rhizome bed. To the west of A is a fault which has disturbed the Cretaceous beds, and west of the fault we collected *Gleichenites* and *Laccopteris*, near locality B, in the neighbourhood of a dyke. Still farther west, at locality C, we found only fragments of Dicotyledonous leaves, including *Platanus latiloba*, the common species at Upernivik Naes, and pieces of Conifers.

Mr. CAMPBELL SMITH, of the British Museum, kindly examined specimens of rock from Angiarsuit: he describes the conglomerate as derived from a muscovite-granite or gneiss, and not far removed from its source of origin; and an arkose as derived from granite or gneiss and almost *in situ.*

Ikorfat.—The gneiss is exposed on the beach. Specimens of *Baiera* were collected at a height of about 800 feet, and at 950 feet *Gleichenites* and coniferous twigs.

Kûk angnertunek.—The sandstones and shales contain much iron and differ in appearance from the Cretaceous strata of other localities. A few shells in nodules were the only fossils found.

Alianaitsunguak.—At this locality, on the south coast of the peninsula, is the first exposure of Cretaceous strata on the north side of the Vaigat. No fossils were found.

Atâ.—The most striking feature is the large fan-shaped delta 2 or 3 miles across strewn with boulders of gneiss, basalt, breccia, and sandstone. About $1\frac{1}{2}$ miles west of the delta we found a few shells in loose pieces of burnt shale, but only fragmentary plants. Some pieces of a large petrified coniferous stem were picked up close to the beach. The marine fauna has been described by DE LORIOL,† STANTON,‡ RAVN,§ and MADSEN.||

Pâtût.—In the cliffs and ravines on this part of the Vaigat coast the sedimentary succession consists of a regular series, more than 1,000 feet in thickness, of sandstones, shales and thin seams of coal, suggesting deposition in a delta.¶ The shales are often bright red and the sandstones porcellanous, both thoroughly baked. Dykes are not infrequent, though, as others have pointed out, there is no evidence that they were the cause of the baking. Many fossil plants were collected among the loose pieces of shale and sandstone on the slopes of the lower ground, mostly Dicotyledons and *Sequoiites.* The burnt beds were found *in situ* at a height of 800 feet, and at 1,500 feet pieces of

* WHITE and SCHUCHERT (98), p. 351.

† DE LORIOL in HEER (83).

‡ WHITE and SCHUCHERT (98), p. 360.

§ RAVN (18).

|| MADSEN (97).

¶ For photograph, see SEWARD (22), Plate XXI.

coniferous wood were discovered as loose blocks, the largest being about 24 inches in circumference.

Atanikerdluk.—The name Atanikerdluk is used by the natives for the small peninsula which is connected by a narrow isthmus with the mainland, but, as STEENSTRUP pointed out, the locality so named by Europeans includes the adjoining mainland, where most of the fossil plants have been collected. The hills rise to a height of over 3,000 feet. Cretaceous sandstones and shales are succeeded in regular sequence by plant-bearing Tertiary strata and basaltic lavas. Mr. CAMPBELL SMITH describes a sample collected in the main ravine as a felspathic sandstone composed of material derived from muscovite gneiss and metamorphic rocks containing garnet and kyanite. He also describes a sandy shale from the same locality as fine-grained, finely laminated, and false-bedded on a small scale, 15 laminæ to the inch being easily counted in some places. He compares the Atanikerdluk beds with beds of modern tidal deltas.*

On the west side of a small ravine (fig. E), at a height of about 200 feet, we obtained many impressions of Dicotyledons, Conifers, and *Pseudocycas* in a black shale, the so-called *Liriodendron* bed of HEER. An exposure of this bed is seen in the photograph (fig. E, Plate 4) at the foot of the shoulder of rock above the left-hand chimney of the house in the foreground. Farther to the east a bed was discovered in the cliff close to sea-level, which appeared to be identical with that in the small ravine. The Cretaceous rocks in the main ravine appeared to be almost completely barren: they consist of false-bedded sandstones, finely laminated shales and unstratified sandy rocks, 20 to 30 feet thick, containing large nodular masses of a much harder sandstone. NORDENSKIÖLD,† BROWN,‡ and other authors§ have described the dykes which penetrate the sedimentary strata on this part of the coast, but full justice has not been done to the impressive vertical walls of basalt,|| which tower to at least 100 feet above the level of the sides of the valley.

At a height of 1,200 feet Mr. HOLTTUM collected several Tertiary plants from STEENSTRUP's locality I. Prof. NATHORST¶ made a careful examination of the Cretaceous and Tertiary beds at Atanikerdluk, and found several new localities, all of which he assigned to HEER's Atane series. His collections, with the localities recorded, are in the Stockholm Museum.

Skansen.—The almost vertical cliffs of basalt along the south-east coast of Disko Island are succeeded towards the north by the yellow sandstones and darker shales, which at Skansen** form the low cliffs on the shore, and farther inland reach a height of 2,000 feet, where they are capped by the Tertiary basalts and the Disko ice-field. The

* Compare the delta-type of sediments described by GOLDMAN in the Maryland Cretaceous area; BERRY (16), p. 111. *See* also BARRELL (12) and the interesting description of modern delta-deposits by COLLET (25).

† NORDENSKIÖLD (72), pp. 452, 457.

‡ BROWN (77), p. 81.

§ DRYGALSKI (97), vol. I, Plate II.

|| SEWARD (22), Plate XXVIII.

¶ NATHORST (86), p. 246.

** RAVN (10).

steep valleys behind Skansen are eroded out of the sedimentary series, which is penetrated by dykes projecting like ruined walls above the sandy slopes.* Very few fossils were found in the course of an ascent to a height of 1,900 feet, but at about 1,200 feet we found a thin laminated carbonaceous layer full of plant fragments, especially rachises of *Gleichenites* (fig. 31, Plate 6), sporangia, and other pieces of carbonised tissues often associated with well-preserved fungal hyphæ and fructifications. Large nodules of hard sandstone and grit, some of which are seen in the upper part of fig. F, Plate 4, are a characteristic feature of the Cretaceous series, both here and at Atanikerdluk.

Dr. RASTALL describes the loose sandstone as consisting chiefly of grains of quartz and decomposed felspar, with a few grains of darker minerals. He compares this and other samples with the Millstone grit as it must have been before cementation: the abundance of kaolinised felspar is a striking feature in common.

Igdlukunguak and *Ritenbenk's coal mine.*†—At these localities farther along the shore we obtained a few imperfectly preserved plants, and at Isunguak some specimens were collected in an ironstone at a height of 300 metres. In 1924 several specimens of Cretaceous plants were sent to me by Mr. PORSILD, which had been found by Mr. ERLING PORSILD and by natives from Ujaragsugssuk.

NATHORST found a bed with roots below that containing plant remains at Igdlukunguak, which confirmed his view that the plants are preserved practically *in situ*.

Hare Island.—The fossil flora consists almost exclusively of leaves of *Acer*, "crowded like those which cover the ground in autumn," with samaras. Beds of tuff with plants which were broken off by showers of cinders and lapilli, including *Ginkgo*, *Juglans*, Pine, Oak, and *Fagus*, are also described by NATHORST. No Cretaceous plants have been found on the island.

III.—COLLECTIONS OF FOSSIL PLANTS FROM WESTERN GREENLAND.

In 1854 Capt. (afterwards Admiral Sir E. A.) INGLEFIELD and Lieut. COLOMB collected Tertiary plants at Atanikerdluk: the former officer presented his specimens to the Museum of Practical Geology, and the latter gave his to the Royal Society of Dublin. The Inglefield collection was afterwards transferred to the British Museum. Sir LEOPOLD M'CLINTOCK, on the return of the "Fox" expedition (1857),‡ presented a collection of Tertiary plants from Atanikerdluk to the Royal Dublin Society: this collection and the much larger Colomb collection are now in the National Museum, Dublin. Other Tertiary plants from Atanikerdluk were presented to the Royal Gardens, Kew, by Dr. LYALL, and that Institution also received specimens from the same locality from Dr. WALKER, a member of M'CLINTOCK's staff, and Mr. J. W. TAYLOR. The great

* SEWARD (22), Plate XXII.

† HEER (68), p. 8; BROWN (77), p. 87; STEENSTRUP, 'Medd. om Grønland,' vol. XXIV, 1901, Plate 18.

‡ M'CLINTOCK (59).

majority of the Kew fossils were subsequently transferred to the British Museum.* The Lyall plants, when first described by HEER,† were said to be from Disko Island, but in a later account were assigned to Atanikerdluk.

In 1866 HEER‡ described the Atanikerdluk material collected by various British expeditions, and in 1868 published a fully illustrated account in the first volume of the 'Flora Fossilis Arctica,'§ supplemented by a description of specimens collected by Mr. OLRIK, the Inspector for North Greenland, and Dr. TORELL. In 1828 BRONGNIART|| described two specimens of a Greenland Fern, which he had seen at Copenhagen, as a new species, *Pecopteris borealis*, believed by him to be from Carboniferous rocks. The type-specimen was no doubt obtained from Kûk, and is a *Gleichenites*. GOEPPERT,¶ in 1861, mentioned the occurrence of plants at Atanikerdluk, which he regarded as evidence of the Miocene age of the beds, and in 1866** he described a few specimens discovered by Dr. RINK in beds afterwards recognised as Cretaceous, but referred by GOEPPERT to the Miocene period. In 1866 HEER†† published an account of a "petrified forest" at Atanikerdluk. In 1869 HEER‡‡ published a paper on collections made by Mr. E. WHYMPER in 1867. Mr. WHYMPER invited Mr. R. BROWN, of Campster, to accompany him as botanist, zoologist, and geologist: it would seem from a statement by the latter author§§ that he and not Mr. WHYMPER collected the fossils. The "Whymper" collections were acquired by the British Museum. A few additional Cretaceous plants were presented to the British Museum by Prof. NATHORST. An account of Mr. WHYMPER's journey is given in a Report of a Committee presented to the British Association in 1868,|||| and published two years later; also in a paper in the 'Alpine Journal.'¶¶

In the third volume of the 'Flora Fossilis Arctica,' HEER*** described specimens of the Fern *Protopteris punctata* (Sternb.) from Ujaragsugssuk, Disko Island, which he at first regarded as Carboniferous in age, but in the Preface to the same volume he corrected his mistake and assigned the plant to a Lower Cretaceous horizon. He published a photograph of this Fern as *Dicksonia punctata* in 1882.††† In the third volume, HEER also described additional Cretaceous plants from Kûk and other localities on the Nûgssuak peninsula, which had been collected by NORDENSKIÖLD, and Tertiary plants assigned to the Miocene period. NORDENSKIÖLD contributed to the 'Geological Magazine' a useful account of the places visited in 1870. In vol. VI of the 'Flora Fossilis Arctica,'

* I am indebted to the Director of the Royal Gardens, Kew; to Prof. JOHNSON, of Dublin; to Dr. KITCHIN, of the Geological Survey; and to Mr. W. N. EDWARDS, of the British Museum, for some of the facts mentioned in this Section.

† HEER (62).

‡ HEER (66).

§ HEER (68).

|| BRONGNIART (28) p. 351, Plate CXIX, figs. 1, 2.

¶ GOEPPERT (61).

** GOEPPERT (66).

†† HEER (66[2]).

‡‡ HEER (69). This paper was reprinted in the 'Flor. Foss. Arct.,' vol. II.

§§ BROWN (77), note, p. 67.

|||| WHYMPER (70).

¶¶ WHYMPER (74).

*** HEER (74[2]), p. 8.

††† HEER (82), Plate XLVII.

HEER revised his earlier accounts of Greenland Cretaceous plants and described many new species founded on material collected by Dr. K. J. V. STEENSTRUP and others. In vol. III, HEER instituted the two series, Kome and Atane, which he correlated respectively with the Urgonian and Cenomanian. The Kome series is based on the plants from Kûk (=Kook or Kome), and the Atane series is named after Atâ on the south coast of the peninsula. In vol. VI he instituted the Patoot series for beds exposed in the neighbourhood of Pâtût and referred them to a position above the Atane series. In vol. VII the palæobotanical results are summarised and a German translation is given of STEENSTRUP's valuable account of the stratigraphy of the plant-bearing beds.

HEER's determination of the Greenland Tertiary rocks as Miocene was discussed at length by Mr. STARKIE GARDNER* who referred them to the Lower Eocene period.

A list of several Dicotyledons and a few Conifers collected by Lieut. R. E. PEARY of the U.S. Navy, from beds said to be of Miocene age, was published by LESQUEREUX.† The late Prof. NATHORST made extensive collections of plants from Western Greenland and described several new species. One of the most interesting, and certainly the most sensational, of his contributions was the discovery of leaves and pieces of inflorescences of a Breadfruit tree, *Artocarpus Dicksoni*, in Cretaceous beds at Igdlukunguak.‡

Lists of plants collected by members of the American expedition of 1892 were published by WHITE and SCHUCHERT in an interesting account of the geology of many localities on the Nûgssuak peninsula. These authors compare the Greenland rocks with certain American series and refer HEER's Miocene beds to the Eocene period; they criticise some of HEER's conclusions on the age of the plant-bearing strata. A short account of Greenland fossil plants is given by VANHOFFEN, with determinations by ENGELHARDT,§ in the second volume of the Drygalski expedition. Dr. A. HEIM|| refers the three series of HEER to the Upper Cretaceous, and suggests that the differences in the vegetation indicated by the fossil plants from different localities may be the expression of different habitats of associations which are approximately of the same geological age. HEIM's paper is illustrated by excellent photographs and useful geological sections. It is noteworthy in this connection that NATHORST¶ had previously commented on the occurrence of distinct types of plants at different horizons at Atanikerdluk, and attributed this to the varying nature of the conditions.

In a paper contributed to the Jubilee volume of the Belgian Geological Society** I revised some of HEER's determinations in the 'Flora Fossilis Arctica' and added descriptions of a few new species.

* GARDNER (87).

† LESQUEREUX (88).

‡ NATHORST (86), p. 239; (90).

§ DRYGALSKI (97).

|| HEIM (11).

¶ NATHORST (86), p. 246.

** SEWARD (25).

IV.—DESCRIPTIONS OF SPECIMENS.

Thallophyta.

FUNGI.

Several specimens of Fungi were obtained from the layer of carbonised plant remains in the cliffs of Skansen (Plate 4, fig. F), and a selection was sent to Mr. J. RAMSBOTTOM, of the British Museum, who kindly supplied the following information:—"The slides show a quantity of undoubted fruit-bodies and mycelium. Though the reference of the fruit-bodies to some definite genus is difficult, if not impossible, a most interesting fact is that they appear to belong wholly to *Asterina*-like Fungi, and the mycelium which occurs, often in considerable quantity, also belongs entirely, or nearly so, to such Fungi. The fruit-bodies are for the most part characteristic, being flattened, radiate, disc-shaped structures somewhat resembling in appearance the Green Alga *Coleochœte*." These remains afford interesting evidence of climatic conditions. Mr. RAMSBOTTOM states that the Asterineæ are characteristic of intertropical regions: he points out that superficial Fungi are more closely related to climatic conditions than are those which live within the tissues of a host; they are unable to absorb much water from the host, and by reason of their exposed position they are extremely liable to desiccation and are able to develop only in a very rainy climate.

Among other examples of fossil Asterinoid Fungi reference may be made to mycelia figured by NATHORST* on leaves of *Sequoia Langsdorfii* (BRONGN.) from Tertiary beds in Ellesmere Island, and to *Phragmothyrites eocœnica* (EDW.) described by EDWARDS† from the Eocene flora of the Isle of Mull.

Pteridophyta.

EQUISETALES.

No example of Equisetaceous plants were found in 1921 in the Greenland rocks. An examination of specimens in the Copenhagen and Stockholm collections, figured by HEER‡ as *Equisetum* or *Equisetites*, convinced me that no satisfactory evidence of the occurrence of the Equisetales has so far been discovered.

LYCOPODIALES.

The specimens figured by HEER as *Selaginella arctica*§ and *Lycopodium redivivum*‖ in the Copenhagen and Stockholm Museums respectively are, I think, indeterminable.

FILICALES.

Gleicheniaceœ. *Gleichenites* GOEPPERT.

Gleichenites is the most abundant genus in the Greenland Cretaceous vegetation: the dichotomous habit, the form of the pinnæ and pinnules, the structure of the rachis,

* NATHORST (15).

† EDWARDS (22).

‡ SEWARD (25), p. 232.

§ HEER (82), Plate XIII, fig. 5.

‖ HEER (74), Plate XIII, fig. 1. *See* also SEWARD (25), p. 234.

the sori and sporangia indicate a remarkable persistence of type through the ages, since part of the country was occupied by a veritable Gleichenietum. An examination of many recent species of *Gleichenia,* in which pinnæ and pinnules show a wide range in size and form, and of the majority of HEER's type-specimens, leads me to the conclusion that many of his "species" are merely forms of a single specific type. It may well be that under a single designation I have included specimens that are specifically distinct, but I have not consciously united forms which afford any evidence of differences which are constant.

Mr. BERRY* in a recent paper vigorously protests against the use of the name *Gleichenites* in preference to *Gleichenia.* The argument that some of the species originally included by GOEPPERT in *Gleichenites* are no longer regarded as true Ferns does not seem to be a valid reason against the employment of that term. He adds, "It is surely nothing but a mental illusion to imagine that the use of an objectionable term like *Gleichenites* indicates a conservation of judgment." There is no mental illusion underlying the recognition of the fact that the Cretaceous fronds which afford evidence of soral characters differ in certain important respects from any recent representatives of the genus *Gleichenia.* Specimens referred by BERRY to *Gleichenia* give no information on the nature of the sporangia and thus lack a feature of some significance in the definition of a genus. As a general rule, it is a sound principle to indicate, by the addition of the termination *ites,* either our ignorance or the occurrence of some character in which a fossil species differs from any existing type. *Gleichenites* does not necessarily mean that a plant so named differs in any essential respect from the recent genus; it means that it is not a recent species, and in the great majority of instances that our knowledge of the sum of the characters is deficient. One of the aims of the Palæobotanist should be to provide data which botanists can use with confidence, though it must be admitted that the temptation to give too much weight to opinions based on insufficient evidence often seriously interferes with the attainment of this object.

GLEICHENITES GIESECKIANA HEER. Plate 5, figs. 1–4, 6–14, 16, 17; Plate 10, fig. 96; Plate 12, fig. 118; text-fig. 2.

In the following list are included only "species" described by HEER: reference is made elsewhere to other records.

Gleichenia Gieseckiana HEER, *ex parte* (68), p. 78, Plates XLIII, 1; XLIV, 2, 3: (74), p. 43, Plates III, 1*d*, 8; VII, 1: (82), p. 6, Plate II, 9.

Pecopteris borealis BRONGN. HEER, *ex parte* (68), p. 81, Plate XLIV, 5.

Gleichenia Zippei (CORDA) HEER (68), p. 79, Plate XLIII, 4: (74), pp. 44, 90, 97, Plates IV–VII, XXV, 1–3. Plate XXVI, 10–13 (74) is probably a different species. (82), p. 7, Plate III, 2.

* BERRY (24).

Pecopteris arctica HEER, *ex parte* (68), p. 80, Plate XLIII, 5. This specimen agrees closely with my fig. 4, Plate 5.

Pecopteris Rinkiana HEER (68), p. 80, Plate XLIII, 5.

Pecopteris hyperborea HEER (68), p. 81, Plate XLIV, 4 : (74), p. 41.

Gleichenia longipennis HEER, *ex parte* (74), p. 46, Plate VI, 4–6 : (82), p. 7, Plate II, 5.

Gleichenia thulensis HEER (74), p. 48, Plates V, 9*b*, X, 18 : (82), p. 7.

Gleichenia comptoniæfolia (DEB. and ETT.) HEER, *ex parte* (74), p. 49, Plate XI, 1, 2 : (82), pp. 8, 36, Plate XLVI, 25 (?).

Gleichenia gracilis HEER (74), *ex parte*, p. 52, Plate X, 5. Under this name are included some forms which are probably specifically distinct. The original of fig. 5 appears to be indistinguishable from *G. Gieseckiana*.

Gleichenia Nauckhoffi HEER (74), Plate XXV, 4.

The Greenland material affords abundant evidence of the occurrence of transitional forms between fronds with pinnæ bearing relatively small pinnules, which are either at right-angles to the axis or curved towards the distal end of the pinna, and pinnæ with larger, recurved pinnules (*cf.* figs. 1, 2, 4, 8–10, 14, Plate 5). Fig. 96, Plate 10, shows a few recurved pinnules on pinnæ exactly like those seen in fig. 1, Plate 5. The smaller forms conform to the type assigned by HEER and other authors to *G. Zippei* (CORD.), while the larger recurved pinnules agree with *G. Gieseckiana*.

The latter name is adopted because of the difficulty of deciding whether CORDA'S *G. Zippei* is identical with the Greenland Fern. CORDA'S Bohemian specimen,* and others subsequently figured by VELENOVSKY,† appear to differ from the Greenland type in the lack of a connecting strip of lamina between adjacent pinnules. A Fern from Austria referred by UNGER‡ to CORDA'S species may be specifically identical with the Arctic species; but the pinnæ are more widely spaced, and the lowest pinnules of each pinna are inclined to the rachis and not parallel to it, as in the specimens reproduced in Plate 5. In many specimens figured by HEER as *G. Zippei* the pinnules are rather smaller and straighter than in his *G. Gieseckiana* : but, on the other hand, recurved pinnules are not infrequent on pinnæ included by him in *G. Zippei*, *e.g.*, the specimen shown in my Plate 10, fig. 96. After examining specimens in the Copenhagen and Stockholm collections I am unable to discover any adequate reason for the retention of both specific names.

The oldest name applied to a Greenland Fern is *Pecopteris borealis* BRONGN., but I have not been able to identify the type-specimen, and BRONGNIART'S illustrations§ do not suggest identity with *G. Gieseckiana*. Specimens in the Copenhagen Museum collected by Dr. RINK at Kûk, the probable locality of BRONGNIART'S type, labelled *Pecopteris borealis*, are indistinguishable from HEER'S *G. Gieseckiana*. The fossil figured by HEER in 1868 (Plate XLIV, 5*b*) as *Pecopteris borealis* is hardly determinable : specimens subsequently referred by him to that species are pieces of *Cladophlebis Oerstedi*. Another name which has priority over *G. Gieseckiana* is *Didymosaurus comptoniæfolius*, DEB.

* CORDA in REUSS (46), Plate XLIX, 2, 3.

† VELENOVSKY (88), Plate III, 3–7.

‡ UNGER (67), Plate II, 1.

§ BRONGNIART (28), Plate CXIX, 1, 2.

and ETT.,* but though HEER included some Greenland impressions in this species, evidence of identity is not convincing. HEER's fig. 1, Plate XI (74) is not accurate in detail: the specimen is undoubtedly identical with those shown in my Plate 5, figs. 1 and 17. HEER's fig. 2, Plate XI, represents a piece of a frond very like that reproduced in my fig. 2, Plate 5.

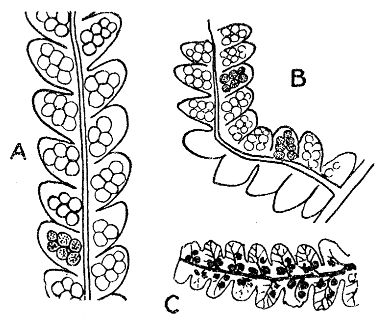
Gleichenites Zippei.—The original of HEER's fig. 4, Plate XIII (74) is rather imperfectly preserved, but it is probably identical with the better example reproduced in my Plate 5, fig. 1. Pieces of pinnæ from Quedlinburg assigned by HEER† to this species may be identical with the Greenland Fern. The illustration of a specimen in the Stockholm Museum represented in his fig. 1, Plate IV (74) is inaccurate; the supposed bud in the large fork is a broken prolongation of the rachis. The sori of HEER's specimen contain several sporangia like those in my Plate 5, fig. 16. His enlarged drawing is not correct. His fig. 3, Plate V (74), is not accurate; the axis on the right is not continuous, and some of the pinnules are recurved as in pinnæ included by HEER in *G. Gieseckiana.* The Stockholm specimen shown in HEER's fig. 4 has been, in part, re-drawn and is reproduced in my Plate 10, fig. 96.

Gleichenites Rinkiana.—The original specimen of HEER's fig. 6, Plate XLIII (68) in the Copenhagen Museum is indistinguishable from the upper part of my fig. 1, Plate 5.

Pecopteris komensis.—Specimens in the Copenhagen Museum from Kûk bearing this name are undoubtedly the same as *G. Gieseckiana.*

Aspidium fecundum, HEER (82), p. 32, Plate XXIX, 5–7, and *Polypodium Graahianum,* HEER (83), p. 3, Plate XLVIII, 4, 5.

I am indebted to Mr. MATHIESEN for the drawings of pinnæ of these ferns shown in text-fig. 2, A, B. On the pinnules of *Aspidium fecundum* there are two alternate rows of contiguous, circular sori about 1 mm. in diameter: in each sorus there are impressions of numerous sporangia, but no details are visible. I have no doubt as to the specific identity of this Fern and the specimen of *Polypodium Graahianum* seen in text-fig. 2, B. These two fossils, from Kardluk and Pâtût respectively, agree closely with *G. Gieseckiana,* but I am not sure of their specific identity with that species.



TEXT-FIG. 2.—A, B, *Gleichenites sp.* × $1\frac{3}{4}$. A = *Aspidium fecundum,* HEER, Kardluk (between Pâtût and Atanikerdluk). B = *Polypodium Graahianum,* HEER, Pâtût. A, B, drawn by Mr. MATHIESEN from specimens in the Copenhagen Museum.
C, (?) *Gleichenites Gieseckiana,* HEER, × $2\frac{1}{4}$, Pagtorfik. Drawn by Mr. J. WALTON (v. 19,013).

The Ferns from Aachen‡ described many years ago need revision in the light of recent work, and it is impossible from the illustrations to compare them in detail with Greenland

* DEBEY and ETTINGSHAUSEN (59), Plate I, figs. 1–5.

† HEER (71²), Plate I, fig. 1.

‡ DEBEY and ETTINGSHAUSEN (59).

specimens. Though the fossils included in *Didymosaurus comptoniæfolius* differ from the great majority of the examples of *G. Gieseckiana* in having smaller pinnæ, they are no doubt closely allied to HEER's species. HEER's fig. 1, Plate XI (74) is not accurate in detail: the specimen is specifically identical with those represented in my figs. 1, 17, Plate 5. There is no good reason for including the specimen shown in HEER's fig. 1, Plate XLIV (83), in the genus *Gleichenites*. The specimens named by DEBEY and ETTINGSHAUSEN *Benizia calopteris** may well be identical with the smaller forms of G. *Gieseckiana*. Under the name *Asplenium* (*Benizia*) *calopteris*, HEER† included specimens from Pâtût, which, though probably a distinct species, agree closely with *G. Gieseckiana*.

Gleichenites Gieseckiana was founded by HEER as *Gleichenia Gieseckiana* on material from Kûk and described as the commonest plant at that locality. He assigned it to the section Mertensia (=Dicranopteris), comparing it especially with *Gleichenia dichotoma* Sw. It may also be compared with *G. polypodioides* Sm. In the original of HEER's fig. 2, Plate XLIV (68), some of the pinnules are recurved, a feature not shown in his figure. In a later account, HEER stated that the sori contain 5 or 6 sporangia, the larger number previously mentioned being explained by the confusion of spores with sporangia. My observations indicate that HEER mistook sporangia for spores. The sori of most of the fertile specimens I have examined contained several sporangia and differ in this respect from those of recent species. A specimen from Atanikerdluk in the Copenhagen collection, referred by HEER to *G. Gieseckiana*, Plate XIII, fig. 4 (82), shows fairly well-preserved sori, each containing 6 or 7 sporangia: his figure is on the whole accurate. The sori are about 1 mm. in diameter, and here and there one sees traces of annuli. It is by no means certain that the Atanikerdluk specimen figured by HEER, or that from the same locality shown in my fig. 15, Plate 5,‡ is specifically identical with the true *G. Gieseckiana*. The specimens in the Copenhagen Museum from Pâtût included by HEER in *G. Gieseckiana* are certainly not examples of that species and are probably forms of *G. Porsildi*.§

Gleichenites Gieseckiana, as employed by me in a more comprehensive sense than by HEER, stands for a Fern agreeing in habit and in the intermittent growth of the main rachis with recent species of *Gleichenia*. The rachis is dichotomously branched (Plate 5, figs. 7, 11, 13: Plate 12, fig. 118). The coiled frond shown in fig. 5 is not in organic connection with any mature pinnæ and may belong to another Fern: a similar specimen shown in fig. 7, Plate 5, is associated with typical fragments of *G. Gieseckiana*. At the base of the main axis seen in fig. 13 at *a*, Plate 5, there is an imperfectly preserved elongated pinnule, agreeing closely in its departure from the normal form with the modified pinnules, or aphlebiæ, associated with the resting buds in recent species. A comparison of the impressions shown in figs. 1, 2, 3, 11, 12, characterised by short, straight or forwardly directed pinnules, with the larger specimens represented in

* DEBEY and ETTINGSHAUSEN (59), Plate V, 13–17.

† HEER (83), p. 5, Plate XLVIII, 5–8.

‡ *See* page 73.

§ *See* page 76.

figs. 8–10, suggests specific difference ; but on the lower pinnæ of fig. 1 some of the segments show a tendency towards a recurved form, and this is more pronounced in the example reproduced in fig. 96, Plate 10. The zigzag form of the axis seen in fig. 3 may be a specific character : a precisely similar form is figured by HEER* under *G. Zippei*. In the recent species *G. flexuosa* (SCHRAD.), recorded as far north as Louisiana, the same feature is seen.

The linear, acuminate pinnæ are attached more or less at right-angles to the rachis and are characterised by the gradually tapered and often much elongated form (fig. 17) ; they may be reflexed (figs. 4, 14). The pinnules are comparatively thick and xerophilous ; they are usually at right-angles to the axis of the pinna, but near the distal end of the pinna they are deltoid and pointed (figs. 6, 17) ; the apex, though generally obtuse, may be acute. The lamina is often lobed on the adaxial side, a feature shared by some Wealden and Upper Jurassic species and particularly evident in the lowest pinnule shown in fig. 1*a* (*see* also figs. 8A, 10, 16). A few forked or simple veins are given off from the midrib at an acute angle (figs. 6A, 8A, 11A, 12A).

Fertile specimens are not very common : examples are shown in figs. 9, 12, 14, 16. On the pinna reproduced in fig. 9 (enlarged in fig. 16), there are from 1 to 6 circular sori per pinnule, and each sorus has at least 12 sporangia. The sori on the smaller pinnules shown in figs. 12, 12A, contain from 12 to 20 sporangia, and the size of the sporangia is about 0·2 by 0·1 mm. The sori occur on the anadrome branch of a lateral vein (fig. 1*b*, Plate 5), a position identical with that in recent species of the section Dicranopteris. The piece of pinna shown in text-fig. 2 C is identical in form with that represented in fig. 12, Plate 5 : on some of the pinnules there are circular sori with numerous sporangia. It may be that this small, fertile pinna belongs to a distinct species, but the material is hardly adequate to serve as a type-specimen.

Many of the specimens from North American Cretaceous rocks referred by authors to *G. Gieseckiana* and other species founded by HEER are too imperfect to be determined with certainty, but there is no doubt of the occurrence of Gleicheniaceous ferns closely allied to or identical with *G. Gieseckiana* in both American† and European floras.

Localities.‡—Upernivik Island, Kûk, Pagtorfik, Kaersuarssuk, Ikorfat, Angiarsuit, Ujaragsugssuk.

GLEICHENITES SP. *Cf.* GLEICHENITES GIESECKIANA, HEER. Plate 5, fig. 15.

The piece of pinna, reproduced three times natural size in fig. 15, though very similar to typical specimens of *Gleichenites Gieseckiana*, differs in the more compact grouping of the pinnules and in their straighter form. It is no doubt identical specifically with

* HEER (74), Plate XXV, 1.

† Some good examples of a *Gleichenites*, specifically distinct from *G. Gieseckiana*, are figured by Knowlton (13) as *Gleichenia pulchella* from Upper Cretaceous rocks of Wyoming.

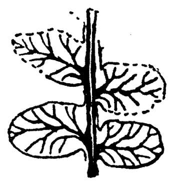
‡ Localities for this and all other species are restricted to places where specimens were collected in 1921 or from which material has been since received.

fertile pinnæ from the peninsula of Atanikerdluk referred by HEER* to *G. Gieseckiana.* HEER's specimen shows sori of 6 to 7 sporangia on which traces of annuli can be seen.

Locality.—Atanikerdluk.

GLEICHENITES (?) WALTONI sp. nov. Plate 6, fig. 28; text-fig. 3.

The specimen on which this species is founded does not afford any decisive evidence of a Gleicheniaceous affinity. I have named it after Mr. J. WALTON, who gave me much assistance in the investigation of the Greenland plants. On the small impression, reproduced twice natural size in fig. 28, the pinnules are free at the base and not united by a common lamina, as in *Gleichenites Gieseckiana*: though usually separate from one another they occasionally overlap; they are at right-angles to the pinna axis and not directed forward, as in the smaller specimens included in *G. Gieseckiana.* The lateral veins are once forked or simple, and in many of the pinnules a small lateral vein is seen to pass directly from the pinna into the base of the lamina (text-fig. 3).



TEXT-FIG. 3.—*Gleichenites* (?) *Waltoni* sp. nov. × 4. Kaersuarssuk. J.W. (V. 16,926).

The type-specimen closely resembles HEER's figures of *Gleichenia micromera*, but in one of the examples of that species in the Stockholm Museum, represented in HEER's fig. 14, Plate X (74), the pinnules overlap as in *G. Nordenskiöldi.* In the Patagonian Fern described by HALLE† as *Gleichenites* sp., *cf. G. micromera*, HEER, the pinnules are more inclined to the axis and overlap. A piece of fertile pinna in the Copenhagen Museum, figured by HEER as *Gleichenia nervosa*,‡ is similar to my specimen, but may be a distinct species: his figure is not accurate. A fragment from the Amboy clays, doubtfully assigned by NEWBERRY§ to *G. micromera,* is similar in habit to *G. Waltoni,* but it is impossible to say whether the American specimen is specifically identical. As BERRY|| points out, his species *Gleichenia argentinica* superficially resembles *G. micromera* and other forms described by HEER.

Until more material has been examined it is hopeless to attempt precise definitions of the various specimens of small Gleicheniaceous fronds recorded by HEER from the Greenland beds.

Locality.—Kaersuarssuk.

GLEICHENITES NORDENSKIÖLDI, HEER. Plate 6, figs. 22, 25, 26; Plate 10, fig. 97.

Gleichenia Nordenskiöldi, HEER, *ex parte* (74), p. 48, Plates VIII, 4, 5; IX, 1–4.

Pecopteris Andersoniana, HEER (74), p. 41, Plate III, 7, 7*b*.

Pecopteris (*Polypodium* (?)) *Andersoniana,* HEER (80), p. 4, Plates I, 10*b*; II, 5–9. The original of HEER's fig. 5 is, in part, reproduced in my fig. 97, Plate 10.

* HEER (82), Plate XIII, 4.

† HALLE (13), Plate I, 16–18.

‡ HEER (82), Plate III, 3.

§ NEWBERRY (95), Plate III, 6.

|| BERRY (24).

Gleichenia longipennis, HEER, *ex parte* (74), Plate VIII, 1–3. The Stockholm specimen shown in HEER's fig. 1 is inaccurately drawn and is no doubt referable to *G. Nordenskiöldi.*

Gleichenia nervosa, HEER (74), p. 53, Plate III, 3–6.

The figured specimens in the Stockholm Museum are, I think, identical with *G. Nordenskiöldi*, but a specimen subsequently figured by HEER* is incorrectly represented and probably specifically distinct.

Good examples of this Fern were collected in 1921, but as HEER's figures correctly illustrate the habit it is unnecessary to refigure large specimens. *Gleichenites Nordenskiöldi* differs from *G. Gieseckiana* in the separate attachment of the relatively short, contiguous, linear, obtuse pinnules; and in the overlapping of the axis by the asymmetrically lobed base of the lamina (fig. 25A, Plate 6; fig. 97A, Plate 10).

The pinnules appear to be thinner than those of *G. Gieseckiana*, and the lateral veins, which are once or occasionally twice forked, are rather more numerous than in *G. Gieseckiana* (fig. 26, Plate 6). The pinnæ are very long and of uniform breadth; they are attached at right-angles to the rachis. No dichotomously branched rachis was found in connection with the pinnæ. The species is characterised by the large number of sori on the pinnules; there appear to be relatively few sporangia in each sorus, but the sporangial groups are not very clearly delimited. As in *G. Gieseckiana*, the sori lie over the anadrome branch of a lateral vein (Plate 10, fig. 97B). The annuli are complete, as in the sporangia from Skansen reproduced in figs. 20, 21, Plate 6. Accurate measurement of the sporangia is hardly possible; some are at least 0·36 mm. long, rather larger than those of *G. Gieseckiana.* It may be that the sporangia were partially sunk in the lamina as in some recent species.

Under *Gleichenia rotula*, HEER included specimens which are no doubt referable to *G. Nordenskiöldi:* the original, in the Stockholm Museum, of his fig. 4, Plate VIII (74) is certainly an example of that species. The sori of the specimen shown in HEER's fig. 1*b*, Plate IX, show projecting ridges as in the figure, but no veins and no annuli are preserved.

Gleichenites Nordenskiöldi was recorded by LESQUEREUX† from the Dakota flora, but the very imperfect material suggests a closer affinity to *G. Gieseckiana.* BERRY‡ figures a similar specimen from Kansas and expresses the opinion that it cannot be distinguished from *G. Zippei.* FONTAINE's *G. Nordenskiöldi*§ from the Potomac group is more like *G. Gieseckiana*, and a fragment from the Shasta formation of California named *G. Nordenskiöldi* (?)|| is indeterminable. A specimen figured by SCHENK¶ as *Alethopteris cycadina*, from the German Wealden beds, shows lobed pinnules as in *G. Nordenskiöldi.*

Localities.—Kaersuarssuk, Pagtorfik, Angiarsuit (loc. B.).

* HEER (82), Plate III, 3. *See* under *G. Waltoni*, p. 74.

† LESQUEREUX (83), Plate I, 1.

‡ BERRY (22[2]), Plate XLVII, 1.

§ FONTAINE (89), Plate XXI, 11.

|| FONTAINE in WARD (05), Plate LXV, 24–29.

¶ SCHENK (71), Plate XXXI, 2. *See* also SEWARD (11[2]), p. 664.

GLEICHENITES PORSILDI sp. nov. Plate 6, figs. 18, 19, 24, 27, 29–31; Plate 12, figs. 122, 124. Text-figs. 4–7.

Gleichenia rigida, HEER, *ex parte* (74), p. 43, Plate I, 1*b*, 5*a*, *b*; (82), p. 6, Plate II, 6, 7.
Aspidium Jenseni, HEER, *ex parte* (82), p. 31, Plates XXIX, 4; XXX, 1–6.
Aspidium Schouwii, HEER (82), p. 31, Plate XXXII, 10.
Cyathea fertilis, HEER, *ex parte* (82), p. 21, Plate XXXI, 3–6.
Cyathea Hammeri, HEER, *ex parte* (82), p. 22, Plates XXXI, 2; XXXV, 4.
Cyathea angusta, HEER (83), p. 1, Plate L, 5. I have not seen the original of fig. 4.
Gleichenia Gieseckiana, HEER, *ex parte* (83), p. 7, Plate L, 1–3.
Gleichenites sp. SEWARD (25), p. 235, Plate A, figs. 7, 8.

The type-specimen of *Gleichenia rigida** in the Copenhagen Museum is imperfectly preserved, but I was able to detect traces of sporangia and anastomosing veins; it is undoubtedly a piece of a *Laccopteris*.† The fossils subsequently referred by HEER to *G. rigida* are true Gleichenias and identical with *G. Porsildi*. The name *rigida*, having been originally given to a specimen generically distinct from those subsequently included under that designation, must be reserved for the type to which it was first applied. I have therefore renamed the species *Gleichenites Porsildi* after Mr. MORTEN PORSILD.

One of the specimens in the Copenhagen Museum, referred by HEER to *Aspidium Jenseni*, shown in his fig. 4, Plate XVI (82), has falcate pinnules almost covered with sporangia, and is not accurately represented: it may be specifically identical with the Fern named by HEER *Pteris Albertsii* (DUNK.).‡ The specimens shown in HEER's Plate XXX, 1 and 4, are characterised by very oblique lateral veins and agree closely with the pinnules seen in my figs. 27, 27A.

Under *Gleichenia Gieseckiana*, HEER included impressions from Pâtût which are certainly distinct from that species as he originally defined it. The original of his fig. 1, Plate L (83), has very oblique veins: that shown in his fig. 3, Plate L, has a coiled bud, but the veins are not visible.

I have elsewhere§ discussed at some length the affinities of the specimens assigned by HEER to *Cyathea fertilis*, *C. Hammeri*, and *C. angusta*: the fossils so named belong, with few exceptions, to a single species of *Gleichenites*, and I include them in *G. Porsildi*. The exceptions are the specimens exhibiting the venation of *Laccopteris* represented inaccurately in HEER's figs. 1 and 7, Plate XXI (82).

In habit the fronds of *Gleichenites Porsildi* present a remarkably close resemblance to those of some recent species, *e.g.*, *Gleichenia glauca* (THBG.), *G. sordida* (COP.), *G. pectinata* (WILLD.) and others of the section Dicranopteris. The primary rachis, which may be 5 mm. broad (Plate 6, figs. 29, 31), gives off two divergent branches, bare of pinnæ in the lower portion (fig. 18, Plate 6); and in the wide angle of the fork there is either a bud or a bud-scar, or an axis has been developed, no doubt after a resting period, as a prolongation of the main rachis (figs. 29, 31*e* and *f*). As in recent species there is a clearly

* HEER (68), Plate XLIV, 1.
† *See* page 80.
‡ HEER (82), p. 29.
§ SEWARD (25), p. 235.

defined discontinuity between the portions of the main axis above and below the dichotomy, and this is emphasised by the presence of a curved ridge immediately below the fork, where the upper end of the rachis is slightly swollen. In some examples a roughness on the carbonised impression of the basal part of the prolongation of the primary axis above the fork suggests scars of protective scales or modified pinnules (*cf.* Plate 5, fig. 13 : *G. Gieseckiana*). The forked axis from Pâtût reproduced in fig. 108, Plate 11, which I have provisionally named *Caulinites gleichenioides*, presents, except in its much greater dimensions, a striking resemblance to a rachis of *Gleichenia :* HEER, on very slender evidence, referred an axis 1·4 cm. broad from Spitsbergen* to *Gleichenia Zippei.*

The carbonised pieces of rachises shown in fig. 31, Plate 6, about half natural size, are a few of a large number obtained from a thin bed of carbonised plant fragments interbedded with sandstone at Skansen (fig. F, Plate 4). There is no proof of the specific identity of these rachises with the fronds of *G. Porsildi* reproduced in figs. 18, 19, 24, 29 ; but the occurrence in the Skansen bed of large pinnules (text-fig. 7, C) agreeing closely with those of *G. Porsildi* is significant. The slender axes shown in figs. 23, 31*a* may belong to another species.

The specimen of which a part is reproduced in fig. 19, Plate 6, lacks both base and apex : it is 20 cm. long. Linear pinnæ are given off alternately and approximately at right-angles from a comparatively slender rachis, and may reach a length of 10 cm. or more. Specimens from Ritenbenk's coal-mine, recently received from Mr. PORSILD, and which I include in this species, demonstrate the occurrence of pinnæ more than 20 cm. long, bearing pinnules 2·5 cm., and occasionally 3 cm. long with a breadth of 6 mm. The forked example shown in fig. 124, Plate 12, with shorter pinnules, is associated with pinnæ bearing pinnules 2·5 cm. in length. It may be possible, when more material has been found, to separate the forms with longer pinnules from those of the type shown in fig. 19, but at present such separation would be purely artificial and not in harmony with the range in size shown by recent species.

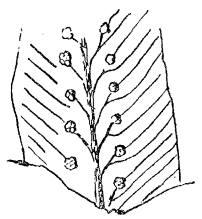
The pinnules of *G. Porsildi* taper gradually to an obtuse apex and are separately attached : in the specimen reproduced in fig. 124, Plate 12, the pinnules are slightly convex and appear to be fairly thick. Fig. 18, Plate 6, shows portions of two branches connected below with the main rachis, and, at the left-hand upper margin of the photograph, part of a pinna is attached to the rachis. On the larger impressions the venation is not always visible, but it is shown distinctly in text-figs. 4, 5, 7 C, and in figs. 27A, 30A, Plate 6 : the lateral veins are oblique and once forked.

Fertile specimens are represented by those assigned by HEER to *Cyathea fertilis* and *C. Hammeri*, and by similar impressions from Ritenbenk's coal-mine. I have elsewhere† described the sori of HEER's figured specimens. A fertile pinnule from Ritenbenk's coal-mine is seen in fig. 122, Plate 12, and another from the same locality is shown in text-fig. 5 : the sori, 1·8 mm. in diameter, are circular or polygonal and contain numerous sporangia (fig. 122, Plate 12). Clusters of spores were isolated from some of the sori.

* HEER (76), Plate XXXII, 7.

† SEWARD (25).

There is a marked contrast in the appearance of fertile pinnules, which unquestionably belong to the same species and occur in close association. Some pinnules are characterised by small depressions or small groups of sporangia above the anadrome branch of a lateral vein (text-fig. 4); and are identical with a fertile pinnule figured by HEER as *Aspidium Jenseni.** Pinnules exhibiting this appearance are seen from below. On the other hand, some pinnules are almost covered by large sori in two rows, as illustrated in my Belgian paper† and as shown in text-fig. 5 and fig. 122, Plate 12. These are seen from the upper side, the soral outlines being impressed on the covering lamina on which the veins are clearly seen (text-fig. 5).



TEXT-FIG. 4.—*Gleichenites Porsildi* sp. nov. × 3. Cast of lower surface of fertile pinnule. Drawn by Mr. T. M. HARRIS. From Ritenbenk's coal-mine. (V. 19,043.)

Associated with the rachises in the black band at Skansen were beautifully preserved sporangia (figs. 20, 21, Plate 6). In the wall of that shown in fig. 21 the cells converge towards the more rounded end, which was probably attached to the receptacle. There is a suggestion of a line of dehiscence in fig. 21: this sporangium agrees in the position of the annulus, which is complete, and in the relation of the annulus to the point of attachment with one of *Gleichenia dichotoma* figured by BOWER,‡ but it differs in its larger size and in the greater number of wall-cells, features in which it recalls the sporangia of *G. circinata* Sw. The fossil sporangium is 0·92 mm. long. Fig. 20 shows one of several dehisced and partially collapsed sporangia. These detached sporangia cannot be definitely referred to *G. Porsildi*, but I have little hesitation in assuming identity: they are larger than those of *G. Nordenskiöldi*, the sporangia of which are larger than those of *G. Gieseckiana*.

TEXT-FIG. 5.—*Gleichenites Porsildi.* × 5. Upper face of pinnule showing sori and veins. Drawn by Mr. T. M. HARRIS. Ritenbenk's coal-mine. (V. 19,020.)

Sections were cut of some of the rachises from Skansen after softening in phenol. Text-fig. 6 was drawn by Mr. WALTON from a much compressed transverse section prepared by Mr. HOLTTUM; in text-fig. 7, A, the effects of distortion have been eliminated by halving the horizontal dimensions and multiplying the vertical dimensions by four. The arrangement of the vascular tissue and the sclerenchyma is very similar to that in *Gleichenia dichotoma*. BOODLE§ states that in *G. dichotoma* the structure of the petiolar strand is more like the type characteristic of the Gleichenia section of the genus. In the Cretaceous species we have, therefore, a point of contact with both sections. An enlarged

* HEER (82), Plate XXX, 6.

† SEWARD (25), Plate A.

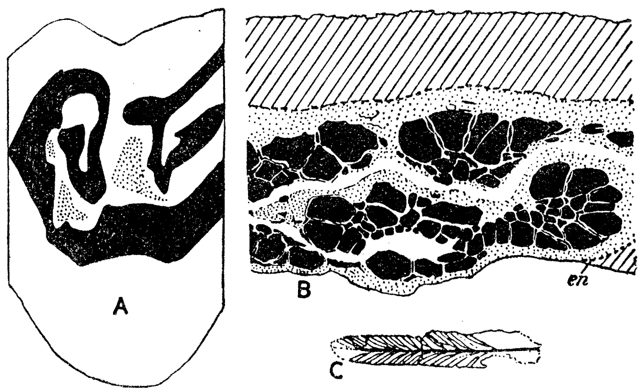
‡ BOWER (00), Plate II.

§ BOODLE (01).

portion of the compressed meristele is shown in text-fig. 7, B. Some of the tracheids have retained their original form, a fact due possibly to the presence in the cavities of some resistant material. The remains of an endodermal layer are seen at *en*, text-fig. 7, B.

TEXT-FIG. 6.—Transverse section of compressed rachis of *Gleichenites sp.* (*? Gleichenites Porsildi*). × 20. Dotted areas = sclerenchyma ; black = vascular tissue. Skansen. J. W. (V. 19,026.)

There are no records (so far as I know) of this Greenland species from other countries which can be regarded as satisfactory evidence of its geographical range. BERRY* figures a piece of pinna from the Cheyenne series of Kansas as *Gleichenia* (?) *bohemica*,



TEXT - FIG. 7. — A, B, Rachis of *Gleichenites*. A, Natural form of the meristele reconstructed from text-fig. 6. B, Enlarged pieces of the meristele. *en* = endodermis. J. W. (V. 19,027.) C, Pinnule of *Gleichenites Porsildi*, slightly enlarged. A-C, Skansen. Drawn by Mr. WALTON. (V. 19,010.)

and suggests a possible identity with a Greenland Fern named by HEER *Pecopteris bohemica*, CORD.† : the specimens in the Copenhagen Museum figured by HEER are too imperfect to be identified with certainty, but they are superficially at least similar to *G. Porsildi.* KRISHTOFOVICH‡ records *G. rigida* from Sakhalin Island.

Localities.—Angiarsuit (loc. B), Upernivik Island, Pâtût, Igdlukunguak, Ritenbenk's coal-mine, Skansen.

MATONINEÆ.

Laccopteris (PRESL.).

In 1921, several well-preserved and for the most part fertile impressions were collected at Kaersuarssuk, exhibiting the characters of *Laccopteris.* No mention is made by HEER of the occurrence of the genus in Greenland floras, though he compared a pinna referred to *Pecopteris bohemica* CORD.§ with *Matonidium.* An examination of some of the specimens in the Copenhagen Museum, figured by HEER as *Cyathea Hammeri,* revealed traces of

* BERRY (22^2), Plate XLVII, 2.

† HEER (74), Plate XXVI, 17.

‡ KRISHTOFOVICH (18) p. 27.

§ HEER (74), Plate XXVI, 17A.

anastomosing veins, while most of those included in *Cyathea* are undoubtedly Gleicheniaceous. HEER's supposed species of *Cyathea* are more fully discussed and illustrated in a recently published paper.*

The Greenland Ferns on which HEER founded the genus *Nathorstia* were thoroughly investigated by NATHORST,† who described the sori as synangia and found no indication of the presence of annulate sporangia. Subsequently examples of the same generic type were described by HALLE‡ from Patagonia, showing circular groups of spore-containing compartments identical with those described by NATHORST. A recent examination of HALLE's material at Stockholm brought to light faint indications of parallel ridges on some of the sori highly suggestive of impressions of annulus cell-walls; and I am inclined to think that the regular ridges seen in some of NATHORST's figures may also be attributed to annuli.

In habit and in venation *Nathorstia* and *Laccopteris* are identical and, as I have elsewhere stated, there is reason to believe that the supposed synangia of *Nathorstia* are not essentially distinct from the sori of *Laccopteris*: the walls of the closely packed sporangia have not been preserved, only impressions of annulus cells are occasionally seen. It is difficult to believe that fronds identical in habit, in venation, and in the form and disposition of the sori belong to Ferns which are members of different families.

Unfortunately none of the specimens collected in 1921 from Angiarsuit, the locality from which the larger examples of the *Nathorstia* type were obtained, throw any light on the structural details of the sori. The piece of pinna shown in fig. 58, Plate 8, is undoubtedly identical with *N. angustifolia*, HEER, and it differs from impressions found at Kaersuarssuk (fig. 48) only in the slightly broader form of the pinnules. The sori of some of the Kaersuarssuk specimens are seen to be composed of annulate sporangia (figs. 59, 60), but those on the pinnæ from Angiarsuit, which occur in sandstone, are not well enough preserved to show any details. I include both sets of fossils in *Laccopteris rigida* (HEER), and believe them to be inseparable from *Laccopteris Dunkeri*, SCHENK. I admit that the structure of the sori described by NATHORST and by HALLE in *Nathorstia* differs in some respects from that of the sori typical of *Laccopteris*, but this difference is, in my opinion, probably the result of preservation and not an expression of any essential difference in their position among the Filices.

LACCOPTERIS RIGIDA (HEER). Plate 8, figs. 48–56, 58–60, 62. Text-fig. 8.

Gleichenia rigida HEER, *ex parte* (68), p. 80, Plate XLIV, 1, 1*b*.
Laccopteris Dunkeri SCHENK (71), p. 219, Plate XXIX, 3–5.
Nathorstia angustifolia HEER (74), p. 7, Plate 1–6; (80) p. 7, Plate I, 1–6.
Cyathea Hammeri HEER, *ex parte* (82), Plate XXXI, 1, 7.

The type-specimen at Copenhagen of HEER's *Gleichenia rigida* from Kûk, though very imperfect, shows traces of sporangia and clear indications of anastomosing veins;

* SEWARD (25).
† NATHORST (08).
‡ HALLE (13), Plate XX.

it is unquestionably a *Laccopteris* and not a *Gleichenites*. The piece of pinna shown in my fig. 50 agrees very closely with HEER's type-specimen. A comparison of specimens of the European species *Laccopteris Dunkeri*, especially some large examples from Quedlinburg in the Richter collection at Stockholm (fig. 125, Plate 12, half nat. size) with the Greenland plant did not enable me to discover any distinguishing features.

The fertile specimens from Kûk on which HEER* founded *Danæites* (afterwards *Nathorstia*) *firmus* are not correctly represented in his figure. The sori are more circular than in the drawing, and anastomosing veins can be seen; the distal end of the pinnule is free from sori, as shown in my figures. As NATHORST pointed out, and an examination of the Stockholm specimens confirms his statements, the fossils figured by HEER in 1874† as *Danæites firmus* differ generically from the type in their Tæniopteroid venation. The true *Danæites firmus*, subsequently transferred to *Nathorstia*, differs from *Laccopteris Dunkeri* only in the slightly greater breadth of the pinnules, so far at least as can be seen in specimens showing no microscopic details. For the present I prefer to speak of HEER's *Nathorstia firma* as *Laccopteris Dunkeri* var. *firma*.

An examination of the specimens on which HEER founded *Nathorstia angustifolia* failed to reveal any features in which they differ from *Laccopteris Dunkeri*. It is noteworthy that HEER described the pinnæ of his Greenland type as agreeing in size and form with *L. Dunkeri*. The impression shown in HEER's Plate I, fig. 2 (80), has anastomosing veins and sori identical with those on the pinna reproduced in my fig. 58.

In 1886, NATHORST‡ figured a specimen from Atanikerdluk as a new Fern, and afterwards named it *Nathorstia latifolia*. The sori, were described as consisting of 18–21 compartments forming a synangium comparable to that of *Christensenia* (*Kaulfussia*). In habit, in the form and disposition of the sori, and, as I have seen in NATHORST's specimens, in venation *Nathorstia latifolia* is a typical *Laccopteris*.

The pedate habit of the Greenland *Laccopteris* is illustrated by the specimens reproduced in figs. 48, 49, 54, and 55, Plate 8; the branching recalls that of the recent species *Matonia pectinata* R. Br. and *M. Foxworthyi* Cop. The pinnæ must have been considerably more than 15 cm. long, bearing pinnules with margins more or less recurved and reaching a length of at least 4 cm. (figs. 53, 58). The lamina is continuous, and there is a prominent midrib giving off anastomosing veins (text-fig. 8A) forming a series of meshes parallel to the midrib. Below the specimen shown in fig. 55 there is a piece of unbranched axis 7·5 cm. long, which is no doubt part of a longer petiole. Most of the specimens are fertile; the circular sori form a row on each side of the midrib, and the apical part of the pinnule is sterile. In some European examples of this species sori extend almost to the apex. The sori are represented either by circular depressions (fig. 62) or by prominent bosses with a central receptacle (fig. 53A). Some sori showing well-preserved sporangia of the *Laccopteris* type are seen in figs. 50, 60, and in text-fig. 8, C. Text-fig. 8, B, shows a plexus of vascular bundles below a sorus.

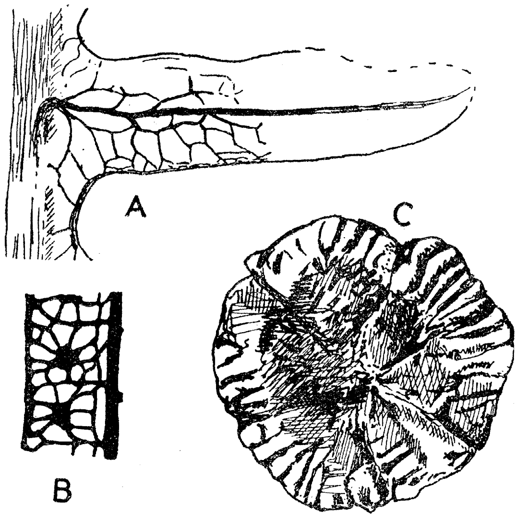
* HEER (68), Plate LIV, 20–22.

† HEER (74), Plates IX, 1A; XII, 1, 2.

‡ NATHORST (86), p. 262.

In the Kaersuarssuk specimens (all those reproduced on Plate 8, except figs. 56, 58) the pinnules are usually 3–4 mm. broad; in the specimens from Angiarsuit (fig. 56, 58) the pinnules reach a breadth of 6 mm.; in *Laccopteris Dunkeri* var. *firma* they are 8 mm. broad, and in *Laccopteris* (*Nathorstia*) *latifolia* still broader.

Localities.—Kaersuarssuk, Angiarsuit.



TEXT-FIG. 8.—*Laccopteris rigida* (HEER). A, Pinnule, × 6. B, Veins below a sorus (V. 19,011), × 10. C, Sorus (V. 19,019), × 30. Kaersuarssuk. J. W.

DIPTERIDINÆ.

Hausmannia DUNKER.

Hausmannia sp. Cf. *Hausmannia Kohlmanni* RICHTER.

I have elsewhere* figured the specimen from Ikorfat named by HEER *Dictyophyllum Dicksoni*† and compared it with the Quedlinburg species described by RICHTER.‡

Hausmannia sp.

The smaller, less distinct leaf from Kûk, named by HEER *Protorhipis cordata*,§ has been redrawn and referred with some hesitation to *Hausmannia*.

FILICES INCERTÆ SEDIS.

Sphenopteris BRONGNIART.

This generic name is adopted for some Greenland Ferns in preference to names implying more knowledge of affinity than we at present possess. The species *Sphenopteris* (*Onychiopsis ?*) *psilotoides* (STOKES and WEBB) is by far the most abundant, but no fertile examples have been found in the Greenland strata. Some comparatively small specimens, similar in habit, but distinguished by broader and less deeply divided pinnules, are assigned to *Sphenopteris* (*Onychiopsis*) *Johnstrupi* HEER. It is difficult to draw a line between the two forms, and it may be that they belong to one specific type. A third form, represented by a few imperfectly preserved impressions is provisionally referred to *Sphenopteris dentata* (VEL.). When more material is available it may be possible to define more precisely the relationship of these, presumably closely allied, Ferns both to one another and to recent genera.

SPHENOPTERIS (ONYCHIOPSIS ?) PSILOTOIDES (STOKES and WEBB). Plate 7, figs. 36, 37, 42, 44–47. Fig. 47 is a reproduction of an English Wealden specimen.

Hymenopteris psilotoides STOKES and WEBB (24), p. 424, Plate XLVI, 7.

Sphenopteris Mantelli BRONGNIART (28^2), p. 50.

* SEWARD (25), Plate A, fig. 3.

† HEER (74), Plate III, 9.

‡ RICHTER (06), Plate I, 1–3.

§ HEER (82), Plate III, 11.

Onychiopsis Mantelli NATHORST (90^2), p. 15 ; SEWARD (94), p. 41, Plates II, 1 ; III, 1–4.

Onhyciopsis elongata (GEYL.), SEWARD (94), p. 55, Plate II, 5.

Sphenopteris (*Onychiopsis ?*) *psilotoides* HALLE (13), p. 29, Plate II, 9, 10.

Asplenium Johnstrupi HEER, *ex parte* (74), p. 32, Plate I, 6, 7.

Dicksonia Johnstrupi HEER (82), p. 1, Plate II.

Asplenium Dicksonianum HEER (74), p. 31, Plate I, 1–5 ; (82), pp. 3, 33, Plates II, 2 ; XXXII, 1–8.

Asplenium Nordenskiöldi HEER (74), p. 33, Plate II, 17*a*, *b*.

Asplenium Foersteri DEB. and ETT. HEER (74), p. 93, Plate XXVI, 1.

Asplenium Pingelianum HEER (82), p. 4, Plate XLVIII, 9.

Asplenium puilaskense HEER (83), p. 53, Plate CVII, 4*a*.

Onychiopsis Goepperti (GOEPP.) BERRY (11^3), p. 281, Plate XXXIV, 3, 4.

The history of this Lower Cretaceous Fern, with lists of synonyms, has been given by several authors and need not be repeated. The discovery of fertile specimens in England, Bohemia, and Japan led to the substitution of *Onychiopsis* for *Sphenopteris ;* but as no trace of sori or sporangia has been found on material from Greenland, I follow HALLE* in the use of the provisional designation. The vegetative features agree closely with those of some recent species of *Onychium*, and the probability is that the resemblance is an expression of affinity, though a very similar form of frond is represented by *Thyrsopteris elegans* KZE. and some other ferns.

Some of the specimens in the Copenhagen and Stockholm collections figured by HEER as *Asplenium*, or *Dicksonia*, *Johnstrupi* are indistinguishable from his *Asplenium Dicksonianum* and from the impressions now included in *Sphenopteris psilotoides ;* the type-specimen of *S. Johnstrupi* has broader pinnules and is, I believe, specifically identical with the fossils shown in Plate 7, fig. 33 and Plate 10, figs. 105, 106. HEER'S *Asplenium Dicksonianum*, many of the figured examples of which I have examined, is identical in habit with *S. psilotoides*. Specimens from the Amboy clays† and other Cretaceous series in America have been referred to *A. Dicksonianum*, but they differ from HEER'S Fern in the greater breadth of the segments and are, in part at least, referable to *Sphenopteris Johnstrupi*. There is no justification for the use of the generic name *Asplenium*, and, as BERRY‡ has pointed out, it is probable that among the numerous American records of *Asplenium Dicksonianum* more than a single type are included.

The type-specimen of *Asplenium Nordenskiöldi* in the Stockholm Museum and the fragment included by HEER in *A. Foersteri* are probably examples of *Sphenopteris psilotoides*. HEER'S *A. puilaskense* would probably not have been separated from his *A. Dicksonianum* had he not, incorrectly as I think, regarded the Puilasok beds as Tertiary.§

Several of the Potomac fossils assigned by FONTAINE|| to *Thyrsopteris*, without any

* HALLE (13).

† NEWBERRY (95).

‡ BERRY (22^2), p. 207.

§ See *postea*, pp. 122, 131.

|| FONTAINE (89).

evidence of affinity to the recent genus, are undoubtedly identical with the Greenland Fern. BERRY,* who has revised FONTAINE's determinations, refers some of the Potomac specimens to *Onychiopsis Goepperti* (SCHENK), a species assigned by me to a new genus *Ruffordia*† because of the discovery of fertile specimens in the English Wealden beds, which suggested, though they did not prove, affinity to the Schizæaceæ. HALLE's discovery‡ of sporangia on the same species from Russian Manchuria supplied the proof. I have no hesitation in referring BERRY's specimens to *Sphenopteris psilotoides*. It is not always easy, in the absence of fertile specimens, to distinguish between *Ruffordia Goepperti* and *S. psilotoides*, but so far no evidence has been obtained of the occurrence of *Ruffordia* in the Greenland flora.

The vegetative features of *Sphenopteris psilotoides*, as represented in the Greenland beds, are clearly shown in figs. 42, 44, 45, Plate 7; and the enlarged drawing, fig. 46, made from one of Mr. WALTON's preparations, illustrates the venation. A comparison of the Greenland Fern with the English Wealden frond reproduced in fig. 47 supports my contention that no distinction can be drawn between the Arctic and the European examples.

Localities.—Kaersuarssuk, Upernivik Island, Pagtorfik, Angiarsuit.

SPHENOPTERIS (ONYCHIOPSIS ?) JOHNSTRUPI HEER. Plate 7, fig. 33; Plate 10, figs. 105, 106.

Sphenopteris (*Asplenium ?*) *Johnstrupi* HEER, *ex parte* (68), p. 78, Plate XLIII, 7.

Jeanpaulia lepida HEER, *ex parte* (74), Plate II.

? *Sphenopteris grevilloides* HEER (74), p. 34, Plate XI, 10, 11.

Dicksonia groenlandica HEER (82), p. 23, Plate XXV, 8; (83), p. 2.

As already stated, the specimens included under this name may, in part at least, be ultimately found to be forms of *Sphenopteris psilotoides*. The fragment from Upernivik Naes shown in fig. 33 is referred to *S. Johnstrupi*, while the pinna from the same locality shown in fig. 36 is included in *S. psilotoides*; no well-defined line of demarcation seems to be indicated. HEER's type-specimen of *S. Johnstrupi* from Kûk, in the Copenhagen Museum, is probably specifically identical with some of the fragments from Aachen named by DEBEY and ETTINGSHAUSEN§ *Asplenium Foersteri* and *A. Brongniarti*, but the material is too incomplete to be determined with certainty. Most of the specimens in the Stockholm Museum figured by HEER as *Jeanpaulia lepida* are indistinguishable from his *S. Johnstrupi*. The fossil represented in HEER's fig. 9, Plate II (74), has been redrawn and reproduced in Plate 10, fig. 105.

Specimens referred by HEER in 1882 to *Sphenopteris lepida* are, I think, referable to *S. psilotoides*.

Fig. 106, Plate 10, represents a specimen from Pâtût in the Stockholm Museum, which appears to be identical with HEER's *Dicksonia groenlandica* from the same locality; it

* BERRY (11), p. 325.

† SEWARD (94), p. 75.

‡ HALLE (21).

§ DEBEY and ETTINGSHAUSEN (59), Plate II.

agrees closely with many of the American examples assigned to *Asplenium Dicksonianum*. The type-specimen of HEER'S *Sphenopteris grevillioides* in the Stockholm Museum is hardly determinable, but it may be a fragment of *S. Johnstrupi ;* NATHORST* compares it with a Fern described by him from Spitsbergen as *Sphenopteris* (?) *de Geeri*. A Potomac species figured by BERRY† as *Onychiopsis latiloba* (FONT.) is similar in habit to *S. Johnstrupi*, but it agrees more closely with the Greenland specimens referred to *Sphenopteris dentata* (Vel.).

Localities.—Upernivik Island, Pâtût, Ikorfat, Atanikerdluk.

SPHENOPTERIS DENATA (VELENOVSKY). Plate 7, figs. 39, 39A.

Kirchnera dentata VELENOVSKY (88), p. 16, Plate II, 12–16.

Sphenopteris latiloba FONTAINE (89), p. 90, Plates XXXV, 3–5; XXXVI, 4–9; XXXVII, 1.

Onychiopsis latiloba (FONT.), BERRY (11), p. 273, Plate XXXIII, 1, 2.

This species, originally described by VELENOVSKY from the Perucer beds of Bohemia, may be specifically identical with specimens, from the same flora, which he named *Thyrsopteris capsulifera*,‡ including a piece of a fertile frond with sori of the *Onychium* type. In addition to *Sphenopteris latiloba*, FONTAINE figured pieces of fronds identical in habit with that species as examples of *Thyrsopteris, e.g., T. divaricata*, which with other supposed species of the genus is included by BERRY in his synonymy of *Onychiopsis latiloba*.§

Specimens in the Quedlinburg collection in the Stockholm Museum labelled *Kirchnera dentata* agree exactly with the Greenland fossil shown in fig. 39. An examination of the type-specimen of *Asplenium Naukhoffianum* HEER|| in the Stockholm Museum showed that the drawings are inaccurate; the segments are more oval than HEER'S figures indicate: it is very similar in habit to *S. dentata*.

A slender axis bears alternate, obliquely set, ovate-linear segments of thin texture; the upper segments are entire and the lower are lobed. The lamina is decurrent and the veins are inclined at an acute angle; they are once-forked (fig. 39A).

Superficially this species resembles some Cretaceous fossils included by authors in *Thinnfeldia, e.g., T. arctica* HEER,¶ from Spitsbergen, BERRY'S *T. Fontainei*,** and *T. granulata* FONT.†† There is, however, no adequate reason for including these fossils in *Thinnfeldia*. ANTEVS,‡‡ in his valuable paper on *Thinnfeldia* and *Dicroidium*, states that *Thinnfeldia* does not occur in North America or in Greenland. Comparison may also be made with specimens from Upper Jurassic beds in Scotland, named by me (though

* NATHORST (97), Plates II, 8; VI, 6.

† BERRY (11[3]), Plate XXXIII, 1, 2.

‡ VELENOVSKY (88), Plate I, 6–12.

§ BERRY (11[3]), p. 273.

|| HEER (80), Plate I, 9–12.

¶ HEER (74), p. 123; NATHORST (97), Plate I, 23, 24.

** BERRY (11[3]), Plate XL, 4–7.

†† BERRY (11[3]), Plate XL, 1, 2.

‡‡ ANTEVS (14).

perhaps incorrectly) *Thinnfeldia rhomboidalis* ETT.* The Wealden species *Alethopteris Huttoni* (SCHIMP.) as figured by SCHENK† and *Pachypteris dalmatica* KERN‡ are other comparable species.

Locality.—Kaersuarssuk.

SPHENOPTERIS JÖRGENSENI (HEER).

Phegopteris Jörgenseni HEER (82), p. 32, Plate XXX, 1–3.

Phegopteris Kornerupi HEER (83), p. 3, Plate XLIX, 3.

Raphælia neuropteroides DEB. and ETT. HEER (83), p. 6, Plate LX, 3.

Phegopteris Grothiana HEER (83), p. 3, Plate XLVIII, 12, 13.

At Igdlukunguak, the locality of HEER'S *Phegopteris Jörgenseni*, we obtained several imperfectly preserved impressions of portions of fronds identical with the type-specimen in the Copenhagen Museum. Other examples were found at Pâtût, and a comparison with these with HEER'S type-specimen of *Phegopteris Kornerupi* from the same locality leads me to include that species as a synonym of *Sphenopteris Jörgenseni ;* the veins are obscure in HEER'S type, and there are no signs of sori. The Aachen fragments named by ETTINGSHAUSEN *Raphælia neuropteroides*,§ though possibly identical with the Greenland plant, are too imperfect to be determined.

The lamina of *S. Jörgenseni* is either entire, more or less crenulate, or divided into broad, obtuse segments, intermediate in venation between *Sphenopteris* and *Cladophlebis*. It may be that a specimen from the Kootanie formation included by FONTAINE in *Cladophlebis falcata montanensis*‖ is referable to *S. Jörgenseni*.

Localities.—Igdlukunguak, Pâtût.

Cladophlebis BRONGNIART.

CLADOPHLEBIS OERSTEDI (HEER). Plate 7, figs. 32, 34, 35. Text-fig. 9.

Aspidium Oerstedi HEER (82), p. 30, Plate XXXV ; (83), p. 2, Plates XLVIII, 11 ; XLIX, 1, 2.

Pecopteris argutula HEER (74), p. 96, Plate XXVI, 8.

Pecopteris borealis BRONGN. HEER, *ex parte* (82), p. 5, Plate II, 9*c*, 10.

Aspidium montanense FONTAINE (92), p. 490, Plates LXXXII, 1–3 ; LXXXIII, 2, 3.

This species was founded on several specimens from Igdlukunguak. The fossils figured by HEER from other localities in 1883 may belong to the same species, but this is not certain. Under *Pecopteris borealis* HEER included specimens in the Copenhagen Museum which are in all probability examples of *Gleichenites Gieseckiana*, and others which are identical with *Cladophlebis Oerstedi*. In addition to *Aspidium montanense* it is possible that smaller specimens from the same locality referred by KNOWLTON¶

* SEWARD (11^2), Plate IV, 66.

† SCHENK (71), Plate VIII, 1.

‡ KERNER (95).

§ DEBEY and ETTINGSHAUSEN (59).

‖ FONTAINE in WARD (05), Plate LXXI, 14–20.

¶ KNOWLTON (19), p. 247.

to *A. Lakesii* (LESQ.), and subsequently named *Dryopteris arguta*, may be identical with the Greenland Fern, but LESQUEREUX's original specimens from Colorado, which he named *Sphenopteris Lakesii*,* belong to a larger type of frond.

The habit of the bipinnate frond of *Cladophlebis Oerstedi* is shown in figs. 32, 34 and 35, Plate 7. Sub-opposite or alternate pinnæ are given off at an acute angle from a comparatively slender rachis; the pinnules, confluent at the base (text-fig. 9), are inclined at an acute angle and may be slightly falcate; they are entire, serrate, or divided into lobes. The lateral veins are simple or once-forked. In the smaller pinnæ (fig. 32) the lamina is divided into acute segments, while in larger pinnæ the segments are relatively broader and less sharply pointed.

TEXT-FIG. 9.—*Cladophlebis Oerstedi* (HEER) × 3. Kaersuarssuk. J. W.

Localities.—Kaersuarssuk, Pagtorfik.

CLADOPHLEBIS FRIGIDA (HEER).

Pecopteris denticulata BRONGN. HEER (74), p. 95, Plate XXVI, 7, 7*b*.

Osmunda Obergiana HEER (74), p. 98, Plates XXVI, 9; XXXII, 7*a*.

Pteris frigida HEER (82), pp. 3, 25, Plates II, V, X–XIII, XVI; (83), p. 51, Plate CII, 8.

The specimens collected in 1921 consist of a few pieces of pinnæ which add nothing to our knowledge of the species as described by HEER. I have elsewhere† described well-preserved examples of *Pteris longipennis* HEER, pointing out that there is no justification for the use of the generic name *Pteris*, and that it is impossible to draw a line between his *P. frigida* and *P. longipennis*. In place of the latter name I suggest *Cladophlebis frigida* var. *longipennis*.

HEER at first referred the Greenland Fern to *Pecopteris denticulata*, and afterwards decided that the more abrupt apices of the pinnules in the Arctic plant and the generally larger and relatively shorter form afforded grounds for specific separation. In 1900‡ I included both *Pteris frigidia* and *P. longipennis* as synonyms of *Cladophlebis denticulata*, and after examining many of HEER's specimens and others subsequently collected I am not convinced that any clearly differences can be recognised. The average size of the pinnules of the Greenland examples is rather larger than in the common Jurassic species, and another more cogent reason for the retention of the specific name *frigida* is the difference in geological age between the Arctic and European Ferns. The type-specimen of *Osmunda Obergiana* at Stockholm is, I think, a piece of *Cladophlebis frigida*, and some of the specimens referred by HEER to *Pteris Albertsii* (DUNK.)§ may be small forms of *C. frigida*. It is at least certain that fronds agreeing generally with the Jurassic type *Cladophlebis denticulata* (BRONGN.) occur abundantly in Jurassic, Lower Cretaceous, and even in Rhætic floras. With few exceptions we know nothing of their soral characters;

* LESQUEREUX (78), Plate II, 1.

† SEWARD (25), p. 238.

‡ SEWARD (00), p. 134.

§ HEER (82), Plate XLVI, 23.

it is impossible to give expression by any satisfactory definitions to one's belief that in BRONGNIART'S designation are included several species and, perhaps, more than one generic type.

Among the many records of Ferns which cannot be distinguished from *C. frigida* reference may be made to Potomac forms figured by FONTAINE,* and to specimens from Upper Jurassic rocks in Scotland.†

The linear, acuminate pinnæ bear contiguous pinnules, which vary considerably in size and shape; some are linear and reach a length of over 2 cm.; others are broadly deltoid. The lamina is thin, straight or falcate, and the margin is usually serrate, especially in the distal portion. The lateral veins arise at an acute angle and are once-forked.

Locality.—Atanikerdluk.

CLADOPHLEBIS ARCTICA (HEER). Plate 8, figs. 61, 61A.

Osmunda arctica HEER (83), p. 7, Plates XLIX, 4–7; L, 6, 8.

Specimens from Pâtût in the Copenhagen Museum are identical in the form of the pinnæ and pinnules with those from the same locality reproduced in fig. 61. As seen in fig. 61A, the basal lateral vein is doubly forked, and this may be a character of some importance: the edge of the lamina is slightly torn and one cannot be certain whether it was entire. There is a very close resemblance between the linear pinnæ of uniform breadth, with their obliquely deltoid segments, assigned to *Cladophlebis arctica* and some pinnæ of *C. frigida* from Atanikerdluk. The possibility of specific identity is suggested also by some examples in the Stockholm Museum from Pâtût labelled *Osmunda arctica*, which show a transition from the short and broad to the more linear form of pinnule.

Locality.—Pâtût.

CLADOPHLEBIS HOLTTUMI sp. nov., Plate 8, figs. 57, 57A.

The specimen on which this species is founded is part of a frond with alternate branches given off at a wide angle; the pinnules are more or less deltoid and the venation (fig. 57A) is intermediate between *Sphenopteris* and *Cladophlebis*. The adaxial margin of the thin lamina is slightly contracted at the base, and a conspicuous feature is the strong curvature of the lamina of the basal pinnule on the lower side of each pinna (fig. 57). I name this type after Mr. HOLTTUM, who collected many of the Greenland plants.

An examination of fossils included by HEER in *Gleichenites acutiloba*‡ and *G. gracilis*§ showed that some of them differ from typical members of the genus in the venation of the pinnules and may be specifically identical with *C. Holttumi*. A more thorough inspection of HEER'S material is needed, but my impression is that some of the specimens with small pinnules referred by him to *Gleichenites* probably belong to another genus.

Localiy.—Kaersuarssuk.

* FONTAINE (89).

† SEWARD (11^2).

‡ HEER (74), Plate XXVI, 14.

§ HEER (74), Plate X, 6.

CLADOPHLEBIS SP. Cf. CLADOPHLEBIS BROWNIANA (DUNKER). Plate 7, fig. 38.

Fig. 38 shows part of a bipinnate frond characterised by a slender rachis and opposite or sub-opposite pinnæ. The pinnules are divided into short and relatively broad lobes and closely resemble those of *Cladophlebis Oerstedi:* the impression is obscure and no venation is seen. Though possibly a form of *C. Oerstedi*, the specimen differs in its more slender construction and in the less falcate pinnules. It agrees with *C. Browniana*,* a species with which ZEILLER† compared a Peruvian Wealden Fern, bearing Schizæaceous sporangia.

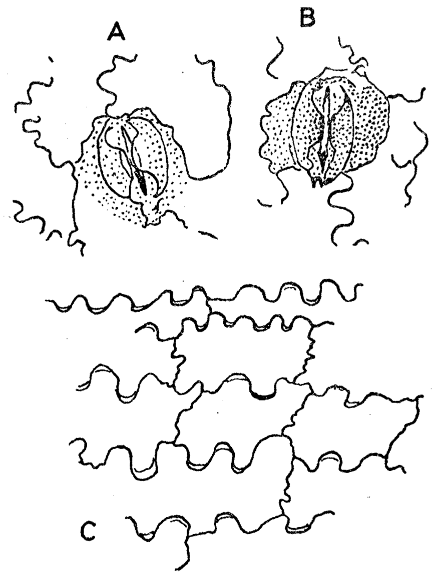
Locality.—Upernivik Naes.

PLANTA INCERTÆ SEDIS. *Tæniopteris* BRONGNIART.

TÆNIOPTERIS ARCTICA (HEER), Plate 7, figs. 40, 41. Text-fig. 10.

Tæniopteris (*Oleandra*) *arctica* NATHORST (97), p. 51.

The incomplete specimens shown in figs. 40, 41, bear a close resemblance to fronds of *Nilssonia*, but in epidermal characters they differ from all species of that genus the cuticular structure of which has been described.‡ Fig. 41 shows a fragment 7 mm. broad with a narrow median ridge and crowded prominent veins or folds in the lamina, unbranched except a few that are forked close to the median line. In the broader piece seen in fig. 40 the midrib is almost covered by the lamina. The largest specimen we found is an incomplete leaf 7 cm. long and 3·7 cm. broad. The upper epidermis of the specimen shown in fig. 40 consists of rectangular cells, while those on the lower surface have less regular outlines: the cells on both faces have sinuous walls (text-fig. 10, C). The stomata (text-fig. 10, A, B) agree in structure with those of certain species of *Tæniopteris*, *Dictyozamites*, and other members of the Bennettitales. Similarly the sinuous walls of the epidermal cells conform to the Bennettitalean type.



TEXT-FIG. 10. — *Tæniopteris arctica* (HEER). Stomata and epiderma cells. × 200. J. W. (V. 19,028.)

Dr. HAMSHAW THOMAS § has advanced weighty arguments in support of the view that some *Tæniopteris* leaves were borne on Bennettitalean stems. The Greenland specimens may belong to a plant allied to *Williamsoniella coronata* THOM., the species to which *Tæniopteris* leaves have been assigned.

* SEWARD (13), Plate XIII.

† ZEILLER (14), p. 7.

‡ THOMAS and BANCROFT (13).

§ THOMAS (15).

The specimens shown in figs. 40, 41 are narrower than those from Upernivik Island named by HEER *Nilssonia Johnstrupi*,* which are not as well preserved as the drawings suggest. Some of the impressions, in the Stockholm Museum, assigned by HEER to *Oleandra arctica* are undoubtedly identical with those we collected. Comparison may also be made with *Nilssonia bohemica* VEL.,† the Potomac species *Tæniopteris nervosa* (FONT.),‡ and *Anomozamites virginicus* FONT,§ also the Wealden species *Tæniopteris Beyrichii* (SCHENK),|| and some of the less divided forms of *Nilssonia Schaumburgensis* (DUNK).¶

Locality.—Angiarsuit (loc. A.).

PLANTA INCERTÆ SEDIS. *Phyllites* STERNBERG.

PHYLLITES SOCIALIS (HEER).

Pecopteris (*Pteris ?*) *socialis* HEER (82), p. 34, Plates VII, 4; VIII, 15; XXXII, 9.

Pecopteris Torelli HEER, *ex parte* (83), p. 53, Plates CII, 1–4; not fig. 5.

A few specimens were found at Kugssinek angnertunek identical in form with the larger impressions from the same locality named by HEER *Pecopteris socialis*. The largest example figured by him [(82), Plate XXXII, 9], which I examined at Copenhagen, is accurately represented; the leaf is bipinnate; in the upper part the lamina is continuous as a wing on the main axis, and the only veins visible are those shown in the illustration. Impressions from Igdlukunguak figured by HEER as *Pecopteris Torelli* differ in the simpler venation and in the form of the ultimate segments from that species as originally described** from the Tertiary flora of Atanikerdluk, and appear to be identical with *P. socialis*.

The absence of any finer venation may be an accident of preservation, but the available material furnishes no conclusive evidence of affinity and, provisionally, I adopt the non-committal term *Phyllites*.

Locality.—Upernivik Island.

Cycadophyta.

BENNETTITALES.

Pseudocycas NATHORST.

PSEUDOCYCAS STEENSTRUPI HEER. Plate 9, figs. 64, 67.

Cycas Steenstrupi HEER (82), p. 40, Plate V.

Pseudocycas Steenstrupi NATHORST (07), p. 8, Plate II, 10, 11.

The type-specimen of this species, from Upernivik Island, represented by an incomplete frond 52 cm. long, is perhaps the most impressive relic of the Greenland Cretaceous vegetation so far discovered. There is no justification for HEER's description of an

* HEER (82), Plate VI, 1–6.
† VELENOVSKY (85), Plate II, 25–28.
‡ BERRY (11^3), Plate LXXVII, 1.
§ FONTAINE (89), Plates XXX, 4; XXXI, 3.
|| SCHENK (71), p. 221.
¶ SEWARD (95), fig. 3A, p. 55.
** HEER (68), Plate II, 15.

imperfectly preserved specimen lying near the frond as a carpellary scale of a Cycad.* The drawing of the frond is fairly accurate, but that of the supposed carpel is wholly misleading.

NATHORST† substituted the generic name *Pseudocycas* for *Cycas* as the result of an investigation of the epidermal structure. More recently Miss HOLDEN‡ dealt with the epidermal characters of different species of *Pseudocycas*, and Prof. HALLE§ made further additions to our knowledge of the genus. The important point is that the fronds of *Pseudocycas* differ in important respects from those of *Cycas*.

The best specimen obtained in 1921 is reproduced in fig. 67; it is a partially carbonised impression 14 cm. long, bearing gradually tapering alternate pinnæ, some of which exceed 7 cm. in length and are 2 to 3 mm. broad. The pinnæ are attached by a slightly expanded base to the upper face of the rachis. A clearly defined ridge occupies the middle line of some of the pinnæ where the carbonised film has been removed. The apices of the pinnæ, seen in other specimens, are acutely pointed. Cuticular membranes did not add any facts to those published by NATHORST. The specimen shown in fig. 64 is probably a piece of a young frond in which the pinnæ are contiguous and more or less imbricate.

KRISHTOFOVICH|| compares some specimens from Sakhalin Island with this species. Fronds of similar habit have been described from British Columbia,¶ Bornholm,** England, Germany, and Portgual.

Localities.—Upernivik Naes, Kugssinek angnertunek.

PSEUDOCYCAS INSIGNIS NATHORST.

Cycas sp. NATHORST (86), p. 262, fig. 5.

Pseudocycas insignis NATHORST (07), p. 4, Plates I, 1–5; II, 1–9; III, 1.

Pseudocycas pumilio NATHORST (07), p. 7, Plate I, 6, 7.

This species was discovered in the black shale of Atanikerdluk,†† where several specimens were obtained in 1921. From this locality (though, according to NATHORST, from a slightly lower horizon) HEER had previously figured specimens which he named *Cycadites Dicksoni*.‡‡ These are probably identical with *Pseudocycas insignis*, but NATHORST found it impossible to examine the type-specimen microscopically.

Though practically identical in habit with *P. Steenstrupi*, *P. insignis* differs in the more prominent median groove on the pinnæ, which are rather more curved than those of the Upernivik species. The rachis of several of the examples collected in 1921 shows a transverse wrinkling like that in *P. Steenstrupi*.

* SEWARD (00), p. 274.

† NATHORST (07).

‡ HOLDEN (14).

§ HALLE (15).

|| KRISHTOFOVICH (18).

¶ BERRY (21).

** MÖLLER (03).

†† In the legend of fig. 617, of Vol. III of my 'Fossil Plants' [SEWARD (17), p. 562], it is incorrectly stated that a specimen reproduced from NATHORST is from the Lias of Hör.

‡‡ HEER (74), p. 99.

Specimens from British Columbia, believed to be Turonian in age, which DAWSON* named *Cycadites Unjiga* may, as BERRY suggests, be identical with the Greenland species.

Locality.—Atanikerdluk.

Ptilophyllum MORRIS.

PTILOPHYLLUM ARCTICUM (GOEPPERT). Plate 7, fig. 43.

Pterophyllum arcticum GOEPPERT (64), p. 174.

Zamites arcticus GOEPPERT (66), p. 134, Plate II, 9, 10. HEER (68), p. 82, Plates III, 14; XLIV, 5*c*.

Zamites brevipennis HEER (74), p. 67, Plate XV, 8–10.

HEER described many well-preserved fronds from Kûk, Ikorfat, and the neighbourhood of Angiarsuit, as species of *Zamites*, but, as I have elsewhere pointed out, they belong to the generic type *Ptilophyllum*.† The *Ptilophyllum* features are well shown in a drawing, lent to me by Prof. NATHORST for reproduction, of a specimen in the Stockholm Museum from Ikorfat.‡ GOEPPERT's specimens differ from that represented in fig. 43 in the slightly smaller segments and in the exposed rachis, whereas some of the specimens named by HEER *Zamites brevipennis* are identical in all respects with that found in 1921. An examination of HEER's figured specimens convinced me that there are no adequate grounds for the retention of *Zamites brevipennis* as a distinct type. HALLE§ has stated that HEER's "species" form a fairly continuous series of forms.

The regular crenulation on one side of the fragment seen in fig. 43 defines the rounded contours of the linear segments: the double boundary line on the edge indicates a xerophilous leaf. The continuous bases of the two rows of segments form a zigzag ridge along the middle line. No veins are visible. A double boundary line is also clearly seen on the edge of the specimen shown in HEER's fig. 9, Plate XV (74).

An identical form is recorded from the Kootanie formation as *Zamites montana* by DAWSON‖ and by FONTAINE¶ as *Z. arcticus*. Specimens, apparently of the same type, are figured by FONTAINE from the Black Hills as *Z. brevipennis*,** and as *Pterophyllum contiguum* SCHENK,†† from the Jurassic beds of Oregon. Species which are no doubt closely allied to the Greenland *Ptilophyllum* are recorded from places as remote as Graham Land, Australia, and Japan.

Locality.—Angiarsuit (loc. A.).

The specimens, in the Copenhagen Museum, figured by HEER as *Williamsonia cretacea*‡‡ are on the whole accurately represented by the drawings, but the preservation is too imperfect to enable one to determine the nature of the fossils with confidence. We found an obscure impression at Idglukunguak which is probably specifically identical

* DAWSON (83), Plate I, fig. 2.

† SEWARD (17), p. 525.

‡ *Ibid.*, p. 526.

§ HALLE (13^2), p. 57.

‖ DAWSON (85), Plate I, 6.

¶ FONTAINE, in WARD (05), Plates LXVIII, 1; LXXIII, 1–6.

** FONTAINE, in WARD (99), Plate CLXII, 10–13.

†† FONTAINE in WARD (05), Plate XIX, figs. 7–11.

‡‡ HEER (82), p. 59, Plates XII, 1; XIII, 9.

with HEER'S species from Atanikerdluk. The Greenland species may well be identical with *Palæanthus* (*Williamsonia*) *problematicus* (NEWB.)* from the Amboy Clays.

In another paper† on Greenland plants I have described three other members of the Bennettitales, *Ptilophyllum Heeri* NATH. (MS.) from Pâtût, *Pterophyllum concinnum*‡ HEER from Ikorfat, a species similar to *Pterophyllum* (*Anomozamites*) *Lyellianum* (DUNK.) from the Wealden series of North Germany, and *Otozamites Schenki* (HEER) from Kûk, a species originally named by HEER *Glossozamites Schenkii*.§

NILSSONIALES. *Pseudoctenis* SEWARD.

PSEUDOCTENIS LATIPENNIS (HEER).

Podozamites latipennis HEER (82), p. 42, Plates XIV, 1–9; XV, 2*a*, 3*b*.

I have recently|| given an account, with illustrations, of some of the specimens from Atanikerdluk referred by HEER to *Podozamites*, and have shown that they are portions of fronds of a *Pseudoctenis*, bearing a striking resemblance to *P. eathiensis* (RICH.),¶ from Upper Jurassic rocks in Scotland, to an English Wealden plant,** and a species described by HALLE†† from the Jurassic flora of Graham Land. Comparison may be made also with *Dioonites borealis* DAWS.‡‡ from Cretaceous beds in the N.W. Territory.

Ginkgoales.

Ginkgoites SEWARD.

GINKGOITES PLURIPARTITA (SCHIMPER). Plate 9, figs. 65, 66, 71, 74, 76 (?), 83, 83A, 84, 86. Text-figs. 11, A, E, F.

Cyclopteris digitata (BRONGN.). DUNKER (46), p. 9, Plates I, 8, 10; V, 5, 6; VI, 11. ETTINGSHAUSEN (52), p. 12, Plate IV, 2.

Baiera pluripartita SCHIMPER (69), p. 423, Plate XXXI, 12.

Baiera arctica HEER (74), p. 37, Plate III, 3.

Ginkgo arctica HEER (82), p. 14.

Ginkgo multinervis HEER (82) p. 46, Plates V, *d*; VIII, 2*b*, 3, 4; IX, 3*b*.

The Greenland leaves shown on Plate 9 are referred to the Wealden species *Ginkgoites pluripartita*, a species with which HEER compared them, because I am unable to discover any features in which they differ from the German type. It is noteworthy that in the German plant-beds, as in those of Upernivik Island, there is an association of leaves differing from one another in the number and breadth of the lobes. With the larger leaves both DUNKER§§ and SCHENK|||| figure smaller forms with narrower segments,

* HOLLICK (06), Plate V, 27–32. *See* also NEWBERRY (95), Plate XXXV, 1–9.

† SEWARD (25).

‡ HEER (74), p. 68, Plates XIV, 15–20; XV, 5*b*, 11.

§ HEER (74), p. 69, Plate XVI, 5–8.

|| SEWARD (25), p. 239.

¶ SEWARD (11^2), *cf.* especially Plate VII, 11.

** SEWARD (17), p. 584, fig. 627.

†† HALLE (13), Plate VI, 6.

‡‡ DAWSON (83), Plate III, 37.

§§ DUNKER (46), Plate V.

|||| SCHENK (71), Plate XXIV.

which they name *Jeanpaulia Brauniana*. SCHIMPER* includes this species as a synonym of his *Baiera pluripartita*; but it may represent a distinct type.

HEER founded his species *Ginkgo multinervis* on material from Upernivik Naes, the locality from which specimens were collected in 1921, in beds containing leaves of *Platanus* and fronds of *Pseudocycas*. Most of HEER's figured specimens, in the Copenhagen Museum, have been examined: the leaf shown in his fig. 4, Plate VIII (82), is torn, and the right-hand lobes are not as truncate as the drawing indicates. This is important, because HEER describes the lobes of the Greenland form as less rounded than those of the Wealden species, a distinction which does not exist. An examination of HEER's type-specimen of *Baiera arctica* in the Stockholm Museum, from Ikorfat, convinced me that it is identical with the leaves from Upernivik Island. A specimen at Stockholm figured by HEER as *Ginkgo tenuestriata*,† a species originally described from Portugal, is not a *Ginkgoites*, but a scale similar to *Pinus upernivikensis* HEER. On the other hand, small leaves described by HEER as *Adiantum formosum*‡ should be included in *Ginkgoites*. The specimen, in the Stockholm Museum, from Atanikerdluk, figured by HEER as *Salisburia primordialis* (74), Plate XVII, 1, and represented as having a broad petiole, does not show any actual connection between the lamina and axis. The seeds assigned by HEER to this species are not determinable, but resemble HEER's *Zamites globuliferus*.§

The leaves reproduced on Plate 9 exhibit a wide range in the degree of dissection of the lamina, wider than one finds on a living *Ginkgo* tree; but anyone who has searched among the shoots of *Ginkgo biloba* knows that it is possible to obtain examples comparable in their variation with those of the fossil type. Leaves such as those represented by figs. 65 and 71 might be named *Ginkgoites multinervis*, and those shown in figs. 83, 84 assigned to another species, the form shown in fig. 74 being accommodated in either category. There may have been several species or varieties of *Ginkgoites* in the Arctic forests; but unless one can recognise some distinctive features based on the form of the lamina or on the structure of the epidermal membrane, it is reasonable and logical to employ a single specific term so long as it is understood that a subsequent separation may be justified by a fuller knowledge of morphological characters. My impression is that extinct species of *Ginkgo* were characterised by a capacity for variation in leaf-form greater than that possessed by the still fairly plastic, surviving species.

The leaf shown in fig. 71 is 4·6 cm. broad; the apparent division on the left-hand side is a fold in the lamina, and the longest sinus is not more than 5–6 mm. deep. The segments are obtuse or more or less truncate, and the veins are numerous, 3–4 in a breadth of 1 mm. The example shown in fig. 65 and that in fig. 74 illustrate a further stage in dissection. Fig. 76 represents an obscure fragment, from Ritenbenk's coal-mine, which is hardly determinable. Fig. 66 shows a specimen in which the petiole is attached to a fragment of a short shoot, and a leaf, similar in form, shown in fig. 86, has a V-shaped

* SCHIMPER (69), p. 423.

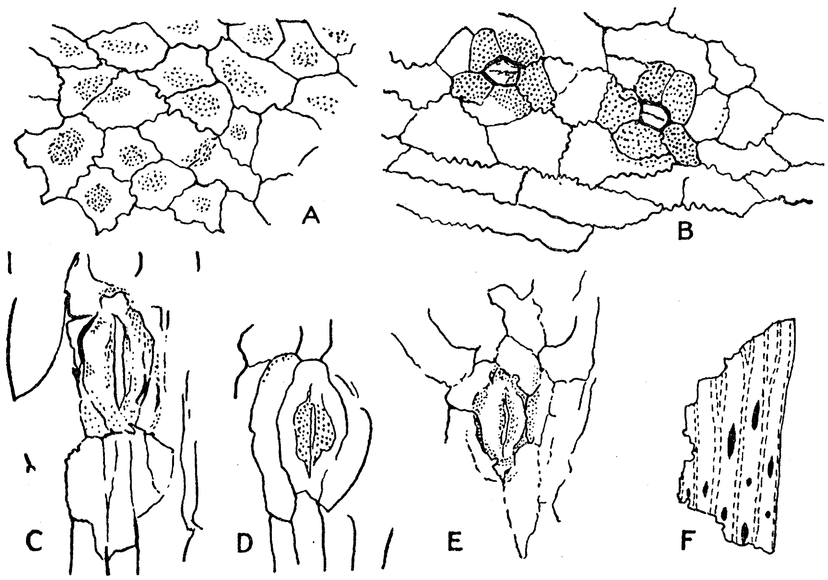
† HEER (82), Plate II, 12A.

‡ HEER (74), p. 35.

§ See *postea*, p. 98.

ridge at the base of the lamina, recalling a feature which is characteristic of the leaves of the recent species. Figs. 83, 84 illustrate a form in which the blade is divided into narrower and more numerous segments: the veins (fig. 83A) are approximately 4 per millimetre.

Text-fig. 11, F, represents a translucent piece of cuticle in which dark patches of secreted material occur between the veins, exactly as in *Ginkgo biloba,* and in *Ginkgoites Obrutschewi* Sew. a Jurassic species from Dzungaria.* Several cuticular preparations were made by Mr. WALTON, but these did not reveal any distinctive features of importance. No definite papillæ were found on the epidermal cells, but, as seen in text-fig. 11, A, some of



TEXT-FIG. 11.—A, E, F. *Ginkgoites pluripartita* (SCHIMP.). A, Epidermal cells with raised areas (dotted). × 200. Upernivik Naes. J. W. (V. 19,041.) E (V. 19,040.). × 200. Upernivik Naes. F, Piece of lamina showing secretory patches and veins. × 6⅔. Upernivik Naes. (V. 19,037.) B, *Phœnicopsis Steenstrupi* sp. nov. Stomata and epidermal cells. × 200. Angiarsuit (loc. A). (V. 19,043). C, D, *Baiera ikorfatensis* sp. nov. Stoma. × 200. Ikorfat. J. W. (C and D: V. 19,038).

the cells suggest raised areas. The cell-walls are generally straight though occasionally sinuous (text-fig. 11, A). The stomata are surrounded by five subsidiary cells (text-fig. 11, E): they agree closely with those of *G. Obrutschewi.* No decisive evidence has been obtained of reproductive organs, but it is possible that the seeds described by HEER as *Zamites globuliferus* may be Ginkgoalean.

Localities.—Upernivik Naes, both North and South of the Settlement; (?) Ritenbenk's coal-mine.

Baiera BRAUN.

None of the Greenland specimens included by HEER in *Baiera* which I have seen can be referred with confidence to that genus.

* SEWARD (11), p. 46.

Baiera arctica HEER (74), p. 37, Plate III, 3. This imperfect specimen in the Stockholm Museum is a typical *Ginkgoites*, like those shown in figs. 71, 74, Plate 9.

Baiera grandis HEER (74), p. 37, Plate III, 4. Probably a torn leaf of a *Ginkgoites*: the drawing of the Stockholm specimen is inaccurate.

Baiera incurvata HEER (82), p. 45, Plate XIII, 6. The type-specimen in the Copenhagen Museum shows no venation and is indeterminable.

Baiera sagittata HEER (82), p. 46, Plate XXX, 18. This very poor specimen, in the Copenhagen Museum, may be a piece of a *Baiera*.

Baiera leptopoda HEER (82), p. 46, Plate XXVIII, 9. This supposed leaf, in the Copenhagen Museum, is probably an axis bearing small leaves which have a ragged edge, and may be a *Sphenopteris*; the drawing is misleading.

BAIERA IKORFATENSIS sp. nov. Plate 9, fig. 81. Text-fig. 11, C, D.

The piece of lamina shown in fig. 81 was found in a bed of shale at Ikorfat containing numerous linear leaves of a *Pityophyllum*. The distal ends of the two broader lobes are incomplete, but in another specimen a segment has an abruptly rounded apex. When slightly magnified the lamina is seen to have relatively prominent veins (not shown in the drawing) about 0·7 mm. apart, and more slender longitudinal striations between the veins; there is also a fine transverse wrinkling, as in many Ginkgoalean leaves.

The epidermal cells are elongated and the walls are straight; stomata occur between the veins. The stomata ($79\mu \times 29\mu$) have truncated ends, and there are indications of a thickened strip parallel to the pore (text-fig. 11, C, D). A long and narrow cell lies on each side of the stoma, and occasionally this is divided by one or two transverse walls. It is noteworthy that the stomata differ from those described by NATHORST in *Baiera spectabilis*,* a Rhætic species with a very similar form of lamina, in the absence of papillæ and the ring of subsidiary cells; but they agree generally with the stomata reproduced in one of NATHORST's figures.† Similar stomata were described on some narrow leaves from Dzungaria referred to *Czekanowskia*.‡

In habit the Greenland leaves are hardly distinguishable from some Alaskan fossils referred, incorrectly as I think, by KNOWLTON§ to *Phœnicopsis speciosa* (HEER), from which they differ in having a dissected lamina, a character not seen in *Phœnicopsis*. The species may also be compared with *Baiera longifolia* (POMEL)|| recorded by HEER from Siberia, and especially with HEER's *B. pulchella*¶ from the same Jurassic flora.

Locality. Ikorfat.

BAIERA SP. *Cf.* BAIERA LINDLEYANA (SCHIMPER). Plate 10, fig. 101.

The leaf shown in fig. 101, in the Stockholm Museum, was originally figured by NATHORST** as *Trichopitys* and later named by him in manuscript *Baiera sp.* There are faint indications of 3–4 veins in the segments. The segments are tapered distally, and

* NATHORST (06), figs. 4–8.

† *Ibid.*, fig. 3.

‡ SEWARD (11), Plate IV, 56, 57.

§ KNOWLTON (14), Plate VIII, 2–4.

|| HEER (76^2), Plates VII, 2, 3; VIII; etc.

¶ HEER (76^2), Plates XX, 3*c*; XXII, 1*a*; (78), Plate VII, 1.

** NATHORST (86), p. 286.

are incomplete. Though unlike any specimens figured by HEER from Greenland, it closely resembles Jurassic leaves assigned to *Baiera Lindleyana** and by SAPORTA† included in *Trichopitys*. HEER'S *Ginkgo concinna*‡ from the Jurassic flora is another example of the same form of leaf.

Locality.—Atanikerdluk.

Phœnicopsis. HEER

PHŒNICOPSIS STEENSTRUPI sp. nov. Plate 9, figs. 82, 82A; Plate 10, figs. 87, 88. Text-fig. 11, B.

Sclerophyllina cretosa (SCHENK), HEER (74), p. 59, Plates XIII, 13, 14; XVII, 12.

Baiera cretosa SCHENK, HEER (82), p. 14.

SCHENK'S specimen of *Baiera cretosa*§ from the Wernsdorf beds differs essentially from the Greenland leaves described by HEER as *Scherophyllina* and subsequently transferred to *Baiera*, in the thicker texture of the lamina and in the dichotomously branched segments. HEER'S leaves are thin and simple: after examining the specimens in the Stockholm Museum I am convinced of their specific identity with those found in 1921 at the locality where his were obtained. Examples were obtained which showed clusters converging towards a common axis, as in the more complete specimens of *Phœnicopsis speciosa* figured by HEER from the Amur region.|| The tapered form of a leaf is seen in fig. 82, Plate 9: the lamina, less than 1 mm. broad at the proximal end, expands to a breadth of about 4 mm., while some examples are 6 mm. broad. There are 8–10 veins in a leaf of 4–6 mm. in breadth, and between each pair a faint interstitial vein is seen in some impressions (82A).

The epidermal cells are elongated parallel to the axis of the long lamina, and have sinuous walls (fig. 87, Plate 10); the stomata occur in rows (fig. 88, Plate 10) and are more numerous on one surface than on the other. Each stoma is surrounded by 4–5 subsidiary cells with highly cuticularised walls (text-fig. 11, B). The epidermal features are very similar to those described by NATHORST¶ in *Czekanowskia rigida* (HEER). In *Desmiophyllum Solmsi* SEW,** a species from Franz Josef Land, with leaves like those from Angiarsuit in form, the cuticular membrane is of a different type.

Though *Phœnicopsis* has been recorded from many Jurassic floras, practically nothing is known of the epidermal characters, and it is mainly because of the information afforded by the cuticles of the Greenland leaves that a new specific name is proposed.

In his species *Zamites globuliferus* (HEER) includes both seeds and linear leaves: the leaves may belong to a *Phœnicopsis*, and, if I am right in thinking the seeds are Ginkgoalean, it is probable that the association is not accidental.

Locality.—Angiarsuit (loc. B.).

Ginkgoales (?).

* SEWARD (11^2), p. 680; (19), fig. 553.

† SAPORTA (84), Plate CLV, 1, 2.

‡ HEER (76^2), Plate XIII, 6*b*.

§ SCHENK (71), Plate I, 7.

|| HEER (76^2), Plates I, 1*d*; II, 3*b*; XXIX, 1, 2 XXX.

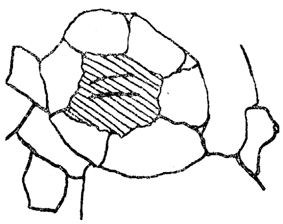
¶ NATHORST (06).

** SEWARD (19), p. 71.

CARPOLITHUS GLOBULIFERUS (HEER). Plate 10, fig. 99. Text-fig. 12.

Zamites globuliferus HEER (82), p. 12, Plate IV, 1–7.

The only specimen, and that a very obscure impression, identical with HEER's seeds which we obtained in 1921 is from Kûk, in a bed of shale containing leaves of *Sciadopitytes Crameri*. I discovered a more clearly preserved example in the Geological Department of the Zürich Hochschule, which Prof. ROLLIER kindly allowed me to borrow for further examination; this is shown in fig. 99. It is labelled by HEER *Zamites globuliferus* from Slibestenfjeld (a locality in the neighbourhood of Angiarsuit). The seed is almost orbicular; 1·3 cm. long with a maximum breadth of 1·8 cm. Several curved grooves converge towards the truncate base, and a few irregular ridges are seen on the left-hand side. An examination of a small piece of the carbonised surface-film revealed the presence of stomata, one of which is diagrammatically shown in text-fig. 12. The circle of subsidiary cells recalls stomata of the *Ginkgo* type.



TEXT-FIG. 12. — *Carpolithus globuliferus* (HEER). Stoma; diagrammatic sketch. From a specimen in the Zürich Hochschule Geological Museum. J. W. (V. 19,037.)

I am inclined to regard this seed as Ginkgoalean rather than Cycadean. If the seed of *Ginkgo biloba* is detached above its basal collar it presents a truncate appearance similar to that of *Carpolithus globuliferus*. HEER states that the seeds occasionally occur in pairs, a feature consistent with a Ginkgoalean affinity.

Locality.—Avkrusak (Slibestensfjeld); Kûk.

Coniferales.

ARAUCARINEÆ.

Dammarites PRESL.

DAMMARITES BOREALIS HEER. Plate 10, fig. 89.

Dammara borealis HEER (82), p. 54, Plate XXXVII, 5.

Eucalyptus Geinitzii HEER, *ex parte* (82), p. 93, Plates XLV, 4–9; XLVI, 12*d*.

Dammara microlepis HEER (82), p. 55, Plate XL, 5.

Dammara macrosperma HEER (83), p. 17, Plate LIII, 11.

In 1874 HEER included in his species *Glyptostrobus grœnlandicus*, a single, radially ribbed scale from Ikorfat which (after examination of the specimen at Stockholm) I think is specifically identical with his *Dammara borealis*, but as the identification is not certain I retain the more familiar name *borealis*. HEER's fig. 5, Plate XXXVII (82) is not very accurate, though the specimen is certainly identical with that shown in my fig. 89, four times natural size. The specimens in the Copenhagen Museum referred by HEER to *Eucalyptus Geinitzii* are scales of *Dammarites*.

The 1921 collection includes two specimens from Pâtût, a larger scale 1·7 cm. broad having several strongly marked grooves and ridges converging towards the short and narrow end: in the middle of the distal margin the flattened surface has a broad acuminate apex; also a smaller form (fig. 89) 1 cm. broad which is strongly convex below the distal edge. A drawing of a specimen in the Stockholm Museum, from Igdlukunguak, lent to me for reproduction in 1919* by Prof. NATHORST, illustrates the characteristic features of a typical scale.

The Araucarian affinity of the Greenland scales included in *Dammarites* has not been proved, and we have no definite knowledge of the vegetative organs to which they belonged. The genus is one of the most widely distributed types in the Upper Cretaceous floras of America and Europe.

Locality.—Pâtût; Igdlukunguak.

? ARAUCARINEÆ.

Pagiophyllum HEER.

PAGIOPHYLLUM AMBIGUUM (HEER). Plate 9, fig. 68; Plate 10, fig. 104.

Sequoia ambigua HEER (74), p. 78, Plate XXI; (82), p. 17, Plate I, 3.

Sequoia gracilis HEER (74), *ex parte*, Plate XXII, 10.

? *Inolepis affinis* HEER (83), p. 11, Plate LIII, 2.

This species was described by HEER as fairly common at Pagtorfik, where several specimens were collected in 1921.

A branch bearing small cones, from Ujaragsugssuk,† which HEER included with some hesitation in *Sequoia ambigua*, is, I think, referable to *S. concinna*. HEER's figures on Plate XXI (74), though accurate representations of the habit, are not correct in details; in his fig. 3 the leaves should be broader. The drawing of the cone in his fig. 2 shows more than can be seen in the specimen. His fig. 6 shows two cones attached to foliage shoots, but evidence of connection is not satisfactory; this specimen has been re-drawn and is reproduced in fig. 104, Plate 10. HEER's type-specimen of *Inolepis affinis*, from Pâtût, may be a branch of *Pagiophyllum ambiguum;* the leaves are broad, falcate, and spirally attached.

Pagiophyllum ambiguum is distinguished by the spirally disposed, short and broad, falcate leaves which, from the occurrence of a keel on the flattened impression, I assume to be tetragonal in section. It differs from *Sequoiites concinna* in the broader and shorter lamina, which is of the *Pagiophyllum* type. No cones were found in 1921 which afford any conclusive evidence of connection with foliage shoots, and such evidence as we have is difficult to interpret. The detached cone (*Conites* sp. A‡), shown in Plate 8, fig. 63, bears a striking resemblance to those shown in fig. 104, which were probably borne on the branches associated with them. The specimen represented in fig. 68,

* SEWARD (19), p. 249.

† HEER (74), Plate XXV, 5.

‡ *See* p. 100.

Plate 9, is closely associated with two seeds, apparently enclosed in a fleshy envelope, which seem to be in their original position, though actual proof of attachment is lacking. If the seeds belong to the branch, comparison is suggested with some recent Podocarps, *e.g.*, *Podocarpus dacrydioides* RICH.* Pending the discovery of more convincing fertile specimens, the affinity of the species must be left in doubt. On the whole, it would seem more probable that the species bore globular cones (fig. 63, Plate 8; fig. 104, Plate 10) similar in the form of the seed-scales to small Araucarian cones. In this connection reference may be made to the detached scale (6 mm. long) shown in fig. 94, Plate 10, which agrees in form with a scale of *Araucaria.*

A specimen from Atanikerdluk figured by HEER as *Selaginella arctica,*† though superficially similar to *Pagiophyllum*, is probably a distinct type.‡

BERRY§ speaks of *Sequoia ambigua* as a widely distributed type, both geologically and geographically, but precise identification of this and similar forms is hardly possible. He shares my view that some of the Wealden examples included in *Sphenolepidium Sternbergianum* (DUNK.) may perhaps be identical with HEER'S plant. The species is undoubtedly represented in the Potomac group.

Localities.—Pagtorfik; Kaersuarssuk.

Conites STERNBERG.

CONITES SP. A. Plate 8, fig. 63. [? = *Pagiophyllum ambiguum* (HEER).]

The cone shown in fig. 63 is almost orbicular; it consists of tangentially elongated imbricate scales, some of which appear to have a small umbo, represented by a slight depression in the middle of the upper surface. Superficially the cone resembles that of an *Agathis.* It is not improbable that this specimen belongs to *Pagiophyllum ambiguum*, as suggested in the account of that species; but in the absence of proof I employ the term *Conites.*

Locality.—Pagtorfik.

CUPRESSINEÆ.

Cupressinocladus SEWARD.

CUPRESSINOCLADUS CRETACEA (HEER). Text-fig. 13.

Libocedrus cretacea HEER (82), p. 49, Plate XXIX, 1–3.

The generic name *Cupressinocladus* is adopted on the ground that no cones are known which indicate affinity to *Libocedrus* rather than to other genera of the same family.

In 1874 HEER founded the species *Thuites Meriana*,|| on sterile branches from Ikorfat, which may be identical with his *Libocedrus cretacea;* the type-specimen, which is very imperfect, shows decussate leaves, but some at least of the specimens subsequently described have spiral leaves, and may be branches of *Cyparissidium.*

* PILGER (03), p. 57; GIBBS (12), Plate XLIX.

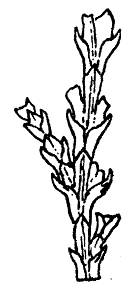
† HEER (82), p. 39.

‡ SEWARD (25), p. 231.

§ BERRY (11[3]), p. 449.

|| HEER (82), p. 49, Plate XXIX, 1–3.

A small piece of a coniferous twig with appressed decussate leaves was found in the peaty bed at Skansen, which agrees in habit with twigs of *Libocedrus*, *Cupressus*, and *Thuja* (text-fig. 13). The structure of the cuticle agrees with that of *Biota orientalis* and some other recent species. The stomatal bands occur on the adaxial face of the leaves and the stomata are less numerous than in recent leaves. Small granules occur on the walls of the epidermal cells, as on those of *Biota orientalis*.



TEXT-FIG. 13.—*Cupressinocladus cretacea* (HEER). × 3. Skansen. J. W. (V. 19,029.)

NEWBERRY* recorded HEER'S species from the Amboy clays, but the leaves of his specimen appear to have less prominent apices and to be more appressed than in the Greenland plant.

Locality.—Skansen.

Moriconia DEBEY and ETTINGSHAUSEN.

MORICONIA CYCLOTOXON DEBEY and ETTINGSHAUSEN (59), p. 59, Plate VIII, 23–27.

Pecopteris kudlistensis HEER (74), p. 97, Plate XXVI, 18.

Moriconia cyclotoxon HEER (82), p. 49, Plate XXXIII, 1–9 ; (83), p. 11, Plates LIII, 10 ; LIV, 1*c*.

Moriconia cyclotoxon KRÄUSEL (22), p. 18, Plate I, 15, 16.

Moriconia americana BERRY (10), p. 186, Plate XX, 5 ; (16), p. 802, Plate LVI, 1.

The systematic position of *Moriconia* has not been definitely established, though it is customary to include it in the Cupressineæ, comparing it especially with *Libocedrus*. The few impressions found at Igdlukunguak do not furnish any fresh evidence. A fairly complete bibliography is given by KRÄUSEL,† who pertinently remarks that we lack evidence justifying the assumption that the genus is closely allied to the recent *Libocedrus* ; we know nothing of the fertile shoots, and no figures or full descriptions have been given of the epidermal characters. It is significant that neither in the specimens recently collected nor in those recorded from other countries is there any substantial carbonised film on the impressions, from which cuticular preparations can be made. KRÄUSEL was, however, able to ascertain that the epidermal cells have smooth walls and that the stomata are orientated parallel to the long axis of the leaf. I agree with KRÄUSEL that the American specimens described as a distinct species do not exhibit any obvious peculiarities. The genus *Androvettia*,‡ instituted from material from Staten Island, has been compared with *Moriconia*, but the surface of the shoots of *Androvettia* was " quite thick and apparently coriaceous in texture." There seems to be no definite evidence in support of the view that *Androvettia* " may prove to be related to *Moriconia*."§

Mr. BERRY|| thinks that this genus may have originated in Greenland and spread thence to the South.

* NEWBERRY (95), Plate X, 1.

† KRÄUSEL (22), p. 18.

‡ HOLLICK and JEFFREY (09), p. 23.

§ BERRY (14^2), p. 105.

|| BERRY (25), p. 29.

The specimen figured by HEER as *Pecopteris kudlistensis* is certainly an impression of *Moriconia*.

Locality.—Igdlukunguak.

SEQUOIINEÆ.

Sequoiites BRONGNIART.

SEQUOIITES CONCINNA HEER. Plate 9, figs. 69, 72, 73, 79, 80.

Sequoia concinna HEER (83), p. 13, Plates XLIX, 8; L, 1*b*; LI, 2–10; LII, 2, 3; LIII, 1*b*.

Sequoia fastigiata (STERNB.), HEER, *ex parte* (74), Plate XXVII, 6; (82), Plates III, 9; XLI, 4*a*, 5.

Sequoia Reichenbachii (GEIN.), HEER (68), *ex parte*, Plate XXVIII, 2.

(?) *Sequoia subulata* HEER, *ex parte* (74), Plate XXXIV, 1*a*.

HEER's illustrations, though on the whole accurate, in some instances show more than can be seen in the specimens. The straighter leaves and stronger axis of the fossil shown in HEER's Plate LII, fig. 1 (82), suggest that it may belong to a distinct species. Specimens from Kûk figured by HEER as *Sequoia Reichenbachii* bear a close resemblance to *S. concinna*, while others are probably referable to HEER's *Sequoia Smittiana*. NATHORST* pointed out that foliage shoots assigned by HEER to *S. Reichenbachii* in his Plate XXXVI (74) are no doubt examples of *Elatides curvifolius* (DUNK).

Sequoiites concinna was described as the commonest Conifer at Pâtût: in habit it agrees with the Tertiary species *S. Coutsiæ* HEER and the recent species *Sequoia gigantea*, but the leaves are usually longer and more falcate. The cones and cone-scales are very like those of recent species. Fig. 79, Plate 9, affords a good illustration of the habit; on the thicker portions of the branch the impressions of the appressed leaf-bases form elongated triangular depressions, often with a median groove (fig. 80). There is a striking similarity between such a specimen as that represented in fig. 80 and a branch of *Sequoia gigantea*. Fig. 69 shows a cone in vertical section: the cone-scales, represented by deep depressions in the burnt shale of Pâtût, are rather suddenly expanded distally from the narrow, proximal end. A single cone-scale, very slightly enlarged (7 mm. broad) is seen in fig. 73; the transverse groove is a characteristic feature on the face of the distal end. The cone represented in fig. 72 probably belongs to this species, though the scales appear to be more pointed; the slender axis lies a few millimetres below the cone, and the latter is probably seen in oblique transverse view.

Some Wealden specimens assigned by authors to *Sphenolepidium Sternbergianum* (DUNK.)† agree closely with *Sequoiites concinna*.

Locality.—Pâtût, found at 370 metres above sea-level *in situ*, and in many loose pieces of shale on the talus slopes.

* NATHORST (97), p. 35.

† SEWARD (95), Plate XVI, 5, 6.

Coniferales *incertæ sedis.* (?) SEQUOIINEÆ.

Elatocladus. HALLE.

Elatocladus Smittiana (HEER), Plate 10, figs. 90, 92; Plate 12, fig. 119; Text-fig. 14; and *Protodammara arctica* sp. nov. (scale), Plate 10, fig. 90.

Sequoia Smittiana HEER (74), p. 82, Plates XII, 10*b*; XVII, 3, 4; XVIII, 1*b*; XX, 5*b*, 7*c*; XXIII, 1–6; (82), p. 17.

Sequoia rigida HEER (74) *ex parte*, p. 30, Plate XXII, 5*g*, 11*a*; (82), p. 51, Plate VII, 10–12; Plate VIII, 7; (83), Plate LIII, 5, 6.

Torreya parvifolia HEER (74), p. 7, Plate XVII, 1, 2.

Cunninghamites borealis HEER (82), p. 55, Plate XXIX, 12.

Sequoia Langsdorfii (BRONGN.) HEER (83), p. 15, Plate LIII, 8.

The generic name *Elatocladus* is substituted for *Sequoiites* because of the lack of any proof of relationship to a recent genus. I am, however, indebted to Dr. FLORIN, of Stockholm, for telling me that in his opinion this Conifer* is more nearly related to *Sequoia* than to any other known genus. He generously gave me several microphotographs of cuticles, one of which is reproduced in fig. 119, Plate 12.

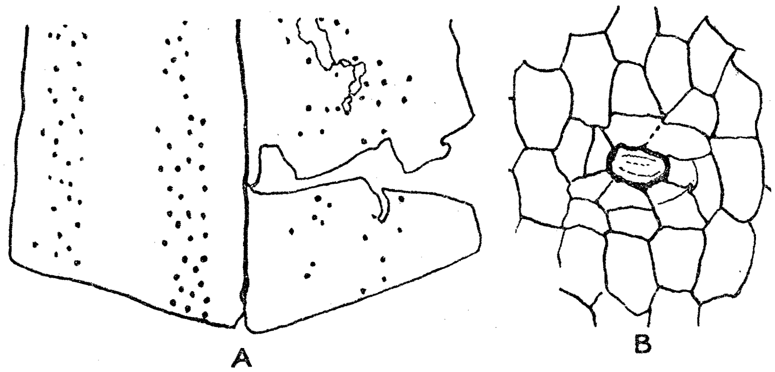
HEER recorded *Sequoia Smittiana* and *Torreya parvifolia* from Ikorfat and Avkrusak, *Sequoia rigida* from Pagtorfik and Avkrusak, and a specimen, which I believe to be a fragment of *Elatocladus Smittiana*, from Kingigtok is assigned to the Tertiary species *Sequoia Langsdorfii*. I am glad to find that Dr. FLORIN's examination of specimens named by HEER *Torreya parvifolia* led to the recognition of epidermal characters like those of *Sequoia Smittiana*, as this confirms an opinion based on my macroscopic examination.

None of the foliage shoots of *Elatocladus Smittiana* which I examined in the Stockholm Museum have cones attached to them. HEER's figs. 1, 3, 5, Plate XXIII (74), are not accurate; some of the leaves have a median groove, but others have not. The branches bear spirally attached, distichous, linear leaves, rarely more than 2 cm. long and about 2 mm. broad; the base of the lamina is decurrent on the comparatively slender axis, and the apex is acute. On many leaves a well-marked groove is a prominent feature. Interspersed with the longer linear leaves are occasional groups of much shorter falcate leaves (fig. 92, Plate 10). The difference between the two forms of leaf recalls the alternation of larger and shorter leaves on shoots of *Araucaria Bidwilli*. One of HEER's figures shows this feature. The leaves are dorsiventral; on one surface the stomata are less regularly arranged than on the other (text-fig. 14, A), where they are confined to two definite bands. The orientation of the guard-cells is irregular; the subsidiary cells form a ring, and are strongly thickened on the inner walls (text-fig. 14, B).

Protodammara arctica sp. nov.—The branch shown in fig. 90, Plate 10, is closely associated with a single, kite-shaped scale, 4·5 mm. long with a maximum breadth of 4 mm. (it is represented rather more than twice natural size in the drawing). In the middle of the proximal end of the scale is a raised area, and near the broadly rounded

* Dr. FLORIN examined the cuticle of the type-specimen [HEER (74), Plate XVIII, 3.]

distal end are three scars where seeds were probably attached, a feature reminding one of the cone-scales of the recent species of *Sciadopitys*. It is difficult to say definitely



TEXT-FIG. 14.—*Elatocladus Smittiana* (HEER). A, Diagrammatic sketch of the two surfaces of a leaf showing the arrangement of the stomata. B, Stoma. × 200. Ikorfat. J. W. (V. 19,034.)

that the scale is not attached, but the association may well be accidental. The scale agrees very closely with those described from the Cretaceous beds of Staten Island as *Protodammara speciosa* HOLL. and JEFF.* and attributed to the Araucarineæ.

Elatocladus Smittiana resembles the widely distributed *E. elegans* (CORD.),† but differs in its more open habit and more slender axis. It may be compared also with *Tumnion carolinum* described by Berry‡ from the Cretaceous flora of Carolina.

Localities.—Ikorfat, Pagtorfik, Upernivik Island.

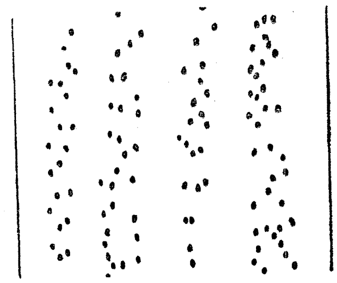
SCIADOPITINEÆ.

Sciadopitytes GOEPPERT.

HALLE§ includes in this genus two species of Greenland Cretaceous leaves, *Sciadopitytes Crameri* (HEER) and *S. Nathorsti* (HALLE). FLORIN|| has slightly modified HALLE's definition of the genus and described several new types: he assumes that the leaves of the various species are double structures. The Tertiary *Sciadopitytes tertiaria* MENZ.¶ agrees with the recent *Sciadopitys* in affording evidence of double structure, but, as Mr. WALTON pointed out to me, there does not seem to be any adequate reason for attributing this character to the Cretaceous and Jurassic species. The leaves are not notched at the apex, and there is no evidence of the occurrence of a double vascular strand. Moreover, the lamina has a broad base, in contrast to the narrow base of leaves borne on short shoots. The existence of a median stomatiferous groove is not proof of a double vascular supply. The relation between the number of grooves and the vascular bundles is not a simple one: in the seedling of *Sciadopitys verticillata*, as Mr. WALTON found, the cotyledonary cuticle (text-fig. 15) has 3–4 stomatal bands; the

* HOLLICK and JEFFREY (09), p. 46.
† SEWARD (19), p. 435.
‡ BERRY (08).
§ HALLE (15).
|| FLORIN (22).
¶ *Ibid.*, p. 263.

juvenile single leaves have sometimes 2 and occasionally 3, a transition from one to the other occurring on the same leaf. On the adult needles there is a single median band. HALLE remarks that there is no evidence, beyond that of cuticular structure, for any relationship between the fossil and recent type of leaf. If, as seems probable, the Cretaceous leaves assigned to *Sciadopitytes* are more closely allied to the recent *Sciadopitys* than to any other genus, the extinct species must have differed considerably in habit from the surviving form, which is now confined to the Far East. It is clear that the leaves were deciduous. FLORIN, in his admirable account of the fossil species, quotes a passage from VELENOVSKY, who speaks of *Sciadopitys* as a relic of the past, an opinion formed independently of any palæobotanical evidence.



TEXT-FIG. 15.—*Sciadopitys verticillata* SIEB. and ZUCC. Diagram of stomatal bands on cotyledon. J. W.

SCIADOPITYTES CRAMERI (HEER).

Pinus Crameri HEER (68), *ex parte*, p. 84, Plate XLIV, 8, 9, 10, 11–16, 18; (74), p. 83, 9, 10, 12–15; (82), p. 17.

Sciadopitytes Crameri HALLE (15), p. 509, Plate XIII, 1–13.

HEER described this species as the commonest fossil at Kûk. The specimen shown in HEER's fig. 17, Plate XLIV (68), as an axis bearing leaves of *Pinus Crameri* is very obscure; it is impossible to recognise the collar at the base of the lateral branches seen in the drawing. In all probability the fossil is part of a large Fern leaf. I was unable to find the original of HEER's fig. 18.

The extraordinary abundance of the leaves of this species in the shale of Kûk and elsewhere reminds one, as HEER says, of the carpet of Fir leaves in a modern forest. We still lack information on the habit of the shoots and reproductive organs. SCHENK examined some of HEER's specimens and noticed a resemblance to *Sciadopitys* in cuticular structure. Later HALLE confirmed SCHENK's opinion and added considerably to our knowledge of the leaf structure. The material collected in 1921 does not enable me to add anything to the facts already published; the length of the xeromorphic leaves varies from 5 to 12 mm. and the breadth from 1·5 to 2 mm.

Localities.—Upernivik Island, Pagtorfik, Kûk, Ikorfat, Angiarsuit (loc. A.).

SCIADOPITYTES NATHORSTI HALLE.

Sciadopitytes Nathorsti HALLE (15), p. 512, Plate XII, 16–29. JOHANSSON (20), p. 253, 1*d–f*; 2*a–c*. FLORIN (22), p. 265.

The variation in length of specimens from Kûk is from 40 to 26 mm. and from 2 mm. to 1·25 mm. broad. The structure has been described by HALLE. Mr. HARRIS found lateral protuberances on the papillæ in this as in the other species. The species is recorded from Atanikerdluk by HEER, from Kûk by FLORIN, and from Andö, in Norway, by JOHANSSON.

Localities.—Kûk, Atanikerdluk.

SCIADOPITYTES EIRIKIANA (HEER).

Pinus Eirikiana HEER (74), p. 85, Plates II, 1 ; XVII, 6, 7 ; XVIII, 2*b* ; XXIII, 16 ; (82), p. 18, Plate IV, 1*c*, 2*c*, 8.

Sciadopitytes Eirikiana FLORIN (22), p. 263, fig. 2*a*.

This species, previously recorded from Kûk and Ikorfat, was obtained in 1921 from Upernivik Naes, Pagtorfik, and Kaersuarssuk. The leaves vary in length from 11 mm. to 20 mm. and in breadth from 1·7 to 2·5 mm.

SCIADOPITYTES (?) AXIS. Plate 10, fig. 95.

The specimen shown in fig. 95 consists of a flattened axis with regular grooves and ridges, and long internodes separated by nodes bearing clusters of linear leaves. At the upper node there are two imperfectly preserved leaves, while at the lower there are indications of 3–4 leaves. Leaf-scars are seen at each node, but the preservation is too poor to afford evidence of the occurrence of scale-leaves or short shoots, and it is not possible to identify the leaves with certainty. The association of leaves apparently agreeing with *S. Eirikiana* and the fact that similar leaves are attached lead me to regard the specimen as a branch of *Sciadopitytes*. The upper internode is narrower than the lower, a feature recalling branches of the recent *Sciadopitys* in which, as Mr. WALTON pointed out to me, there is a considerable reduction in the amount of vascular tissue from one internode to the next above.

Locality.—Upernivik Naes.

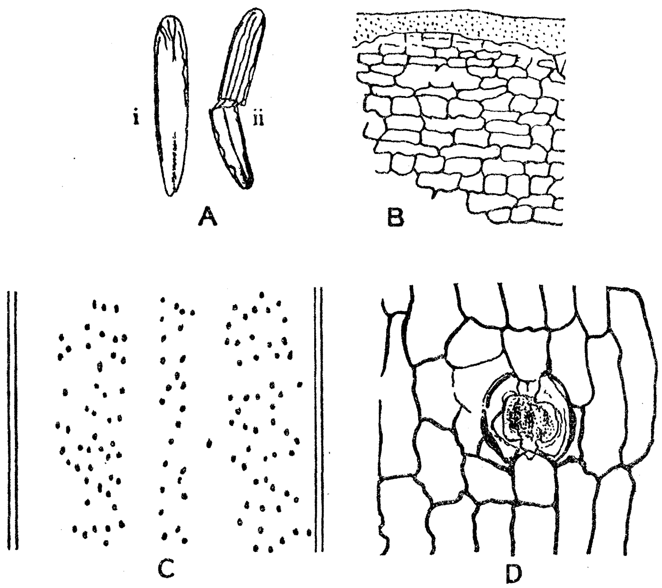
Pityophyllum NATHORST.

PITYOPHYLLUM CRASSUM sp. nov. Text-fig. 16.

The leaf shown in text-fig. 16, A, i, has a broad obtuse apex, and tapers gradually to a narrow base. A median ridge is seen at the lower end, but this dies out a short distance above the base. Near the apex are a few prominent ribs, and two of them are prolonged near the margin of the lamina, one being sinuous. On the other side of the leaf there is an approximately median groove. In another leaf (text-fig. 16, A, ii), there are five ridges on the upper half, but on the lower only three are seen ; where the leaf is broken across a few strands connect the two slightly separated halves, and these correspond with some of the ridges. These strands are resistant to a macerating reagent and after treatment have an amber colour ; they may represent contents of secretory canals.

The heavily cuticularised margin denotes a leaf of leathery texture (text-fig. 16, B). On one surface there are no stomata ; on the other are three stomatal bands (text-fig. 16, C), but no groove or papillate cells. The guard-cells are usually orientated parallel to the leaf-axis (text-fig. 16, D). The epidermal cells are approximately square and in regular rows.

A leaf figured by HEER from Ikorfat as *Pinus lingulata,* Plate XXIII, fig. 18 (74), resembles *Pityophyllum* in size and form. The leaves vary in length from 13 to 30 mm., and in breadth from 2 to 3 mm. Although this type of leaf differs considerably from any species of *Sciadopitytes*, it must be borne in mind that in the juvenile foliage of the recent species the stomata are arranged in two, and it may be three, rows. In the juvenile leaf one finds a complete transition, as Mr. WALTON pointed out, from stomata surrounded by papillæ, as in the adult form, to stomata without papillæ. There are no deep grooves on the simple needles of the young plant. In the cotyledons a still



TEXT-FIG. 16.—*Pityophyllum crassum* sp. nov. A, i, ii, Leaves (V. 19,021*a* and *b*). × 1⅓. B, Epidermal cells and thick cuticle (V. 19,023). × 66. C, Stomatal bands (V. 19,022). × 13. D, Stoma (V. 19,024). × 200. Angiarsuit (loc. A.). J. W.

simpler arrangement is found; the stomata occur in about four rather indefinite bands separated by narrow strips of slightly elongated epidermal cells. There is no grooving and a complete absence of papillate walls. In the three forms of cuticle afforded by the different leaves of *Sciadopitys verticillata*, we have, as it were, a résumé of the features exhibited by the cuticular structure of the Greenland species of *Pityophyllum*.

Locality.—Angiarsuit (loc. B).

ABIETINEÆ.

Pityolepis NATHORST.

I employ this generic name for cone-scales which cannot be assigned definitely to a plant of which the vegetative features are known, but which are believed to belong to some Abeitineous Conifer.

PITYOLEPIS RUGOSA sp. nov. Plate 9, figs. 77, 78.

At the narrow end of the left-hand scale of the two shown in fig. 78 the outlines of two small seeds are indicated; the scale is strongly convex; it is 1·7 cm. long and 1·2 cm. broad at the distal end. The surface is irregularly, longitudinally wrinkled, a feature characteristic of the scales of some recent Pines, *e.g.*, *Pinus Laricio* POIR. The scale on the right is slightly concave. In fig. 77 the original margin of a rather smaller scale is more clearly seen; two smooth and raised areas at the narrow end mark the position of seeds.

The specimens on which this species is founded were found at Upernivik Naes, the locality from which HEER obtained his *Pinus* (*Abies*) *upernivikensis*.* HEER'S specimen is represented as bearing two winged seeds, but an examination of it failed to reveal any evidence of seeds. His fossil is finely striated longitudinally, though it shows no transverse wrinkling like that seen in my figs. 77 and 78. Another scale figured by HEER as *Pinus*, Plate III, 10 (82), is not as clearly preserved as the drawing suggests; I was unable to detect any seeds. Scales previously referred by HEER to *Pinus*, Plate XVII, 8 (74), are much more irregularly ribbed than the figure shows. *Pityolepis rugosa* may be compared with the scales of *Pityostrobus Dunkeri* (CARR.)†; *Abietites macrocarpus* FONT.‡ from the Potomac group, and with cones figured by FLICHE§ from the Cenomanian beds of the Argonne.

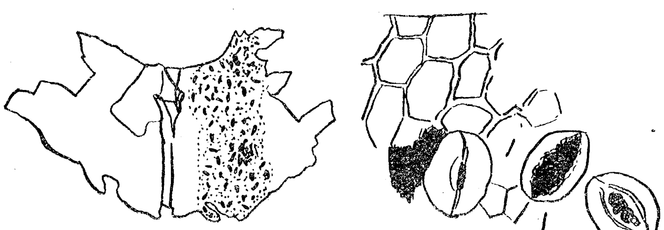
Locality.—Upernivik Island.

Coniferales *incertæ sedis.*

ELATOCLADUS DICKSONIANA (HEER). Plate 10, fig. 91. Text-fig. 17.

Torreya Dicksoniana HEER (74), p. 70, Plate XVIII, 1–4; (82), p. 15; (83), Plate CIX, 4.

It is sometimes difficult to distinguish clearly between the vegetative shoots of this species and those of *Elatocladus Smittiana*, but after an examination of the material described by HEER and that subsequently collected I have no hesitation in separating



TEXT-FIG. 17.—*Elatocladus Dicksoniana* (HEER). A, Part of a leaf showing one of two stomatal bands. × 15. B, Stoma. × 160. Kaersuarssuk. T. M. H. (V. 19,032.)

specimens such as that shown in Plate 10, fig. 91, from the type represented in fig. 92. In *E. Dicksoniana* the leaves are broader, apparently thicker, and more acutely pointed; there is no median groove, but indications of several parallel veins. The leaves are usually less than 2 cm. long and reach a breadth of at least 3 mm.; they are spiral and decurrent.

* HEER (82), p. 56, Plate IX, 7.

† SEWARD (19), p. 383.

‡ FONTAINE (89), p. 262.

§ FLICHE (96).

No very good preparations of the cuticle were obtained; stomata were seen on one surface where they occur in two bands, each 0·8 mm. broad, just within the margin of the lamina. One stomatal band is seen in text-fig. 17, A. The guard-cells have heavily cuticularised inner walls and are not accompanied by any well-defined subsidiary cells (text-fig. 17, B); the stomata are 65–70μ long and 50μ broad.

Localities.—Pagtorfik, Kaersuarssuk.

ELATOCLADUS SUBULATA (HEER). Plate 9, fig. 85.

Sequoia subulata HEER, *ex parte* (74), p. 102, Plates XVII, 3*b*, 7, 8*b*, 15*a*; XXVIII, 3–6; XXIX, 2*c*, 7*b*; (82), p. 54, Plate V*c*, Plate XVII, 1, 9*b*.

A specimen shown in HEER's fig. 1*a*, Plate XXXIV (74), as *Sequoia subulata* is more probably a piece of *Sequoiites concinna*. The very obscure specimen in the Copenhagen Museum shown in HEER's Plate VIII, fig. 8 (82), is probably a fragment of *Sphenopteris psilotoides*, and the cone figured in his Plate XVII, fig. 2 (82) as *Sequoia subulata* is possibly *S. concinna*.

HEER speaks of this species as the commonest Conifer in the " Liriodendron " bed at Atanikerdluk. The leaves are spiral, straight, acute, and decurrent, usually about 8 mm. long and set acutely on the axis. The material is not well enough preserved to show the structure of the cuticle. In some examples a median vein is seen; but the specimens we collected are obscure. The breadth of the axis is slightly exaggerated in the drawing.

Locality.—Atanikerdluk.

ELATOCLADUS MACILENTA (HEER).

Juniperus macilenta HEER (82), p. 47, Plate XXXV, 10, 11.

Juniperus hypnoides HEER (82), *ex parte*, p. 47, Plate XLVI, 18.

This Conifer, represented by small, sterile shoots, was described by HEER as fairly common at Igdlukunguak, where we collected a few specimens; he described the leaves as opposite, decurrent, and about 2 mm. long. HEER's two Greenland species *Juniperus macilenta* and *J. hypnoides* were transferred by me to *Cupressinocladus*,* in order to avoid the implication of affinity to *Juniperus*; but an examination of the actual specimens showed that the leaves are spirally arranged and not decussate.

The habit of *Elatocladus macilenta* is clearly seen in HEER's figures; it agrees generally with *E. subtilis*, but the leaves are narrower, straighter, and more delicate. Nothing is known of the reproductive organs. One specimen in the Copenhagen Museum figured by HEER as *Juniperus hypnoides* is, I believe, identical with his *J. macilenta*, whereas that shown in his fig. 3, Plate XLIV (82) as *J. hypnoides* is probably referable to *Elatocladus subtilis*.

Locality.—Igdlukunguak.

* SEWARD (19), p. 310.

ELATOCLADUS SUBTILIS (HEER).

Widdringtonites subtilis HEER (74), p. 101, Plate XXVIII, 1.

Callitrites subtilis (HEER) SEWARD (19), p. 339.

Juniperus hypnoides HEER (82), *ex parte*, Plate XLIV, 3.

HEER founded this species on material from Atanikerdluk characterised by its densely branched, slender twigs bearing spirally disposed, small, decurrent, imbricate leaves, either falcate or straight. He subsequently included in this species a fragment from Upernivik Island and another from Atanikerdluk, both of which may belong to *Cyparissidium gracile* HEER. In 1921 some impressions were found in the black shale of Atanikerdluk, which are too obscure to be reproduced satisfactorily; they bear closely crowded, small branches with falcate or straight leaves.

Widdringtonites subtilis has been recorded from several Cretaceous localities in North America, and some of the specimens bear small cones* recalling those of recent Callitrineæ: from most of the examples figured by American authors the Greenland fossils differ in their more spreading and less appressed leaves, but BERRY† points out that in material from the Tuscaloosa flora, Alabama, the foliage shoots exhibit a certain degree of dimorphism. The generic name *Callitrites* was substituted by me for *Widdringtonites* on the ground that we have no clear indication of a closer affinity to *Widdringtonia* than to some other members of the family. I adopt the non-commital term *Elatocladus* because, in the absence of fertile shoots, resemblances based on vegetative shoots, especially such as are not peculiar to one family of Conifers, are wholly insufficient as criteria of relationship.

The Conifer represented by HEER's type-specimen of *Widdringtonites subtilis* and by larger examples obtained in 1921 agrees very closely with some of the smaller forms included by HEER in *Sequoia subulata*, and it is not certain that a definite distinction can be drawn.

Branches referred to *Widdringtonites Reichii* (ETT.) from Greenland and other countries agree generally in habit with *Elatocladus subtilis*, but in the former type the leaves are less spreading and more closely appressed to the axis. I am unable to distinguish some of the slender branches figured by HEER as *W. Reichii* from small shoots of his *Cyparissidium gracile*.

Locality.—Atanikerdluk.

ELATOCLADUS UPERNIVIKENSIS sp. nov. Plate 10, fig. 103. Text-fig. 18.

The small piece of shoot shown in fig. 103 is one of several fragmentary specimens found at Upernivik Naes which differ from *Elatocladus Smittiana* in bearing more widely spaced leaves. The leaves are flat, linear, acute, 1·5 cm. long and decurrent on an axis about 2 mm. wide; they are spirally disposed and no veins are visible. They are thicker and more xeromorphic than those of *E. Smittiana*. On the upper surface, on which

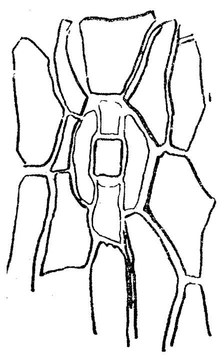
* BERRY (14^2), Plate II, 14–17.

† BERRY (19), p. 67.

there appear to be no stomata, the cells are elongated and have straight walls, while those on the lower surface are more hexagonal and occur in longitudinal rows interrupted by the stomata. Above each stoma is an approximately square opening surrounded by, probably, four cells with highly cuticularised walls (text-fig. 18).

The material is insufficient to afford any decisive evidence of affinity.

Locality.—Upernivik Island.



TEXT-FIG. 18.—*Elatocladus upernivikensis* sp. nov. Stoma. × 280. Upernivik Naes. T. M. H. (V. 19,033.)

TEXT-FIG. 19.—*Elatocladus sp., cf. Cephalotaxopsis brevifolia* (FONT.). × 2. Atanikerdluk (coast section). J. W. (V. 17,000.)

ELATOCLADUS SP., CF. CEPHALOTAXOPSIS BREVIFOLIA (FONT.). Text-fig. 19.

The single, imperfectly preserved specimen on sandstone shown in text-fig. 19 appears to be distinct from *Elatocladus Smittiana* in the stiffer foliage and in the more oblique attachment of the leaves to a thin axis. Moreover, the leaves are not obviously decurrent, though the preservation is too imperfect to admit of a complete description. There is no median groove on the lamina.

BERRY* has given a synonymy of FONTAINE's Potomac species.

Locality.—Atanikerdluk (coast section).

Cyparissidium HEER.

CYPARISSIDIUM GRACILE HEER. Plate 10, fig. 100; Plate 11, fig. 107. Text-fig. 20.

Widdringtonites gracilis HEER (68), p. 83, Plate XLIII, 1*e*, 3*c*, *f*, *g*.

Cyparissidium gracile HEER (74), p. 74, Plates XVII, 5*b*, *c*; XIX; XX, 1*e*; XXI, 9*b*, 10*d*; (82), pp. 16, 50, Plates I, 2; VII, 5–9; XXVIII, 8; (83), p. 12.

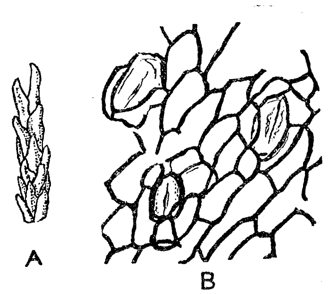
(?) *Sequoia gracilis* HEER (74), *ex parte*, Plate XXII, 1*a*, 4, 7, 9.

A specimen referred by HEER to *Widdringtonites Reichii* (ETT.). Plate XXVIII, fig. 5 (82) is inaccurately represented; the leaves are longer and more oval than in the

* BERRY (11[3]), p. 379.

drawing; it may be a piece of *Cyparissidium.* Similarly, specimens included by HEER in *Thuites Meriana* and *Sequoia gracilis* are probably referable to *Cyparissidium.*

Cyparissidium gracile is described as the commonest Conifer at Pagtorfik. The more slender branches are indistinguishable from specimens assigned by authors to *Widdringtonites*, and the more robust forms are typical examples of *Brachyphyllum.* The long and slender branches bear spirally disposed leaves appressed to the axis with only the apex free; the lamina is either elongate oval or more or less triangular and short. Though usually sparsely branched, the more slender shoots may form close tufts. Shoots of the same type are recorded from Lower Cretaceous floras as *Sphenolepidium Kurrianum* (DUNK.). None of the specimens collected in 1921 bear cones. The specimen shown incorrectly in HEER's fig. 9, Plate XIX (74), is reproduced from a careful drawing made for me at Stockholm in fig. 100, Plate 10. The cone-scales are irregularly ribbed, and the ribs converge slightly towards the apex: the scales are broad and flat.



TEXT-FIG. 20. — *Cyparissidium gracile* HEER. A, × 3. B, × 150. SKANSEN. J. W. (A, V. 19,031; B, V. 19,030.)

Carbonised twigs indistinguishable from the impressions were found in abundance with rachises of *Gleichenites* in the peaty bed at Skansen (fig. 107; text-fig. 20, A). The stomata apparently occur almost exclusively on the adaxial face of the leaves; each is surrounded by 5–6 subsidiary cells (text-fig. 20, B). The epidermal walls are approximately isodiametric and not elongated parallel to the foliar axis.

Potomac specimens included in the genus *Arthrotaxopsis*, *e.g.*, *A. expansus* FONT.* are very similar in habit to the Greenland species.

Localities.—Pagtorfik, Kaersuarssuk, Skansen.

Conites sp. B. Plate 9, fig. 70.

The partially disorganised cone shown in fig. 70 is characterised by the distally rounded and relatively large scales, only three of which are seen; in front a pair of slightly divergent scales and part of another scale behind. The preservation is too imperfect to admit of accurate identification. The form suggests comparison with cones of Callitrineæ.

Locality.—Pâtût.

Conites sp. C. Plate 9, fig. 75.

This more elongated strobilus, attached to an imperfectly preserved slender axis which resembles *Cyparissidium gracile* HEER, bears fan-shaped, spirally disposed scales, characterised by radial grooves, that are possibly the impressions of vascular strands.

Locality.—Pâtût.

* FONTAINE (89), p. 241.

Monocotyledoneæ, *incertæ sedis.*

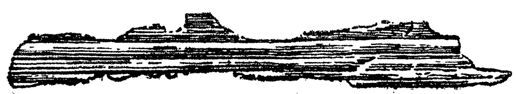
PALMÆ.

Flabellaria STERNBERG.

Flabellaria (?) *sp.* Text-fig. 21.

The occurrence of Palms in the Greenland Cretaceous floras has not been demonstrated : HEER does not include the family in his final list of plants. The fragment shown in text-fig. 21, though probably a piece of a Palm leaf, may belong to some other Monocotyledon. The portions of parallel-veined leaves from Atanikerdluk named by HEER *Flabellaria grönlandica** and said to be of Tertiary age, though similar to the specimen shown in text-fig. 21, are probably specifically distinct. The badly preserved and larger specimens from Tertiary strata on the coast of Disko Island, described as *Flabellaria Johnstrupi,*† and now in the Copenhagen Museum, are too indistinct to be assigned to a definite position. SCHENK‡ regarded some of HEER's supposed Palms as ripple-marked surfaces. Neither from Cretaceous nor Tertiary rocks in Greenland have we any thoroughly satisfactory evidence of the occurrence of Palms.

Text-fig. 21 shows the macroscopic features of part of a specimen from Upernivik Island found near the dyke seen in photo A, Plate 4. It consists of a torn fragment of a



TEXT-FIG. 21.—*Flabellaria* (?) *sp.* Nat. size. Kugssinek angnertunek. Drawn by Mr. T. A. BROCK. (V. 16,993.)

lamina divided longitudinally into very slightly convex strips, which on magnification reveal the occurrence of numerous parallel striations suggestive of rows of regular cells. In macroscopic and microscopic features the fossil shows a striking resemblance to the leaves of recent Palms, but complete ignorance of the habit of the leaf renders impossible any precise comparison. With some hesitation the generic name *Flabellaria* is adopted : it is used in the sense of implying probable affinity to the Palmæ, but indicating, as LESQUEREUX said, a Palm the position of which is not well authenticated.

HEER's *Iridium grœnlandicum*§ may be a closely allied Tertiary species, and similar leaf fragments are referred by HEER to *Phragmites œningensis* Al. Br. and to *Arundo grœnlandica.*

Strips of lamina similar to that shown in text-fig. 21 were described by LESQUEREUX from the Dakota beds of Kansas as *Flabellaria* (?) *minima* and subsequently transferred to *Geonomites.*‖ A species of *Geonomites* figured by BERRY¶ from Tennessee may also be compared with the Greenland fragment. The wealth of undoubted Palm material is a

* HEER (83), p. 69.

† HEER (83), p. 70.

‡ SCHENK (88), p. 205.

§ HEER (68), Plate III, 10, 11.

‖ LESQUEREUX (74), p. 56.

¶ BERRY (25), p. 37.

striking feature of the Eocene flora of the Raton Mesa region,* and representatives of the family are recorded from other American localities.

Culmites BRONGNIART.

Culmites grœnlandica (HEER).

Arundo grœnlandica HEER (74), p. 104, Plate XXVIII, 9, 10; (82), p. 57, Plate XVII, 10; (83), p. 18, Plate LIV, 1–3.

The nature of the fossils included by HEER in this species has already been discussed: some are indistinguishable from his *Equisetum amissum* and from the slender axes characteristic of the Rhizome bed, while others are stems having the habit of some recent Monocotyledons, though not referable to any one genus. In 1921 several examples of *Culmites grœnlandica* were collected at Pâtût: one of the largest is 2·5 cm. broad, and shows an incomplete internode 11 cm. long, also a nodal groove; and another specimen, 7 mm. broad, bears several obliquely attached roots agreeing exactly with those figured by HEER† from the same locality. A similar type of stem was described by ETTINGSHAUSEN‡ from the Cretaceous flora of Saxony as *Culmites cretaceus*.

The generic name *Culmites* is here employed as a general designation for stems believed to be monocotyledonous, but which cannot be precisely determined. SAPORTA§ has used the term *Caulomorpha* in a similar sense, and his *C. bambusina*, a Jurassic species, resembles the Greenland stems; but whether or not it is a Monocotyledon cannot be definitely determined.

Locality.—Pâtût.

(?) LILIACEÆ.

Macclintockia HEER.

In a recent account of the genus I have given a description of a new species, *Macclintockia Hallei*,‖ founded on a specimen in the Stockholm Museum collected by Prof. NATHORST at Pâtût.

MACCLINTOCKIA CRETACEA HEER. Plate 12, fig. 123.

Macclintockia cretacea HEER (82), p. 70, Plates XXXVI, 1, 2*a*; XXXVII, 2–4.

Macclintockia appendiculata HEER (82), p. 71, Plate XXXVII, 1.

The leaf shown in fig. 123, Plate 12, is 9·5 cm. long and 7·5 cm. broad; neither base nor apex are preserved. There are five primary veins, which almost meet at the incomplete base, and bend gradually inwards in the distal part of the entire lamina. None of the finer veins are seen. It is probable that the base was lobed as *Macclintockia appendiculata* HEER from Igdlukunguak, the locality from which the leaf shown in fig. 123 was obtained.

HEER speaks of the systematic position of these leaves as doubtful, but inclines towards

* KNOWLTON in LEE and KNOWLTON (17).

† HEER (83), Plate LIV, 2, 3.

‡ ETTINGSHAUSEN (67), Plate I, 3.

§ SAPORTA (91), pp. 80, 85.

‖ SEWARD (25), p. 255.

SAPORTA's view that *Macclintockia* is related to recent members of the Urticaceæ. LESQUEREUX* assigned a piece of a much smaller leaf from the Dakota beds of Kansas to one of HEER's species, but, I think, incorrectly.

In size, in the number and arrangement of the veins the fossil leaf presents a striking resemblance to *Dioscorea abyssinica* HOCHST., *D. glabra* ROXB., and other species. I have elsewhere expressed the opinion that *Macclintockia* is most nearly allied to *Smilax*.

Locality.—Igdlukunguak.

Dicotyledoneæ.

FAGACEÆ.

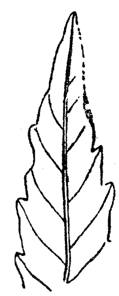
Quercus. L.

QUERCUS JOHNSTRUPI HEER. Text-fig. 22.

Quercus Johnstrupi HEER (82), p. 24, Plate LVI, 7–12.

Quercus cuspidigera HEER (82), p. 25, Plate LVI, 22.

The generic name *Quercus* is adopted with some hesitation in preference to *Quercophyllum*. Specimens of leaves, none of them complete, which are undoubtedly specifically identical with HEER's fossils from the same locality were collected in 1921 at Pâtût. The impression shown in text-fig. 22 is part of an ovate-elliptical leaf, barely 2 cm. broad, with an elongate-acuminate apex like that figured by HEER as *Q. cuspidigera*. The secondary veins are craspedodrome and almost straight: the lamina is deeply serrate in the broader part, but the apex is entire. Leaves of this type appear to be very rare in American Cretaceous floras. Specimens figured by VELENOVSKY† from Bohemia as *Myrica Zenkeri* (ETT.) may belong to the Greenland species, but ETTINGSHAUSEN's species *Dryandroides Zenkeri*‡ from Niederschöna is probably distinct. As ETTINGSHAUSEN and KRAŠAN pointed out,§ *Q. Johnstrupi* agrees closely with the recent species *Q. sessiliflora*. A leaf of *Q. corrugata* HOOK, figured by LAURENT|| has an acuminate apex very similar to that seen in text-fig. 22, and an equally pronounced drip-tip occurs in leaves of *Q. cuspidata* THUNB. of Japan.



TEXT-FIG. 22.—*Quercus Johnstrupi* HEER. Nat. size. Pâtût. T.A.B. (V. 16,994.)

Locality.—Pâtût.

MORACEÆ.

Artocarpus sp. (*cf. Artocarpus Dicksoni* NATH.). Plate 11, fig. 113.

NATHORST's discovery in the Cretaceous beds at Igdlukunguak of splendid leaves and pieces of inflorescence exhibiting a remarkably close resemblance to the foliage and

* LESQUEREUX (91), Plate LIX, 4.

† VELENOVSKY (82), Plate X, figs. 12, 21, 22.

‡ ETTINGSHAUSEN (67), Plate III, figs. 1, 3, 11.

§ ETTINGSHAUSEN and KRAŠAN (87), p. 249.

|| LAURENT (12), p. 199, fig. 109.

fertile shoots of *Artocarpus incisa* FORST. affords one of the most impressive illustrations of the contrast between Cretaceous and recent Arctic vegetation.

The fragment reproduced in fig. 113, about ten times natural size, was found at Ikorfat, 360 metres above sea-level; an examination of NATHORST'S specimens in the Stockholm Museum convinced me that the fragment is part of a male inflorescence, possibly specifically identical with *A. Dicksoni*. The surface is covered with slightly raised carbonised areas about 0·08 mm. in diameter. Several species of *Artocarpus* have been recorded from Upper Cretaceous and from Tertiary strata in North America, similar in leaf-form to the Greenland type. NATHORST pointed out that LESQUEREUX'S Laramie species *Aralia pungens* and *Myrica* (?) *Lessigii* agree closely with *Artocarpus Dicksoni*, and since his paper was published additional examples of both these American species have been recorded, under the name *Artocarpus*, from several localities.* Leaves of similar form have been described as *A. dubia* HOLL.† and *A. similis* KN.‡ from the Wilcox and Raton formations respectively.

Locality.—Ikorfat.

MENISPERMACEÆ.

Menispermites LESQUEREUX.

Menispermites dentatus HEER. Plate 11, fig. 112.

The specimen from Igdlukunguak (fig. 112) is a piece of a peltate leaf characterised by the presence of several primary veins radiating from an eccentrically placed petiole; the lower part of the very slightly cordate lamina is entire, but the upper portion is not preserved. The veins below the petiolar scar are more slender than those above it; the lower veins bend upwards and form loops near the margin, a feature more clearly shown in the specimen figured by HEER. An examination of the type-fossil in the Copenhagen Museum convinced me of its specific identity with the larger impression shown in fig. 112. The lamina is torn and there is no reason to suppose that it was originally trilobed, as HEER described it. KRASSER§ considered *M. dentatus* to be a stipule of a *Liriodendron* leaf, but this is very improbable, even apart from the fact that we have no real evidence of the occurrence of *Liriodendron* in the Cretaceous vegetation of Greenland.

In the radially disposed veins the Igdlukunguak fossil agrees with *Nelumbium* and several Menispermaceous species. HEER described an incomplete leaf from the same locality as *Nelumbium arcticum*,|| which differs from *Menispermites dentatus* in the greater breadth of the veins and in the presence of a median rib. The type-specimen of the *Nelumbium*, in the Copenhagen Museum, is not very accurately represented; the spreading veins are not all equal; there is a stronger central rib and the others are shown as less prominent and rather faintly marked black lines. HEER'S specimen and others from

* KNOWLTON (19), p. 100. *See* also BERRY (16), p. 194; (25), p. 48.

† BERRY (16^2), p. 196.

‡ KNOWLTON (17), p. 306.

§ KRASSER (96), p. 137.

|| HEER (82), Plate XL, fig. 6.

Igdlukunguak in the Stockholm collection are, I believe, correctly referred to the Nymphæaceæ. HEER compared *Menispermites dentatus* with the common tropical plant *Cissampelos Pareira* L., in which the petiole may be either marginal or intramarginal. Comparison may also be made with other Menispermaceæ, *e.g.*, *Stephania rotunda* (MIQ.), *S. hernandifolia* (WILLD.), *S. glabra* (ROXB.), *Menispermum canadense* L. In the leaves of many Menispermaceæ there is a definite midrib, but not in all: in *Nelumbium* the primary veins are all of equal breadth, whereas in peltate Menispermaceous leaves there is the same inequality in thickness as in the fossil between the veins above and below the eccentric petiole. Moreover, the upward curvature of the veins in the basal part of the lamina is a feature shared by recent Menispermaceæ and *Menispermites*.

BERRY* substitutes the generic name *Nelumbites* for *Menispermites* for the Potomac species *M. virginiensis* FONT.† on the ground that the primary veins fork as in recent Nelumbiums; but in *Stephania* the primary veins also fork. FONTAINE described the Potomac leaf as deeply auriculate; the lamina may have been torn: BERRY speaks of it as peltate.

The Dakotan fossils from Kansas on which LESQUEREUX founded the genus *Menispermites*‡ differ from *M. dentatus* in the smaller number of primary veins, but his species *M. grandis*§ may be identical with the Greenland type. BERRY'S *M. potomacensis*|| differs from *M. dentatus* in the smaller number of veins and in the origin of the primaries from the basal edge of the lamina: a similar difference is shown by *M. acutilobus* LESQ. as figured by HOLLICK¶ from Martha's Vineyard.

Though the evidence can hardly be said to be convincing, my impression is that the use of the name *Menispermites*, in the sense of close relationship to recent Menispermaceæ, is justifiable. LAURENT** has discussed Cretaceous and Tertiary species of Menispermaceæ.

Locality.—Igdlukunguak.

Menispermites Nordenskiöldi (HEER). Text-fig. 23.

Apeibopsis Nordenskiöldi HEER (74), p. 23, Plate V, 6.

Populus stygia HEER, *ex parte* (82), p. 64, Plates VII, 5; XVIII, 5; XXXIX, 1. The fragment referred to this species by HEER in 1874 is too imperfect to be identified.

Pterospermites cordifolius HEER (82), p. 94, Plate XXVII, 2, 3.

Nuphar cordifolius FRITEL (13^2), p. 295.

From beds at Puilasok regarded by him as Tertiary, but which I believe to be Cretaceous, HEER described some imperfect leaves as *Apeibopsis Nordenskiöldi* agreeing in the form of the lamina and in venation with those which he subsequently named *Pterospermites cordifolius*. The latter species has been transferred by FRITEL to the genus *Nuphar*; the *Apeibopsis* he regards as a very closely allied form. The incomplete impression shown

* BERRY (16), p. 839.

† FONTAINE (89), Plate CLXI.

‡ LESQUEREUX (74), p. 94.

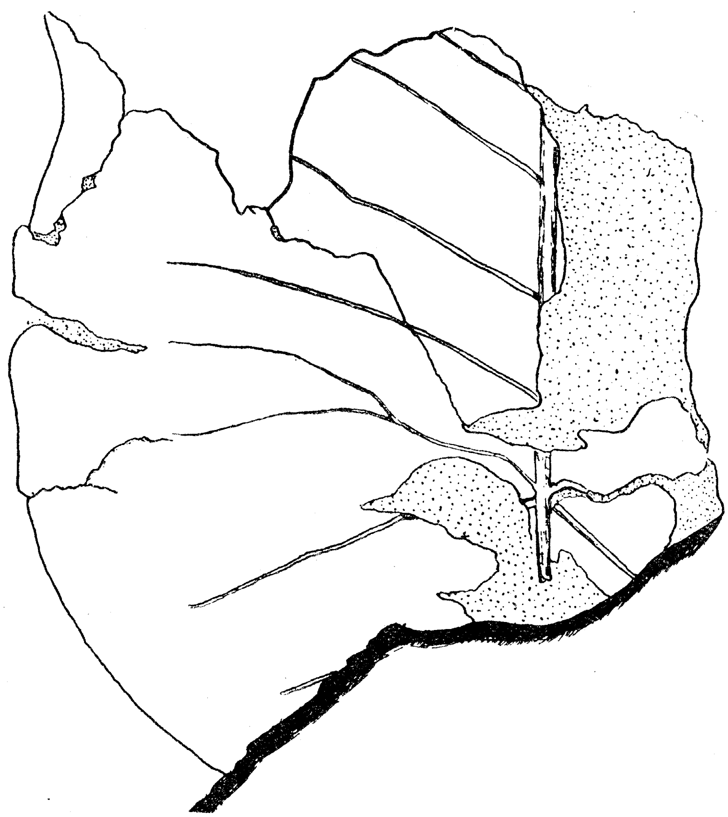
§ LESQUEREUX (83), Plate XV, figs. 1, 2.

|| BERRY (11^3), Plate XCIII, figs. 3, 4.

¶ HOLLICK (06), Plate XII, fig. 8.

** LAURENT (12), p. 112.

in text-fig. 23, from Atanikerdluk, is part of a large and apparently thin leaf with an entire margin: the base of the lamina is not preserved. A few secondary veins are clearly shown, and those from the lower part of the strong midrib curve downwards. There can be no doubt as to the specific identity of this specimen and *Pterospermites cordifolius* from the same locality, the original of which I examined in the Copenhagen Museum. HEER'S figures of that species are fairly accurate, but the leaf represented in his fig. 3, Plate XXVII, is too imperfect to show the form of the base. HEER'S *Populus stygia*



TEXT-FIG. 23.—*Menispermites Nordenskiöldi* (HEER). Nat. size. Atanikerdluk. T. A. B. (V. 19,000.)

is probably the same species; but as the type-specimen is a fragment which cannot be identified with certainty, it is inadvisable to use this specific name. FRITEL, in his account of *Pterospermites cordifolius*, does not consider the possibility of affinity to the Dakotan leaves referred by LESQUEREUX to *Pterospermites multinervis* and subsequently included in his genus *Protophyllum*.* My impression is that the American and Greenland species are at least very closely allied. FRITEL'S contention is that the Greenland leaves agree more closely with those of *Nuphar luteum* than with any Menispermaceous species. *Nuphar* leaves are always auriculate and fleshy, but if I am right in believing *Pterospermites multinervis* and similar forms to be nearly related to *M. Nordenskiöldi,* the form of the lamina conforms more closely to that of certain recent Menispermaceæ than

* LESQUEREUX (91), Plate XLIII, fig. 2. *See* also NEWBERRY (98), Plate VII, fig. 4.

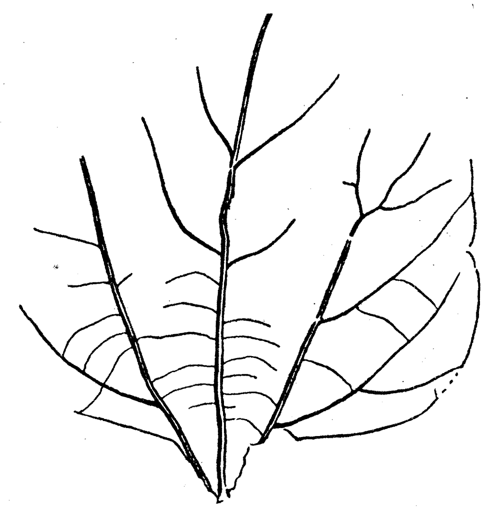
to any species of Nymphæaceæ. The fact that some leaves included by LESQUEREUX in *Protophyllum* are peltate, whereas no undoubted examples of peltate leaves occur among those from Greenland, is probably of no great importance. DIELS* states that some recent Menispermaceæ possess both cordate and peltate leaves. In *Nuphar*, as FRITEL points out, the secondary veins are closer together than in the Greenland leaves, which in the smaller and more distant veins agree more closely with Menispermaceæ. The balance of evidence seems to be in favour of assigning the Greenland specimens to the Menispermaceæ.

It is not clear on what grounds some of the leaves figured by KNOWLTON† from the Raton formation are referred to *Ficus* rather than to a genus implying affinity to the Menispermaceæ.

Locality.—Atanikerdluk.

(?) *Menispermites sp.* Text-fig. 24.

This torn and incomplete leaf from Igdlukunguak, though too fragmentary to be referred with confidence to a systematic position, is not improbably a Menispermaceous species. It is part of a leaf about 6·5 cm. broad: the actual base is not preserved, nor is it possible to see the precise relation to one another or to the petiole of the three main veins. A few secondary veins are given off at an acute angle from the primaries, and in some places tertiary veins are seen to form a series of rectangular connecting strands.



TEXT-FIG. 24.—*Menispermites sp.* Nat. size. Igdlukunguak. T. A. B. (V. 19,003.)

In venation characters the specimen agrees closely with some recent Menispermaceæ, *e.g.*, species of *Cocculus* and *Abuta*.‡ The rectangular tertiary veins and the approximately equal importance of the three primary veins are Menispermaceous features. Several Greenland leaves described by HEER under different generic names bear a close resemblance to the Igdlukunguak fossil, particularly some of the Pâtût leaves included by HEER§ in *Platanus affinis* LESQ., a species which I have included in *Platanus Newberryana* HEER.‖ Many of the specimens from supposed Tertiary strata referred by the same author to *Populus* may be related forms. A Cretaceous specimen figured by KRISHTOFOVICH from Sakhalin Island as *Hedera McClurii* HEER¶ may be identical with the fragment shown in text-fig. 24. Incidentally it may be suggested that certain leaves included

* DIELS (10), p. 7.

† KNOWLTON (17), Plates LXXII, LXXIII, CXII.

‡ MIERS (71).

§ HEER (83), Plate LVII, figs. 1–6.

‖ See *postea*, p. 129.

¶ KRISHTOFOVICH (18), p. 59.

by authors under HEER's species of *Hedera* agree closely with species of the Sterculiaceous genus *Eriolæna.* Other comparable leaves are *Phyllites rhomboideus* LESQ. and *Paliurus cretaceus* LESQ.*; also *Cocculus extinctus* as figured by VELENOVSKY† from Bohemia.

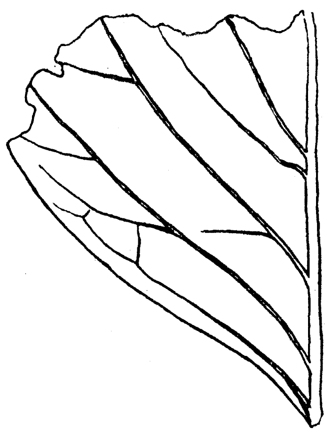
Accurate identification is perhaps impossible, but I venture to think that the Cretaceous leaves to which reference has been made may be regarded as possible representatives of the Menispermaceæ.

Locality.—Igdlukunguak.

MAGNOLIACEÆ.

Magnoliæphyllum KRASSER.

The generic name *Magnolia* has been applied by Palæobotanists to a very large number of leaves from Cretaceous and Tertiary strata on inadequate grounds. In an account of some Tertiary fossils from Assam‡ I drew attention to the widespread occurrence among several tropical and sub-tropical families of leaves which, in the absence of the finer veins, could not be distinguished from those of *Magnolia.* FRITEL§ has emphasised the considerable range in leaf-form in recent species of *Magnolia* in contrast to the constancy in venation characters: he deals especially with Cretaceous species, and under *Magnolia alternans* HEER includes species which have been referred by authors to *Ficus, Daphnophyllum, Juglans, Aralia, Persea, Andromeda,* and some other genera. In the leaves collected in Greenland the finer venation is not preserved, and it is appropriate therefore to adopt the more general designation *Magnoliæphyllum.*|| No examples of reproductive shoots have been described from Greenland. HOLLICK¶ figures an impression from the Dakota beds of Kansas as *Magnolia palæopetala,* which, as he supposes, may well be a floral leaf of some large-flowered *Magnolia.* A piece of a flower-axis is described by MARTY** from Oligocene beds in the Auvergne district.



TEXT-FIG. 25. — *Magnoliæphyllum alternans* (HEER). Nat. size. Atanikerdluk. T. A. B. (V. 19,005.)

MAGNOLIÆPHYLLUM ALTERNANS (HEER). Text-fig. 25.

Magnolia alternans HEER, CAPELLINI and HEER (67), p. 20, Plates III, 2–4; IV, 1–2; HEER (74), p. 115, Plates XXXIII, 1–4; XXXIV, 4; HEER (82), p. 91, Plate XLVI, 21; FRITEL (13), p. 289.

Magnolia Capellini HEER, CAPELLINI and HEER (67), p. 21, Plate III, 5, 6; HEER (74), p. 119, Plate XXXIII, 1–4; HEER (82), p. 90, Plates XXIV, 3–5; XXV, 1–3; XLV, 1; BERRY (19), p. 89, Plates XVIII, 1; XXXII, 7. BERRY gives references to

* LESQUEREUX (74), Plate VI, fig. 8; (91), Plate XXXV, fig. 3.

† VELENOVSKY (87), Plate XXIX, figs. 1, 3.

‡ SEWARD (12).

§ FRITEL (13).

|| KRASSER (96), p. 131.

¶ HOLLICK (03).

** MARTY (15).

American specimens included in this species, which supplement those previously given by FRITEL (13).

The basal portion of a leaf represented in text-fig. 25 shows a few tertiary veins and a slender secondary vein parallel to the cuneate base of the lamina. The grosser features are well illustrated by HEER. Though the evidence is not conclusive, it is probable that *Magnoliæphyllum alternans* is a representative of the Magnoliaceæ and, as MARTY says, related to recent forms of the *Magnolia grandiflora* group.

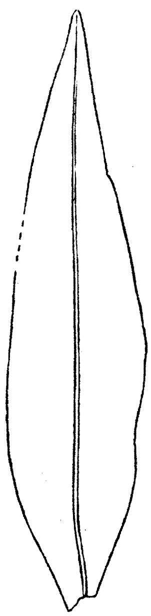
Localities.—Atanikerdluk.

LAURACEÆ.

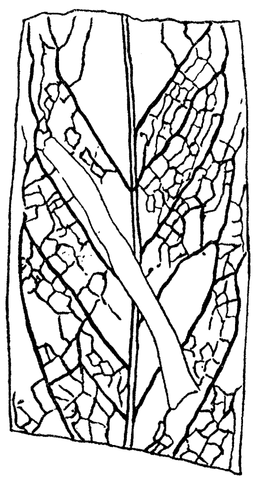
Laurophyllum GOEPPERT.

LAUROPHYLLUM PLUTONIUM (HEER). Text-figs. 26, 27.

GOEPPERT's designation,* first used for some Tertiary leaves from Java, is adopted in preference to *Laurus* because of the difficulty of determining whether the fossils are more



TEXT-FIG. 26.—*Laurophyllum plutonium* (HEER). Nat. size. Atanikerdluk. T. A. B. (V. 19,001.)



TEXT-FIG. 27.—*Laurophyllum plutonium*. × 3. Pâtût. T. A. B. (V. 16,996.)

closely related to *Laurus* than to *Ocotea* or other genera. Comparison with recent species having leaves similar in form to those from the Greenland rocks leads me to refer the fossils to the Lauraceæ, and to consider them as nearly allied to certain recent representatives of *Ocotea*, *e.g.*, *O. guianensis* AUBL. and a species figured by ETTINGSHAUSEN† as *O.* sp. *brasiliensis*. The leaves of *Laurophyllum plutonium* are linear-lanceolate, reaching a length of 11 cm. or more, and from 1 to 2 cm. broad, the greatest breadth being

* GOEPPERT (53), p. 434.

† ETTINGSHAUSEN (61), Plate VI, fig. 7.

usually a little below the middle of the lamina. The lamina is entire, frequently very gradually tapered to an acuminate apex: the cuneate base is decurrent for a short distance on the petiole (text-fig. 26). From a strong midrib, secondary veins, about 2 to 3 mm. apart (text-fig. 27), are given off at an acute angle, and form acutely pointed marginal loops. Near the base the secondary veins are parallel to the edge of the lamina. The tertiary veins form approximately rectangular or polygonal meshes.

A specimen of *Laurophyllum* from Atâ, which is probably referable to *L. plutonium*, afforded some small pieces of carbonised films which enabled Mr. HARRIS to supply the following notes. No stomata were found on the upper surface, the cuticle of which is thicker than that on the lower face: the epidermal cells are unusually small and have rounded polygonal walls, except over the larger veins, where the walls tend to become rectangular. No hairs or papillæ were seen. The cells on the lower surface are similar in size and shape to those on the upper face, but the walls are more delicate. The stomata are flush with the surface and are not much thickened: there appear to be two laterally placed subsidiary cells. The cuticles of some species of *Ocotea—e.g., O. Stromburgkiana* BENTH. and HOSK.—are very similar to those of the fossil leaf.

Unless the venation is well preserved it is impossible to determine the affinity of leaves of this form, as it recurs in several cycles of affinity. In 1874 HEER referred some leaves from Puilasok (Disko Island) to *Andromeda narbonensis*, a Tertiary species founded by SAPORTA, which does not seem to be closely related to the Greenland type. The Puilasok specimens assigned by HEER to a Miocene age are indistinguishable in form and venation from those collected at Pâtût and other localities. As I have elsewhere stated, both the Ferns and Angiosperms from Puilasok suggest a Cretaceous rather than a Tertiary flora.

It is not improbable that the Nebraskan Cretaceous leaves described by HEER as *Myrtophyllum* (*Eucalyptus*) *Geinitzii* are closely allied to *L. plutonium*, or even identical with it. A large number of specimens from American and European Cretaceous floras have been figured under the name *Eucalyptus Geinitzii*: some of them are characterised by a well-defined marginal vein connecting the secondary veins, as in recent species of *Eucalyptus*, but others appear to be identical with *L. plutonium*. The great majority of the supposed flower-buds of *Eucalyptus* figured by HEER and other authors are now referred to the genus *Dammarites*. MAIDEN,* in his Monograph of *Eucalyptus*, does not accept as trustworthy many of the records of fossil species.

I am not at present concerned with the history of *Eucalyptus*, but only with the confusion in some instances between that genus and leaves of the *Laurophyllum* type. The following list includes a few Cretaceous leaves which are either identical with *L. plutonium* or closely allied to it.

Andromeda narbonensis SAP. HEER (74), p. 22, Plates IV, V. HEER's specimens are probably referable to *L. plutonium* and distinct from SAPORTA's species.

Laurus plutonia HEER (82), p. 75, Plates XIX, XX, XXIV, XXVIII, XLII.

Laurus angusta HEER (82), p. 76, Plates XX, 1*b*, 7; XLIII, 1*c*.

* MAIDEN (22).

Proteoides longus HEER (74), p. 110, Plates XXIX, 8*b*, XXXI, 1*c*.

Proteoides vexans HEER (74), p. 111, Plate XXXI, 9, 10.

The fossils from Atanikerdluk referred to *Proteoides* are probably leaves of *Laurophyllum*, but the venation is hardly visible.

Myrtophyllum Geinitzii HEER (74), p. 116, Plate XXXII, 14–17.

Eucalyptus Geinitzii HEER (82), p. 93, Plate XLVI, 12*c*.

Some of the leaves from Moravia figured by KRASSER (96) under this name and others from the Amboy clays included in the same species by NEWBERRY (95), Plate XXXII, should be transferred to *L. plutonium*.

Myrica longa HEER, LESQUEREUX (91), Plate III, 1–6.

Myrica indigena KRASSER (96), p. 129, Plate XV, 1.

Salix proteæfolia LESQUEREUX (74), p. 60, Plate V, 1–4; (83), Plate I, 14–16.

Salix inæqualis NEWBERRY (95), p. 67, Plates XVI, 1, 4, 6; XVII, 2–7.

Salix lanceolata HOLLICK (06), p. 52, Plate VIII, 1*a*, 1–6.

Laurophyllum elegans HOLLICK (06), p. 81, Plate XXVII, 1–5.

The wide distribution of *L. plutonium* in American Cretaceous floras is shown by the references in KNOWLTON's Catalogue.* It must be admitted that we have little evidence on which to base any definite statement on the geological or geographical distribution of the Lauraceæ; but it is certain that leaves of the type represented by *L. plutonium* are abundant in both American and European floras.

The *Laurophyllum* type is characterised by the highly inclined secondary veins, with acutely pointed marginal loops, but without the clearly marked marginal vein of *Eucalyptus*.†

Localities.—Pâtût, Atâ, Atanikerdluk (the "Liriodendron" bed, the Peninsula, and the Coast Section), Igdlukunguak.

Dicotyledoneæ *incertæ sedis.*

Cinnamomoides SEWARD.

I have elsewhere‡ criticised the reference by HEER of some Cretaceous leaves from Atanikerdluk and other Greenland localities to *Cinnamomum*, and suggested the employment of the non-committal name *Cinnamomoides* for specimens characterised by the type of venation represented by *Cinnamomum Camphora*, but which cannot with any degree of certainty be assigned to the Lauraceæ rather than to genera belonging to several other families. Trinerved leaves in which the finer venation cannot be recognised may be compared, with equal reason, to *Zizyphus* (Rhamnaceæ), genera of Menispermaceæ, *e.g.*, *Cocculus laurifolius*, *Viburnum*, *e.g.*, *V. cinnamomifolium* and *V. Davidii*§ (Caprifoliaceæ), *Strychnos* (Loganiaceæ), and other plants. BERRY|| refers some Tertiary

* KNOWLTON (19), p. 347.

† For definition of the *Eucalyptus* type, *see* BERRY (19), p. 126.

‡ SEWARD (25), p. 253.

§ STAPF (23).

|| BERRY (21[2]), p. 176.

examples from Costa Rica to the genus *Goeppertia* NEES (Lauraceæ), but admits that he knows of no certain characters by which to distinguish them from *Cinnamomum*.

A specimen from Angiarsuit figured in a recently published paper on Greenland plants* is believed to be the same species as imperfectly preserved impressions assigned by HEER to *Cinnamomum sezannense* WAT. and transferred by me to *C. Newberryi* BERRY,† a common type in American beds, formerly known as *C. intermedium* NEWB. The specimen with which I am now concerned (text-fig. 28) is distinguished by a broader lamina and a more rounded base and is referred to *Cinnamomoides Heeri* (LESQ.). It is 5 cm. broad and is part of an ovate leaf characterised by three strong primaries, a midrib and two sub-opposite veins given off above the base of the entire lamina. A few secondary veins are seen. There are indications at the base of a marginal rib very similar to that of some leaves of *Cinnamomum* trees figured by LAURENT.

CINNAMOMOIDES HEERI (LESQ.). Text-fig. 28.

Cinnamomum Heeri LESQUEREUX (59), p. 361 ; (74), Plate XXVIII, 11 ; (91), Plate XV, 1.

Cinnamomum Heeri NEWBERRY (98), Plate XVII, 3.

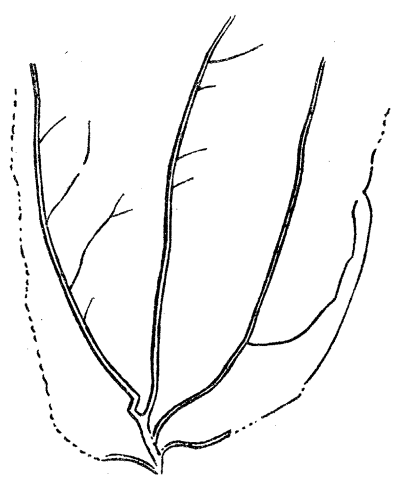
Cinnamomum membranaceum LESQ., HOLLICK (06), p. 75, Plate XXIX, 5, 6.

This, as BERRY suggests, may be a variant of *C. Newberryi*.

Menispermites sp. DAWSON (93), Plate XI, 50.

Sassafras acutilobum LESQ., NEWBERRY (95), Plate XXVI, 5, 6.

Cocculus aff. *C. extinctus* VEL., KRISHTOFOVICH (18), fig. 8.



TEXT-FIG. 28.—*Cinnamomoides Heeri* (LESQ.). Nat. size. Atanikerdluk. T. A. B. (V. 19,006.)

The leaves from Bohemia figured by VELENOVSKY as *Cocculus extinctus* are smaller and narrower than the specimens from Greenland and Sakhalin Island.

Though authors have not always drawn a distinction between the narrower form of leaf represented by *Cinnamomoides Newberryi* and the broader leaves of *C. Heeri*, it is convenient to assign specimens having a more rounded and less cuneate base, stronger primaries, and a broader lamina to *C. Heeri*, as defined by BERRY,‡ who amplifies the original definition given by LESQUEREUX.

Localities.—*Cinnamomoides Newberryi* (BERRY), Angiarsuit; *Cinnamomoides Heeri* (LESQ.), Atanikerdluk.

* SEWARD (25), Plate C, fig. 29.

† BERRY (11), p. 150.

‡ This author has recently discussed the geographical range of *C. Newberryi* (25), p. 75.

PLATANACEÆ.

Platanus L.

The abundance in Cretaceous floras of *Platanus* leaves practically indistinguishable from those of recent species is well established. NEWBERRY, in his description of *Platanus nobilis* NEWB.* from the Dakota group, spoke of the leaves, 45 cm. long and approximately as broad as long, as " rivalled by no living species." Though we are not at present concerned with Tertiary species, reference may be made to a well-preserved leaf from Spitsbergen in the Stockholm Museum with a lamina 26 cm. in breadth. In size, in the polymorphism of the foliage, and in their wide geographical range in temperate and Arctic regions of the Old and New Worlds, the Cretaceous Planes far surpass recent members of the family. It would be interesting to know whether these ancient types resembled their descendants in the morphology of the flowers as closely as in the form of the leaves. The wealth of material furnishes a remarkable illustration of changes in climate; it tells much of the wanderings of the Platanaceæ, and one is tempted to assume that the delimitation of the Planes from certain other Dicotyledons was less definite in the Cretaceous period than it is to-day. LAURENT† speaks of the approximately simultaneous appearance of closely allied forms of *Platanus* over a wide area as one of the most striking results obtained from a comparison of Cretaceous floras.

Although numerous leaves were collected in 1921, particularly at Upernivik Naes (Upernivik Island), no reproductive shoots were found. HEER'S opinion that the abundance of leaves in the Upernivik beds points to the existence of a Platanus forest was no doubt well founded. He mentioned the occurrence of flowers, but I failed to discover any specimens in the Copenhagen collection. An imperfect fossil described by him as a fruit-head of *Platanus affinis*‡ is probably a badly preserved cone of some Conifer. VELENOVSKY figured fruit-heads from the Perucer beds of Bohemia,§ and the Stockholm collection includes good specimens from the Lower Cretaceous plant-beds of Quedlinburg.

PLATANUS LATILOBA, NEWBERRY. Plate 11, fig. 109. Text-fig. 29.

This species, founded on material from the Dakota sandstones of Nebraska, was thus defined||: Leaves petiolate, three-lobed, decurrent at the base, lobes broad, obtuse or abruptly acuminate; principle nerves three, secondary nerves issuing from them at an acute angle, tertiary nerves leaving the secondary at right-angles, forming a network on the surface of the leaf, of which the areolæ are sub-quadrate. NEWBERRY noticed the close resemblance of his species to both *Platanus occidentalis* L. and *P. orientalis* L.

It has been customary to speak of the Greenland leaves as *Platanus Heerii* LESQ., and there is no doubt as to their specific identity with some at least of the fossils so named by LESQUEREUX. The older name is adopted, both on the ground of priority and because the trilobed lamina of the majority of the Greenland specimens agrees more

* NEWBERRY (98), p. 106; WARD (87), p. 35.

† LAURENT (07), p. 361.

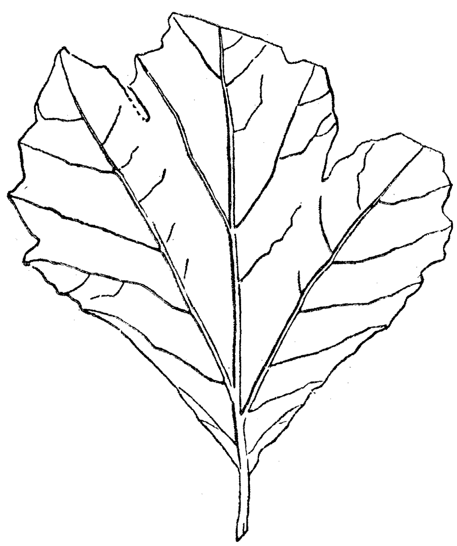
‡ HEER (83), Plate LVII, fig. 5.

§ VELENOVSKY (89), Plate I, fig. 1.

|| NEWBERRY (68), p. 23.

closely with that of *P. latiloba* than with the feebly lobed or entire leaves included in *P. Heerii*. The occurrence of every gradation from an entire to a deeply lobed lamina reveals a tendency to vary such as one finds in living trees. The polymorphism of recent Planes is demonstrated by the illustrations in JAENNICKE'S monograph.* Attention has also been called by HENRY and FLOOD† to the untrustworthiness of the outlines of the lobes and the difference between an entire or more or less dentate margin. It is impossible to separate within narrow limits the large number of leaves from American and other Cretaceous strata which conform generally to *P. latiloba :* the longer the time one gives to a comparative examination of the published figures the more hopeless it seems to attempt a definition of species save in a liberal sense. NEWBERRY'S definition may be amplified in a few particulars.

Leaves usually trilobed ; lobes broadly obtuse or abruptly acuminate, separated by sinuses which vary in depth and breadth, but are usually rounded. Leaves that are deeply trilobed pass through intermediate stages into leaves that are entire. The margin is typically entire or slightly undulate : it may show a tendency to denticulation. In many specimens the length of the lamina is exceeded by the breadth : in some the lamina is about 18 cm. broad and 16 cm. long. The base is cuneate and decurrent in varying degrees on the upper part of the petiole, occasionally expanded into a more or less prominent basal lobe. From the midrib two strong primary veins are given off a short distance above the base of the lamina : the lateral primaries, though usually alternate, may be sub-opposite. The secondary veins are straight or very slightly curved and craspedodrome. Tertiary veins are approximately at right-angles to the secondaries, simple or forked ; those on the lower side of the lateral lobes tend to become camptodrome, and bend upwards near the margin to form loops. One or more secondary veins are frequently given off direct from the midrib below the origin of the lateral primaries, a feature that is often seen in the leaves of recent species.



TEXT-FIG. 29.—*Platanus latiloba* NEWB. Nat. size. Upernivik Naes. T. A. B. (V. 19,002.)

Platanus latiloba shows a striking resemblance in form and venation to some examples of *P. occidentalis*, a species in which the lamina is usually trilobed and often broader than long. In size the Greenland leaves correspond closely with those of the recent species, the most massive and tallest deciduous tree of the forests of the eastern half of the United States.‡

* JAENNICKE (99).

† HENRY and FLOOD (20) ; ELWES and HENRY (N. D.), Vol. III.

‡ SARGENT (05), p. 343.

A typical leaf, though in dimensions exceeded by many of the Upernivik specimens, is represented in fig. 109, Plate 11 : the sinuses are broad and rounded, and the lamina extends beyond the lowest of the two primary veins. A smaller leaf is seen in text-fig. 29 : it is 4 cm. broad and 3·5 cm. long : the base is relatively narrower and more cuneate. The lateral primaries are alternate, and below them are secondary veins parallel to the margin of the broadly dentate lamina. The finer venation of this species is on the whole correctly shown in HEER's figures.

The species included in the following list are believed to be either identical with *P. latiloba* or at least not to be distinguished from it by any well-defined or constant features.

Platanus latiloba NEWBERRY (68), p. 23 ; (98) p. 105, Plate I, 4.

Sassafras latilobum (NEWB.) KNOWLTON (19), p. 584.

Platanus Heerii LESQUEREUX (72), p. 303 ; (74) p. 70, Plates VIII, 1 ; IX, 1, 2. Fig. 4, Plate VIII, is incorrectly referred to *P. Heerii* (83), p. 44, Plate III, 1.

Platanus Heerii LESQ., HEER (82), p. 72, Plates VII, 1–2 ; VIII, 1, 2*a* ; IX, 1–4.

Platanus aceroides ? GOEPP. var. *latior* LESQUEREUX (68), p. 97.

Platanus primæva LESQ. (74), p. 68, Plates VII, 2 ; XXVI, 2 ; (92) p. 72, Plate VIII, 7.

Platanus primæva var. *subintegrifolia* LESQ. (74), Plate IX, 3. Not fig. 4.

Platanus primæva var. *Heerii* JANKÓ (90), p. 455.

Platanus recurvata LESQ. (74), p. 71, Plate X, 3–5.

Sassafras cretaceum recurvatum (LESQ.) NEWBERRY (98), p. 99, Plate IX, 2.

Sassafras (*Araliopsis*) *mirabile* LESQ. (74), p. 80, Plate XII, 1.

Platanus latior (LESQ.) KNOWLTON (98), p. 170.

Platanus latior BERRY (22), p. 164.

? *Platanus Shirleyensis* BERRY (19), p. 83, Plate XV.

Credneria rhomboidea VELENOVSKY (82), p. 11, Plates III, 2, 3 ; IV, 1.

Platanus rhomboidea VELENOVSKY (89), p. 17, Plates II, 10 ; VI, 2, 3.

Platanus Velenovskyana KRASSER (96), p. 138, Plate XV, 2.

KRASSER substituted this specific name for *rhomboidea* because LESQUEREUX had previously employed the latter for a Tertiary species.

Platanus pseudo-Guillelmæ KRASSER (96), p. 139, Plate XIV, 2.

The large Dakotan leaf figured by LESQUEREUX as *Sassafras* (*Araliopsis*) *papillosum** may be a form of *P. latiloba*, as may also be *Sassafras* (*Araliopsis*) *cretaceum* var. *grossedentatum*.† The imperfectly preserved large leaves described by KRASSER‡ from Moravia under different specific names include, in addition to those cited in the above list, specimens which can hardly be separated from the Greenland type. *Platanus Velenovskyana*, as figured by KRISHTOFOVICH§ from Cenomanian beds in the Ural Province, is probably a form of *P. latiloba*, and ROMANOVSKY's incomplete specimen

* LESQUEREUX (91), Plate VI, fig. 7.

† LESQUEREUX (91), Plate LI, fig. 5.

‡ KRASSER (96).

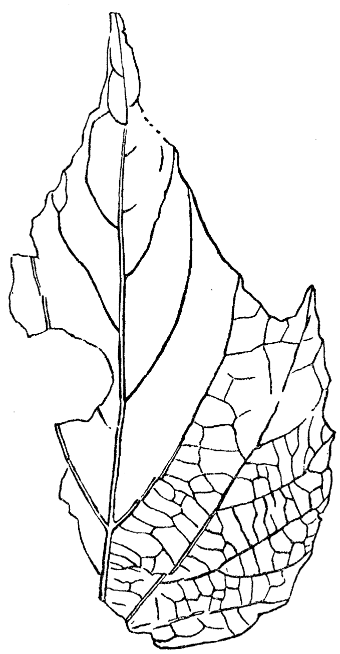
§ KRISHTOFOVICH (14), figs. 5, 6.

from Turkestan* may be correctly referred by him to *P. Heerii*. Fragmentary examples from the Raritan formation of Maryland figured by BERRY† as *P. Heerii*, though too incomplete to be specifically determined, no doubt represent a closely allied, if not identical, type.

Localities.—Upernivik Naes, 500 feet above sea-level north of the Settlement, and in the second valley south of the Settlement; Angiarsuit (Loc. C.); Atanikerdluk Peninsula. Specimens which may belong to this species, but are too incomplete to be determined with confidence, were found at Pâtût and Igdlukunguak.

PLATANUS NEWBERRYANA HEER. Plate 11, fig. 116, text-fig. 30.

The trilobed leaf, preserved as an impression on the bright red, burnt sandstone of Pâtût, is 10 cm. long and 9 cm. broad: the apex is acuminate, the margin undulate-dentate, and the base rounded. Numerous craspedodrome secondary veins are given off at an acute angle: the finer venation is not shown. In another specimen from the same locality the rounded base is intact, and a marginal vein is seen below the junction of the two lowest of the inclined secondaries on each side of the lamina. In a third specimen, otherwise identical with that shown in fig. 116, the base is cuneate. The tertiary venation, clearly preserved in some of the Pâtût examples, is of the *Platanus* type, as seen in HEER's illustration of a specimen referred to *Sterculia variabilis* SAP.,‡ but which is, I think, indistinguishable from *P. Newberryana*. The leaf represented in text-fig. 30, also from Pâtût, is characterised by a long, acuminate drip-tip. The lamina has a rounded base: the veins are clearly preserved, and form marginal loops. These leaves agree very closely with the recent species *Platanus mexicana* MORIC. as figured by JAENNICKE,§ and with specimens of the same species in the Lindley collection at Cambridge. HEER founded *P. Newberryana* on a fragment from the Dakota beds of Nebraska, which is inadequate to serve as the type of a new species. From the same locality LESQUEREUX figured under HEER's designation trilobed leaves with a decurrent lamina, which he compared with the young foliage of *Platanus occidentalis*. The same author instituted the species *P. affinis*, for Nebraskan material differing in no essential feature from *P. Newberryana*. An examination of the original specimen of HEER's *Acer edentatum*, indistinguishable from the leaf shown in text-fig. 30, confirmed my suspicion that it is a form of



TEXT-FIG. 30.—*Platanus Newberryana* HEER. Nat. size. Pâtût. T. A. B. (V. 16,999.)

* ROMANOVSKY (90), Plate XVII, fig. 11.

† BERRY (16), Plates LXV–LXVII.

‡ HEER (83), Plate LVII, fig. 7.

§ JAENNICKE (99), Plate X, figs. 8, 9.

P. Newberryana. Similarly the leaves named by HEER *Acer caudatum* are of the same type. It is noteworthy that PAX* does not include these Greenland species among the fossil representatives of *Acer.* Some of the specimens from the Montana formation included by KNOWLTON† in *Ficus* would perhaps be more appropriately referred to *Platanus.*

The following list includes Cretaceous leaves either specifically identical with *P. Newberryana* or closely allied to it.

Platanus Newberryana HEER, LESQUEREUX (74), p. 72, Plates VIII, 2, 3; IX, 3.

Platanus Newberryana HEER (83), p. 28, Plates LIX, 1–6; LX, 1.

Platanus affinis LESQUEREUX (72), p. 423; (74) p. 71, Plate IV, 4.

Platanus affinis LESQ., HEER (82), p. 73, Plate XXVIII, 16, 17; (83) p. 28, Plates LVII, 1–6; LIX, 7. Some of the specimens are trilobed, others are entire. The specimen figured by HEER as a fruit-head (83), Plate LVII, 5, is probably an imperfect cone of a Conifer.

Cissites affinis LESQUEREUX (83), p. 67.

Acer edentatum HEER (83), p. 39, Plate LXV, 3.

Acer caudatum HEER (83), p. 38, Plate LXV, 1, 2.

Sterculia variabilis SAP., HEER (83), p. 38, Plate LVII, 7.

Protophyllum minus LESQUEREUX (74), p. 104, Plate XXVII, 1.

Protophyllum nebrascense LESQUEREUX (74), p. 103, Plate XXVII, 3.

Platanus aquehongensis HOLLICK (06), p. 82, Plate XXXI, 6. This specimen, though rather larger than the Greenland leaves, is probably a nearly related form.

Platanus asperæformis BERRY (19), p. 83, Plate XVI, 1. In this species, from the Tuscaloosa formation of Alabama, BERRY includes one of the Greenland specimens figured by HEER (83), Plate LXV, 3, as *Platanus Newberryana.*

Localities.—Pâtût, Ritenbenk's coal-mine.

Platanophyllum. FONTAINE.

This generic name was adopted by FONTAINE‡ for incomplete leaves from the Patapsco formation of Maryland which he believed to be allied to *Platanus.* The type-species, *P. crassinerve,* founded on inadequate material, was subsequently included by BERRY§ in FONTAINE'S genus *Araliæphyllum.*|| FRITEL¶ attempted to clear up some of the confusion caused by the use of different generic names and by the excessive multiplication of specific terms for leaves which cannot be distinguished by any clearly defined characters. He employed *Aralia* for specimens agreeing in venation with recent species of *Oreopanax, Tetrapanax,* and other Araliaceæ, while the majority of Cretaceous leaves he assigned to *Araliæphyllum.* In the latter genus the median vein of each of the lowest lobes of the palmate leaf is given off from one of the lateral primaries a short distance

* PAX (02), p. 77.

† KNOWLTON (00).

‡ FONTAINE (89), p. 316.

§ BERRY (11^3), p. 488.

|| FONTAINE (89), p. 316.

¶ FRITEL (14).

above the junction of the petiole and blade: this feature is characteristic of *Platanus* leaves, and indeed it is also seen in some of the leaves included by FRITEL in *Aralia*, the genus in which the radially disposed veins are supposed to have a common origin. My view is that the difference in the arrangement of the ribs by which FRITEL'S two genera are distinguished does not afford a satisfactory basis of classification when applied to Cretaceous specimens. The *Araliæphyllum* type, as he defines it, suggests closer alliance to the Platanaceæ than the Araliaceæ. LESTER WARD,* in a contribution to the History of *Platanus*, drew attention to the close resemblance between fossils included in *Aralia*, *Platanus*, *Sassafras*, and *Liquidambar*, and expressed the opinion that many of them are probably related to *Platanus*. A Tertiary species from the Auvergne, *Platanus Schimperi* (HEER), referred by some authors to *Acer* and *Aralia*, is included by LAURENT† in *Platanus*: it agrees very closely with the Greenland leaf shown in Plate 10, fig. 102. FRITEL states that he agrees with LAURENT'S reference of this species to *Platanus*, and adds that the generic name *Araliæphyllum* is not intended to imply a nearer relationship to the Araliaceæ than to the Platanaceæ. The adoption of *Platanophyllum* is intended to express the view that leaves so named are probably related to recent species of *Platanus*. Cretaceous leaves possessing similar or identical morphological characters have been allocated to *Platanus*, *Aralia*,‡ *Liquidambar*, *Sassafras*,§ *Sterculia*, *Cissites*, and other genera: from the chaos of nomenclature there emerges the conviction that the earlier Cretaceous floras contained many trees with foliage constructed on the *Platanus* plan. Accurate specific delimitation is impossible. It would seem, as BERRY says, that in the extinct species foliar characters are found in combination that were subsequently distributed among different genera. The earlier records of Dicotyledons afford an illustration of fluctuation in leaf-form about a central type, and one is impressed by the extraordinary similarity both in outline and in venation between the Cretaceous and recent types.

PLATANOPHYLLUM INSIGNE (HEER). Plate 11, fig. 111; Plate 12, fig. 121; text-fig. 31.

Fig. 111 shows an impression on the black shale of Atanikerdluk, from the locality shown in Photo. E, Plate 4, of an incomplete and apparently trilobed leaf which must have been rather more than 12 cm. long. The more striking features are: the asymmetrical terminal lobe with a broadly rounded, short, acuminate apex; the broad and well-rounded sinus on the left-hand side (shown more clearly in text-fig. 31), a few secondary veins arising at an acute angle and almost straight, not as much curved as in the otherwise similar leaves of *Ficus carica* L. and species of *Cissus* or *Vitis*. It is impossible to determine whether the veins are camptodrome or craspedodrome, but a faintly preserved secondary vein is seen to bifurcate close to the sinus into two widely divergent branches (text-fig. 31). In 1869 HEER described a piece of leaf from the Dakota group

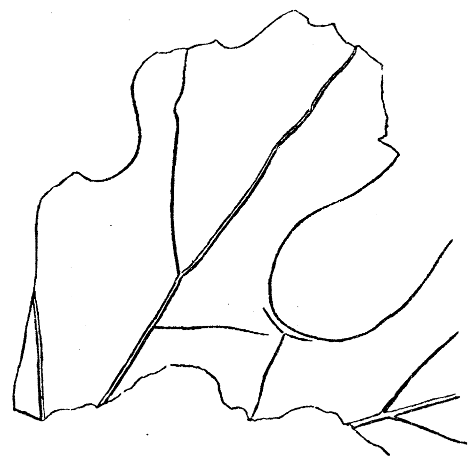
* WARD (88). *See* also BERRY (14).

† LAURENT (12), p. 102. SAPORTA and MARION (85), p. 207, also regard this species as a *Platanus*.

‡ BERRY (03).

§ BERRY (02).

of Nebraska as *Cissites insignis*: "Cissites foliis coriaceis, palmatis, profunde trilobatis, lobis lateralibus valde inæqualibus, lobis apice crenatis." In 1882 he founded the species *Cissites formosus* on imperfect material from Atanikerdluk, and the drawings represent with fair accuracy the specimens in the Copenhagen Museum. Leaves from Puilasok, the most westerly locality on the south coast of Disko Island, where coal-bearing strata were found by the Danish geologists, named by HEER *Cissites puilasokensis* and believed by him to be Miocene in age, are no doubt specifically identical with the Atanikerdluk species, and probably came from Cretaceous rocks. Other plants from Puilasok seem to be Cretaceous and not Tertiary species.



TEXT-FIG. 31.—*Platanophyllum insigne* (HEER). Nat. size. Piece of the leaf shown in fig. 111, Plate 11. Atanikerdluk. T. A. B. (V. 16,989.)

The leaf reproduced in Plate 12, fig. 121, is 12 cm. long and 12·5 cm. broad; it is trilobed and entire. The ovate, obtuse terminal lobe is separated from the lateral lobes by a fairly broad and rounded sinus. Close to the base two lateral primaries spring alternately from the median vein: a few, almost straight secondary are faintly indicated, but nothing can be seen of the tertiary veins. On the same slab of stone is a scale of *Dammarites borealis* HEER and an imperfectly preserved piece of *Moriconia*, also a portion of a cone which may belong to *Sequoiites concinna* HEER.

Except in the absence of subordinate lobes, the impression shown in fig. 121 agrees with that reproduced in fig. 111, Plate 11, but unfortunately the incompleteness of the latter specimen precludes any comparison of the basal part of the lamina. Attention has already been called to the inconstancy of the form of the margin in recent forms of *Platanus*, and the absence of subordinate lobes is probably not a specific character. There is no doubt that a leaf from Igdlukunguak, a locality about 10 km. from Amisut, where the leaf we are considering was found, figured by HEER* as *Aralia grœnlandica*, is identical specifically with that shown in fig. 121. I am inclined to think that both are referable to *Platanophyllum insigne*.

Fig. 121 bears a close resemblance to leaves of the recent *Sassafras officinale* NEES, but it differs in the basal position of the origin of the lateral primaries and in the broadly rounded base. In the leaves of another recent member of the Laurineæ, *Lindera triloba*,† the primaries unite nearer to the petiole, and the base of the lamina is rounded and not cuneate as in *Sassafras*. A Cretaceous species, *Lindera venusta* LESQ., subsequently named by KNOWLTON‡ *Benzoin venustum*, agrees closely with the Greenland fossil; and a

* HEER (82), p. 84.

† LAURENT (12), Plate III, 2.

‡ KNOWLTON (98), p. 47.

specimen from Sakhalin Island, described by KRISHTOFOVICH as a new species, *Aralia Polevoii*,* is hardly distinguishable from LESQUEREUX's Dakotan leaf.

A specimen from the Patapsco formation assigned by BERRY to *Araliæphyllum magnifolium* FONT. may be specifically identical with that shown in fig. 121. BERRY† includes as synonyms some other forms figured by FONTAINE. In most of the examples figured by these authors there is a strong lateral branch given off on the lower side of each of the lateral primaries, a character which is also seen in most of the leaves referred by authors to *Aralia groenlandica* and *A. Ravniana*. In his account of Cretaceous leaves assigned to *Araliæphyllum*, FRITEL states that the occurrence of a branch on the lateral primaries is not a constant character. It is difficult to decide how much significance should be attached to the absence of such branches in the specimen shown in fig. 121 as a criterion of affinity. BERRY describes the Patapsco species as coriaceous in texture; but the Greenland leaf appears to be thin. Another Patapsco leaf, *Sassafras potomacensis* BERRY,‡ agrees more closely with fig. 121 in texture and in the absence of strong lateral branches. The same author has described similar trilobed leaves as *Platanus shirleyensis*,§ which, however, may be referable to *P. latiloba*. BERRY admits that his *Platanus* agrees closely with *Sassafras*, and adds that it is connected by transitional forms with leaves which are undoubtedly referable to *Platanus*.

Enough has been said to illustrate the difficulty of determining the correct position of such specimens as those reproduced in figs. 111, 121. I am disposed to think the balance of evidence is in favour of an alliance to *Platanus*.

A careful comparison of the Greenland specimens, and of the published drawings of American fossils referred to *Cissites formosus* and other species included in the following list, with leaves of *Ficus carica* L., various species of *Cissus* and *Vitis*, *Sassafras*, and *Platanus*, leads me to employ the name *Platanophyllum* in preference to a designation implying affinity to the Vitaceæ, Moraceæ, or other families.

Cissites insignis HEER, CAPELLINI and HEER (67), p. 19, Plate II, 3–5.

Cissites formosus HEER (82), p. 85, Plate XXI, 5–8. Several incomplete leaves from the Dakota group and other horizons are so named by American Palæobotanists.

Cissites ingens var. *parvifolia* LESQ. (91), Plate LVII, 3, 4.

Cissites dentato-lobatus LESQ. (91), Plate LVI, 4.

Cissites formosus magothiensis BERRY (16), Plate LXXVIII, 3.

Cissites panduratus KNOWLTON (17), p. 274, Plate XLIX, 10.

Aralia groenlandica HEER (82), p. 84, Plates XXXVIII, 3; XXXIX, 1; XLVI, 16.

Aralia groenlandica HOLLICK (06), Plate XXXVII, 3–6.

Araliæphyllum groenlandicum FRITEL (14), p. 21.

Aralia Ravniana BERRY (22^2), Plates LVIII; LIX, 4.

Aralia rotundiloba NEWBERRY (95), Plate XXXVI, 9.

Aralia Polevoii KRISHTOFOVICH (18), p. 56, fig. 12.

* KRISHTOFOVICH (18), p. 56.

† BERRY (11^3), p. 491.

‡ BERRY (11^3), p. 487, Plate XCIV, 1.

§ BERRY (19), p. 83, Plate XV, 1–5.

Leaves from the Potomac formation named by FONTAINE *Vitiphyllum* (*Cissites*) *parvifolium*, and more adequately illustrated by BERRY as *Cissites parvifolius*,* are probably not referable to *Platanophyllum*. SAPORTA'S species *Cissites obtusilobus*† from Portugal may be identical specifically with the American type, and is probably not a member of the Platanaceæ. Of similar habit, though larger, are VELENOVSKY'S Bohemian species *Cissites vitifolia*‡ and *Cissites uralensis* KRISH.§ from the Ural Province. BERRY'S Texas specimens|| included in *C. formosus* are smaller than the Greenland leaves, and agree more closely with his *Cissites parvifolius*.

While it is fairly certain that Platanaceous species closely allied to *P. insigne* existed in the Lower Cretaceous Patapsco flora, it is in the Dakota and Amboy floras that we first find leaves indistinguishable from the Greenland type.

Localities.—Atanikerdluk, Amisut, south of Unartoq, which is about 10 km. from Igdlukunguak.

PLATANOPHYLLUM PFAFFIANUM (HEER). Plate 10, fig. 93.

Sassafras Pfaffiana HEER (83), p. 29, Plate LV, 18.

The imperfectly preserved and incomplete leaf from Pâtût may be specifically identical with *Platanophyllum insigne*, but there can be no reasonable doubt as to its close resemblance to HEER'S *Sassafras Pfaffiana* from the same locality. The specimen, 9·5 cm., is characterised by the longer and more spreading lateral lobes: the primary veins are broader than in *P. insigne*, and below the alternately attached primaries a more slender vein is given off from the petiolar strand near the edge of the lamina, a feature frequently seen in recent species of *Platanus*. A specimen of *Platanus orientalis* L. var. *cuneata* WILLD., in the British Museum, from Lydia, to which my attention was drawn by Mr. R. GOOD, bears a close resemblance in the venation to the leaf shown in fig. 93. Similar marginal veins occur in *Oreopanax*, but as in other palmate Araliaceous leaves the primary veins arise nearer together from the main vascular strand than in *Platanus*. While I have no doubt that some Cretaceous leaves referred to *Aralia grœnlandica* HEER are specifically identical with *P. Pfaffianum*, others agree more closely with *P. insigne*. Similar leaves are described by NEWBERRY¶ from the Amboy Clays as *Acerites multiformis* and *Aralia patens*. LAURENT** refers to *Sassafras Pfaffiana* as possibly a member of the genus to which HEER assigned it, but so far as it is possible to base an opinion on the very poor specimens figured by HEER and that reproduced in fig. 93, I venture to think that they are Platanaceous.

Locality.—Pâtût.

* BERRY (11^3), Plates XCI, XCII.

† SAPORTA (94), Plate XXXIV, figs. 12, 13.

‡ VELENOVSKY (86), Plates XVII, fig. 6 ; XVIII, fig. 12.

§ KRISHTOFOVICH (14), p. 609.

|| BERRY (22), Plate XL, fig. 5.

¶ NEWBERRY (95).

** LAURENT (12), p. 133.

PLATANOPHYLLUM WELLINGTONIANUM (LESQUEREUX). Plate 10, fig. 102.

Aralia Wellingtoniana LESQUEREUX (91), p. 131, Plates XXI, 1 ; XXII, 2, 3.

Aralia Jörgenseni HEER (83), p. 116, Plate CI, 1.

The impression on burnt shale from Pâtût shown in fig. 102 represents a portion of a trilobed leaf : the margin is only partially intact and appears to be entire ; the lamina is decurrent at the cuneate base below the point of origin from the midrib of the two sub-opposite lateral primaries. The secondary veins are fairly numerous, and seem to be craspedodrome ; the finer venation is not preserved. The Pâtût leaf agrees closely with *Aralia Wellingtonia*, a Dakotan species, fully described by BERRY,* which FRITEL† regards as a trilobed form of *Araliæphyllum Saportanum* (LESQ.). It is impossible to draw any satisfactory line between *A. Saportanum*,‡ *A. quinquepartitum* (LESQ.),§ *A. Wellingtonianum*, *Sterculia lugubris* LESQ.,|| *Aralia formosa* HEER,¶ (a Moravian form also recorded from Bohemia and America), *Aralia calomorpha* SAP., from Portugal.** A species from Unartok (Disko Island) named by HEER *Aralia Jörgenseni*, and said to be from Miocene beds, agrees closely with the Pâtût leaf, and may well be Cretaceous in age. Another similar form is represented by the French Tertiary species figured by LAURENT as *Platanus Schimperi*.††

It has been customary to refer leaves like that shown in fig. 102 to *Aralia* or *Araliæphyllum* ; but there is no definite evidence of Araliaceous affinity. The disposition of the primary veins is a feature more suggestive of the Platanaceæ. Leaves of the recent species *Platanus Wrightii* WATS.‡‡ and of *P. orientalis* var. *digitata*§§ agree in their narrow lobes with *Platanophyllum Wellingtonianum*.

Locality. Pâtût.

PLATANOPHYLLUM GEISLERI sp. nov. Plate 12, fig. 120.

The specimen represented in fig. 120, Plate 12, was found at Ujaragsugssuk, Disko Island, by the Greenlander in charge of the Settlement, LUDWIG GEISLER, and sent to me by Mr. PORSILD. Five long and asymmetrical lobes are separated by broad and rounded sinuses : the main veins, the only part of the venation visible, appear to meet at the base of the lamina. In form this leaf is similar to the larger three-lobed example seen in fig. 93, Plate 10 : the lamina is 3·5 cm. long and about 4·6 cm. broad. The species agrees very closely with many larger leaves referred by authors to *Aralia*, *e.g.*, *A. Saportanea* LESQ., *A. Wellingtoniana* LESQ., *A. concreta* LESQ., and others which FRITEL assigns to *Araliæphyllum*.

Platanophyllum Geisleri may be a small form of some previously recorded Cretaceous species, but for the present I prefer to give it a distinctive name.

Locality. Ujaragsugssuk.

* BERRY (22), p. 176.

† FRITEL (14), p. 7.

‡ LESQUEREUX (83), p. 61.

§ LESQUEREUX (74), p. 90.

|| LESQUEREUX (83), p. 81.

¶ HEER (69^2), p. 18.

** SAPORTA (94), p. 188.

†† LAURENT (12), p. 102.

‡‡ JAENNICKE (99), Plate X, figs. 12, 13.

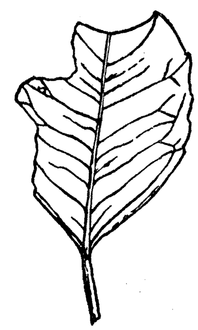
§§ *Ibid.*, Plate I, fig. 13.

Leguminosæ.

Dalbergites BERRY.*

DALBERGITES SIMPLEX (NEWBERRY). Plate 11, fig. 110. Text-fig. 32.

In my 'Notes on the Cretaceous Flora of Greenland: a Critical Revision,'† I discussed at length the affinity of the leaves from Atanikerdluk and other Greenland localities assigned by HEER to his Nebraskan species *Liriodendron Meekii*, and expressed the opinion that, as some other authors have said, the so-called leaves are leaflets of a Leguminous plant related to *Dalbergia*, or possibly *Pterocarpus*. Reasons were given for adopting NEWBERRY'S specific term *simplex*. The specimen from Igdlukunguak, shown in fig. 110, illustrates the typical form of the lamina; and impressions from Atanikerdluk, in the Stockholm Museum, figured in my former paper, exhibit the secondary and tertiary veins. The leaf shown in text-fig. 32, from Pâtût, illustrates the coarser venation. No evidence has so far been published in confirmation of the frequently repeated statement that *Liriodendron* was a member of the Cretaceous flora of Greenland. My own reference‡ to the occurrence of *Liriodendron* in Greenland was made before I had critically examined the fossils which Mr. HOLTTUM and I collected.

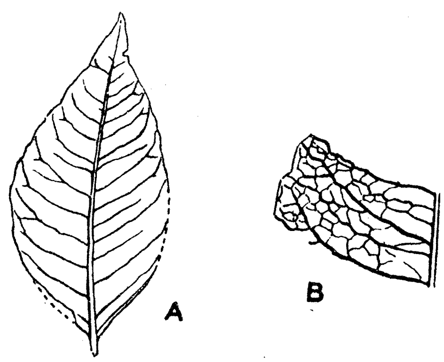


TEXT-FIG. 32.—*Dalbergites simplex* (NEWB.). Nat. size. Pâtût. T. A. B. (V. 16,997).

Mr. BERRY§ has recently recorded a species of *Dalbergia* (*D. Cretacea* BERRY) from the Ripley flora, which is very similar to the Greenland form.

Localities. Atanikerdluk, Igdlukunguak.

DALBERGITES BOREALIS (HEER). Text-fig. 33, A, B.



TEXT-FIG. 33.—*Dalbergites borealis* (HEER). A, nat. size; B, × 2. Pâtût. T. A. B. (V. 16,998).

Myrsine borealis HEER (74), p. 113, Plate XXXII, 23; (82) p. 81, Plates XXIV, 7B, 8; XLIV, 5A; XLVI, 19, 20. As previously pointed out, some of the leaflets so named by HEER may belong to *Dalbergites simplex*.

Myrsine consobrina HEER (83), p. 112, Plate CVII, 11. This form, said by HEER to be Miocene in age, may be specifically identical with *D. borealis*.

Myrsine borealis HOLLICK (06), p. 102, Plate XXXIX, 10, 11. HOLLICK records the species from Martha's Vineyard and Long Island. Other references to the occurrence of the species in American Cretaceous beds are given by KNOWLTON (19), p. 400.

* BERRY (16^2), p. 247.

† SEWARD (25), p. 245, *et seq.*

‡ SEWARD (22), p. 91.

§ BERRY (25), p. 59.

The impression on pale yellow burnt shale from Pâtût, reproduced in text-fig. 33, A, is 4·5 cm. long, and has a maximum breadth of 2·4 cm.: the lamina is entire, and is characterised by a tapered acuminate apex and a cuneate base. The midrib is relatively strong: numerous camptodrome secondary veins, which are often forked, curve upwards close to the margin: the tertiary veins form irregular meshes (text-fig. 33, B).

It is probable that specimens from the Cretaceous flora of Grünbach, in Austria, figured by ETTINGSHAUSEN* as *Ficus Geinitzii*, are specifically identical with the Pâtût leaflet, but in view of the inferiority of his examples it would be unwise to adopt the older designation. A comparison of the Greenland specimen with leaves of recent species of *Myrsine* and with leaflets of *Dalbergia*—*e.g.*, *D. ovata* Grah., *D. championi* Thw., *D. riparia* BENTH.—convinced me that the agreement with *Dalbergia* is much closer than with *Myrsine*: in the acuminate apex, as in the venation, the correspondence is remarkably accurate. BERRY's species *Dalbergites ellipticifolius*,† from the Lower Eocene Granada formation (Mississippi), is probably a closely related type.

Locality. Pâtût.

Plantæ incertæ sedis.

Carpolithus Linnæus.

CARPOLITHUS OBLONGUS (HEER). Plate 11, fig. 114.

Tetraphyllum oblongum HEER (82), p. 105, Plate XXVI, 5B, 6.

This species, from Atanikerdluk, was referred by HEER to a genus founded by HOSIUS and VON DER MARCK‡ for an obscure fossil from the Cretaceous rocks of Westphalia, and spoken of as a fruit or leaflets. The Atanikerdluk specimen shown in fig. 114 is 2 cm. long, bounded on one side by a raised curved band broken across near one end, and overlapping a less prominent central strip, beyond which is a slightly concave area. It is rounded at one end and truncate at the other.

The specimen is probably a woody fruit of an Angiosperm. A similar form is figured by BERRY from Lower Eocene beds in Tennessee as *Carpolithus prangosoides*§: it may also be compared with a Cretaceous Portuguese species, *Carpites plicicostatus*, described by SAPORTA.‖ Fruits of *Cocculus macrocarpus* WIGHT. are similar in size and form, but are characterised by a transverse ribbing, and those of some species of *Pterospermum* are not unlike the fossil. The most striking resemblance is shown by fruits of some recent species of *Dioscorea*, the genus with which the leaf reproduced in fig. 123, Plate 12, is compared. From the material available it is, however, hardly possible to express any definite opinion on the botanical position.

Locality. Atanikerdluk.

* ETTINGSHAUSEN (67), Plate II, figs. 7, 9–11.

† BERRY (16^2), Plate LIV, fig. 10.

‡ HOSIUS and VON DER MARCK (80), p. 13, Plate XXV, fig. 14.

§ BERRY (16^2), Plate CIV, fig. 9.

‖ SAPORTA (94), Plate XXVI, fig. 8.

CARPOLITHUS (?) STIPULIFORMIS sp. nov. Plate 10, fig. 98.

The oval fruit-like specimen from Atanikerdluk shown in the figure is referred with some hesitation to *Carpolithus*: a convex central area is surrounded by an imperfectly preserved flat border, and there is a well-marked median ridge at one end, which soon dies out and appears to break up into three faintly shown veins (not seen in the drawing). The specific name is chosen because of the resemblance to a stipule covering a bud: it is not improbable that this resemblance may be more than superficial. A stipule-protected bud of *Bucklandia populnea* R. Br., except in the absence of a flat border, is similar in size and form to the Atanikerdluk fossil.

Locality. Atanikerdluk ("Liriodendron" bed).

I have elsewhere* figured two specimens from the Cretaceous rocks of Greenland as species of *Carpolithus*, *Carpolithus Holttumi* and *Carpolithus* (?) *Heimi*.

CAULINITES GLEICHENIOIDES sp. nov. Plate 11, fig. 108.

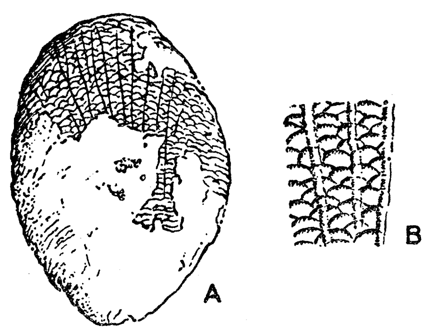
This forked axis, 3·2 cm. broad below the dichotomy, except in its greater size, closely resembles a rachis of *Gleichenia*.† Its systematic position must be left in doubt.

Locality. Pâtût.

Phyllites BRONGNIART.

PHYLLITES sp. Text-fig. 34, A, B.

This specimen, from Atanikerdluk, is an impression of some oval body of which the precise boundaries are obscure. Part of it is covered by a carbonaceous film, which shows no surface-features save a fine reticulation of cracks, a superinduced secondary structure: below the film are several divergent veins, some of which are forked. The veins are represented in the figured half of the specimen by grooves, and over them is a reticulum of anastomosing ridges: on the reverse half the veins are ridges, and the reticulum consists of slightly raised carbonaceous meshes, suggesting masses of spores (text-fig. 34, B), but treatment with macerating solution did not reveal any structure.



TEXT-FIG. 34.—*Phyllites sp.* A, nat. size; B, × 3. Atanikerdluk, T. A. B. (V, 19,004).

The specimen may be compared with the supposed seeds of *Nilssonia Johnstrupi* HEER,‡ which are more orbicular but show traces of a transverse wrinkling: it is probably a foliar organ which served as a protective scale. A sketch, which is slightly diagrammatic, is reproduced in the hope that better examples may be discovered.

Locality. Atanikerdluk ("Liriodendron" bed).

* SEWARD (25), Plate C, figs. 27, 28.

† *See* page 77.

‡ HEER (82), Plate VI, figs. 4C, B.

Krannera VELENOVSKY.

KRANNERA MARGINATA (HEER). Plate 11, fig. 115.

Podozamites marginatus HEER (82), p. 43, Plate XVI, 10.

The piece of lamina from the Peninsula of Atanikerdluk, reproduced in fig. 115, is 8·5 cm. long and incomplete at both ends : the parallel veins are about 0·6 mm. apart. A slight convexity along the margins and the occurrence of two deep cavities, possibly made by insects, indicate that the leaf is strong and thick. In its tapered form and other features the specimen agrees with HEER's *Podozamites marginatus*, a Greenland species which I have elsewhere suggested is probably generically distinct from his *P. latipennis*, a type that has been transferred to the genus *Pseudoctenis*.* Specimens of the Bohemian leaves in the Stockholm Museum, described by VELENOVSKY as *Krannera mirabilis*,† and assigned by him on unconvincing evidence to the Gymnosperms, agree in form and in the disposition of the veins with the leaf shown in fig. 115. Leaves of similar form from Cretaceous rocks have been referred to *Arundo*,‡ *Bambusium*,§ *Eolirion*,‖ *Pterophyllum*,¶ and other genera : they may be Monocotyledonous, but their affinity is uncertain. NEWBERRY** doubtfully assigned specimens from the Amboy Clays to *Podozamites marginatus*, and they may be specifically identical with it : fossils from the Raritan formation†† and from the Tuscaloosa formation‡‡ referred by BERRY to HEER's species are superficially, at least, similar to the Greenland specimens. The relationship of these leaves cannot be determined on the available data.

Locality. Atanikerdluk Peninsula.

TEXT-FIG. 35.—*Carpolithus sp.* × 2. Angiarsuit (*loc. C.*). T. A. B. (V, 16,995).

CARPOLITHUS SP. Text-fig. 35.

The small ovate seed, or fruit, from Angiarsuit is 6 mm. long : the raised central region is surrounded by a narrow, flat border beyond which (not shown in the drawing) there are traces of carbonaceous material suggesting a fleshy envelope. The specimen may possibly be a seed of a *Ginkgoites*, but one cannot determine either its precise morphological nature or its systematic position.

Locality. Angiarsuit (loc. C.).

* SEWARD (25).

† VELENOVSKY (85), p. 1.

‡ HEER (74), Plate XXVIII, fig. 11 ; (83) Plate LIV, fig. 1B.

§ HEER (81), Plate XIX, figs. 1–3.

‖ HOSIUS and VON DER MARCK (80), Plate XXVI, fig. 24.

¶ FONTAINE IN WARD (05), Plate LXVII, fig. 9.

** NEWBERRY (95), Plate XIII, figs. 5, 6.

†† BERRY (16), Plate LI, fig. 8.

‡‡ BERRY (19), Plate VI, fig. 1.

Fasciculites COTTA.

FASCICULITES GROENLANDICUS HEER. Plate 11, fig. 117.

Fasciculites groenlandicus HEER (68), p. 85, Plate XLIV, 23 ; (74) p. 88 ; (82) p. 19.

I am unable to determine the nature of the fossils assigned to this species ; there is no evidence that it is a plant, and it may be part of an animal. COTTA's generic term, adopted by HEER, is provisionally retained pending further light on the specimens. The type-species from Kûk was thus defined : " F. fasciculis vasorum 1 mm. latis, cylindricis, æqualibus, numerosissimis." HEER records the species from Kûk, Ikorfat, and Angiarsuit.

At Kûk we found pieces of shale covered with crowded masses of black or dark brown rods, usually straight and unbranched, from 0·5 mm. to rather more than 1 mm. in diameter. In the specimen reproduced in fig. 117 the rods are curved, but as a rule they form parallel groups, which may be 9–10 cm. long. The rods are hard and brittle, and the fractured ends are bright and smooth. Microscopical examination after treatment with a macerating solution failed to reveal any trace of cellular structure in the amber coloured rods.

HEER believed them to be vascular bundles of some woody Monocotyledon, possibly a Palm. He also compared them with the roots of the Wealden Fern *Endogenites erosa* (= *Tempskya Schimperi*). SCHENK adopted the name *Fasciculites* for fibres which cannot be referred to a definite systematic position, and was inclined to regard the Greenland species as representing vascular bundles of a Palm. Superficially there is a close resemblance between *Fasciculites groenlandicus* and the vascular strands which one finds in loose masses among partially decayed leaf-sheaths of some recent Palms. On microscopical examination the recent Palm strands show outlines of cells impressed on the surface, and on maceration the elements readily fall apart. It is difficult to believe that among the numerous specimens collected at different localities some at least would not have retained traces of structure had such existed. Many examples have been treated in various ways, but no suggestion of cellular structure has been found.

GOTHAN and MATHIESEN have described some Tertiary coal from Germany as Fasciculitenkohle, which consists of closely packed parallel fibres, but the fibres show cell-structure and are not the same as those from Greenland.

I am inclined to regard *Fasciculites groenlandicus* as animal rather than vegetable in origin.

Localities. Kûk ; Angiarsuit (loc. E) ; Kaersuarssuk coal-mine.

V.—THE COMPOSITION OF THE FLORA AND THE DISTRIBUTION OF SPECIES IN GREENLAND.

In the following list are included all the species described in Section IV, and a few described in my 'Notes sur la Flore Crétacique du Groenland.'

Filicales.

GLEICHENIACEÆ.

Gleichenites Gieseckiana HEER.
Gleichenites sp. cf. G. Gieseckiana.
Gleichenites (?) Waltoni sp. nov.
Gleichenites Nordenskiöldi HEER.
Gleichenites Porsildi sp. nov.

MATONINEÆ.

Laccopteris rigida (HEER).

DIPTERIDINÆ.

Hausmannia sp. cf. H. Kohlmanni RICHT.
Hausmannia sp.

Filicales incertæ sedis.

Sphenopteris (Onychiopsis ?) psilotoides ST. and WEBB.
Sphenopteris (Onychiopsis ?) Johnstrupi HEER.
Sphenopteris dentata VEL.
Sphenopteris Jörgenseni HEER.
Cladophlebis Oerstedi (HEER).
Cladophlebis frigida (HEER).
Cladophlebis frigida var. *longipennis.*
Cladophlebis arctica (HEER).
Cladophlebis Holttumi sp. nov.
Cladophlebis sp. cf. C. Browniana (DUNK).

Plantæ incertæ sedis.

Tæniopteris arctica HEER.
Phyllites socialis (HEER).

Cycadophyta.

BENNETTITALES.

Pseudocycas Steenstrupi (HEER).
Pseudocycas insignis NATH.
Ptilophyllum arcticum (GOEPP.).
Ptilophyllum Heeri NATH. MS.
Pterophyllum concinnum HEER.
Otozamites Schenki (HEER).
Williamsonia (?) *cretacea* HEER.

NILSSONIALES.

Pseudoctenis latipennis (HEER).

Ginkgoales.

Ginkgoites pluripartita (SCHIMP.).
Baiera ikorfatensis sp. nov.
Baiera sp. cf. B. Lindleyana (SCHIMP.).
Phœnicopsis Steenstrupi sp. nov.

Ginkgoales (?).

Carpolithus globuliferus (HEER).

Coniferales.

ARAUCARINEÆ.

Dammarites borealis HEER.

(?) ARAUCARINEÆ.

Pagiophyllum ambiguum (HEER).
Conites sp. A. (?) = *Pagiophyllum ambiguum.*

CUPRESSINEÆ.

Cupressinocladus cretacea (HEER).
Moriconia cyclotoxon DEB. & ETT.

SEQUOIINEÆ.

Sequoiites concinna HEER.

(?) SEQUOIINEÆ.

Elatocladus Smittiana (HEER).

SCIADOPITINEÆ.

Sciadopitytes Crameri (HEER).
Sciadopitytes Eirikiana (HEER).
Sciadopitytes Nathorsti HALLE.
Sciadopitytes axis.
Pityophyllum crassum sp. nov.

ABIETINEÆ.

Pityolepis rugosa sp. nov.

Coniferales incertæ sedis.

Protodammara arctica sp. nov.
Elatocladus Dicksoniana (HEER).
Elatocladus subulata (HEER).
Elatocladus macilenta (HEER).
Elatocladus subtilis (HEER).
Elatocladus upernivikensis sp. nov.
Elatocladus sp. cf. *Cephalotaxopsis brevifolia* (FONT.).
Cyparissidium gracile HEER.
Conites sp. B.
Conites sp. C.

Monocotyledoneæ.

Flabellaria (?) *sp.*
Culmites groenlandica (HEER).
Macclintockia cretacea HEER.
Macclintockia Hallei SEW.

Dicotyledoneæ.

FAGACEÆ.

Quercus Johnstrupi HEER.

MORACEÆ.

Artocarpus sp. cf. *A. Dicksoni* NATH.

MENISPERMACEÆ.

Menispermites dentatus LESQ.
Menispermites Nordenskiöldi (HEER).
Menispermites sp.

MAGNOLIACEÆ.

Magnoliæphyllum alternans (HEER).

LAURACEÆ.

Laurophyllum plutonium (HEER).
Cinnamomoides Heeri (LESQ.).
Cinnamomoides Newberryi (BERRY).

PLATANACEÆ.

Platanus latiloba NEWB.
Platanus Newberryana HEER.
Platanophyllum insigne (HEER).
Platanophyllum Pfaffianum (HEER).
Platanophyllum Wellingtonianum (LESQ.).
Platanophyllum Geisleri sp. nov.

LEGUMINOSÆ.

Dalbergites simplex (NEWB.).
Dalbergites borealis (HEER).

Plantæ incertæ sedis.

Carpolithus oblongus (HEER).
Carpolithus (?) *stipuliformis* sp. nov.
Carpolithus Holttumi SEW.
Carpolithus (?) *Heimi* SEW.
Caulinites gleichenioides sp. nov.
Phyllites sp.
Krannera marginata (HEER).
Carpolithus sp.

Fossilis incertæ sedis.

Fasciculites groenlandicus HEER.

The following Table includes species collected by Mr. HOLTTUM and myself in 1921, and some of HEER's species which I have examined. HEER's records are given only for species which I have seen at Copenhagen or Stockholm.

Under Upernivik Island are included all the places where we obtained specimens: such observations as we made did not enable us to discover any facts in favour of a geological separation of the plant-bearing beds. HEER allocates all the plants from Upernivik Island to his Atane, or middle, series.

The plant beds on the North coast of the Nûgssuak peninsula are assigned by HEER to his Kome series, the lowest member of his Greenland group. I have not drawn a distinction in the Table between the different localities where plants were collected at Angiarsuit. In the Patoot series HEER includes the bulk of the beds at Pâtût on the South coast of the peninsula. The plants we collected at Pâtût were in part found in pieces of shale on the talus slopes or in the bed of a glacier stream, and in part *in situ* at a height of about 400 metres above sea-level. Most of the plants from Atanikerdluk were obtained from HEER's "Liriodendron" bed. HEER included all the Cretaceous plants from the Atanikerdluk district in his Atane series.

TABLE A.

		Nûgssuak Peninsula.							Disko Island.			
		North Coast.					South Coast.					
	Upernivik. I.	Kûk.	Pagtorfik.	Kaersuarssuk.	Angiarsuit.	Ikorfat.	Pâtût.	Atanikerdluk.	Skansen.	Ujaragsugssuk.	Igdlukunguak.	Ritenbenk's Coal.
Filicales.												
Gleichenites Gieseckiana	◆	◆	◆	◆	◆	◆	◆	? ◆		◆		◆
G. Nordenskiöldi		◆	◆	◆	◆							
G. Porsildi	◆	◆			◆		◆		◆		◆	
Gleichenites (?) *Waltoni*				◆								
Laccopteris rigida		◆	◆	◆	◆							
Hausmannia sp.						◆						
Sphenopteris psilotoides	◆	◆	◆	◆	◆							
S. Johnstrupi	◆	◆				◆	◆	◆				
S. dentata			? ◆	◆								
S. Jörgenseni							◆				◆	
Cladophlebis Oerstedi			◆	◆								
C. frigida								◆				
C. arctica							◆					
C. Holttumi				◆								
Cladophlebis sp.	◆											
Plantæ incertæ sedis.												
Tæniopteris arctica		◆			◆							
Phyllites Socialis	◆											
Cycadophyta.												
Pseudocycas Steenstrupi	◆											
P. insignis								◆				
Ptilophyllum arcticum					◆	◆						
P. Heeri							◆					
Pterophyllum concinnum ...						◆						
Otozamites Schenki		◆										
Pseudoctenis latipennis								◆				
Williamsonia (?) *cretacea* ...											◆	
Ginkgoales.												
Ginkgoites pluripartita	◆					◆						◆
Baiera ikorfatensis						◆						
Baiera sp.								◆				
Phœnicopsis Steenstrupi					◆							
Carpolithus globuliferus		◆			◆							

TABLE A—continued.

		Nugssuak Peninsula.							Disko Island.			
		North Coast.					South Coast.					
	Upernivik. I.	Kûk.	Pagtorfik.	Kaersuarssuk.	Angiarsuit.	Ikorfat.	Pâtût.	Atanikerdluk.	Skansen.	Ujaragsugssuk.	Igdlukunguak.	Ritenbenk's Coal.
Coniferales.												
Dammarites borealis						◆	◆				◆	
Pagiophyllum ambiguum... ...		◆	◆	◆	◆	◆	? ◆					
Cupressinocladus cretacea ...						? ◆			◆			
Moriconia cyclotoxon											◆	
Sequoiites concinna	? ◆						◆					
Elatocladus Smittiana	◆		◆			◆						
E. Dicksoniana			◆	◆		◆						
E. subulata								◆				
E. macilenta											◆	
E. subtilis								◆				
E. upernivikensis	◆											
Elatocladus sp.								◆				
Sciadopitytes Crameri	◆	◆	◆		◆	◆						
S. Nathorsti		◆						◆				
S. Eirikiana	◆	◆	◆	◆	◆	◆						
Pityolepis rugosa	◆											
Protodammara arctica			◆									
Cyparissidium gracile	◆	◆	◆	◆	◆		? ◆		◆			
Pityophyllum crassum				◆	◆							
Angiospermæ.												
Macclintockia cretacea											◆	
M. Hallei							◆					
Quercus Johnstrupi							◆					
Artocarpus sp.						◆						
Menispermites dentatus											◆	
M. Nordenskiöldi								◆				
Magnoliæphyllum alternans ...								◆				
Laurophyllum plutonium ...					◆		◆	◆			◆	
Cinnamomoides Heeri								◆				
Cinnamomoides Newberryi ...					◆							
Platanus latiloba	◆				◆		◆	◆			◆	
P. Newberryana							◆					
Platanophyllum insigne								◆			◆	
P. Pfaffianum							◆					
P. Wellingtonianum							◆					
P. Geisleri										◆		
Dalbergites simplex								◆			◆	
D. borealis							◆					
Fossilis incertæ sedis.												
Fasciculites groenlandicus ...		◆		◆	◆	◆						

VI.—CONCLUSION.

A.—*Comparison of the Cretaceous vegetation of Greenland with that of other regions: the Problem of Geological Age.*

The sub-division of the Cretaceous system adopted by HAUG* into Eocretaceous (or Neocomian), Mesocretaceous, and Neocretaceous is based to a large extent on faunal differences: the simpler twofold division into Lower and Upper Cretaceous, based on Palæobotanical data, is more frequently used by English and American authors.

Upper Cretaceous	Danian.	
	Maestrichtian.	
	Campanian.	
	Santonian.	
	Coniacian (Emscherian).	
	Turonian.	
	Cenomanian.	
Lower Cretaceous	Albian (Upper Gault) Greensand and Lower Greensand.	Neocomian.
	Aptian.	
	Barremian.	
	Hauterivian (Wealden).	
	Valangian.	

Table of Distribution (*Table B*).

In the Table I have indicated the occurrence in other parts of the Northern Hemisphere, and in floras ranging in age from Jurassic to Upper Cretaceous, of species believed to be more or less closely related to Greenland plants. No attempt is made to distinguish between specific identity and resemblance suggesting affinity. A Greenland species is not infrequently compared with species described by authors under generic names different from those used in the descriptive part of this paper. All that is claimed for the Table is that it gives an approximate estimate of the degrees of similarity between the Greenland flora and those of other regions.

* HAUG (20), p. 1167.

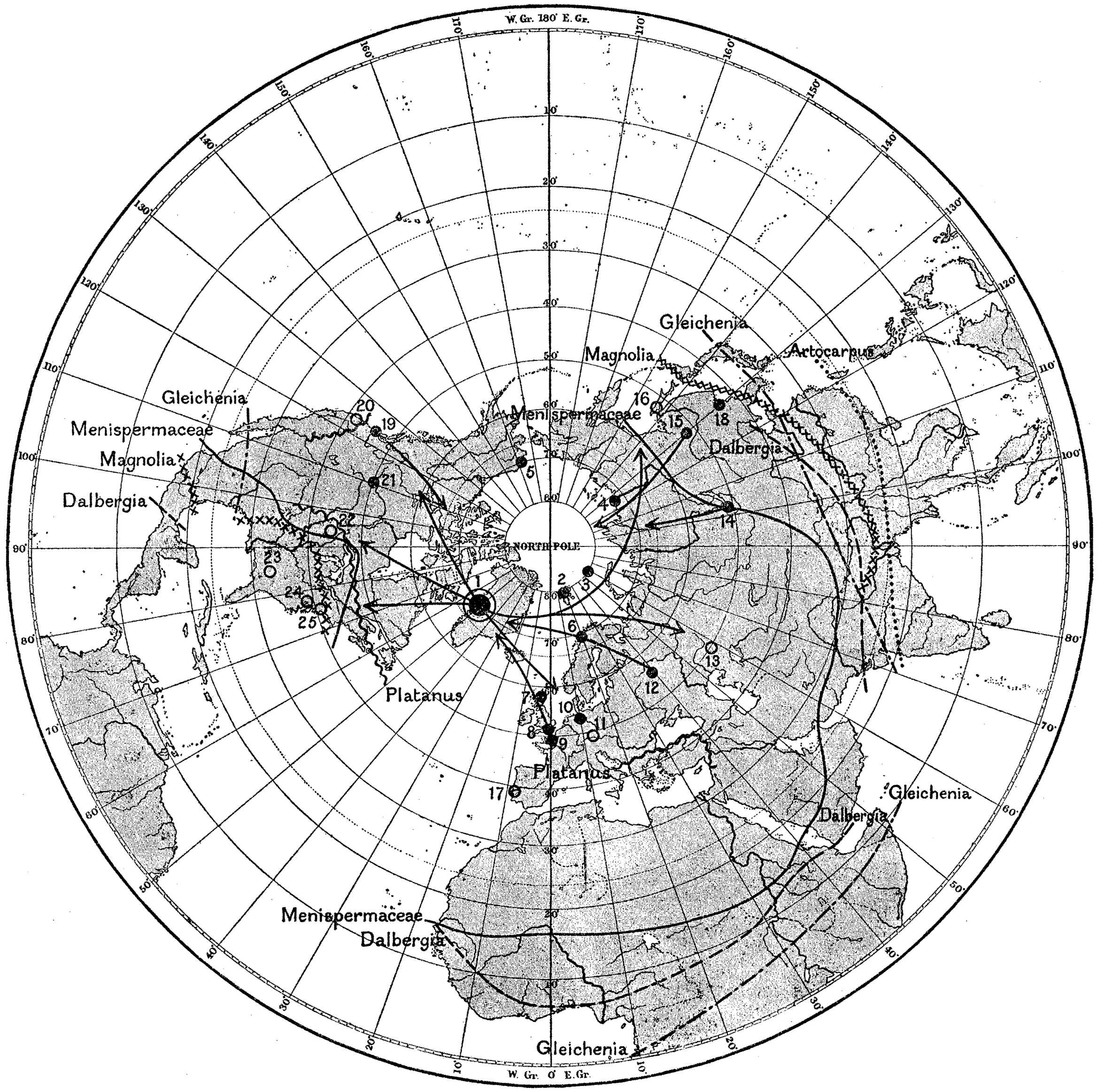
TABLE OF DISTRIBUTION. The numbers are repeated on Map II.

TABLE B.

Greenland.	Spitsbergen.	F. J. Land.	Lena.	Alaska.	Andö.	Sutherland.	England.	France and Belgium.	N. Germany.	Quedlinburg.	Bohemia.	Russia.	Urals.	Siberia.	Sakhalin.	Portugal.	Vladivostock.	Oregon.	Shasta.	Kootanie.	Dakota.	Eastern Gulf.	Potomac.	N. Jersey.
1	2	3	4	5	6	7	8	9	10	11A	11B	12	13	14–15	16	17	18	19	20	21	22	23	24	25
Gleichenites Gieseckiana ...	◆						◆	◆	◆	◆		◆			◆				◆		◆			◆
G. Nordenskioldi						◆			◆															
G. Porsildi															◆									
Laccopteris rigida						◆	◆	◆	◆	◆	◆	◆			◆		◆							
Hausmannia sp.						◆	◆	◆	◆	◆						◆			◆					
Sphenopteris psilotoides ...	◆	◆		◆		◆	◆	◆	◆	◆	◆				◆	◆				◆	◆	◆	◆	
S. Johnstrupi	◆												◆	◆	◆	◆			◆		◆	◆	◆	◆
S. dentata	◆	◆				◆			◆		◆			◆									◆	
Cladophlebis Oerstedi			◆															◆		◆			◆	
C. frigida						◆	◆	◆			◆		◆	◆	◆		◆		◆		◆		◆	
C. sp. cf. C. Browniana ...	◆						◆	◆	◆			◆			◆	◆			◆	◆			◆	
Tæniopteris arctica	◆		◆			◆	◆	◆	◆		◆			◆	◆			◆	◆					
Pseudocycas Steenstrupi ...							◆		◆					◆	◆	◆					◆			◆
Pterophyllum concinnum ...				◆			◆		◆										◆					
Ptilophyllum arcticum ...		◆				◆	◆		◆									◆		◆				
P. Heeri						◆		◆										◆	◆					
Otozamites Schenki				◆		◆	◆		◆						◆	◆								
Pseudoctenis latipennis ...	◆					◆	◆							◆				◆	◆		◆		◆	
Williamsonia cretacea																		◆			◆			◆
Ginkgoites pluripartita ...	◆	◆	◆	◆		◆		◆	◆					◆	◆			◆						
Baiera ikorfatensis	◆		◆	◆	◆									◆										
B. sp. cf. B. Lindleyana ...	◆				◆	◆								◆									◆	
Phœnicopsis Steenstrupi ...	◆	◆	◆	◆	◆	◆								◆	◆					◆				
Dammarites borealis											◆				◆						◆	◆		◆

TABLE B—*continued.*

Greenland. 1	Spitsbergen. 2	F. J. Land. 3	Lena. 4	Alaska. 5	Andö. 6	Sutherland. 7	England. 8	France and Belgium. 9	N. Germany. 10	Quedlinburg. 11A	Bohemia. 11B	Russia. 12	Urals. 13	Siberia. 14–15	Sakhalin. 16	Portugal. 17	Vladivostock. 18	Oregon. 19	Shasta. 20	Kootanie. 21	Dakota. 22	Eastern Gulf. 23	Potomac. 24	N. Jersey. 25
Pagiophyllum ambiguum ...						◆	◆		◆											◆	◆	◆	◆	◆
Cupressinocladus cretacea ...							◆	◆							◆	◆					◆			◆
Moriconia cyclotoxon																					◆	◆		◆
Sequoiites concinna																								
Elatocladus Smittiana ...	◆							◆							◆								◆	
E. Dicksoniana				◆							◆													
E. subtilis											◆										◆	◆	◆	◆
Sciadopitytes spp.	◆	◆	◆		◆				◆					◆				◆						
Pityolepis rugosa		◆						◆											◆	◆			◆	
Cyparissidium gracile					◆		◆	◆	◆		◆							◆	◆		◆		◆	◆
Macclintockia cretacea ...											◆				◆									
Menispermites dentatus ...															◆								◆	
M. Nordenskiöldi																					◆			
Menispermites (?) sp.											◆				◆						◆	◆		◆
Magnoliæphyllum alternans ...											◆										◆	◆		◆
Laurophyllum plutonium ...											◆										◆	◆	◆	◆
Cinnamomoides Newberryi ...											◆				◆						◆	◆		◆
C. Heeri											◆										◆	◆		◆
Platanus latiloba											◆		◆		◆						◆	◆		
P. Newberryana											◆		◆								◆	◆		◆
Platanophyllum insigne ...											◆		◆		◆						◆	◆	◆	◆
P. Wellingtonianum											◆					◆					◆			◆
Dalbergites simplex											◆										◆	◆		◆
D. borealis																					◆	◆		◆
Krannera marginata	◆			◆						◆								◆			◆			



MAP II.

Notes to Map II.

For convenience of reference the geographical position of a selected number of floras is shown on the Map. Many Cretaceous floras are omitted, as my object is not to give a comprehensive account of the world's vegetation, but to draw attention to the richer floras which present the closest affinity to the flora of Greenland. References to literature other than those given in the following Notes will be found in Dr. KNOWLTON'S Catalogue,* in the Summaries by Mr. BERRY,† and in the Catalogue by Dr. MARIE STOPES.‡

* KNOWLTON (19).

† BERRY (11^3), (16).

‡ STOPES (13), (15).

The older floras, without Angiosperms, are shown in solid black: the later floras, in which Angiosperms are abundant, are represented as circles.

The arrows indicate the two streams of migration, the northward trend of the Jurassic-Wealden floras, and the dispersal from Arctic lands of some of the oldest members of the present dominant group of Angiosperms.

The present, approximate, northern boundaries of the distribution areas of some of the Angiosperm families and genera which are represented in the Greenland Cretaceous flora are also indicated, and for these I am indebted to my friend Mr. RONALD GOOD.

The northern boundaries of the families and genera shown in Map II must be regarded as only approximations to the facts of geographical distribution. Thus a member of the Menispermaceæ, *Cocculus pendulus* DIELS, is recorded from localities in Egypt and elsewhere farther north than the line drawn for the family.

Map II. Locality 2. *Spitsbergen.**—NATHORST assigns the plants from Kap Staratschin and Advent Bay to the Upper Jurassic period (including Wealden), and those from Kap Boheman to the Middle Jurassic. All three floras include Greenland types and, botanically, there is no clear distinction between them. The comparisons made in the Table are based for the most part on resemblances which do not amount to specific identity.

3. *Franz Josef Land.*†—The material is too meagre and imperfect to be compared in detail with the Greenland flora, or to be assigned within narrow limits to a geological horizon. NATHORST considered the flora to be Upper Jurassic, or transitional to Cretaceous. I regard it as more Jurassic than Cretaceous.

4. *Lena.*‡—This Jurassic flora is also insufficient for accurate correlation: it differs considerably from that of Greenland, but there are a few connecting links.

5. *Alaska.*§—KNOWLTON regards the Cape Lisburne flora as definitely Jurassic, and not Jurassic-Cretaceous as FONTAINE supposed. It is probably Upper Jurassic in age. KNOWLTON has also described an older Jurassic flora from Alaska [KNOWLTON (16)].

6. *Andö.*‖—This small flora has been assigned both to the Kimmeridgian and to a Mid-Jurassic position. The few samples collected indicate, in my opinion, an association very similar to that in the Greenland vegetation.

7. *North-East Scotland.*¶—The plants from Sutherland exhibit a very striking resemblance, often amounting to specific identity, to those of Greenland. This Scottish flora is no doubt Upper Jurassic in age, and though probably not contemporaneous with that of Greenland, it may well represent an assemblage of forms which wandered farther north and, within the Arctic circle, became associated with recently evolved Angio-

* NATHORST (97); HEER (76).

† NEWTON and TEALL (97); NATHORST (99); SOLMS-LAUBACH (04).

‡ HEER (78).

§ FONTAINE IN WARD (05); KNOWLTON (14).

‖ HEER (77); JOHANNSON (20); FLORIN (22).

¶ SEWARD (11^2); SEWARD and BANCROFT (13); FLORIN (22).

sperms. It is significant that this flora, unlike the majority of Jurassic floras, resembles that of Greenland in the conspicuous part played by Gleicheniaceous Ferns.

8. *England.**—The Wealden flora of England is connected with the Greenland flora by some identical species, and by others that are closely allied. The Gleicheniaceæ, though inconspicuous, are almost certainly represented. The absence of *Ginkgoites* may be only a local peculiarity.

9. *Northern France and Belgium.*†—The ABBÉ CARPENTIER's preliminary account of the Wealden flora of France demonstrates a close affinity to the older members of the Greenland flora. The Wealden flora of Belgium, only a portion of which has been described, agrees closely with those of England and France. The floras of Aachen and Holland, from localities not far from the Wealden area, are not included in the Table : they show affinities to the Greenland flora, but the rich collections from Aachen have never been fully described. Both these floras are usually spoken of as Upper Cretaceous.

10. *North-West Germany.*‡—The flora agrees closely with those from other Wealden localities and, apart from the absence of Angiosperms, with the flora of Greenland.

11, A. *Saxony.*§—From several localities many Cretaceous plants have been collected, some from Lower, others from Upper, Cretaceous beds. The records given in the Table (11, A) refer only to those from the older strata near Quedlinburg, assigned by RICHTER to the Hauterivian series. Several of RICHTER's specimens were examined in the Stockholm Museum, and I was struck by their close agreement with Greenland species—*e.g.*, *Laccopteris* (fig. 125, Plate 12), *Krannera*, and other genera. The Saxon plants as a whole clearly point to a succession of types comparable to that in Greenland, but in the Lower Cretaceous flora of Quedlinburg we miss the Arctic Angiosperms.

11, B. *Bohemia and Moravia.*‖—In these floras, which are regarded as approximately Cenomanian, the modern phase of the Greenland flora is reproduced. There is a larger proportion of Ferns, especially the Bohemian Gleicheniaceæ, than in the American floras. The species of *Matonidium* from Kunstadt is an unusually late survival of the genus in the Northern Hemisphere.

12. *Klin.*¶—This flora, which has a definitely Wealden facies, needs revision.

13. *Ural Province.***—The few fossils described from beds spoken of as Cenomanian demonstrate the occurrence of a flora in Eastern Europe closely allied both to central European and North American floras.

14, 15. *Siberia.*††—The Jurassic floras of Irkutsk and the Amur district include several species closely allied to Greenland plants, which at a later date reached the Arctic regions. The absence of Gleicheniaceæ and *Laccopteris* is noteworthy.

* SEWARD (94), (95), (13).

† CARPENTIER (21), (21^2), (22) ; SEWARD (00^2) ; FRAIPONT (21).

‡ DUNKER (46) ; ETTINGSHAUSEN (52) ; SCHENK (71), (75) ; LIPPS (23).

§ RICHTER (06).

‖ VELENOVSKY (82), (84), (85), (86), (87), (87^2), (88), (89) ; FRIČ and BAYER (01) ; KRASSER (96).

¶ TRAUTSCHOLD (76).

** KRISHTOFOVICH (14).

†† HEER (76^2), (78) ; SEWARD (12^2).

16. *Sakhalin Island.**—In a preliminary account of this flora it is stated that the stratigraphy has been incompletely studied: a threefold division of the strata is proposed, based on Palæobotanical data. The oldest series is correlated by KRISHTOFOVICH with HEER's Kome series and the Albian stage: the middle is referred to the Cenomanian, and the upper to the Senonian. The flora as a whole bears a striking resemblance to that of Greenland: the latter is distinguished by the greater variety of Gleicheniaceæ and by the larger number of Angiosperms.

17. *Portugal.*†—This rich flora includes plants ranging in age from Neocomian to Upper Cretaceous horizons: it is much less closely allied to the Greenland flora than those from other localities, and suggests a different geographical province.

18. *Vladivostock.*‡—A small flora including species linking it both with the floras of Japan and Korea and the flora of Greenland.

19. *Oregon.*§—A Jurassic flora recalling those of Europe and Siberia, and containing elements represented in the later Greenland flora.

20. *Shasta.*‖—This Californian flora may be compared with the Wealden floras of Europe: it includes plants very similar to Greenland species.

21. *Kootanie.*¶—The Lower Cretaceous Kootanie flora of Alberta and Montana includes species which may be identical with Greenland forms.

22. *Dakota.***—The Cretaceous floras of the United States have for many years occupied the attention of American Palæobotanists, and the mass of data is bewildering. The difficulty of correlating the floras, both with one another and with those of other parts of the world, is increased by the large number of local names employed. As Prof. LAURENT says, the American memoirs are liberally illustrated, and whether or not one agrees with the determinations, one is grateful for the wealth of material recorded.

The term Dakota, first used in 1861 for certain Cretaceous beds in Nebraska, was afterwards employed in a wider sense and embraced plant-bearing strata which, as BERRY says, are probably not all of the same age. KNOWLTON records Dakotan floras in the States of Colorado, the Dakotas, New Mexico, Wyoming, Nebraska and Montana. It has been customary to regard them as Cenomanian, though BERRY considers that they may be equivalent to the Turonian of Europe. To approximately the same stage in botanical history may be assigned the flora of the Woodbine sands (Texas), the rich Tuscaloosa flora (Map, 23), and the Raritan flora of New Jersey (Map, 25). In all these floras Dicotyledons are the dominant plants, and several of them are identical with Greenland species. *Gleichenites* is poorly represented; *Laccopteris*, *Hausmannia*, and many other Greenland types are absent. There are practically no Cycads, and several of the characteristic Greenland Conifers are either absent or represented by meagre material.

* KRISHTOFOVICH (18), (18^2); HEER (78^2).

† HEER (81); SAPORTA (94).

‡ KRISHTOFOVICH (23).

§ WARD (05).

‖ WARD (05).

¶ DAWSON (85), (92); FONTAINE (92); WARD (05); SEWARD (24^2).

** LESQUEREUX (91); CAPELLINI and HEER (67); BERRY (22), (22^2).

23. *Eastern Gulf Region.**—The rich floras of Tuscaloosa and Ripley consist mainly of Angiosperms and, as BERRY points out, these include wide-ranging species which are represented in the Greenland flora. The Ripley flora is believed to be Emscherian, and the Tuscaloosa flora is slightly older.

24. *Potomac.*†—The Potomac group of the Coastal Plain agrees in several respects with the Greenland Cretaceous formation; it consists of a thick series of freshwater beds, characterised by false-bedding and resting on older crystalline rocks. The three formations into which the group has been divided are separated from one another by unconformities, though Palæobotanically there is no clear difference between them save in the relative abundance of Angiosperms in the uppermost formation. The lowest (Patuxent) and the middle series (Arundel) are correlated with the Neocomian of Europe: in these two floras there are no undoubted Angiosperms comparable with those of Greenland. On the other hand, the upper series (Patapsco), correlated with the Albian, includes several Dicotyledons, some of which are Greenland types. Among the Pteridophytes and Gymnosperms of the older Potomac beds are several Greenland forms; but *Gleichenites*, *Laccopteris*, and *Ginkgoites* are unrepresented. The Greenland vegetation is more closely linked with the Upper Jurassic flora of Scotland and the Wealden floras of Europe.

25. *New Jersey*‡—The Cretaceous floras of New Jersey, notably the Raritan and Magothy floras, correlated respectively with the Cenomanian and Turonian, represent a later phase than the Potomac formation. They contain a high percentage of Dicotyledons, and several Greenland species have been recognised.

Towards the close of the Lower Cretaceous period there began an almost world-wide overflowing of the continents by the ocean, which reached its maximum in the early days of the Upper Cretaceous period, and is usually spoken of as the Cenomanian Transgression. The oldest Cretaceous plant-bearing beds in England and other parts of Europe are continental deposits intercalated with marine sediments: these include the Wealden series of the South of England, Northern France, Belgium, Northern Germany, Portugal, and a few other European regions; also the lower portion of the Potomac group, and beds of the same age along the axis of the Rocky Mountains (the Kootanie formation). The Wealden floras are essentially Jurassic in character: Ferns and Gymnosperms are the dominant plants: Angiosperms of the modern type are unrepresented.

For the botanist the Cretaceous period has a special interest. It was from the Cretaceous rocks of Greenland that HEER described the then oldest Dicotyledon which, on wholly inadequate evidence, he named *Populus primæva*.§ Subsequently other leaves were recorded from Lower Cretaceous strata in Portugal and North America as archaic Dicotyledons, but their affinities have not been definitely determined. The

* BERRY (14²), (19), (25).

† WARD (05); BERRY (11³).

‡ NEWBERRY (95); HOLLICK (06); HOLLICK and JEFFREY (09); BERRY (11).

§ SEWARD (25), p. 244.

outstanding feature of the oldest Cretaceous floras is the complete, or almost complete, absence of plants which have the morphological characters we now associate with Angiosperms. On the other hand, the discovery of several petrified Dicotyledons in Aptian rocks in England,* which do not exhibit features that can be regarded as primitive, clearly points to a long antecedent period of evolution. In 1904 I figured a single specimen from the Jurassic beds of Stonesfield,† which in form and venation appears to be Dicotyledonous. In a recently published paper, Dr. THOMAS‡ has described in detail two genera of Angiospermous fruits. Though actual proof is lacking, it is probable that the leaves long known as *Sagenopteris* represent the foliage of these Jurassic Angiosperms. Dr. THOMAS shows that the Jurassic type of reproductive shoot was in existence at least as early as the Rhætic period, but it was not until the Cretaceous period had well begun that Angiosperms, agreeing with present-day genera in the morphological characters of the foliage-shoots, assumed a prominent position in the vegetation of the world.

The rise to dominance of the Angiosperms has almost the appearance of a sudden revolution. "Nothing is more extraordinary," wrote DARWIN to HOOKER in 1857, "in the history of the vegetable kingdom, as it seems to me, than the apparently very sudden or abrupt development of the higher plants." The difference between the lowest Cretaceous floras, in which the Jurassic tradition is continued, and the later Cretaceous floras, rich in wide-ranging Angiosperms essentially modern in type, is a remarkable feature. It is reasonable to suggest that the shifting of the balance of power was not merely the expression of a stage in organic evolution, but that it may have been a response to some physical stimulus. The Cenomanian Transgression may have been a potent factor which reacted on the plant world.

HEER's division of the Greenland rocks into the three series Kome, Atane, and Patoot, with their correlation with European equivalents, has until recently been generally accepted. Reference has already been made to the opinion of WHITE and SCHUCHERT, based on the discovery of additional Dicotyledonous leaves, that the Kome series does not occupy so low a position as HEER suggested; also to HEIM's belief that all the Cretaceous plant-beds in West Greenland belong to the Upper portion of the Cretaceous system. BERRY§ has recently expressed the opinion that the limits of HEER's Greenland floras do not rest on a sure foundation. HEER compared the flora of the Kome series with that obtained from European Wealden formations, and with the Lower Cretaceous Wernsdorf beds of Austria: the Atane series he regarded as Cenomanian, a conclusion that has been generally accepted. He assigned the Patoot series to the uppermost Cretaceous. The regular sequence of beds, both Cretaceous and Tertiary, especially well seen at Atanikerdluk, includes records of successive floras which flourished for a comparatively long period on the Arctic portion of a North Atlantic continent.

It is difficult accurately to correlate the Cretaceous members of this series with the

* STOPES (12), (15).

† SEWARD (04), Plate XI, figs. 5, 6.

‡ THOMAS (25).

§ BERRY (25).

scattered records in other regions, and I am convinced that until more facts are available we cannot overcome the difficulty. My view is that the Greenland Cretaceous flora represents more fully than the floras of other countries the early stages in the transitional period from an older Jurassic-Wealden vegetation to the type of flora which continued into the Tertiary period, and still persists in regions remote from its original home. A comparison of late Cretaceous floras and those of Tertiary age with recent floras reveals differences which can be expressed mainly in terms of geographical distribution: climatic changes and other factors have played an important part, but geological history demonstrates not only the recurrent appearance of new families and genera, with the development of herbaceous plants in the wake of deciduous Angiosperms; it reveals also wanderings from one hemisphere to another, and the persistence in warmer regions of forms which I regard as the direct descendants of Cretaceous species. In the early stages of their career the ancestral species were able to live in a temperate climate, and to adapt themselves to alternate periods of concentrated activity and prolonged quiescence, such as we now associate with Arctic lands.

We will first consider the Greenland vegetation as a whole, regarding it, for the present at least, as a single unit. It includes Ferns and Gymnosperms which are Jurassic-Wealden in type; and with these survivals of the cosmopolitan Jurassic vegetation are several Angiosperms. From the Kome series at Ikorfat HEER recorded his *Populus primæva*, and a few other Dicotyledons were subsequently collected by WHITE and SCHUCHERT from the same series. At Ikorfat Mr. HOLTTUM and I found a fragment of an inflorescence of *Artocarpus* (Plate 11, fig. 113). In the rocks of Upernivik Island occur side by side Wealden Ferns and Gymnosperms and *Platanus* leaves hardly distinguishable from living species. The point I wish to make is that in the Cretaceous floras of Greenland, Dicotyledons, which are surprisingly modern in the form of the leaves, occur in association with Ferns and Gymnosperms, which in other parts of the world are characteristic of floras distinguished by an absence of any recognisable examples of modern Angiosperms. This fact lends support to the view that it was within the Arctic circle that the evolution of deciduous Angiosperms progressed with greater rapidity and energy than in more southern latitudes. A factor concerned in this development may have been the alternation of continuous sunshine and a long period of rest.

The Greenland flora agrees most closely with Lower Cretaceous floras of Europe and North America, and with floras of the Old and New Worlds which are usually regarded as Cenomanian in age. A study of American and European floras shows that the distinction drawn between the Lower and Upper Cretaceous is supported by Palæobotanical evidence, but in Greenland we find an admixture of plants which does not admit of so simple a classification. The land that is now Greenland is an exceedingly ancient portion of a large continent* which served as a refuge for immigrants from other, less stable, areas in more southern latitudes; and it is this more permanent attribute of Greenland—its

* For a map of the world in the Middle Cretaceous period, *see* SCHUCHERT in PIRSSON and SCHUCHERT (20), p. 891.

greater immunity from the destructive effects of geological revolutions—that gives a peculiar interest and importance to the investigation of the floras. The flora of Greenland as a whole represents a stage of Cretaceous history, as measured by American and European standards, equivalent to Neocomian-Cenomanian or -Turonian.

In his final revision of the Greenland floras HEER recognised 88 species from localities on the north coast of the Nûgssuak peninsula included in the Kome series: 177 species from Upernivik Island, Atanikerdluk, and localities on the coast of Disko Island referred to the Atane series, and 116 species from the Patoot series. An examination of his figured specimens and other material collected in 1921 has convinced me that he considerably over-estimated the number of species. HEER recorded 43 Ferns from the Kome series: I estimate the number at about 20. For his 10 species of Cycadophyta I substitute 4. Similar reductions have been made in the lists from the other series. Table A on pages 88, 89, shows that there is a striking resemblance in the records from the places assigned by HEER to the Kome series, which have afforded only a very small number of Angiosperms. On the other hand, there seems to be no adequate reason for referring the plant-beds of Upernivik Island to a higher division of the Cretaceous system than that with which the Kome series was compared by HEER. The Wealden character of the Upernivik flora is clearly demonstrated: the abundance of *Platanus* leaves is a characteristic feature, but that is not a sound argument for its reference to a higher horizon. Many of the Upernivik plants are identical with Kome species, and it is noteworthy that specimens of *Platanus* leaves from Angarsuit, one of HEER's Kome localities, are almost certainly specifically identical with the Upernivik form. The majority of the Atanikerdluk species are not recorded either from Kome localities or from Upernivik Island: the greater abundance and variety of Dicotyledons and the almost complete absence of *Gleichenites* are characteristic features of the Atanikerdluk flora, which probably indicate a higher position in the Cretaceous system. On the other hand, the Atanikerdluk *Pseudocycas* affords a link with Upernivik Island. The material from Disko Island is less abundant, but the species from Igdlukunguak indicate an advance in the development of Dicotyledons over the flora of Upernivik Island and that from the north coast of the Nûgssuak peninsula. The Patoot flora, obtained in part from loose blocks of rock, includes Ferns, which appear to be identical specifically with those from HEER's Kome and Atane series, together with Gymnosperms not recorded from other places in Greenland, and a few distinct species of Dicotyledons. The discovery of a *Ptilophyllum* at Pâtût shows that HEER was incorrect in stating that Cycads are unrepresented in the Patoot series.

In justice to HEER it must be admitted that his classification has served a useful purpose. It is clear that the many hundred feet of plant-bearing strata represent a long period, during which certain types of Pteridophytes and Gymnosperms continued to flourish on the northern continent while the development of the more modern Angiosperms was gradually effected. The older, Jurassic-Wealden, elements of the Greenland flora are regarded as migrants from the south: the Angiosperms are believed to be the advance guard of a race which subsequently spread over the world from an Arctic home (Map). Some of the genera which occur in the beds of Western Greenland were members of the rich Rhætic flora of East Greenland, of the closely allied Rhætic flora of Southern Sweden, and of the Lower Jurassic flora of Bornholm.* We will first deal with the Jurassic-Wealden genera which in earlier days flourished along the western border of North America (Map, 19), in Europe, Siberia (Maps, 14, 15), India, and elsewhere, and persisted into the Wealden phase. The Gleicheniaceæ are more abundant and varied in Greenland than in any other regions of the Cretaceous or Jurassic world. The family is represented in floras older than that of Greenland, in Poland, India, and other countries. In the Arctic lands the wanderers from the south found conditions favourable to vigorous growth and development. It is probable that the alternate periods of continuous activity and prolonged rest were in harmony with Ferns possessing fronds capable of intermittent growth. The Gleicheniaceæ† are now widely spread across the globe in the southern hemisphere, and while they are in a special sense characteristic of tropical countries, they include species able to exist as far south as the Magellan Straits, the Falkland Islands, the South Island of New Zealand, or at an altitude of 12,000 feet in New Guinea and over 10,000 feet on Ruwenzori. The genus *Laccopteris* is now recorded for the first time from Greenland, where it is represented by a form indistinguishable from the European Wealden species *L. rigida*, and closely allied to Jurassic and Rhætic examples. Its nearest living relative, *Matonia*, has a limited range in Malaya. *Hausmannia* is another Arctic wanderer from older and more southern floras: in the Rhætic and Lower Jurassic periods it existed in Southern Sweden and in Bornholm, and at a later stage in Northern Scotland. The recent genus *Dipteris*, a Malayan and Indian Fern, is a survival of a stock which in early Cretaceous days had reached the Arctic continent. *Pseudocycas* and *Pseudoctenis* are examples of Cycadophytes which penetrated within the Arctic circle. The Greenland species of *Ptilophyllum* are survivals of a far-ranging Jurassic genus, and *Otozamites* and *Pterophyllum* are derivatives from more southern floras. *Ginkgoites pluripartita* is a Wealden species differing in no essential respect either from Jurassic ancestors or from Tertiary descendants. The species of *Baiera* and the single representative of *Phœnicopsis* are additional links with the pre-Cretaceous vegetation. The Conifers are more difficult to interpret, but species of *Elatocladus*, *Sequoiites concinna* and others are reminiscent of Jurassic-Wealden types: with them is *Moriconia*, a genus which, as BERRY points out, is unknown from any other part of the world in rocks as old as those of Greenland. In all probability the Conifers of Greenland were in part derived from older members of the group which had reached the far north, and in part consisted of more recently evolved types which were northern in origin. The abundance of *Sciadopitytes* is a striking feature of some of the Greenland beds: this type is now represented by a species in the Far East.

Jurassic-Wealden floras extended farther north than Western Greenland (Map, 2, 3),

* MÖLLER (02), (03).

† With reference to the present and past distribution of Ferns, see SEWARD (22[2]).

but, though linked by some of their elements with the flora of Greenland, they are probably slightly earlier, and all of them lack the Angiosperm associates which give a special character to the vegetation we are now considering. Other Jurassic-Wealden floras are mentioned in the Notes on the Map.

I regard the Greenland flora, or at least that part of it we are now discussing, as belonging to the same botanical province as the Upper Jurassic flora of Scotland and the Wealden floras of North-West Europe, though not necessarily contemporaneous with them.

Passing to the floras of the Old and New Worlds, in which Dicotyledons more or less closely allied to Arctic species play a dominant part, we find a striking falling-off in the representatives of Greenland Pteridophytes and Gymnosperms. The Greenland flora must be correlated with two categories of more southern floras, Neocomian and Cenomanian-Turonian. The time interval comprised within the Greenland strata may be longer than that represented by a single flora, but the important point is that we cannot draw any clear line between different phases of the vegetation. There is a more intimate mixture of old and new types than in more southern floras. The floras of Dakota, the Eastern Gulf region, and New Jersey (Map, 22, 23, 25) agree closely in their Angiosperms with the newer features of the Greenland flora: they differ in the absence of most of the older elements. The vegetation of Greenland is not strictly comparable with any one flora elsewhere: it is peculiar in exhibiting more clearly than other associations a combination of relics of the old order, and recently evolved members of a class destined to colonise the world. The Potomac formation (Map, 24) resembles the Cretaceous system of Greenland in several respects, but there are no representatives of *Laccopteris*, *Gleichenites*, *Pseudocycas*, *Ginkgoites*, and some other genera characteristic of the more northern flora. The Potomac floras were probably contemporaneous with the flora of Greenland, but the area occupied by the former was never reached by several of the Jurassic-Wealden species which found their way to Greenland.* When the earlier Potomac vegetation flourished the modern types of Angiosperms had not travelled so far south, and it is only during the later stages of the Potomac period, and in the interval represented by the unconformity between the Potomac and Raritan formations, that the main army of the recently evolved Angiosperms occupied American territory.

In the Old World the floras, having Angiosperms as abundant components, which most closely resemble the flora of Greenland are those of Sakhalin Island (Map, 16) and Bohemia (Map, 11): in both Jurassic-Wealden forms occur, though to a less extent than in Greenland. I regard these floras as somewhat later than at least the earlier phase of the Greenland vegetation.

The earlier members of the Greenland flora may not have been contemporaneous with Wealden floras of Europe, but the difference in time was comparatively slight. There was a northward spread of Jurassic genera, and on the Arctic continent they became

* It is noteworthy that the genera *Tempskya* and *Weichselia*, two widely distributed Wealden plants, have not been found in Greenland.

associated with newly created Angiosperms. A migration of Angiosperms from an Arctic home is no new idea: my contention is that such revision of the Greenland flora as I have been able to make, while lending support to the Arctic origin of many deciduous Dicotyledonous trees, also leads to the conclusion that the Cretaceous vegetation of Greenland was richer than has previously been supposed in members of older floras that wandered north in the later stages of the Jurassic-Wealden period.

The close resemblance between the Ripley flora of the Eastern Gulf region (Map, 23) and HEER's Patoot flora, to which BERRY* has drawn attention, should not, I think, be regarded as evidence of the existence at one period of time of a uniform type of vegetation from Greenland to the Mexican Gulf. Similarity in composition of floras separated by many degrees of latitude may be interpreted as the record of a migration from the north: the floras of the different localities are essentially similar because they are samples of a vegetation which originally existed in Arctic lands, gradually spread along divergent routes, and at a later date established itself in the southern part of North America.

B.—*The Cretaceous Climate.*

There remains the vexed question of climatic conditions. A comparison of the present areas of distribution of Angiosperms agreeing in a greater or less degree with those of Greenland (Map II) points to a migration either across the equator or to the Mediterranean region, and demonstrates that it is in sub-tropical or tropical lands that we find the greater number of Cretaceous types. During the early part of the Tertiary period the vegetation of Europe still retained traces of the older Arctic floras: the genus *Platanus* was one of the few which has survived north of the Mediterranean. The majority reached the Tropics, where they still remain. At first sight it would seem that the climate of Cretaceous Greenland was almost tropical, and it has often been assumed that the only possible method of providing the necessary conditions is by taking liberties with the axis of the earth. To this course there are serious objections: there is no astronomical support for assuming a change in the position of the axis since an age more remote than the Cretaceous, and were it permissible to assume a different position of the Arctic regions in relation to the sun, difficulties, though solved in one place, would be raised in others.†

The objection to any wandering of the poles may be partly met by assuming a sliding movement of the crust. WEGENER says, "We shall, therefore, for all purposes, understand by the wandering of the poles a displacement of the poles on the earth's surface, without reference to whether this was produced by a movement of the crust, or by a displacement of the axis in the interior of the earth, or by both together."‡ It is highly probable that movement of the continental masses constitutes an important factor which must be taken into account in relation to climatic changes in the past. A comparatively

* BERRY (25).

† SEWARD (24).

‡ WEGENER (24), p. 93. *See also* KÖPPEN and WEGENER (24).

stable axis does not preclude the assumption of crustal displacement which altered the position of land areas in relation to the pole.

It is, I think, reasonable to assume that in Cretaceous Greenland, as at present, short summers with continuous sunshine alternated with longer periods of comparative darkness. There is no difficulty in picturing deciduous Angiosperms, Ferns such as Gleichenias, with their resting buds, and ancestors of Conifers which are now able to withstand conditions more severe than those of Cretaceous Greenland, enduring with impunity an Arctic night. Mr. BROOKS* reminds us that, assuming the determination of temperature by solar radiation in the past as in the present, there must have been climatic zones in former periods. The existence of low land in the Arctic zone, and a widespread ocean causing a freer interchange between tropical and northern waters, would substantially raise the temperature. The change needed to enable a sub-tropical flora to exist in high latitudes is not great: if the temperature in Norway (lat. 65° N.) were raised 8° C. in winter and 4° C. in summer the conditions would approximate to those of the North Island of New Zealand with its sub-tropical flora.† The present climate of Greenland is probably abnormal: as KNOWLTON‡ says, the normal state is greater uniformity, milder and more equable conditions than at present. Uniformity must, however, not be taken in too literal a sense, but rather as implying differences between Arctic and other regions less pronounced than we are familiar with to-day. Moreover, the close agreement between widely separated floras, which is expressed by the use of the same geological time-designation, may not mean their co-existence in regions far apart, but in part at least may represent a composite picture of a wave of vegetation which, in a relatively short time, spread over many degrees of latitude.

Arguments based on past as compared with present areas of distribution may be fallacious. The present distribution of *Artocarpus*, the Menispermaceæ, the Magnoliaceæ,§ *Dalbergia* (*see* Map) and other genera or families represented in the Greenland flora, undoubtedly point to an Arctic environment very different from that of to-day; but as times have changed in the world, the plants themselves have in all probability changed also in their reactions to external factors. The genus *Platanus*, though occupying south temperate regions, is able to withstand relatively severe conditions. JAENNICKE‖ states that Plane trees in Germany lived through winters which were fatal to many other trees. *Ginkgo* is a very adaptable tree in northern climates: it lives out of doors as far north as Viborg in Finland (lat. 60° N.). *Sciadopitys* is said by WILSON¶ to be perfectly hardy in the Harvard Arboretum. Other Cretaceous genera that are now confined to the Tropics may well have been represented by species better able to endure hardships than many of their less robust ancestors.

* BROOKS (22).

† HUNTINGTON and VISHER (22), p. 177.

‡ KNOWLTON (19[2]).

§ GOOD (25).

‖ JAENNICKE (99).

¶ I am indebted to Mr. E. H. WILSON for these facts (Letter, April, 1924). See also WILSON (20), p. 66.

The climate of Greenland was probably comparable with that of Southern Europe to-day: genera that are now characteristic members of tropical floras, the floras which are in part legacies from the Cretaceous age, were then represented by species less sensitive than their modern descendants to external factors.* Such climatic changes as seem to be demanded by Palæobotanical evidence can be accounted for without calling to our aid explanations based on purely hypothetical departures from the order of nature. Nothing is absolutely stable: the history of the kosmos has been punctuated by a succession of cycles, revolutions in the organic and in the inorganic world; but revolutions which are the result of changes in the distribution of land and water, in the form and height of continents, in the circulation of ocean currents; not revolutions consequent on variations in the position of the earth's axis far greater than any that are consistent with astronomical principles.

"The past seizes upon us with its shadowy hand and holds us to listen to its tale." The danger is lest the contrasts between the Greenland of the past and the Greenland of the present, which greatly increase the fascination of the task of interpreting the records, may exercise too great an influence upon the imagination and tend to deaden one's sense of proportion. I can only hope that this contribution to the botany of an ancient Arctic continent may stimulate others to extend and render more precise our knowledge of Cretaceous Greenland.

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* NATHORST (11^2).

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EXPLANATION OF PLATES.

PLATE 4.

Photograph A.—Section at Upernivik Naes (Upernivik Island) showing plant-bearing shales overlain by sandstones which are intersected by an oblique basaltic dyke. The photograph of Mr. R. E. HOLTTUM at the lower right-hand corner shows the scale. (Photo. A. C. S.)

Photo. B.—Entrance to ravine at Kugssinek Angnertunek (Upernivik Island). (Photo. A. C. S.)

Photo. C.—Sandstones, shales, and carbonaceous beds on the beach at Kûk (North side of Nûgssuak Peninsula). The photograph of the author at the lower right-hand corner shows the scale. (Photo. R. E. H.)

Photo. D.—Section at sea-level at Kûk showing decomposed gneiss of the Archæan land-surface, and, in the upper part of the photograph, Cretaceous sedimentary strata. (Photo. A. C. S.)

Photo. E.—The lower part of the cliff at Atanikerdluk (South side of Nûgssuak Peninsula), showing talus-slopes and exposure of Cretaceous plant-bearing rocks. HEER'S "Liriodendron bed" is exposed on the face of the lowest shoulder above the house. (Photo. A. C. S.)

Photo. F.—Cretaceous sandstone at Skansen (Disko Island), showing large nodules near the top, and lower down, just above Mr. E. Porsild, a narrow band, rich in carbonised rachises of *Gleichenites*, and other plants (Photo. A. C. S.).

PLATE 5.

The Photographs reproduced on this and the succeeding plates, with a few exceptions, were taken by Mr. W. TAMS. The drawings, unless otherwise stated, are by Mr. T. A. BROCK.

The magnification is given only when the specimen is not represented natural size.

The numbers in parentheses are from the British Museum Register.

FIG. 1.—*Gleichenites Gieseckiana* HEER. 1a, slightly enlarged pinnules showing the lobed lamina of the lowest; 1b, a forked lateral vein showing the position of a sorus. Kaersuarssuk. (V, 16,900.)

FIGS. 2, 3.—*G. Gieseckiana*. Kaersuarssuk. (Fig. 2, V, 16,901; fig. 3, V, 16,902.)

FIG. 4.—*G. Gieseckiana*. Kûk. (V, 16,903.)

FIG. 5.—Rachis in vernation. (?) *Gleichenites Gieseckiana*. Kaersuarssuk. (V, 16,904.)

FIG. 6.—*G. Gieseckiana*. 6A, Pinnule enlarged. Kugssinek angertunek. (V, 16,905.)

FIG. 7.—*G. Gieseckiana*. Coiled bud in fork of rachis. Kaersuarssuk. (V, 16,906.)

FIG. 8.—*G. Gieseckiana*. 8A, Lobed pinnules slightly enlarged. Pagtorfik. (V, 16,907.)

FIG. 9.—*G. Gieseckiana*. Fertile pinna, a piece of which is enlarged in fig. 16. Pagtorfik. (V, 16,908.)

FIG. 10.—*G. Gieseckiana*. Pinnæ with recurved pinnules. × 2½. Pagtorfik. (V, 16,909.)

FIG. 11.—*Gleichenia Gieseckiana*. 11A, Pinnule enlarged. Kaersuarssuk. (V, 16,910.)

FIG. 12.—*G. Gieseckiana*. Fertile pinnæ. 12A, pinnule enlarged to show sori. Pagtorfik. 12A drawn by Mr. J. WALTON. (V, 16,911.)

FIG. 13.—*G. Gieseckiana*. Forked rachis showing a modified pinnule, *a*, at the base of the prolonged axis. Pagtorfik. (V, 16,912.)

FIG. 14.—*G. Gieseckiana*. Fertile pinnæ. Kaersuarssuk. (V, 16,913.)

FIG. 15.—*Gleichenites sp.* × 3. Atanikerdluk. (V, 16,914.)

FIG. 16.—*Gleichenia Gieseckiana*. × 15. Enlarged piece of fig. 9. Pagtorfik. (V, 16,908.)

FIG. 17.—*G. Gieseckiana*. × 2½. Kaersuarssuk. (V, 16,915.)

PLATE 6.

FIG. 18.—*Gleichenites Porsildi* sp. nov. Forked axis with pinna attached. 18A, Pinnule. × 5. Angiarsuit (loc. B). (V, 16,916.)

FIG. 19.—*G. Porsildi.* Angiarsuit. (V, 16,917.)

FIG. 20.—Sporangium, (?) *Gleichenites Porsildi.* × 70. Skansen. (V, 16,918.)

FIG. 21.—Sporangium, (?) *G. Porsildi,* showing line of dehiscence. × 40. Skansen. (V, 16,919.)

FIG. 22.—*Gleichenites Nordenskiöldi* HEER. Pagtorfik. (V, 16,920.)

FIG. 23.—*Gleichenites sp.* Pieces of carbonised axes, half natural size. Skansen. (V, 16,921.)

FIG. 24.—*Gleichenites Porsildi.* Angiarsuit. (V, 16,922.)

FIG. 25.—*Gleichenites Nordenskiöldi.* 25A, pinnules enlarged. × 3. Pagtorfik.

FIG. 26.—*G. Nordenskiöldi.* × 7. Angiarsuit. Drawn by Mr. J. WALTON. (V, 16,924.)

FIG. 27.—*Gleichenites Porsildi.* 27A. × 2. Igdlukunguak. (V, 16,925.)

FIG. 28.—*Gleichenites* (?) *Waltoni* sp. nov. × 2. Kaersuarssuk. (V, 16,926.)

FIG. 29.—*Gleichenia Porsildi,* forked rachis. Angiarsuit. (V, 19,016.)

FIG. 30.—*G. Porsildi.* 30A. × 2. Pâtût. (V, 16,928.)

FIG. 31.—Carbonised rachises, (?) *Gleichenites Porsildi,* Skansen. Photo. Mr. J. WALTON. (V, 16,929.)

PLATE 7.

FIG. 32.—*Cladophlebis Oerstedi* (HEER). Kaersuarssuk. (V, 16,930.)

FIG. 33.—*Sphenopteris* (? *Onychiopsis*) *Johnstrupi* HEER. Kugssinek angnertunek. (V, 16,935.)

FIG. 34.—*Cladophlebis Oerstedi.* Kaersuarssuk. (V, 19,044.)

FIG. 35.—*C. Oerstedi.* Kaersuarssuk. (V, 16,934.)

FIG. 36.—*Sphenopteris* (? *Onychiopsis*) *psilotoides* St. and Webb. Kugssinek angnertunek. (V, 16,938.)

FIG. 37.—*S.* (? *Onychiopsis*) *psilotoides.* Kaersuarssuk. (V, 16,931.)

FIG. 38.—*Cladophlebis sp.* cf. *C. Browniana* (Dunk.). Upernivik Naes. (V, 16,937.)

FIG. 39.—*Sphenopteris dentata* Vel. 39A, pinnule enlarged. Kaersuarssuk. (V, 16,936.)

FIG. 40.—*Taeniopteris arctica* (HEER). Angiarsuit.

FIG. 41.—*T. arctica* (HEER). Angiarsuit. (V, 16,949.)

FIG. 42.—*Sphenopteris* (? *Onychiopsis*) *psilotoides.* Kaersuarssuk. (V, 16,933.)

FIG. 43.—*Ptilophyllum arcticum* (GOEPP.). Angiarsuit. (V, 16,939.)

FIG. 44.—*Sphenopteris* (? *Onychiopsis*) *psilotoides.* Kaersuarssuk. (V, 16,932.)

FIG. 45.—*S.* (? *Onychiopsis*) *psilotoides.* Kaersuarssuk. (V, 16,900.)

FIG. 46.—Pinnule of *Sphenopteris* (? *Onychiopsis*) *psilotoides,* enlarged to show the veins. Drawn by Mr. J. WALTON. (V, 19,042.)

FIG. 47.—Pinnule of *S.* (? *Onychiopsis*) *psilotoides.* Part of a frond from the Wealden beds of Sussex, England. (V, 3161.)

PLATE 8.

FIG. 48.—*Laccopteris rigida* (HEER). Pinnæ in their natural position. Kaersuarssuk. (V, 16,944.)

FIG. 49.—*L. rigida* (HEER). Kaersuarssuk. (V, 16,943.)

FIG. 50.—*L. rigida* (HEER). Kaersuarssuk. (V, 16,947.)

FIG. 51.—*L. rigida* (HEER). The upper part of fig. 58. Angiarsuit. (V, 16,941.)

FIG. 52.—*L. rigida* (HEER). The upper pinnules are fertile. Angiarsuit. (V, 16,948.)

FIG. 53.—*L. rigida* (HEER). Fertile pinna. 53A, × 2, showing sori. Kaersuarssuk. (V, 16,942.)

FIG. 54.—*L. rigida* (HEER). Showing habit. Kaersuarssuk. (V, 16,906.)

FIG. 55.—*L. rigida* (HEER). Part of branched frond and of fertile pinna. Kaersuarssuk. (V, 16,946.)

FIG. 56.—*L. rigida* (HEER). Fertile pinnule. Angiarsuit. (V, 16,940.)

FIG. 57.—*Sphenopteris Holttumi* sp. nov. 57A, enlarged pinnule. × 3. Kaersuarssuk. (V, 16,958.)

FIG. 58.—*Laccopteris rigida*. Angiarsuit. (V, 16,941.)

FIG. 59.—*L. rigida*. Sorus. × 30. (V, 16,945.)

FIG. 60.—*L. rigida*. Sorus. × 15. Kaersuarssuk. (V, 16,945.)

FIG. 61.—*Cladophlebis arctica* (HEER). (V, 16, 961.) 61A. × 2. Pâtût. (16,963.)

FIG. 62.—*Laccopteris rigida*. Pinnæ of fig. 48 enlarged. × 2.

FIG. 63.—*Conites sp. A*. Pagtorfik. (V, 16,957.)

PLATE 9.

FIG. 64.—*Pseudocycas Steenstrupi* (HEER). Kugssinek angnertunek. (V, 16,954.)

FIG. 65.—*Ginkgoites pluripartita* (SCHIMP.). Upernivik Naes. (V, 16,950.)

FIG. 66.—*G. pluripartita* (SCHIMP.). Leaf attached to the remains of a short shoot. Upernivik Naes. (V, 16,951.)

FIG. 67.—*Pseudocycas Steenstrupi*. Upernivik Naes. (V, 16,956.)

FIG. 68.—*Pagiophyllum ambiguum* (HEER). Two seeds in close association with a foliage shoot; enlarged. Pagtorfik. (V, 16,974.)

FIG. 69.—*Sequoiites concinna* (HEER). Pâtût. (V, 16,978.)

FIG. 70.—*Conites sp.* B. Pâtût. (V, 16,970.)

FIG. 71.—*Ginkgoites pluripartita*. Upernivik Naes. (V, 19,017.)

FIG. 72.—*Sequoiites concinna*. Pâtût. (V, 16,972.)

FIG. 73.—*S. concinna*. Cone-scale. Pâtût. (V, 16,971.)

FIG. 74.—*Ginkgoites pluripartita*. Upernivik Naes. (V, 16,955.)

FIG. 75.—*Conites sp.* C. Pâtût. (V, 16,973.)

FIG. 76.—*Ginkgoites pluripartita* (?). Ritenbenk's Coal-mine. (V, 16,964.)

FIG. 77.—*Pityolepsis rugosa* sp. nov. Upernivik Naes. (V, 16,953.)

FIG. 78.—*P. rugosa* sp. nov. Upernivik Naes. (V, 16,952.)

FIG. 79.—*Sequoiites concinna*. Pâtût. (V, 19,018.)

FIG. 80.—*S. concinna*. Pâtût. (V, 16,977.)

FIG. 81.—*Baiera ikorfatensis* sp. nov. Ikorfat. (V, 16,965.)

FIG. 82.—*Phœnicopsis Steenstrupi* sp. nov. Fig. 82A, Lamina enlarged. × 3. Angiarsuit. (V, 16,968.)

FIG. 83.—*Ginkgoites pluripartita*. Fig. 83A, Venation enlarged. Upernivik Naes. (V, 16,962.)

FIG. 84.—*G. pluripartita*. Upernivik Naes. (V, 16,960.)

FIG. 85.—*Elatocladus subulata* (HEER). Atanikerdluk. (V, 16,967.)

FIG. 86.—*Ginkgoites pluripartita*. Upernivik Naes. (V, 16,959.)

PLATE 10.

FIG. 87.—*Phœnicopsis Steenstrupi* sp. nov. Stomata and epidermal cells. × 176. Angiarsuit (loc. A.). (V, 19,036.)

FIG. 88.—*P. Steenstrupi*. × 18. Angiarsuit. (V, 19,035.)

FIG. 89.—*Dammarites borealis* HEER. × 4. Pâtût. (V, 16,966.)

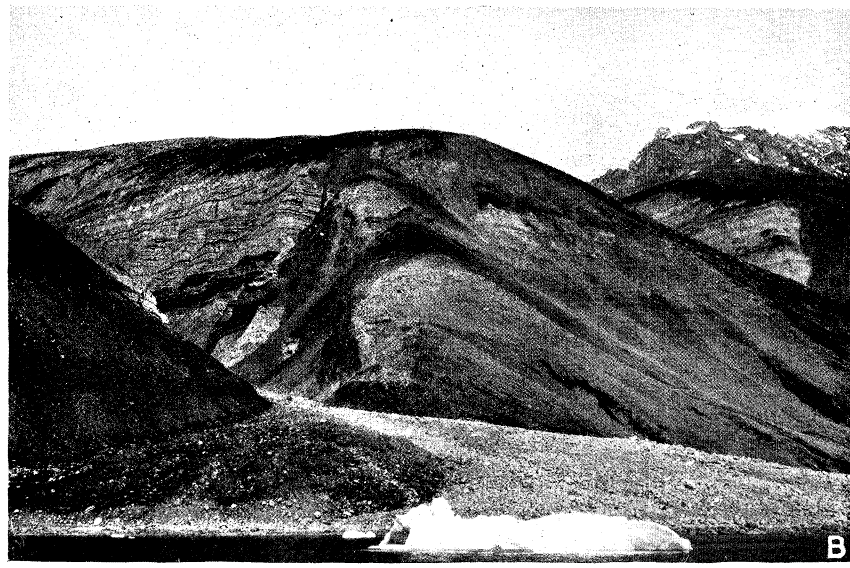
FIG. 90.—*Elatocladus Smittiana* (HEER) and, in close association with the branch, a scale of *Protodammara arctica* sp. nov. × 2. (V, 16,975.)

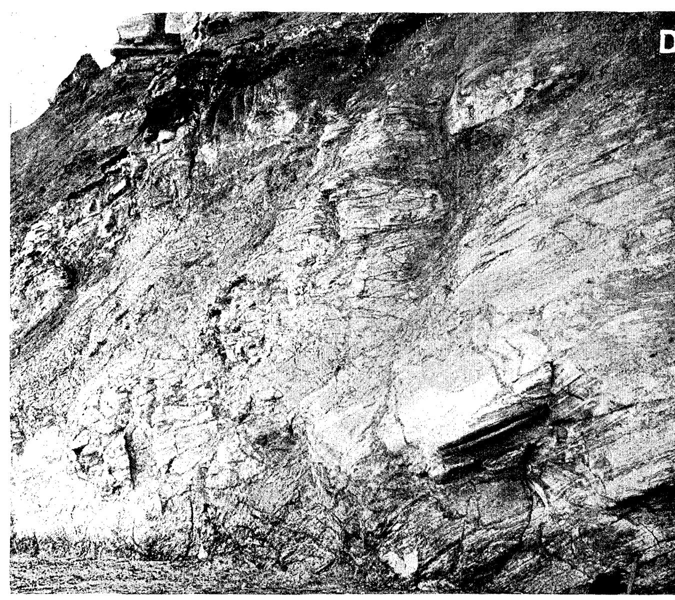
FIG. 91.—*Elatocladus Dicksoniana* (HEER). Kaersuarssuk. (V, 16,969.)

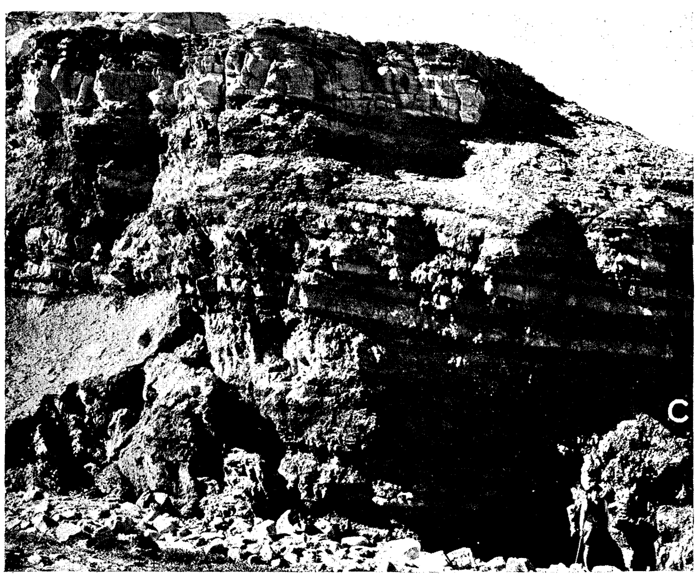
FIG. 92.—*Elatocladus Smittiana* (HEER). Branch with two forms of leaf. Ikorfat. (V, 16,976.)

FIG. 93.—*Platanophyllum Pfaffianum* (HEER). Pâtût. (V, 19,015.)

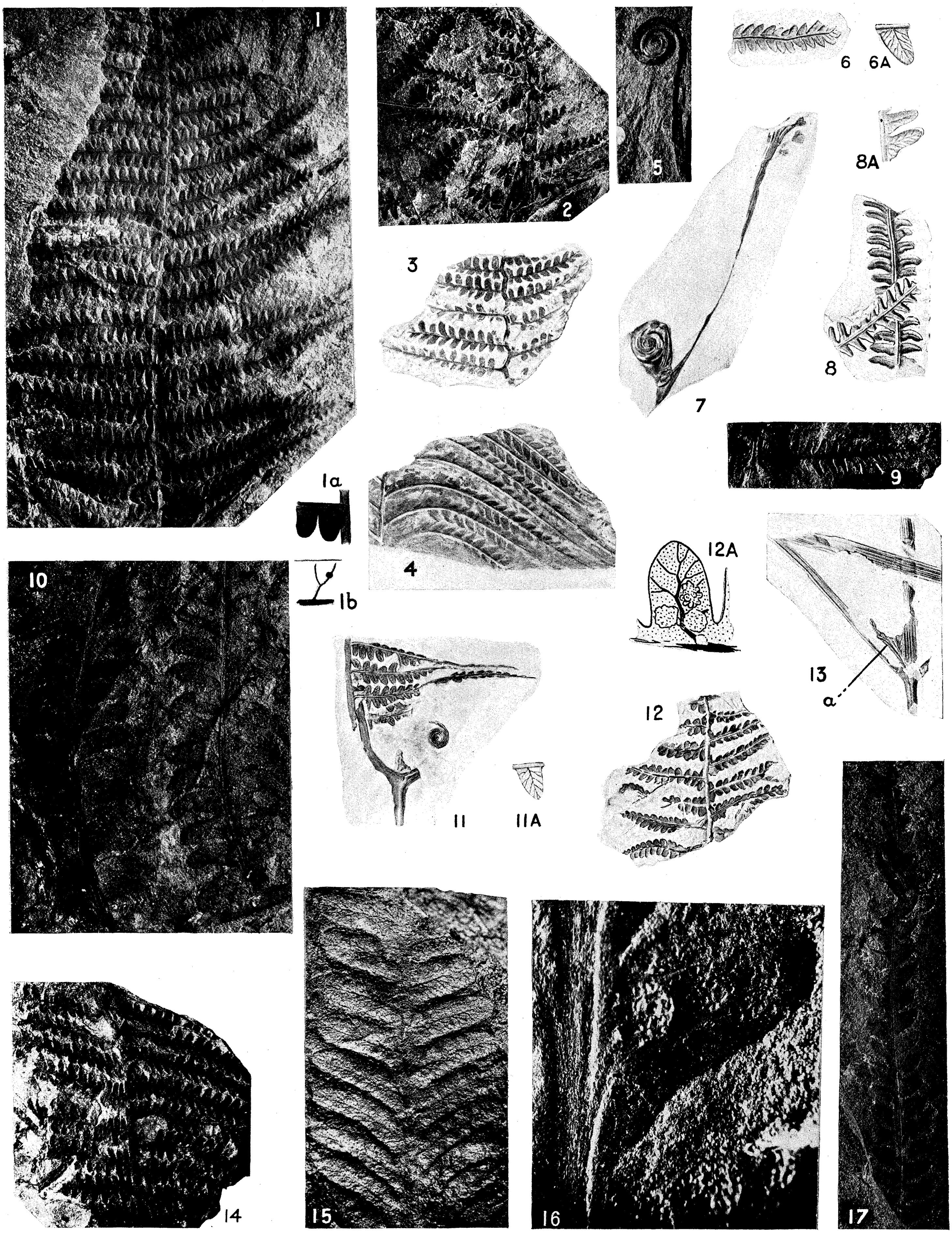
FIG. 94.—Cone-scale, cf. *Araucarites* sp. × 3. Pagtorfik. (V, 16,990.)



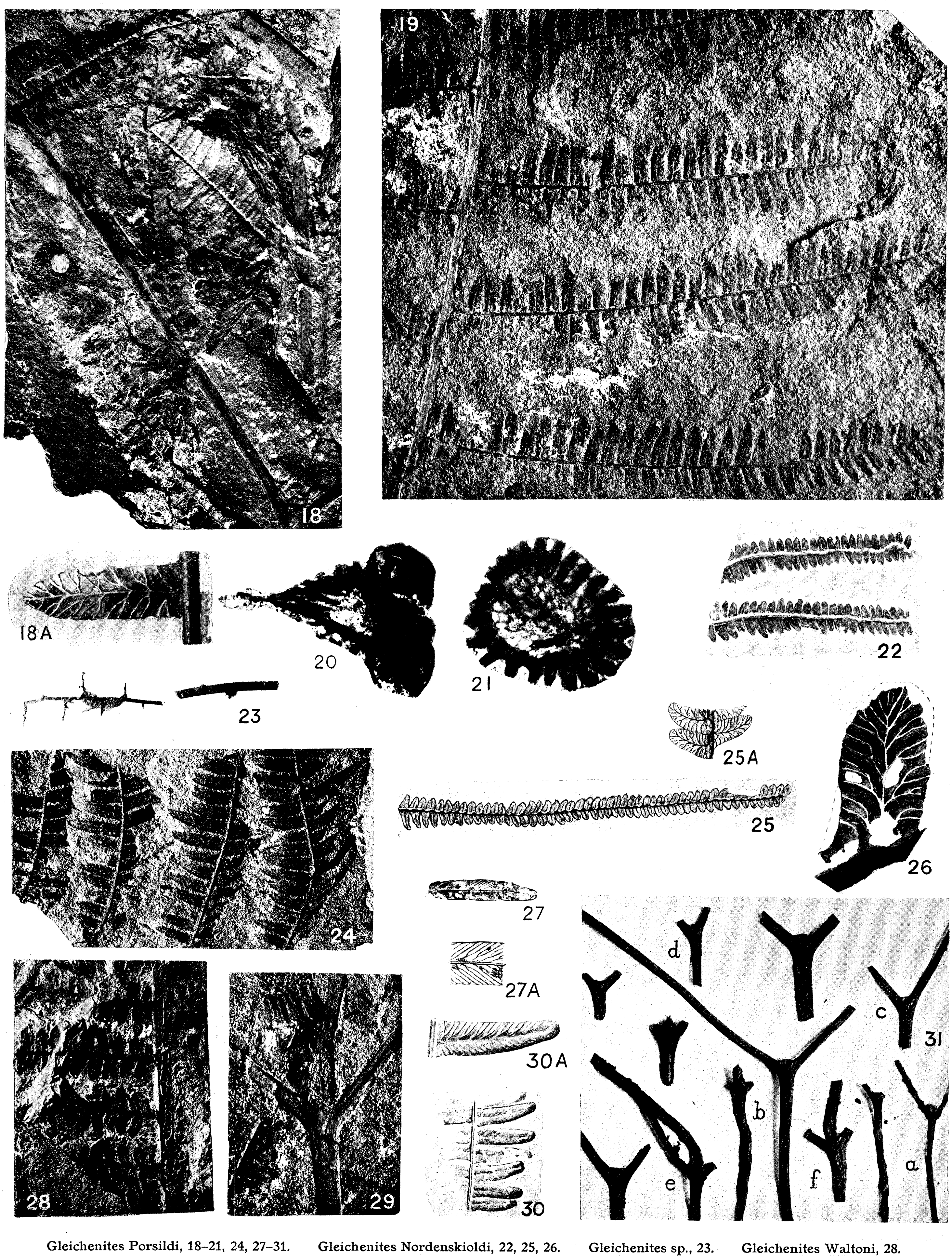




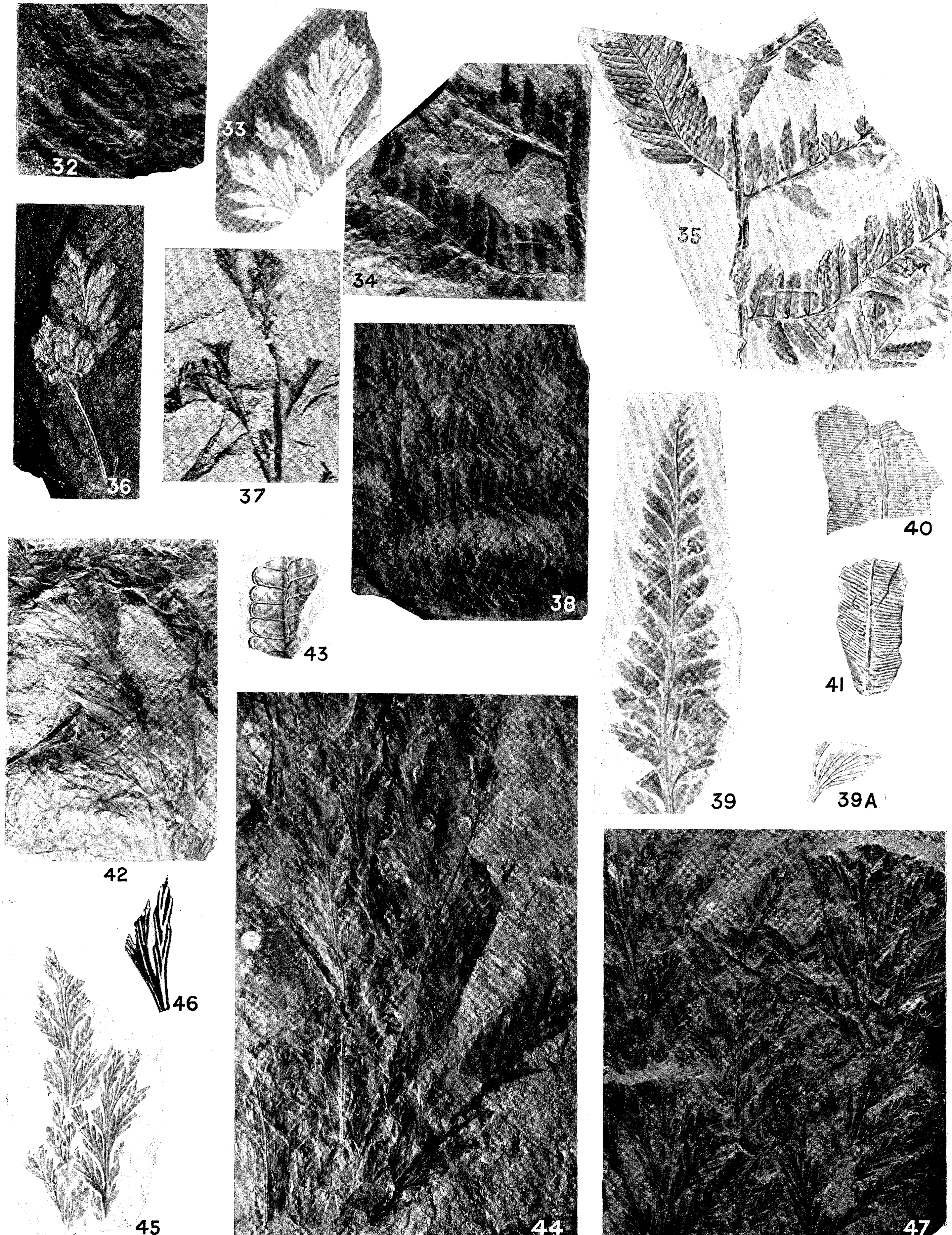
A, B, Upernivik Island. C, D, Kûk (Nugssuak Peninsula). E, Atanikerdluk (Nugssuak Peninsula). F, Skansen (Disko Island).



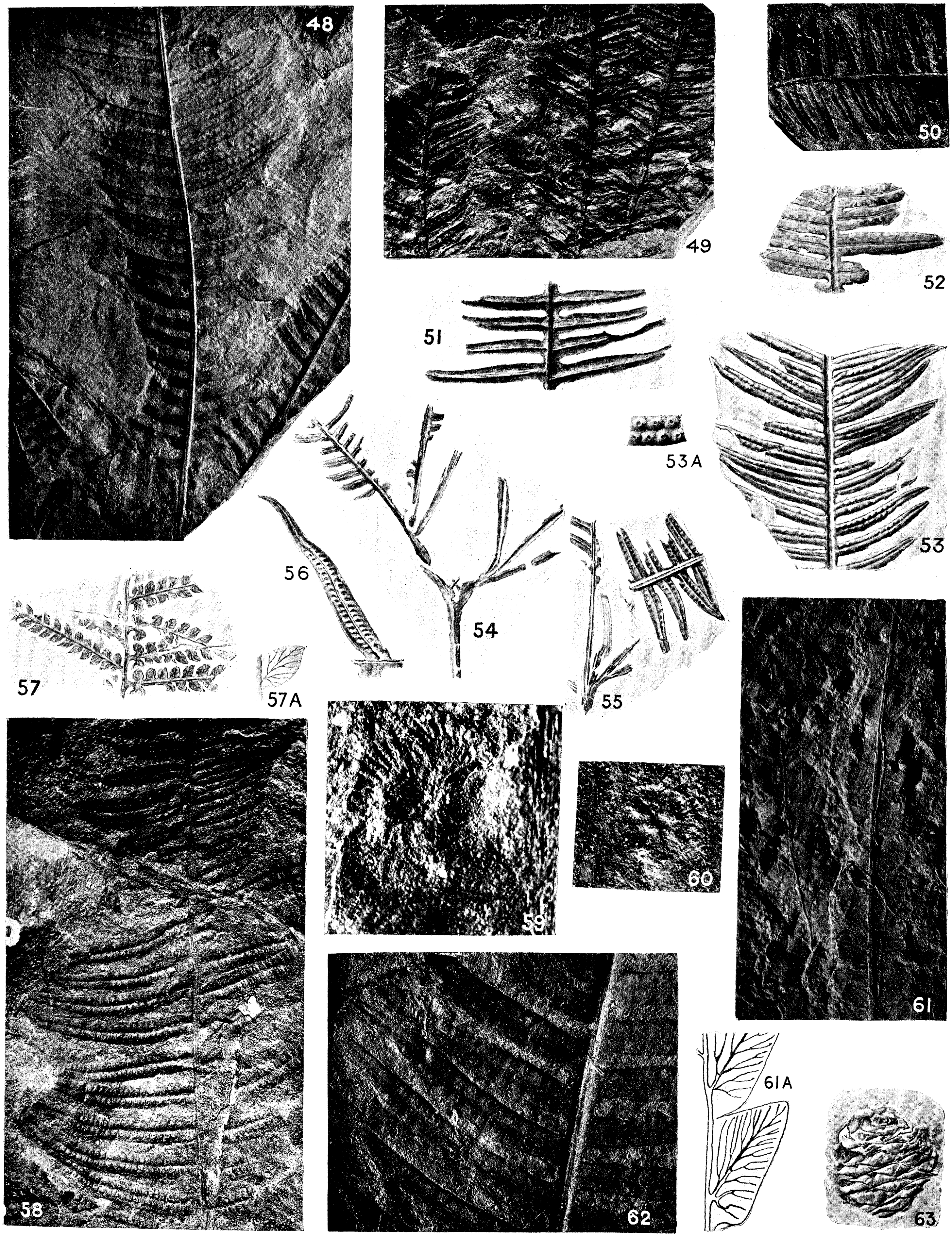
Gleichenites Gieseckiana, 1–4, 6–14, 16, 17. Gleichenites sp., 5, 15.



Gleichenites Porsildi, 18–21, 24, 27–31. Gleichenites Nordenskioldi, 22, 25, 26. Gleichenites sp., 23. Gleichenites Waltoni, 28.

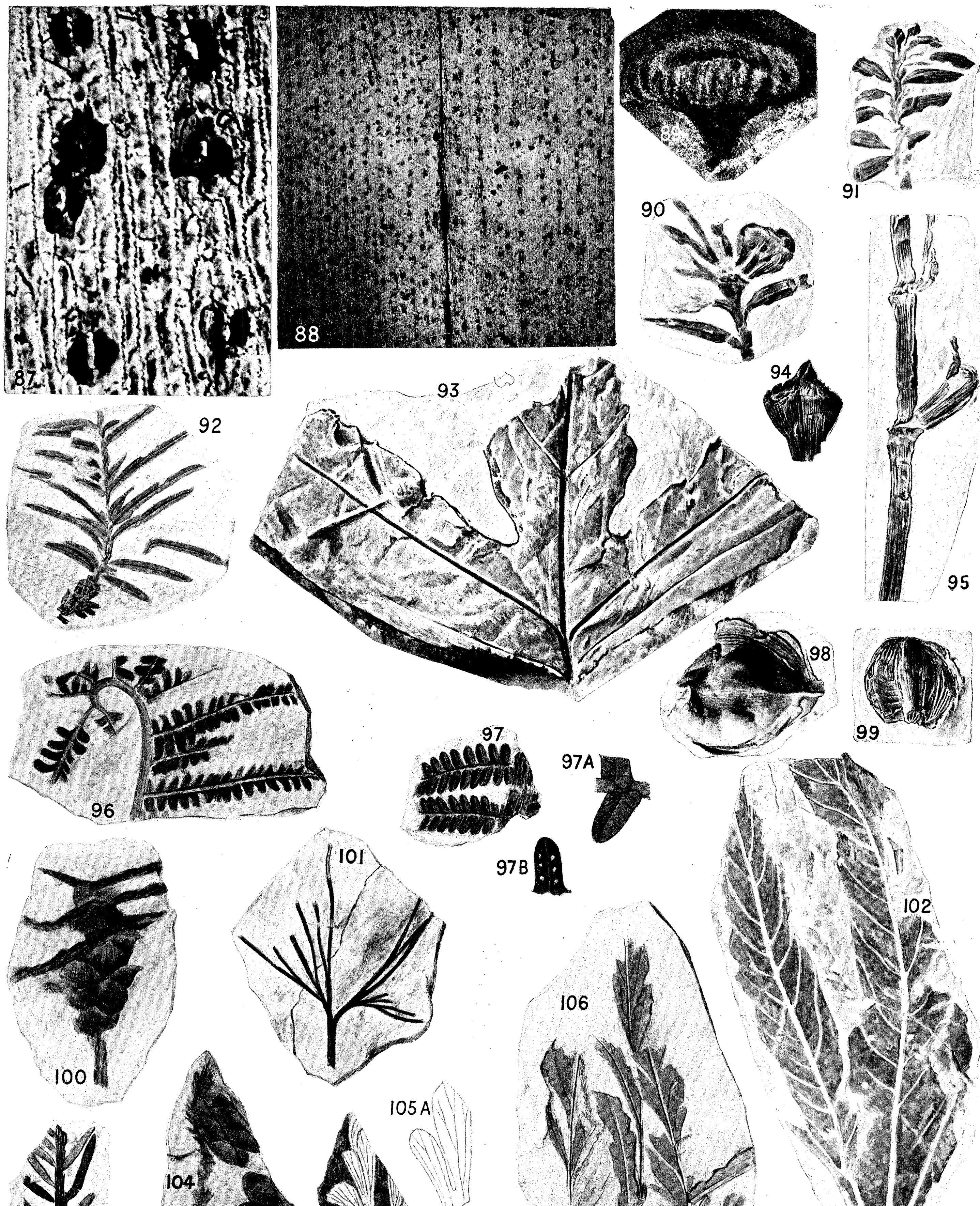


Cladophlebis Oerstedi, 32, 34, 35. Sphenopteris (? Onychiopsis) Johnstrupi, 33. Sphenopteris (? Onychiopsis) psilotoides, 36, 37, 42, 44–47. Cladophlebis sp., 38. Sphenopteris dentata, 39. Taeniopteris arctica, 40, 41. Ptilophyllum arcticum, 43.

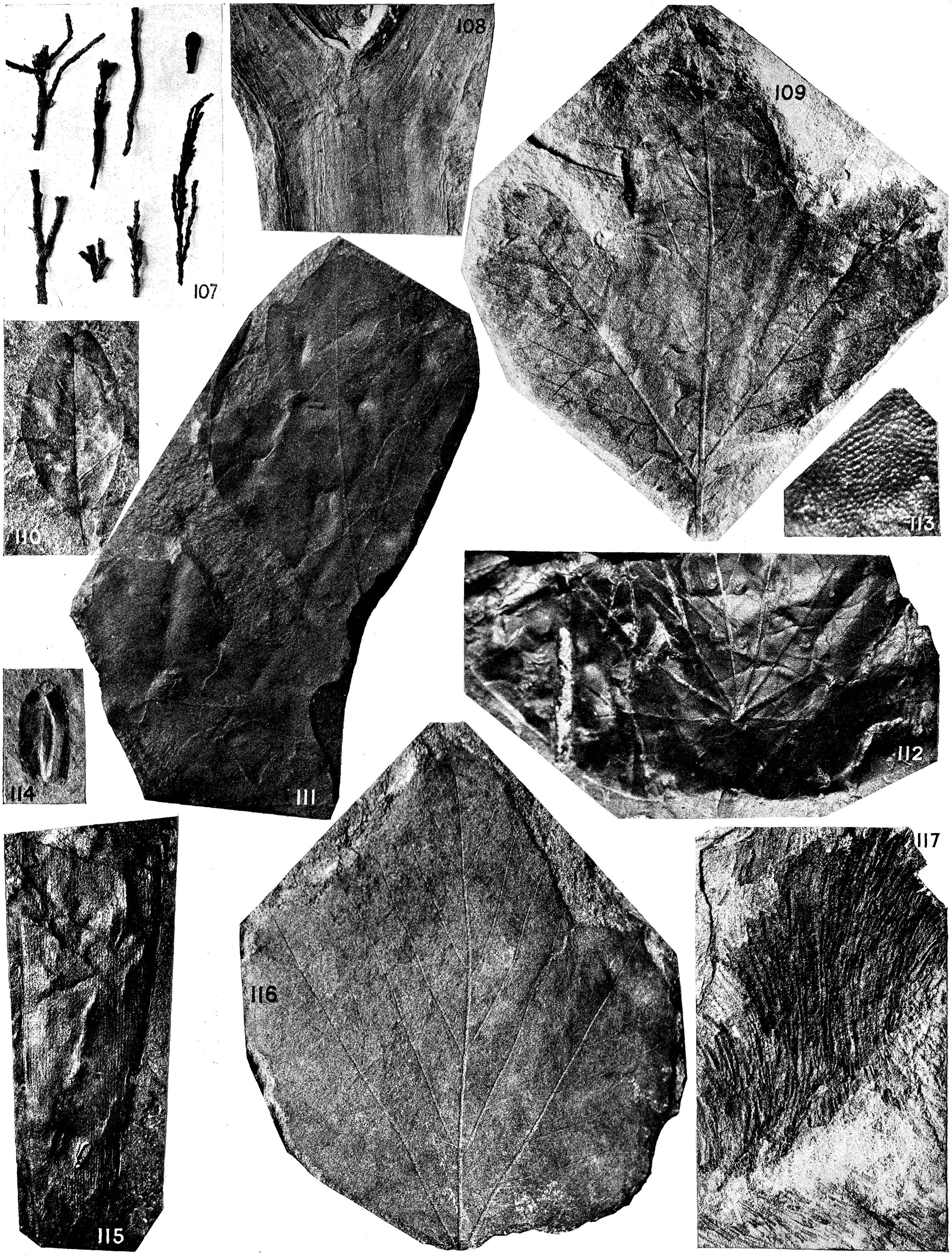


Laccopteris rigida, 48–56, 58–60, 62. Sphenopteris Holttumi, 57. Cladophlebis arctica, 61. Conites sp. A., 63.

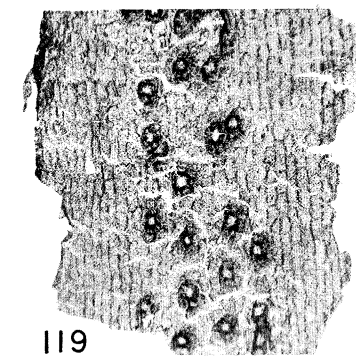
Pseudocycas Steenstrupi, 64, 67. Ginkgoites pluripartita, 65, 66, 71, 74, 76, 83, 84, 86. Pagiophyllum ambiguum, 68. Sequoiites concinna, 69, 72, 73, 79, 80. Conites sp. B., 70. Conites sp. C., 75. Pityolepis rugosa, 77, 78. Baiera ikorfatensis, 81. Phoenicopsis Steenstrupi, 82. Elatocladus subulata, 85.

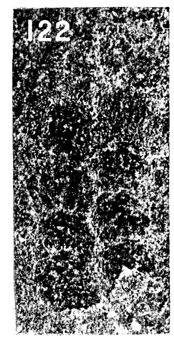


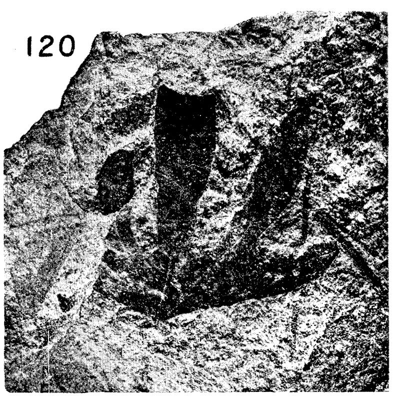
Phoenicopsis Steenstrupi, 87, 88. Dammarites borealis, 89. Elatocladus Smittiana, 90, 92. Protodammara arctica, 90 (scale). Elatocladus Dicksoniana, 91. Platanophyllum Pfaffianum, 93. Cone-scale, 94. Sciadopitytes, 95. Gleichenites Gieseckiana, 96. Gleichenites Nordenskioldi, 97. Carpolithus (?) stipuliformis, 98. Carpolithus globuliferus, 99. Cyparissidium gracile, 100. Baiera sp., 101. Platanophyllum Wellingtonianum, 102. Elatocladus upernivikensis, 103. Pagiophyllum ambiguum, 104. Sphenopteris (? Onychiopsis) Johnstrupi, 105, 106.



Cyparissidium gracile, 107. Forked axis, 108. Plantanus latiloba, 109. Dalbergites simplex, 110. Platanophyllum insigne, 111. Menispermites dentatus, 112. Artocarpus sp., 113. Carpolithus oblongus, 114. Krannera marginata, 115. Platanus Newberryana, 116. Fasciculites groenlandicus, 117.







Gleichenites Gieseckiana, 118. Elatocladus Smittiana, 119. Platanophyllum Geisleri, 120. Platanophyllum insigne, 121. Gleichenites Porsildi, 122, 124. Macclintockia cretacea, 123. Laccopteris rigida, 125.

FIG. 95.—*Sciadopitytes* axis bearing leaves. Upernivik Naes. (V, 16,979.)

FIG. 96.—*Gleichenites Gieseckiana* HEER. Drawn by Mrs. EKBLOM from a specimen figured by HEER from Pagtorfik. Stockholm Museum.

FIG. 97.—*Gleichenites Nordenskiöldi* HEER. Drawn by Mrs. EKBLOM from a specimen figured by HEER from Pagtorfik. Stockholm Museum. Fig. 97A, Pinnules overlapping the axis. × 3. Fig. 97B, fertile pinnule. × 3.

FIG. 98.—*Carpolithus* (?) *stipuliformis* sp. nov. Atanikerdluk. (V, 16,986.)

FIG. 99.—*Carpolithus globuliferus* (HEER). Angiarsuit. Geological Museum, Zürich Hochschule.

FIG. 100.—*Cyparissidium gracile* HEER. Cone and branches, drawn by Mrs. EKBLOM from a specimen figured by HEER, from Pagtorfik. Stockholm Museum.

FIG. 101.—*Baiera sp.* cf. *Baiera Lindleyana* (SCHIMP.). Drawn by Mrs. EKBLOM from a specimen figured by NATHORST, from Atanikerdluk. Stockholm Museum.

FIG. 102.—*Platanophyllum Wellingtonianum* (LESQ.). Pâtût. (V, 16,991.)

FIG. 103.—*Elatocladus upernivikensis* sp. nov. Upernivik Naes. (V, 16,985.)

FIG. 104.—*Pagiophyllum ambiguum* (HEER). Drawn by Mrs. EKBLOM from a specimen figured by HEER, from Pagtorfik. Stockholm Museum.

FIG. 105.—*Sphenopteris* (? *Onychiopsis*) *Johnstrupi* (HEER). Drawn by Mrs. EKBLOM from a specimen figured by HEER, from Ikorfat. Stockholm Museum. Fig. 105A, Pinnules enlarged. × 2.

FIG. 106.—*S.* (? *Onychiopsis*) *Johnstrupi*. Drawn by Mrs. EKBLOM from a specimen, from Pâtût. Stockholm Museum.

PLATE 11.

FIG. 107.—*Cyparissidium gracile* HEER. Carbonised branches. Skansen. (V, 16,980.)

FIG. 108.—*Caulinites gleichenioides* sp. nov. Pâtût. (V, 16,984.)

FIG. 109.—*Platanus latiloba* NEWB. Upernivik Naes.

FIG. 110.—*Dalbergites simplex* (NEWB.). Igdlukunguak. (V, 16,987.)

FIG. 111.—*Platanophyllum insigne* (HEER). Atanikerdluk. (V, 16,989.)

FIG. 112.—*Menispermites dentatus* HEER. Igdlukunguak. (V, 19,008.)

FIG. 113.—*Artocarpus sp.* Piece of inflorescence enlarged. × 10. Ikorfat. (V, 16,983.)

FIG. 114.—*Carpolithus oblongus* (HEER). Atanikerdluk. (V, 16,982.)

FIG. 115.—*Krannera marginata* (HEER). Atanikerdluk peninsula. (V, 16,988.)

FIG. 116.—*Platanus Newberryana* HEER. Pâtût. (V, 16,992.)

FIG. 117.—*Fasciculites groenlandicus* HEER. Kûk. (V, 16,981.)

PLATE 12.

FIG. 118.—*Gleichenites Gieseckiana* HEER. Ujaragsugssuk. (V, 19,025.)

FIG. 119.—*Elatocladus Smittiana* (HEER). × 50. One of the two stomatal bands. Photograph by Dr. FLORIN of HEER's type-specimen in the Stockholm Museum.

FIG. 120.—*Platanophyllum Geisleri* sp. nov. (V, 19,014.)

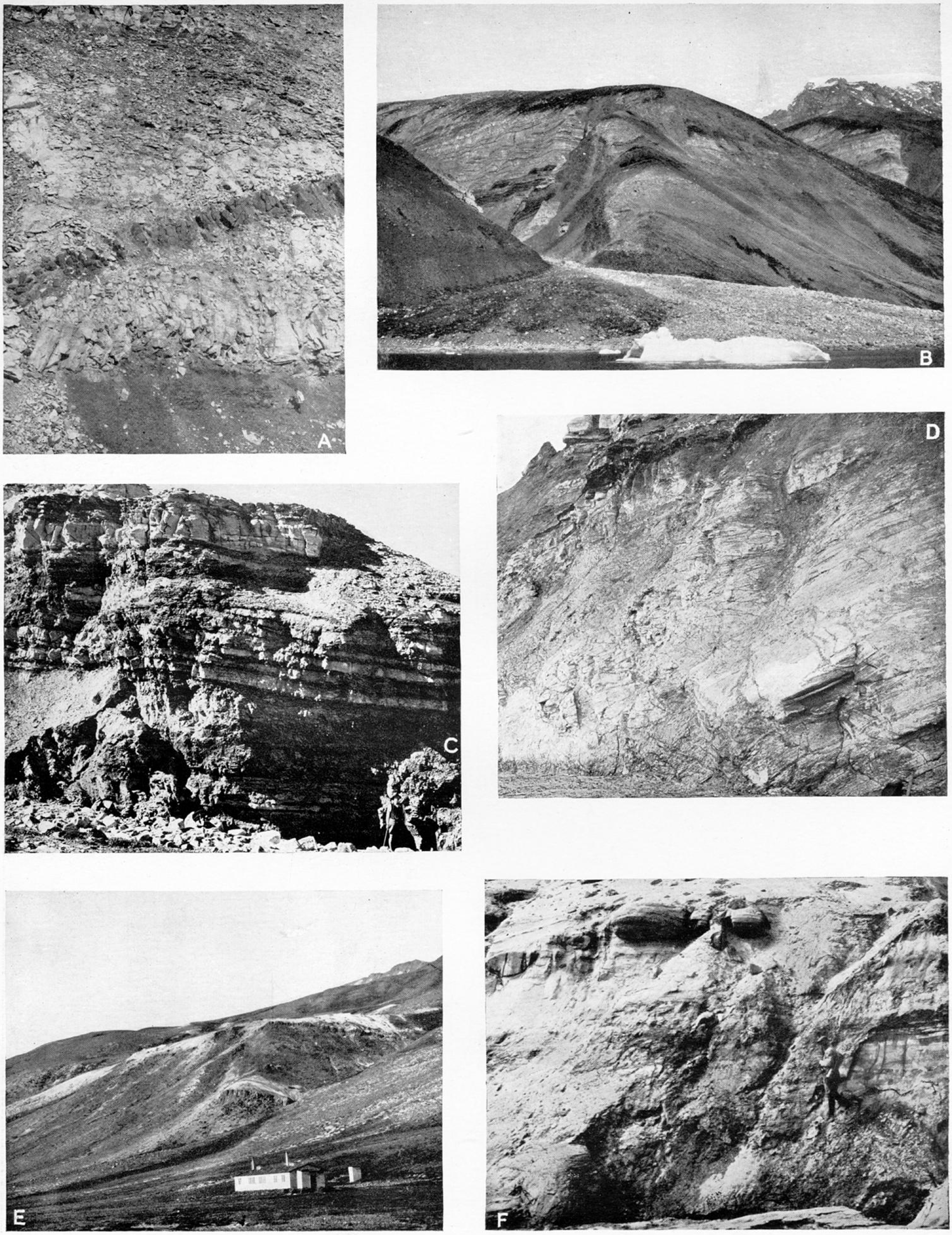
FIG. 121.—*Platanophyllum insigne* (HEER). (V, 19,015.)

FIG. 122.—*Gleichenites Porsildi* sp. nov. Two rows of sori. on pinnule ; enlarged. Ritenbenk's Coal-mine, Disko Island.

FIG. 123.—*Macclintockia cretacea* HEER. (V, 19,009.)

FIG. 124.—*Gleichenites Porsildi*. Ritenbenk's Coal-mine.

FIG. 125.—*Laccopteris rigida* (HEER). Photographed by Dr. FLORIN from a specimen from Quedlinburg in the Richter collection, Stockholm Museum. Half natural size.



A, B, Upernivik Island. C, D, Kûk (Nugssuak Peninsula). E, Atanikerdluk (Nugssuak Peninsula). F, Skansen (Disko Island).

PLATE 4.

Photograph A.—Section at Upernivik Naes (Upernivik Island) showing plant-bearing shales overlain by sandstones which are intersected by an oblique basaltic dyke. The photograph of Mr. R. E. HOLTTUM at the lower right-hand corner shows the scale. (Photo. A. C. S.)

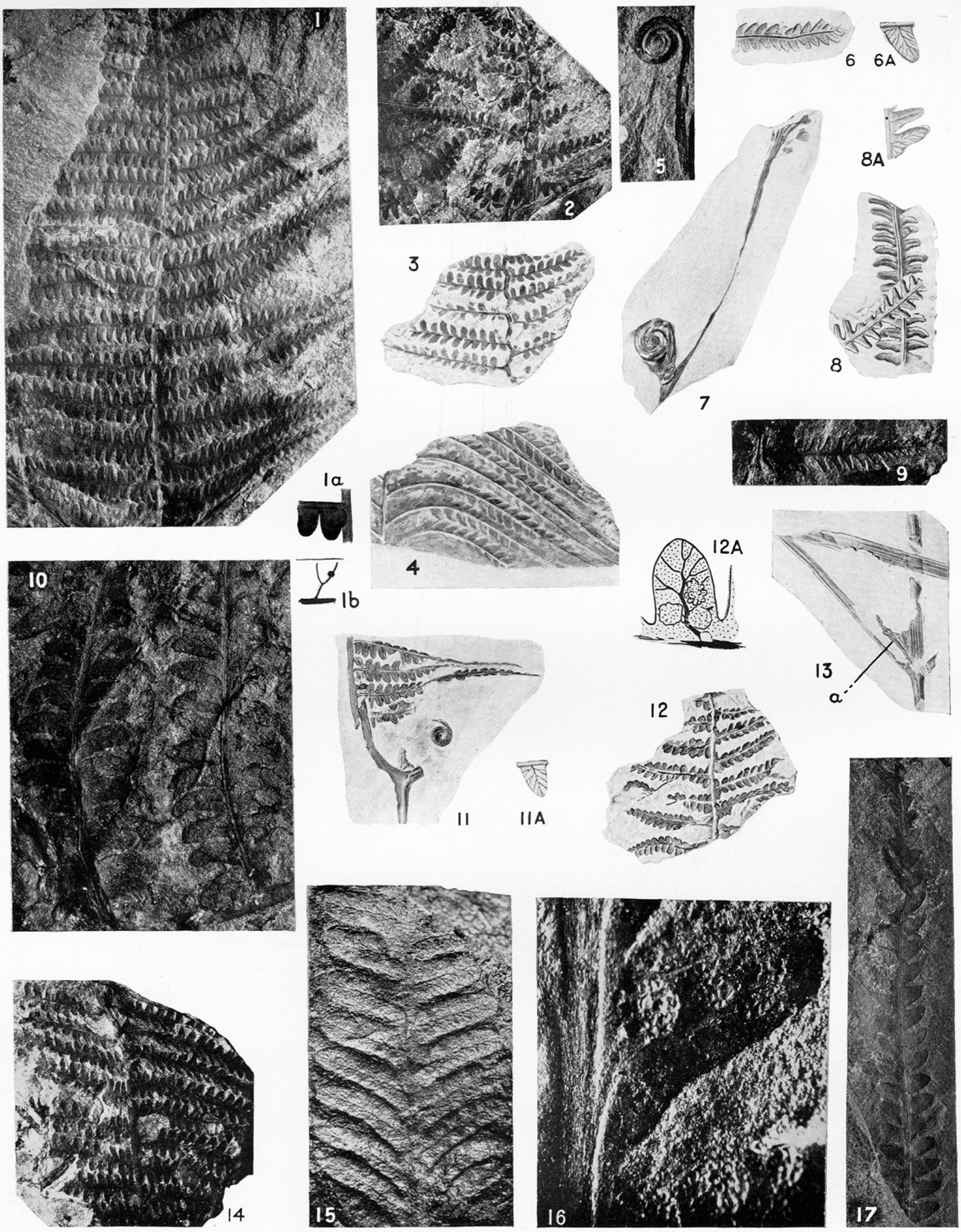
Photo. B.—Entrance to ravine at Kugssinek Angnertunek (Upernivik Island). (Photo. A. C. S.)

Photo. C.—Sandstones, shales, and carbonaceous beds on the beach at Kûk (North side of Nûgssuak Peninsula). The photograph of the author at the lower right-hand corner shows the scale. (Photo. R. E. H.)

Photo. D.—Section at sea-level at Kûk showing decomposed gneiss of the Archæan land-surface, and, in the upper part of the photograph, Cretaceous sedimentary strata. (Photo. A. C. S.)

Photo. E.—The lower part of the cliff at Atanikerdluk (South side of Nûgssuak Peninsula), showing talus-slopes and exposure of Cretaceous plant-bearing rocks. HEER'S "Liriodendron bed" is exposed on the face of the lowest shoulder above the house. (Photo. A. C. S.)

Photo. F.—Cretaceous sandstone at Skansen (Disko Island), showing large nodules near the top, and lower down, just above Mr. E. Porsild, a narrow band, rich in carbonised rachises of *Gleichenites*, and other plants (Photo. A. C. S.).



Gleichenites Gieseckiana, 1–4, 6–14, 16, 17. Gleichenites sp., 5, 15.

PLATE 5.

The Photographs reproduced on this and the succeeding plates, with a few exceptions, were taken by Mr. W. TAMS. The drawings, unless otherwise stated, are by Mr. T. A. BROCK.

The magnification is given only when the specimen is not represented natural size.

The numbers in parentheses are from the British Museum Register.

FIG. 1.—*Gleichenites Gieseckiana* HEER. 1a, slightly enlarged pinnules showing the lobed lamina of the lowest; 1b, a forked lateral vein showing the position of a sorus. Kaersuarssuk. (V, 16,900.)

FIGS. 2, 3.—*G. Gieseckiana*. Kaersuarssuk. (Fig. 2, V, 16,901; fig. 3, V, 16,902.)

FIG. 4.—*G. Gieseckiana*. Kûk. (V, 16,903.)

FIG. 5.—Rachis in vernation. (?) *Gleichenites Gieseckiana*. Kaersuarssuk. (V, 16,904.)

FIG. 6.—*G. Gieseckiana*. 6A, Pinnule enlarged. Kugssinek angertunek. (V, 16,905.)

FIG. 7.—*G. Gieseckiana*. Coiled bud in fork of rachis. Kaersuarssuk. (V, 16,906.)

FIG. 8.—*G. Gieseckiana*. 8A, Lobed pinnules slightly enlarged. Pagtorfik. (V, 16,907.)

FIG. 9.—*G. Gieseckiana*. Fertile pinna, a piece of which is enlarged in fig. 16. Pagtorfik. (V, 16,908.)

FIG. 10.—*G. Gieseckiana*. Pinnæ with recurved pinnules. $\times 2\frac{1}{2}$. Pagtorfik. (V, 16,909.)

FIG. 11.—*Gleichenia Gieseckiana*. 11A, Pinnule enlarged. Kaersuarssuk. (V, 16,910.)

FIG. 12.—*G. Gieseckiana*. Fertile pinnæ. 12A, pinnule enlarged to show sori. Pagtorfik. 12A drawn by Mr. J. WALTON. (V, 16,911.)

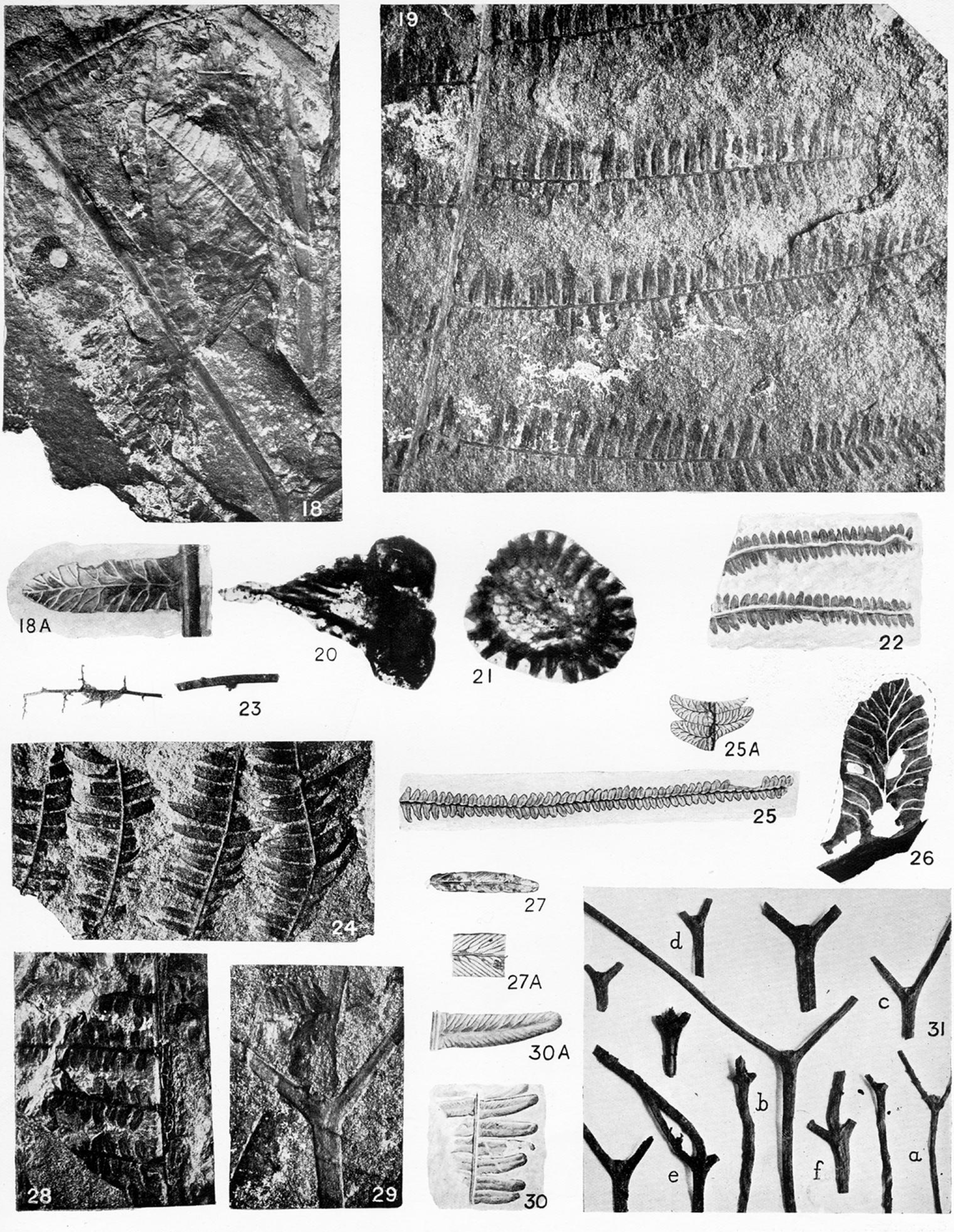
FIG. 13.—*G. Gieseckiana*. Forked rachis showing a modified pinnule, *a*, at the base of the prolonged axis. Pagtorfik. (V, 16,912.)

FIG. 14.—*G. Gieseckiana*. Fertile pinnæ. Kaersuarssuk. (V, 16,913.)

FIG. 15.—*Gleichenites sp.* $\times 3$. Atanikerdluk. (V, 16,914.)

FIG. 16.—*Gleichenia Gieseckiana*. $\times 15$. Enlarged piece of fig. 9. Pagtorfik. (V, 16,908.)

FIG. 17.—*G. Gieseckiana*. $\times 2\frac{1}{2}$. Kaersuarssuk. (V, 16,915.)



Gleichenites Porsildi, 18–21, 24, 27–31. Gleichenites Nordenskioldi, 22, 25, 26. Gleichenites sp., 23. Gleichenites Waltoni, 28.

Plate 6.

Fig. 18.—*Gleichenites Porsildi* sp. nov. Forked axis with pinna attached. 18A, Pinnule. × 5. Angiarsuit (loc. B). (V, 16,916.)

Fig. 19.—*G. Porsildi.* Angiarsuit. (V, 16,917.)

Fig. 20.—Sporangium, (?) *Gleichenites Porsildi.* × 70. Skansen. (V, 16,918.)

Fig. 21.—Sporangium, (?) *G. Porsildi,* showing line of dehiscence. × 40. Skansen. (V, 16,919.)

Fig. 22.—*Gleichenites Nordenskiöldi* Heer. Pagtorfik. (V, 16,920.)

Fig. 23.—*Gleichenites sp.* Pieces of carbonised axes, half natural size. Skansen. (V, 16,921.)

Fig. 24.—*Gleichenites Porsildi.* Angiarsuit. (V, 16,922.)

Fig. 25.—*Gleichenites Nordenskiöldi.* 25A, pinnules enlarged. × 3. Pagtorfik.

Fig. 26.—*G. Nordenskiöldi.* × 7. Angiarsuit. Drawn by Mr. J. Walton. (V, 16,924.)

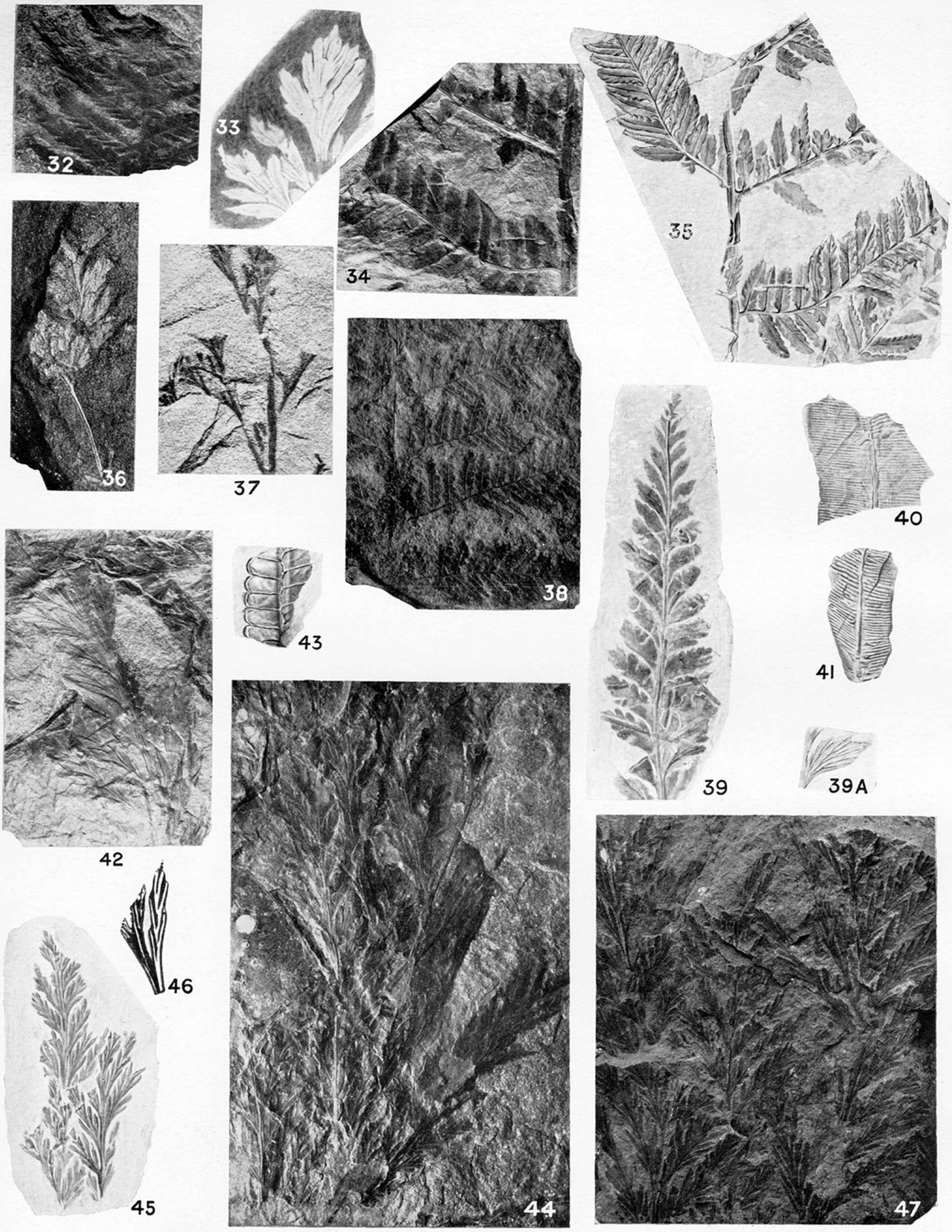
Fig. 27.—*Gleichenites Porsildi.* 27A. × 2. Igdlukunguak. (V, 16,925.)

Fig. 28.—*Gleichenites* (?) *Waltoni* sp. nov. × 2. Kaersuarssuk. (V, 16,926.)

Fig. 29.—*Gleichenia Porsildi,* forked rachis. Angiarsuit. (V, 19,016.)

Fig. 30.—*G. Porsildi.* 30A. × 2. Pâtût. (V, 16,928.)

Fig. 31.—Carbonised rachises, (?) *Gleichenites Porsildi,* Skansen. Photo. Mr. J. Walton. (V, 16,929.)



Cladophlebis Oerstedi, 32, 34, 35. Sphenopteris (? Onychiopsis) Johnstrupi, 33. Sphenopteris (? Onychiopsis) psilotoides, 36, 37, 42, 44–47.
Cladophlebis sp., 38. Sphenopteris dentata, 39. Taeniopteris arctica, 40, 41. Ptilophyllum arcticum, 43.

PLATE 7.

FIG. 32.—*Cladophlebis Oerstedi* (HEER). Kaersuarssuk. (V, 16,930.)

FIG. 33.—*Sphenopteris* (? *Onychiopsis*) *Johnstrupi* HEER. Kugssinek angnertunek. (V, 16,935.)

FIG. 34.—*Cladophlebis Oerstedi*. Kaersuarssuk. (V, 19,044.)

FIG. 35.—*C. Oerstedi*. Kaersuarssuk. (V, 16,934.)

FIG. 36.—*Sphenopteris* (? *Onychiopsis*) *psilotoides* St. and Webb. Kugssinek angnertunek. (V, 16,938.)

FIG. 37.—*S.* (? *Onychiopsis*) *psilotoides*. Kaersuarssuk. (V, 16,931.)

FIG. 38.—*Cladophlebis sp.* cf. *C. Browniana* (Dunk.). Upernivik Naes. (V, 16,937.)

FIG. 39.—*Sphenopteris dentata* Vel. 39A, pinnule enlarged. Kaersuarssuk. (V, 16,936.)

FIG. 40.—*Taeniopteris arctica* (HEER). Angiarsuit.

FIG. 41.—*T. arctica* (HEER). Angiarsuit. (V, 16,949.)

FIG. 42.—*Sphenopteris* (? *Onychiopsis*) *psilotoides*. Kaersuarssuk. (V, 16,933.)

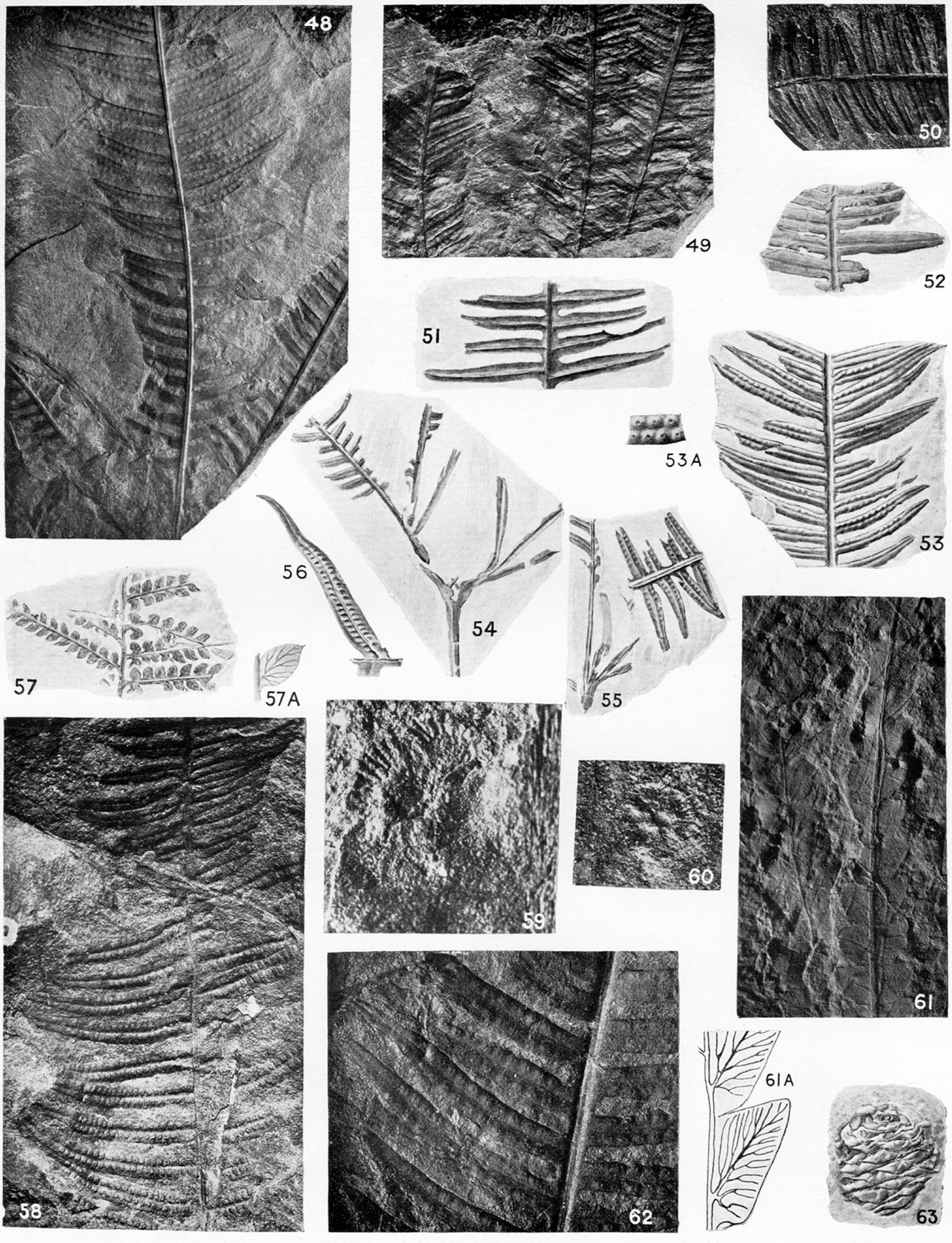
FIG. 43.—*Ptilophyllum arcticum* (GOEPP.). Angiarsuit. (V, 16,939.)

FIG. 44.—*Sphenopteris* (? *Onychiopsis*) *psilotoides*. Kaersuarssuk. (V, 16,932.)

FIG. 45.—*S.* (? *Onychiopsis*) *psilotoides*. Kaersuarssuk. (V, 16,900.)

FIG. 46.—Pinnule of *Sphenopteris* (? *Onychiopsis*) *psilotoides*, enlarged to show the veins. Drawn by Mr. J. WALTON. (V, 19,042.)

FIG. 47.—Pinnule of *S.* (? *Onychiopsis*) *psilotoides*. Part of a frond from the Wealden beds of Sussex, England. (V, 3161.)



Laccopteris rigida, 48–56, 58–60, 62. Sphenopteris Holttumi, 57. Cladophlebis arctica, 61. Conites sp. A., 63.

PLATE 8.

FIG. 48.—*Laccopteris rigida* (HEER). Pinnæ in their natural position. Kaersuarssuk. (V, 16,944.)
FIG. 49.—*L. rigida* (HEER). Kaersuarssuk. (V, 16,943.)
FIG. 50.—*L. rigida* (HEER). Kaersuarssuk. (V, 16,947.)
FIG. 51.—*L. rigida* (HEER). The upper part of fig. 58. Angiarsuit. (V, 16,941.)
FIG. 52.—*L. rigida* (HEER). The upper pinnules are fertile. Angiarsuit. (V, 16,948.)
FIG. 53.—*L. rigida* (HEER). Fertile pinna. 53A, × 2, showing sori. Kaersuarssuk. (V, 16,942.)
FIG. 54.—*L. rigida* (HEER). Showing habit. Kaersuarssuk. (V, 16,906.)
FIG. 55.—*L. rigida* (HEER). Part of branched frond and of fertile pinna. Kaersuarssuk. (V, 16,946.)
FIG. 56.—*L. rigida* (HEER). Fertile pinnule. Angiarsuit. (V, 16,940.)
FIG. 57.—*Sphenopteris Holttumi* sp. nov. 57A, enlarged pinnule. × 3. Kaersuarssuk. (V, 16,958.)
FIG. 58.—*Laccopteris rigida*. Angiarsuit. (V, 16,941.)
FIG. 59.—*L. rigida*. Sorus. × 30. (V, 16,945.)
FIG. 60.—*L. rigida*. Sorus. × 15. Kaersuarssuk. (V, 16,945.)
FIG. 61.—*Cladophlebis arctica* (HEER). (V, 16, 961.) 61A. × 2. Pâtût. (16,963.)
FIG. 62.—*Laccopteris rigida*. Pinnæ of fig. 48 enlarged. × 2.
FIG. 63.—*Conites sp. A*. Pagtorfik. (V, 16,957.)

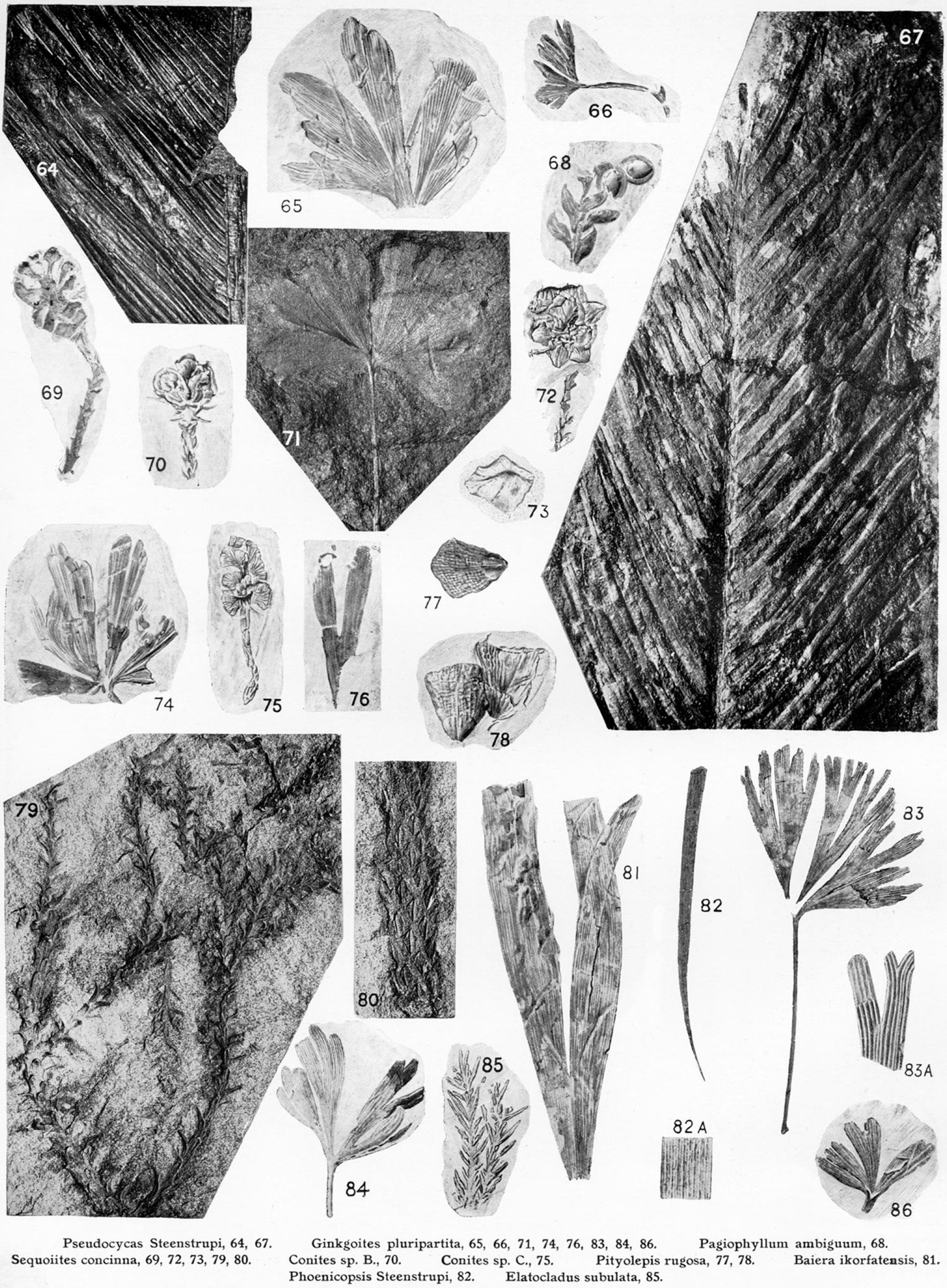


PLATE 9.

FIG. 64.—*Pseudocycas Steenstrupi* (HEER). Kugssinek angnertunek. (V, 16,954.)

FIG. 65.—*Ginkgoites pluripartita* (SCHIMP.). Upernivik Naes. (V, 16,950.)

FIG. 66.—*G. pluripartita* (SCHIMP.). Leaf attached to the remains of a short shoot. Upernivik Naes. (V, 16,951.)

FIG. 67.—*Pseudocycas Steenstrupi*. Upernivik Naes. (V, 16,956.)

FIG. 68.—*Pagiophyllum ambiguum* (HEER). Two seeds in close association with a foliage shoot; enlarged. Pagtorfik. (V, 16,974.)

FIG. 69.—*Sequoiites concinna* (HEER). Pâtût. (V, 16,978.)

FIG. 70.—*Conites sp.* B. Pâtût. (V, 16,970.)

FIG. 71.—*Ginkgoites pluripartita*. Upernivik Naes. (V, 19,017.)

FIG. 72.—*Sequoiites concinna*. Pâtût. (V, 16,972.)

FIG. 73.—*S. concinna*. Cone-scale. Pâtût. (V, 16,971.)

FIG. 74.—*Ginkgoites pluripartita*. Upernivik Naes. (V, 16,955.)

FIG. 75.—*Conites sp.* C. Pâtût. (V, 16,973.)

FIG. 76.—*Ginkgoites pluripartita* (?). Ritenbenk's Coal-mine. (V, 16,964.)

FIG. 77.—*Pityolepsis rugosa* sp. nov. Upernivik Naes. (V, 16,953.)

FIG. 78.—*P. rugosa* sp. nov. Upernivik Naes. (V, 16,952.)

FIG. 79.—*Sequoiites concinna*. Pâtût. (V, 19,018.)

FIG. 80.—*S. concinna*. Pâtût. (V, 16,977.)

FIG. 81.—*Baiera ikorfatensis* sp. nov. Ikorfat. (V, 16,965.)

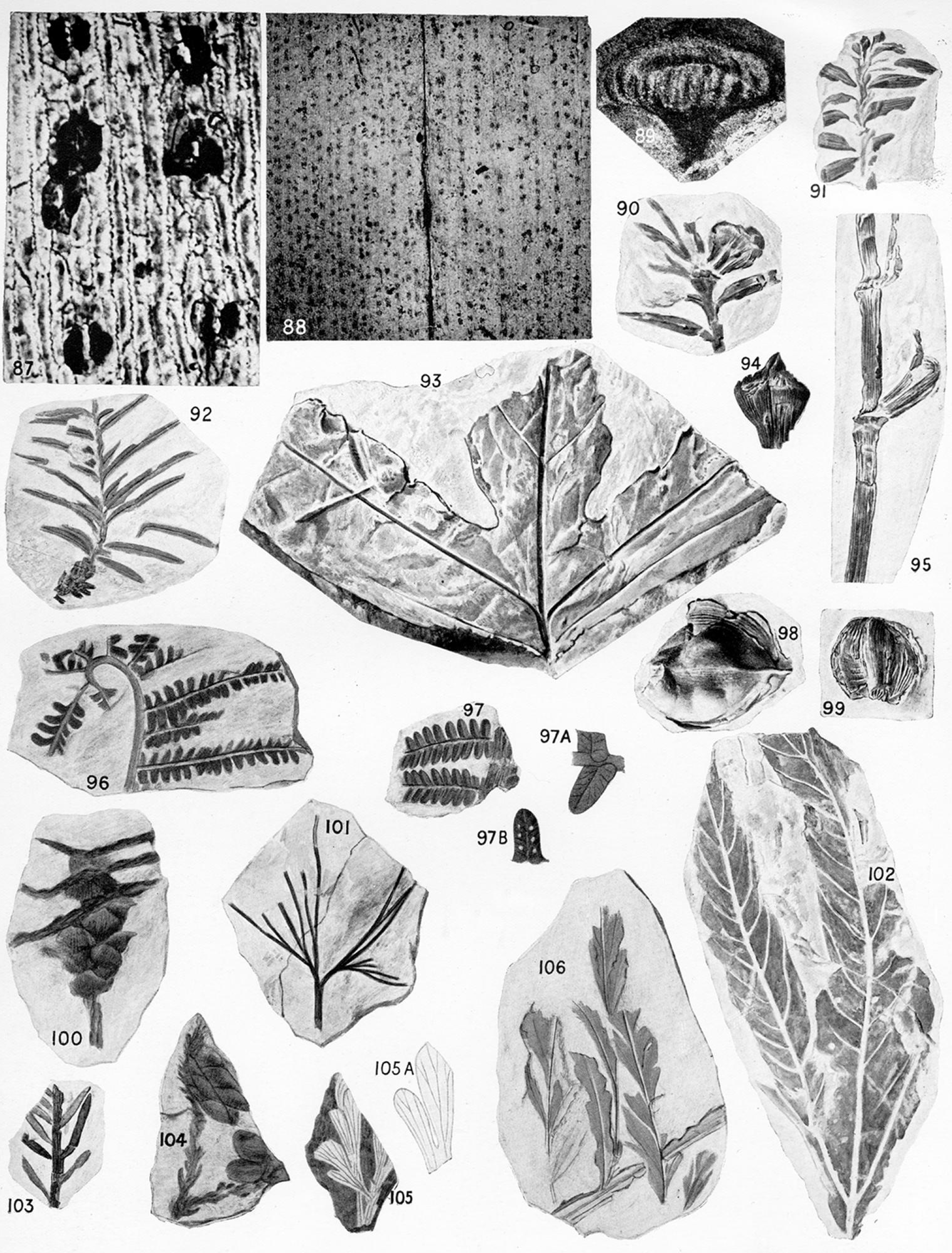
FIG. 82.—*Phœnicopsis Steenstrupi* sp. nov. Fig. 82A, Lamina enlarged. × 3. Angiarsuit. (V, 16,968.)

FIG. 83.—*Ginkgoites pluripartita*. Fig. 83A, Venation enlarged. Upernivik Naes. (V, 16,962.)

FIG. 84.—*G. pluripartita*. Upernivik Naes. (V, 16,960.)

FIG. 85.—*Elatocladus subulata* (HEER). Atanikerdluk. (V, 16,967.)

FIG. 86.—*Ginkgoites pluripartita*. Upernivik Naes. (V, 16,959.)



Phoenicopsis Steenstrupi, 87, 88. Dammarites borealis, 89. Elatocladus Smittiana, 90, 92. Protodammara arctica, 90 (scale). Elatocladus Dicksoniana, 91. Platanophyllum Pfaffianum, 93. Cone-scale, 94. Sciadopitytes, 95. Gleichenites Gieseckiana, 96. Gleichenites Nordenskioldi, 97. Carpolithus (?) stipuliformis, 98. Carpolithus globuliferus, 99. Cyparissidium gracile, 100. Baiera sp., 101. Platanophyllum Wellingtonianum, 102. Elatocladus upernivikensis, 103. Pagiophyllum ambiguum, 104. Sphenopteris (? Onychiopsis) Johnstrupi, 105, 106.

PLATE 10.

FIG. 87.—*Phœnicopsis Steenstrupi* sp. nov. Stomata and epidermal cells. × 176. Angiarsuit (loc. A.). (V, 19,036.)

FIG. 88.—*P. Steenstrupi.* × 18. Angiarsuit. (V, 19,035.)

FIG. 89.—*Dammarites borealis* HEER. × 4. Pâtût. (V, 16,966.)

FIG. 90.—*Elatocladus Smittiana* (HEER) and, in close association with the branch, a scale of *Protodammara arctica* sp. nov. × 2. (V, 16,975.)

FIG. 91.—*Elatocladus Dicksoniana* (HEER). Kaersuarssuk. (V, 16,969.)

FIG. 92.—*Elatocladus Smittiana* (HEER). Branch with two forms of leaf. Ikorfat. (V, 16,976.)

FIG. 93.—*Platanophyllum Pfaffianum* (HEER). Pâtût. (V, 19,015.)

FIG. 94.—Cone-scale, cf. *Araucarites* sp. × 3. Pagtorfik. (V, 16,990.)

FIG. 95.—*Sciadopitytes* axis bearing leaves. Upernivik Naes. (V, 16,979.)

FIG. 96.—*Gleichenites Gieseckiana* HEER. Drawn by Mrs. EKBLOM from a specimen figured by HEER from Pagtorfik. Stockholm Museum.

FIG. 97.—*Gleichenites Nordenskiöldi* HEER. Drawn by Mrs. EKBLOM from a specimen figured by HEER from Pagtorfik. Stockholm Museum. Fig. 97A, Pinnules overlapping the axis. × 3. Fig. 97B, fertile pinnule. × 3.

FIG. 98.—*Carpolithus* (?) *stipuliformis* sp. nov. Atanikerdluk. (V, 16,986.)

FIG. 99.—*Carpolithus globuliferus* (HEER). Angiarsuit. Geological Museum, Zürich Hochschule.

FIG. 100.—*Cyparissidium gracile* HEER. Cone and branches, drawn by Mrs. EKBLOM from a specimen figured by HEER, from Pagtorfik. Stockholm Museum.

FIG. 101.—*Baiera sp.* cf. *Baiera Lindleyana* (SCHIMP.). Drawn by Mrs. EKBLOM from a specimen figured by NATHORST, from Atanikerdluk. Stockholm Museum.

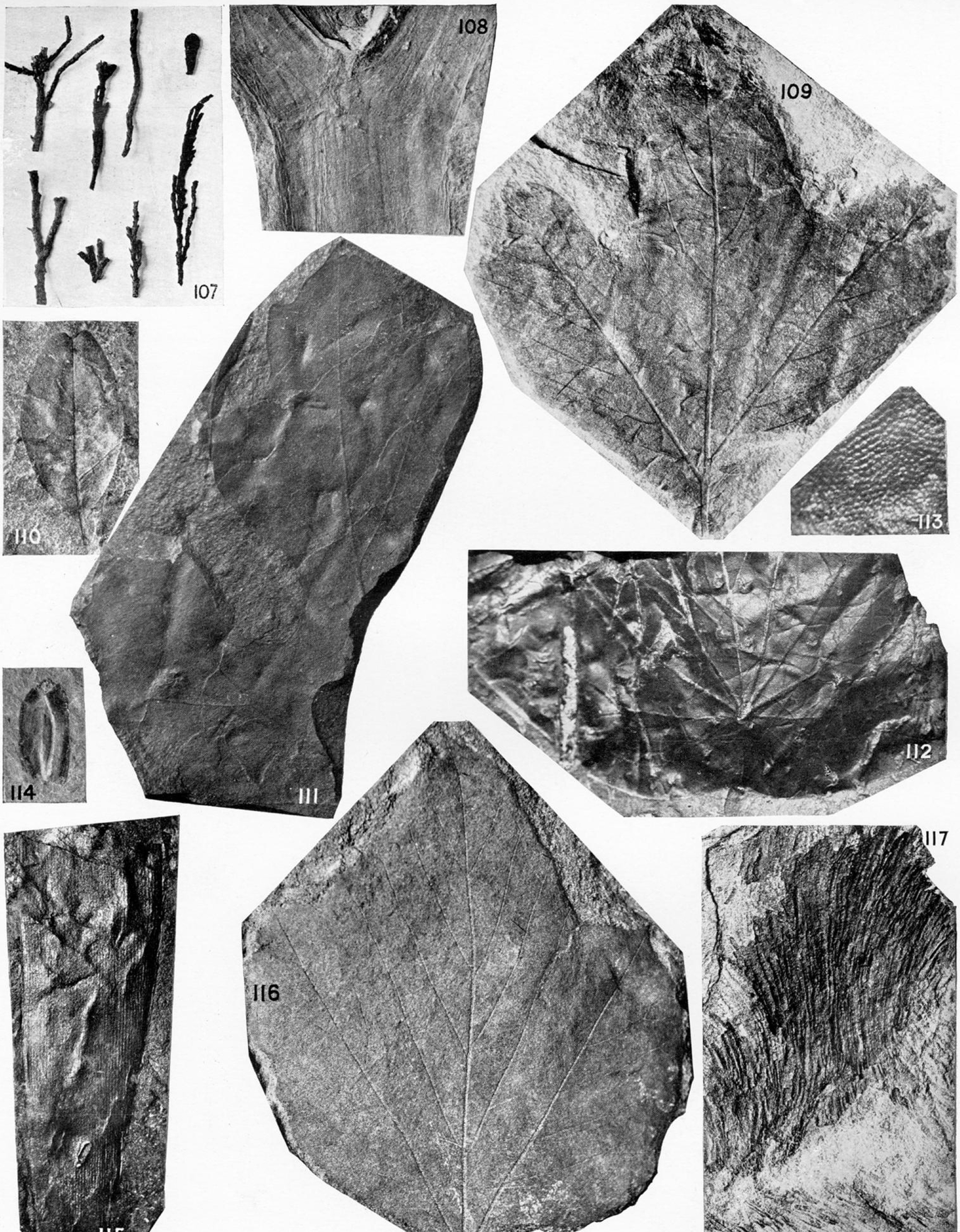
FIG. 102.—*Platanophyllum Wellingtonianum* (LESQ.). Pâtût. (V, 16,991.)

FIG. 103.—*Elatocladus upernivikensis* sp. nov. Upernivik Naes. (V, 16,985.)

FIG. 104.—*Pagiophyllum ambiguum* (HEER). Drawn by Mrs. EKBLOM from a specimen figured by HEER, from Pagtorfik. Stockholm Museum.

FIG. 105.—*Sphenopteris* (? *Onychiopsis*) *Johnstrupi* (HEER). Drawn by Mrs. EKBLOM from a specimen figured by HEER, from Ikorfat. Stockholm Museum. Fig. 105A, Pinnules enlarged. × 2.

FIG. 106.—*S.* (? *Onychiopsis*) *Johnstrupi.* Drawn by Mrs. EKBLOM from a specimen, from Pâtût. Stockholm Museum.



Cyparissidium gracile, 107. Forked axis, 108. Plantanus latiloba, 109. Dalbergites simplex, 110. Platanophyllum insigne, 111. Menispermites dentatus, 112. Artocarpus sp., 113. Carpolithus oblongus, 114. Krannera marginata, 115. Platanus Newberryana, 116. Fasciculites groenlandicus, 117.

PLATE 11.

FIG. 107.—*Cyparissidium gracile* HEER. Carbonised branches. Skansen. (V, 16,980.)

FIG. 108.—*Caulinites gleichenioides* sp. nov. Pâtût. (V, 16,984.)

FIG. 109.—*Platanus latiloba* NEWB. Upernivik Naes.

FIG. 110.—*Dalbergites simplex* (NEWB.). Igdlukunguak. (V, 16,987.)

FIG. 111.—*Platanophyllum insigne* (HEER). Atanikerdluk. (V, 16,989.)

FIG. 112.—*Menispermites dentatus* HEER. Igdlukunguak. (V, 19,008.)

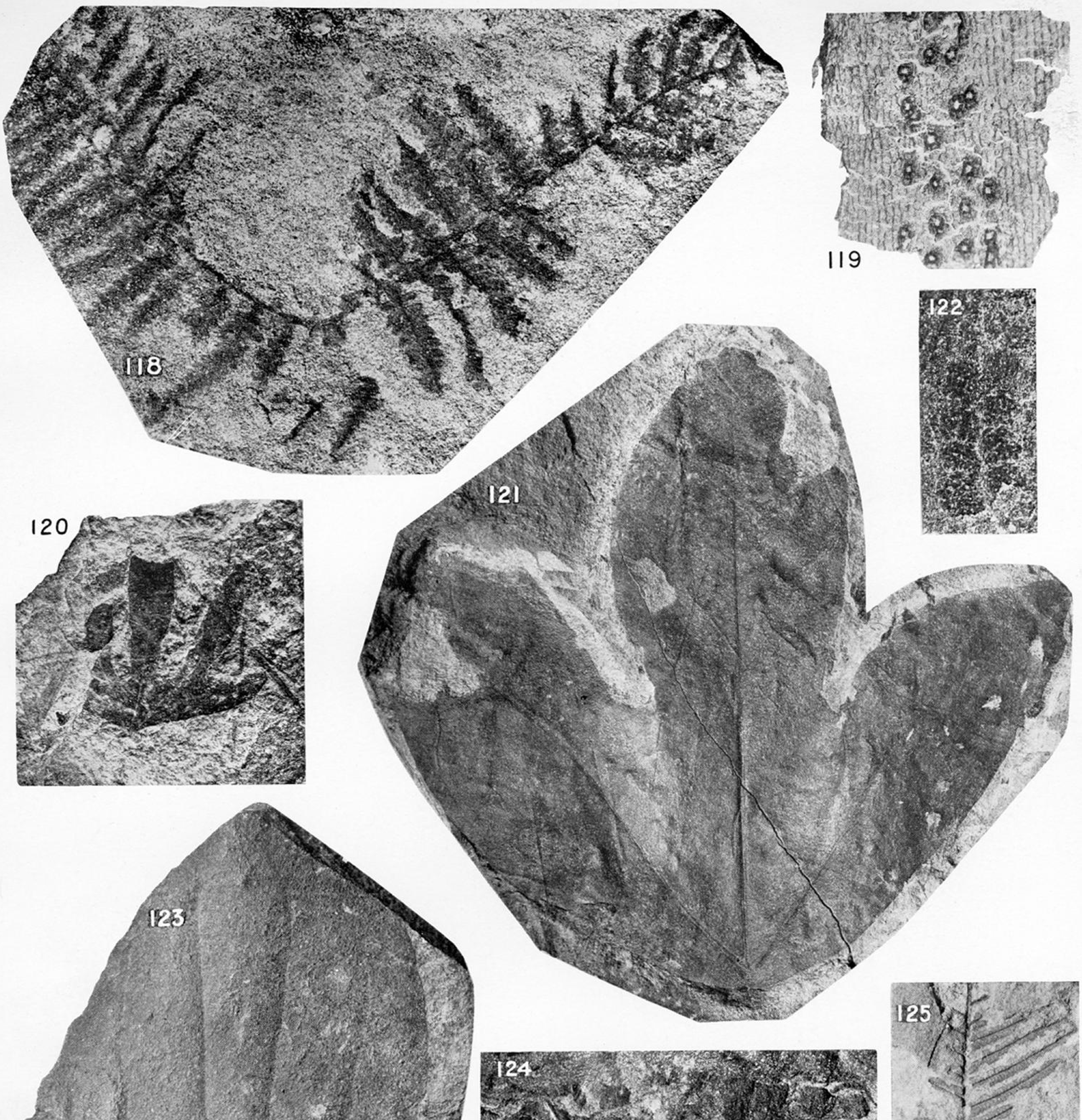
FIG. 113.—*Artocarpus sp.* Piece of inflorescence enlarged. × 10. Ikorfat. (V, 16,983.)

FIG. 114.—*Carpolithus oblongus* (HEER). Atanikerdluk. (V, 16,982.)

FIG. 115.—*Krannera marginata* (HEER). Atanikerdluk peninsula. (V, 16,988.)

FIG. 116.—*Platanus Newberryana* HEER. Pâtût. (V, 16,992.)

FIG. 117.—*Fasciculites groenlandicus* HEER. Kûk. (V, 16,981.)



Gleichenites Gieseckiana, 118. Elatocladus Smittiana, 119. Platanophyllum Geisleri, 120. Platanophyllum insigne, 121.
Gleichenites Porsildi, 122, 124. Macclintockia cretacea, 123. Laccopteris rigida, 125.

PLATE 12.

FIG. 118.—*Gleichenites Gieseckiana* HEER. Ujaragsugssuk. (V, 19,025.)

FIG. 119.—*Elatocladus Smittiana* (HEER). × 50. One of the two stomatal bands. Photograph by Dr. FLORIN of HEER's type-specimen in the Stockholm Museum.

FIG. 120.—*Platanophyllum Geisleri* sp. nov. (V, 19,014.)

FIG. 121.—*Platanophyllum insigne* (HEER). (V, 19,015.)

FIG. 122.—*Gleichenites Porsildi* sp. nov. Two rows of sori. on pinnule; enlarged. Ritenbenk's Coal-mine, Disko Island.

FIG. 123.—*Macclintockia cretacea* HEER. (V, 19,009.)

FIG. 124.—*Gleichenites Porsildi*. Ritenbenk's Coal-mine.

FIG. 125.—*Laccopteris rigida* (HEER). Photographed by Dr. FLORIN from a specimen from Quedlinburg in the Richter collection, Stockholm Museum. Half natural size.