THE NORWEGIAN

NORTH POLAR EXPEDITION 1893–1896

SCIENTIFIC RESULTS

VOLUME I

THE NORWEGIAN

NORTH

POLAR EXPEDITION

1893—1896

SCIENTIFIC RESULTS

EDITED BY

FRIDTJOF NANSEN

VOLUME I

PUBLISHED BY THE FRIDTJOF NANSEN FUND
FOR THE ADVANCEMENT OF SCIENCE

CHRISTIANIA
JACOB DYBWAD

LONDON,
NEW YORK, BOMBAY
LONGMANS, GREEN, AND CO.

LEIPZIG
F. A. BROCKHAUS

1900

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III.

FOSSIL PLANTS FROM FRANZ JOSEF LAND

BY

A. G. NATHORST.

INTRODUCTION.

Shortly after his return from the expedition with the "Fram," Dr. Nansen informed me that when in Franz Josef Land he had collected a goodly number of fossil plants, and requested me to examine them. This offer I could not withstand, though fully occupied with other work, especially as for my work in connection with the fossil Jurassic flora of Spitsbergen, it was particularly interesting to become acquainted with the Jurassic flora of Franz Josef Land. Having given a reply in the affirmative to Dr. Nansen's request, the material he had collected arrived in such good time that I was enabled to give a short account of it in the book Nansen published describing his voyage. Unfortunately there is a misstatement in "Farthest North". When first examining the material received, I believed that I had discovered, among the ferns, fragments of an *Onychiopsis*, a supposition which, however, after a subsequent examination proved erroneous. A correction forwarded in good time by Nansen to the English publisher was not attended to, and consequently, the error is still to be found in "Farthest North". In the Swedish and Norwegian editions it is, however, corrected.

There is no need for me to dwell on the occurrence of these fossil plants, Dr. Nansen himself having given a full description thereof. Both Nansen and Dr. Kœttlitz are of opinion that the plant-bearing strata must be considered as interstratified between two different tiers of basalt (old lava flows), an opinion which is confirmed by the analogous conditions on King Charles

Land, which I observed in the summer of 1898, and on which I shall touch in my work on the geology of this land.

The plant-bearing rock is broken into rather sharp-cornered, small fragments, the surface being white, yellowish, or brownish, while it is darker in fresh fractures. Some pieces show a kind of conglomerate structure, being composed of small rounded white fragments, reminding one of those that are not uncommon in volcanic tuffs, and this variety, at any rate microscopically, shows some resemblance to the white clays which are derived from volcanic tuffs. Whether this will be confirmed by further microscopical examination I cannot at present say.

The organic substance of the plants is sometimes still to be seen in a brownish softer variety of the rock, which is more like a soft bituminous shale. But the harder white or yellowish varieties only present impressions, or, more correctly speaking, the cavities left by the leaves, as their organic substance has entirely disappeared, without any other taking its place. In cross fractures, consequently, there may sometimes be seen cavities which are complete transverse sections of the coniferous leaves.

Unfortunately most of the remains of the plants are very fragmentary, and as, moreover, the leaves in themselves are small, and are not by any difference of colour distinguishable from the rock, the examination of the material has been very arduous, having almost without exception been made under the magnifying lens. There would have been no occasion to mention this, had the material been better, but as it is, the question as to the age of the deposit can only approximately be settled, as will be seen from the latter part of this article.

During the time that has elapsed since Nansen came back, the Jackson-Harmsworth expedition has also returned, and the fossils collected by the latter party have been described by Messrs. *E. T. Newton* and *J. J. H. Teall*; besides which, *Dr. Kœttlitz* has given a detailed account of the geological conditions of the various localities.[1] In the article first mentioned, suggestion is made

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[1] *E. T. Newton* and *J. J. H. Teall*, 'Notes on a collection of Rocks and Fossils from Franz Josef Land'. Quarterly Journ. Geol. Soc. London, vol. 53 (1897), p. 477. 'Additional notes on Rocks and Fossils from Franz Josef Land'. Ibidem, vol. 54 (1898), p. 646. *R. Kœttlitz*, 'Observations of the geology of Franz Josef Land'. Ibidem, vol. 54 (1898), p. 620.

of the possibility of there being plant-bearing strata of Permian and Tertiary age, besides the Jurassic ones.

With regard to the supposed Permian fossils, they have been found at Cook's Rock and Cape Stephen in coarse sandstone, abounding in remains of plants. *Newton* mentions *Phyllotheca* cfr. *columnaris*, *Rhiptozamites* cfr. *Gœpperti*, *Anomozamites?*, *Zamiopteris* cfr. *glossopteroides* *Asplenium* cfr. *whitbiense*.

These plant-remains represented in pl. 41 accompanying the paper of Newton and Teall, do not seem so well preserved that it is possible to identify any of them with certainty, and it may be observed that the first and last species in the list of fossils given above are Jurassic. There is nothing to prevent the so-called *Phyllotheca* from being an *Equisetum* or *Schizoneura*, and both *Rhiptozamites* and *Zamiopteris* are very doubtful, which is also the case with *Anomozamites* (?). Of the so-called *Asplenium* cfr. *whitbiense*, the most one can say is that it seems to be a fern of the *Cladophlebis* type.

But though, in consequence, I cannot hazard any definite opinion concerning this fossil flora, I must say that to me it seems, it might well belong to the uppermost Trias or Rhætic. In the summer of 1898 at Bell Sound, Spitsbergen, a flora of this age was met with which was remarkable for large leaves resembling those classed by Newton as *Zamiopteris* and *Rhiptozamites*, although the venation of those leaves was too badly preserved to allow my giving any definite opinion at present as to their generic determination. This plant-bearing stratum is succeeded by the transgrading marine Jurassic beds of Oxfordian age. I therefore do not consider it impossible that the plant-bearing sandstone at Cook's Rock and Cape Stephen may belong to the uppermost Trias, though more complete material is necessary before the question can be decided with any certainty.

With regard to the silicified slab found in the same locality, the leaves of which resembled *Baiera* and *Podozamites*, as also the leaves of a *Ginkgo*, I firmly believe that it is of Jurassic and not of Tertiary age. Similar *Ginkgo* forms are also found in the Jurassic beds, and I possess a somewhat similar specimen from King Charles Land. The coniferous twig on the same slab, which is called by Newton *Pinites*, should rather be considered as a *Pachyphyllum*, or some allied genus. That the compressed vegetable remains from

Cape Richthofen are probably not Tertiary I have previously pointed out to Mr. Newton, who quotes my opinion in the later article.

The plant-bearing strata of Franz Josef Land, which are as yet known to us, all belong, in consequence — with the exception of those from Cook's Rock and Cape Stephen, the age of which is still uncertain — to the Upper Jurassic, or the transition beds to the Cretaceous, while as yet, no Tertiary strata have been discovered.

DESCRIPTION OF SPECIES.

FUNGI.

Pl. I. figs. 56 and (magnified) 56a.

The specimen fig. 56, twice enlarged, is a fragment of a coniferous leaf (*Taxites*) which on either side of the midrib presents small circular impressions, in the centre of which, on further enlargement (fig. 56a), a small dot is seen. The regular position of the round impressions gives the magnified figure a certain resemblance to a *Laccopteris*, but the leaf is plainly coniferous, and, near the margins, similar round impressions are also present. There is not the slightest doubt that the circular impressions are caused by a parasite fungus; but that is all that can be said on the matter, as no further definition can be given. Another coniferous leaf on the same slab is also attacked by a similar fungus, which has, moreover, been observed also on other specimens.

FILICALES.

CLADOPHLEBIS, Brongniart.

Cladophlebis sp.

Pl. I. figs. 1 and (magnified) 43.

This small fragment represents the ordinary *Cladophlebis* type found in Jurassic deposits, but it cannot be definitely determined as to the species.

SPHENOPTERIS, Brongniart.

Sphenopteris sp. a.

Pl. I. figs. 2 and (magnified) 44.

It is possible that this small fragment belongs to a species not previously described. It is, however, difficult to decide whether it should be brought under *Cladophlebis* or *Sphenopteris*, though the latter seems more probable. The pinnules certainly present an obvious midrib, but it is possible that these pinnules themselves, in a more developed stadium, are divided in the manner characterising *Sphenopteris*, and that the specimen in question is only the very apex of the secondary segment. Owing to the undulating margin of the pinnules, there is a certain resemblance to *Asplenium petruschinense* Heer, from the Jurassic strata of Siberia (Flora fossilis arctica, vol. 5), but it is not possible to decide whether this resemblance points to any real affinity. The same holds good concerning *Asplenium Czekanowskianum* Heer, from the Atyrkan, a tributary of the Lena River at Lat. 71° 15′ between Lena and Olenek. (Flora fossilis artica, vol. 5).

The specimen is especially interesting because the epidermic cells have made distinct impressions in the rock substance, so that their oval form can be observed under a strong magnifying lens, or the microscope.

Sphenopteris sp. b.

Pl. I. figs. 3 and (magnified) 45.

This fragment belongs to the *Sphenopteris* (*Thyrsopteris*) *Murrayana*-type which is wide-spread in the Jurassic strata, but it is insufficient for any definite determination.

Sphenopteris sp. c.

Pl. I. figs. 4 and (magnified) 46.

Of this type also there is but the fragment represented, which is too incomplete for any certain determination. It may be compared with *Sphenopteris* (*Thyrsopteris*) *Maakiana* Heer from Siberian strata (Flora fossilis arctica, vol. 4), but also shows some similarity to *Sphenopteris denticulata* Brongn. from the Yorkshire oolite, as also to *Dicksonia borealis* Heer from the strata of Northern Siberia. The venation is probably more intricate than the drawing represents, but it is difficult to make it out.

Sphenopteris (*Adiantites*) sp. d.

Pl. I. figs. 5, 6 and (magnified) 47, 48.

Of this species three specimens are here represented, the one (wood-cut fig. 1) I only received after the plates were printed. As is seen from the drawings, the leaves are constructed as in the *Adiantum*, the oblique wedge-shaped leaflets being devoid of any distinct midrib and attached to the rachis by their posterior part. The anterior margin is more or less uneven. The figures will speak for themselves.

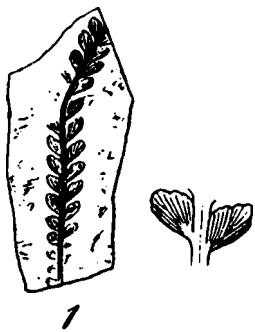

Fig. 1. *Sphenopteris* (*Adiantites*) sp. d. in natural size and two pinnules magnified.

The species is probably new, in so far as can be judged from this incomplete material. Of the species previously described, it somewhat resembles *Adiantites Nympharum* Heer from Bureja in Amur, (Flora foss. arctica, vol. 4), the pinnules of which are however considerably larger.

Newton and Teall[1] have described two specimens from Cape Flora, bringing them under *Thyrsopteris*, though at the same time they draw attention to their similarity to *Adiantites amurensis* Heer. It seems to me that the likeness to *Adiantites Nympharum* is still greater, indeed, it may not be altogether impossible that they belong to this species. Whether the form described above should be considered as an earlier stage of development of the species described by Newton and Teall cannot be determined from the material at hand.

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[1] 'Notes on a collection of Rocks and Fossils from Franz Josef Land', etc. Quarterly Journ. Geol. Soc. vol. 53, p. 477.

CYCADALES.

PTENOPHYLLUM, Brongniart.

Pterophyllum ? sp.

Pl. I. figs 7 and (magnified) 57.

The only specimen that with any certainty belongs to the Cycadales is the little fragment in question. It is a pinna of a frond, probably regularly divided, the pinnae of which in their entire breadth have been attached to the rachis. They are rounded at the apex, and, when enlarged, four unbranched veins are visible in the pinna represented.

This is no true *Pterophyllum*, though provisionally I place the specimen in this genus. It is more of a *Ctenophyllum* or *Ptilophyllum* which, however, cannot be decided from the material before us. Until better material be obtainable, it is not worth while discussing the relationship of this species to forms previously described. It might also be compared with those species of *Zamites* and *Pterophyllum* from the Urgonian strata of Greenland described by Heer.

PODOZAMITES, Fr. Braun.

Podozamites? sp.

Pl. I. fig. 31.

Newton and Teall, in their paper cited above, mention the occurrence of pinnae resembling those of *Podozamites*. I am, however, not fully convinced that the specimens represented on their plate 38, figs. 11 and 12 — or at any rate their fig. 11 — should not rather be classed as *Feildenia*. On the other hand it is not quite impossible that our specimen plate I, fig. 31, which shows about 18 fine veins, should really be referred to *Podozamites*; in which case it would be yet another species of *Cycadales* which has been found in Franz Josef Land.

CONIFERÆ.

GINKGO, Linné.

The Ginkgo forms found here are among the most interesting remains of the entire flora. Unfortunately, most of the leaves are but fragmentary, so that it is difficult to determine with any certainty how many species really occur. The occurrence of at least two species I consider fairly certain, probably the number is still larger in reality.

Ginkgo polaris, Nathorst.
Pl. I. figs. 8—19 and (magnified) 51.

Ginkgo polaris Nathorst, Nansen's 'Farthest North', London, vol. II. p. 486, fig. 6. 'Fram over Polhavet', Christiania, vol. II. p. 520, fig. 6.

This species is represented here with a perfect leaf (fig. 8) which has already been figured and named in the short summary of fossil plants of Franz Josef Land, included in Nansen's description of the Fram expedition 1893—96. The leaf has a truncated base, and, in the manner characteristic of this genus, is repeatedly dichotomously divided into eight lobes, the apex of which is rounded, or mostly somewhat truncated with a depression in the middle. The petiole of the leaf is short and slender. The number of veins in the lobes vary from five to ten.

Of the other specimens included under the same species, those represented in figs. 14, 15, and 17, differ by having a more wedge-shaped base, but it is just possible that the two latter figures only present the one half of the leaf. If the specimen fig. 8 be imagined as divided into two halves, the base of each of the halves would also be wedge-shaped. On the other hand as regards the specimen fig. 14, it is probably a young leaf which has not yet undergone any further division.

Of the species already described, *Ginkgo polaris* can especially be compared with *Ginkgo sibirica* Heer and *Ginkgo flabellata* Heer (Flora fossilis arctica, vols. 4 & 5) from the Jurassic strata of East Siberia, without the existence of any complete agreement with either. The leaves of the former are larger, with a more powerful petiole, the lobes also being more rounded. This is also the case with the lobes of *Ginkgo flabellata*, which moreover, are narrower; the number of veins in the lobes being also fewer (according to Heer but 3—5).

Nevertheless it must be admitted there is a very great resemblance between *Ginkgo polaris* and the two species mentioned, so that there is the temptation of classing some fragments with the one species, some with the other. As, however, the most perfect specimen of *Ginkgo polaris* does not agree with either, I have deemed it more correct to consider it as a species of its own, more particularly as no one of the many specimens examined by me, or by Newton or Teall, presents so long and strong a petiole as those possessed by the species from East Siberia.

To *Ginkgo polaris* we must therefore refer the specimens represented by Newton and Teall in pl. 38, figs 4 and 5, which they call *Ginkgo sibirica*. If they had belonged to the latter species, at any rate the specimen fig. 5, should still have shown the long petiole of the leaf. The specimen figured in their second paper, (plate 29, fig. 3) and which they with hesitation refer to *Ginkgo polaris*, is also characterised by a very short petiole.

Ginkgo polaris Nathorst var. *pygmæa* n. var.

Pl. I. figs. 20, 21 and (magnified) 50, 52.

It is probable that these specimens are only a variety of the preceding, since transition forms do not seem wanting (fig. 18). The specimen fig. 20 is the very smallest of all the Ginkgo leaves hitherto described, as it is even smaller than Heer's *Ginkgo pusilla* from the Jurassic strata of East Siberia, which itself is very closely allied to *Ginkgo flabellata*. The specimen in question has its leaf divided into four lobes, while the fragmentary specimen fig. 21 is divided into six, but with signs of a commencing division of the two innermost lobes, which are consequently broader than the rest. The veins in the specimen fig. 20 are five in each lobe, in the specimen fig. 21 similar in number in the narrower lobes, but nine to ten in those that are broader.

Ginkgo sp.

Pl. I. figs. 22—24.

In my opinion these specimens belong to a separate species, as they differ from *Ginkgo polaris* by having a larger, less deeply divided lamina, more distinct venation and often present a peculiar structure (fig. 23a enlarged) which seems to correspond with transverse cracks in the carbonised leaf sub-

stance; pointing therefore to rather thick leaves. A specimen, sent to me after the plates were printed, is figured in fig. 2 annexed.

Probably the specimens figs. 1—3, plate 38, of Newton's and Teall's afore-mentioned work should be referred to this same species.

Fig. 2. *Ginkgo* sp.

Both in form and venation these specimens, as far as can be judged from the material at hand, show no small resemblance to *Ginkgo pluripatita* Schimper sp. from the Weald of Germany[1]. More complete specimens are however necessary, in order to decide the relationship between the two.

Male flower of *Ginkgo*.

Pl. I. figs. 33 and (magnified) 49.

This specimen is evidently a male flower of some plant belonging to the *Ginkgo* family, probably of the genus *Ginkgo* itself. The anthers are visible on either side of the axis, but their number or nature cannot be definitely ascertained. Such male flowers of the Ginkgo family may be named *Ginkganthus*.

CZEKANOWSKIA, Heer.

Czekanowskia cf. *rigida* Heer.
Pl. I. figs. 35 and 54 (magnified).

That *Czekanowskia rigida*, Heer (Flora foss. arctica, vol. 4) is represented in the collection from Franz Josef Land seems fairly indisputable from the specimen fig. 35, which plainly shows the dichotomous branching of the narrow leaves. The midrib is also shown very clearly.

Besides this specimen, there are many others which seem to point to the occurrence of the same species. First of all, let me mention fig. 37, a specimen which shows several leaves proceeding from a short shoot. Unfortunately they are in a bad state of preservation, so that one might question whether it could not be a *Phoenicopsis*. There is certainly also some likeness to *Pinites*, but, for that, the leaves seem to have been of too weak a consistency.

The specimen represented by fig. 36 may also be deemed fascicular leaves of *Czekanowskia*, as also specimen fig. 38, while the specimen fig.

[1] Schenk, 'Die Flora der nordwest-deutschen Wealdenformation', p. 212, pl. 24, figs. 1—8. Palaeontographica, vol. 19, 1871.

34 (enlarged fig. 55) which shows narrower leaves, might tend to the supposition of the occurrence of *Cz. setacea.* It really seems as if the leaves of some were dichotomously branched, but it is not quite certain, so that here also our thoughts may turn to leaves of *Pinites.*

PHOENICOPSIS, Heer.

Phoenicopsis cf. *augustifolia* Heer.

Pl. I. figs. 39—41, pl. II. figs. 1—6.

The occurrence of the genus *Phoenicopsis* is proved by the specimen figured on Pl. I, fig. 41, which presents a fascicule of long linear leaves with parallel veins proceeding from a short shoot. Unfortunately the leaves of this specimen are in such a bad state of preservation, and run into one another so, that their true breadth cannot be ascertained. Consequently neither their form nor the number of veins on each leaf can be determined; these seem however to have been at least ten. The specimen, fig. 39, on the same plate, shows a fasciculate arrangement of the leaves, but they do not reach down to the short shoot.

Heer (Flora fossilis arctica, vol. 4) states the number of veins in *Phoenicopsis angustifolia* to be 6—10, in *Ph. speciosa* to be 15—23, in *Ph. latior* to be 20—30. Those specimens figured in Pl. II. which I suppose may belong here, have 8—10 veins, except the specimen, fig. 2, in which the upper part of the leaf shows 11. The species thus seems probably to be *angustifolia,* but this cannot be determined with perfect certainty, owing to the present material being so bad.

The fossil which is figured by Newton and Teall in their first paper on Pl. 38, fig. 10, and with some hesitation brought under *Baiera,* should evidently be placed here. The specimen is figured upside down.

FEILDENIA, Heer.

The occurrence of this genus is assumed by me chiefly in consequence of the specimen that is represented Pl. I, fig. 28 and which, as also fig. 29, has already been figured in Nansen's 'Farthest North' (vol. II, p. 486, fig. 4 & 5). However, elsewhere[1] I have adduced the difficulty of distinguishing the

[1] *A. G. Nathorst,* 'Zur mesozoischen Flora Spitzbergens'. Kgl. Svenska Vetenskaps Akademiens Handlingar, vol. 30, no. 1, Stockholm 1897.

leaves of this plant from those of *Phoenicopsis*, and suggested that the two genera may perhaps coincide. If it be difficult to distinguish complete leaves of the two genera the one from the other, this difficulty is of course greatly increased when such fragmentary specimens as those in question are to be determined. For this reason it is with a certain degree of hesitation I include them under this genus. The occurrence of *Feildenia* is, however, not unexpected, as it is represented in the Upper Jurassic flora of Spitsbergen.

Feildenia sp.

Pl. I. figs. 25—30, 32.

The specimen figured in fig. 28 presents a falciform bend at the base of the leaf, still more pronounced than that usual in *Feildenia Nordenskiöldi* Nath. (l. c.) from Spitsbergen. On the contrary the base of the leaf of the specimen fig. 27 is straight, the apex is rounded and not oblique, as is generally the case with the species described from Spitsbergen. In this the number of the veins is usually 6, only exceptionally 10, while 8 to 10 seems to be the usual number in the specimens from Franz Josef Land. If these really belong to the *Feildenia* they may therefore probably belong to a new species. One specimen in the brown softer rock with but 6 veins is, however, very similar to *Feildenia Nordenskiöldi* Nath. from Spitsbergen.

TAXITES, Brongniart.

Taxites cf. *gramineus* Heer sp.

Pl. II. figs. 20—23.

Cycadites gramineus Heer, 'Beiträge zur foss. Flora Spitzbergens', p. 34, pl. 8, fig. 7 (?), 8. Heer, 'Beiträge zur Jura-Flora Ostsibiriens etc.' p. 100. pl. 26, fig. 4.

Taxites gramineus Nathorst, 'Zur mesozoischen Flora Spitzbergens', p. 17.

As far as may be ascertained from these fragmentary specimens, they seem to agree very well with *Taxites gramineus* Heer sp. from the Jurassic strata of Spitsbergen and East Siberia. The leaves are about 3 to 3·5 mm. in breadth and present transverse impressions on their surface, which may certainly be considered a phenomenon of dessication, but which, at the same time, doubtless is connected with some structural peculiarity, as they so often are seen in this sort of leaf.

The specimen fig. 23 is broader than the others (4 mm.), but not more so than fully permits of its belonging to the same species. A similar specimen from Spitsbergen is figured in my work cited above (Pl. I, fig. 14).

ABIETITES, Coeppert.

Abietites (?) sp.

Pl. I. figs. 42, and (magnified) 53.

In my opinion this leaf is complete, and not the apex of a leaf of *Pinites* (*Pityophyllum*) as seems proved by its narrowing off at its base and the special structure thereof. It may therefore be compared to leaves of *Tsuga*; as however there may be a question also of *Sequoia* and other genera it cannot be determined with certainty. Nor do the other conifer remains give any clue, as among them seeds are found which may be said to point both to *Abies* and *Sequoia*.

PINITES, Endlicher.

There cannot be the slightest doubt that the genus *Pinus* — to the extent hat *Linné* has allowed it — is represented in the fossil flora from Franz, Josef Land. As, however, the various remains are usually found separately, there is no possibility of deciding, in each case, whether there may not also occur some closely allied but now extinct genus. It is therefore wiser to use the denomination *Pinites* for these remains, which in no way precludes that in many cases, they should in reality belong to *Pinus* itself. In accordance with the nomenclature[1] already in use we will call the leaves *Pityophyllum*; the twigs *Pityocladus*; the cones *Pityostrobus*; the seeds *Pityospermum*; the male flowers *Pityanthus*. It is plainly more correct to name these organs separately than to connect them with one another, which will always prove more or less arbitrary and uncertain. These names are of course provisional, and will be withdrawn, so soon as the connection of the different organs with one another be proved.

Pityanthus sp.

Pl. II. figs. 7, and (magnified) 7 a.

It appears to me fairly certain that this object is a *Pinus*-like male flower, though the details of the structure of the anthers cannot be distinguished. Their edges appear however to have been fimbriated.

[1] *A. G. Nathorst*, 'Zur mesozoischen Flora Spitzbergens', l. c. p. 62.

Pityostrobus sp. a.

Pl. II. figs. 9, 10, and (magnified) 9 a, 10 a.

These specimens, as is generally the case with mesozoic forms, belong to the sub-division *Sapinus*, which is characterised by thin scales of cone. Thus we can choose between the genera *Cedrus*, *Larix*, *Abies*, *Tsuga* and *Picea*, of which the two last must be given the first place, if, on the whole there can be question of any known genus, which cannot be determined from the scanty material available.

The scales, as previously stated, are thin, and seem to have had an obtuse apex. They are furnished with longitudinal striæ which curve outwards on either side (fig. 9 a). The specimen fig. 10 shows parts of the scales nearer their base, with indications of impressions made by the two seeds.

Pityostrobus (?) sp. b.

Pl. II. figs 11, and (magnified) 11 a.

Possibly this little specimen may be a young cone, or more correctly the female flower of a species, which belongs to the genus *Pinus* in a limited signification. The round object presents rather powerful rhomboid impressions, and recalls *Strobilites Heeri* Nath. from the Jurassic strata of Spitsbergen [1] which Heer, in his day, considered a young *Pinus* cone.[2] On the other hand there might also be the question of some short shoot, for which reason it is with great hesitation I describe the fragment as *Pityostrobus*.

Pityospermum cf. *Maakianum* Heer sp.

Pl. II. fig. 15.

Pinus Maakiana Heer, 'Beiträge zur Juraflora Ostsibiriens und des Amurlandes,' p. 76, pl. 14, fig. 1.

This specimen agrees so entirely with the seeds of *Pinus Maakiana* described by Heer, more especially with his fig. 1, that the identity of the

[1] *Nathorst* l. c. p. 20.

[2] *Heer*, 'Beiträge zur fossilen Flora Spitzbergens', p. 45, pl. 9, fig. 7, 8. Flora fossilis arctica, vol. 4.

two can scarcely be doubted. It is much smaller than the other specimens. Probably the specimen represented by fig. 16 should also be placed here, but it is so torn that any determination of it is very uncertain. The specimen figured in the accompanying text-figure (fig. 3) differs by being narrower-winged, but Heer's fig. 1b is also more narrow-winged than his fig. 1a. Heer is of opinion that *Pinus Maakiana* may possibly belong to the genus *Tsuga*.

Fig. 3. Pityospermum.

Pityospermum cf. *cuneatum* Nathorst.

Pl. II. fig. 14.

Owing to the smallness of the seed itself (scarcely one third of the seed-wing) and what appears to be an almost truncate apex of the wing, and also as regards its dimensions, this specimen seems closely allied to *Pityospermum cuneatum* from the Upper Jurassic strata of Spitsbergen, already described by me[1]. However, the identity of the two—owing to the incompleteness of the specimen in question—cannot be considered certain.

Pityospermum Nanseni n. sp.

Pl. II. figs. 12, 13.

As a type for this species we must first of all reckon that specimen represented in the annexed text-figure (fig. 4) which, of all the seeds obtained, is the most complete. It is about 11 mm. in length, the seed itself is almost round, not quite half as long as the wing, this latter having its greatest breadth about the middle. As regards its form in other respects, I refer the reader to the figure; the wing shows as usual, fine striæ radiating towards the outer margin.

Fig. 4. *Pityospermum Nanseni.* Natural size.

Another complete specimen to be entered here is that figured by *Newton* and *Teall* in their Pl. 38, fig. 6. It has the same form and dimensions, differing only by the outer margin of the wing stretching as far as the lower side of the seed.

Here we must certainly also include the specimen on Pl. II. fig. 13, possibly also fig. 12, the wing of which, probably owing simply to its state of preservation, appears narrower.

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[1] *Nathorst*, 'Zur mesozoischen Flora Spitzbergens', p. 63, pl. 5, fig. 38.

Pityospermum sp.

Pl. II. figs. 17, 18 and (magnified) 18a.

This specimen differs by the considerable size of the seed and the greater length of the wing, which also appears to be narrower. It is, however, so obliterated in the specimen, fig. 18, that its real form cannot be ascertained with any certainty.

Whether the specimen, fig. 19, is really a winged seed is uncertain, the part that should correspond to the wing seems too thick for that. It ought therefore at present to be considered as *incertae sedis*.

Newton and Teall have also figured two winged seeds (l. c. Pl. 38, figs. 7, 8) which evidently belong to one or two other species characterised by very large seeds. Their specimen fig. 8 is about 28 mm. in length.

It therefore appears as if there had been five or six species of *Pinites* growing in the same locality, which is not however *per se* improbable. From the Tertiary Taxodium slate at Cape Staratschin of Spitsbergen, Heer has described no less than 11 different species founded on seeds and scales, so that the occurrence is not without analogy among cases previously known. It is moreover possible that a part of these winged seeds may have been carried hither from a considerable distance.

Pityophyllum cf. *Staratschini* Heer sp.

Pl. II. figs. 24, 25.

Pinus Staratschini Heer 'Kreideflora der arktischen Zone', p. 129, pl. 38, fig. 6, 7. (Kgl. Svenska Vetenskaps Akademiens Handlingar vol. 12, no. 6 and Flora fossilis arctica, vol. 3).

Pityophyllum Staratschini Nathorst 'Zur mesozoischen Flora Spitzbergens', pp. 41, 68, pls. 5, 6, figs. 28—30, 32—36.

These leaves are narrower than those of *Taxites gramineus* Heer, while, at the same time, they are broader than the leaves of *Pityophyllum Lindströmi*. The surface presents the same transverse rugosities as in the former species, which is also the case with very similar leaves described by me from the Upper Jurassic beds at Advent Bay, Spitsbergen. The insufficiency of the material, however, renders the determination far from certain.

Pityophyllum cf. *Lindströmi* Nath.

Pl. II. figs. 26—34a, 38.

Pityophyllum Lindströmi Nathorst 'Zur mesozoischen Flora Spitzbergens,' pp. 40, 67, pl. 5, figs. 13—15, 18—31; pl. 6, figs. 17, 18.

The leaves of this species are generally 1—1.5, seldom 2 mm. in breadth and often show a distinct midrib, at times with an indication of two marginal veins, and moreover finer longitudinal striæ, which, I suppose, correspond with the rows of stomata. No such transverse rugosities as exist in the preceding species are present. On the lower (outer) side the leaves are convex, but on the upper (inner) side concave, as is seen by the transverse-section fig. 38, and moreover in many other specimens. For a more particular description I must refer the reader to my work cited above.

Probably the two specimens, figs. 35 (enlarged 35a) and 36, should also be included here, as they are probably to be considered as short shoots; if this be so, the species must have had many leaves in each short shoot.

The leaves in question are the most common fossils of the plant-bearing stratum, and occur in most specimens of the rock. As in the collection from Advent Bay, Spitsbergen, so also in Franz Josef Land there are accumulations of broken coniferous leaves connected in such a manner that it must be deduced that they have been the abode of some phryganid larva. This seems to indicate that the deposit, as is also probable from other reasons, has originated in fresh water.

CARPOLITHES, Sternberg.

Carpolithes sp. a.

Pl. II. figs. 8 and 8a (magnified).

A somewhat oblique seed, the margin of which has evidently been surrounded by a narrow wing. It may be compared with my *Carpolithes* sp. c. from the Upper Jurassic strata of Spitsbergen (Nathorst, l. c. p. 69, Taf. 5, figs. 47—49, 51) though the specimen before us is far less symmetrical. Among the conifers of the present day the seeds of *Sequoia* are rather like it in appearance.

Carpolithes sp. b.

Pl. II. figs. 40 and 40a (magnified).

This may be the seed of *Taxites* or *Ginkgo*, but may even be a wingless *Pityospermum*, or one where the wing has fallen off.

Carpolithes sp. c.

Pl. II. figs. 41 and 41a (magnified).

An oval seed, striated, (fig. 41a). It is possible that it may be a *Pityospermum* without wings.

Carpolithes sp. d.

Pl. II. fig. 42 (twice magnified).

Two seeds, not unlike the preceding though more acute, are here fixed at the side of each other. It may be considered that they are impressions of two *Pinus* seeds affixed to the scale of cone.

Carpolithes sp. e.

The cast of a seed represented in the accompanying letterpress-figure (fig. 5) has on the whole a heart-like form though with a truncate base. In the centre there is a deep impression or cavity, and the apex appears cleft. Thus it bears a faint resemblance to certain *Samaropsis*-forms from Eastern Siberia described by Heer, without, however, any complete agreement with any of them.

Fig. 5.
Carpolithes sp. e.
natural size and magnified.

INCERTAE SEDIS.

Fig. 6.

The object here represented (fig. 6) is probably an inflorescence of some conifer. As, however, it may be also compared with twigs, I have thought it wiser to enter the fossil as *incertae sedis*. The cylindrical objects lying beside and above one another, on the surface, present a sculpture (badly represented in the figure) which seems to indicate that they have been constructed of small, closely packed scales. If, on the other hand, the objects be considered twigs, the sculpture would be derived from leaf-scars.

Fig. 6.
Incertae sedis.

GEOLOGICAL AGE OF THE PLANT-BEARING DEPOSIT.

A glance at the accompanying list (on pp. 23—24) of the fossil plants described in these pages, will at once prove to specialists that the fossil flora from the deposit between the basalt beds of Franz Josef Land, has its greatest resemblance with the previously known Jurassic floras from Siberia and Spitsbergen. Of these, that of Siberia and the flora of Cape Boheman of Spitsbergen have by *Heer* (and afterwards by me) been brought under the Brown Jura, an opinion which, as regards the latter flora, is no longer tenable; the investigations carried on by me during the summer of 1898 having proved that it must be placed above the Oxfordian Aucella-bearing deposits. We may thus, to begin with, affirm that the plant-bearing deposit of Franz Josef Land is younger than the Oxfordian, or belongs to its uppermost portion, which also harmonises with the supposition of the lowest basalt-bed having its place above the Oxfordian marine deposits containing *Ammonites Lamberti.* There is, moreover, no doubt whatever that the flora of Franz Josef Land is younger than that of Cape Boheman and Siberia, a circumstance which is proved by its ample supply of the *Pinites* species. In this respect it agrees more with the youngest Jurassic flora of Spitsbergen, viz: that described by me as found at Advent Bay, and by *Heer* as discovered at Cape Staratschin. As a matter of fact the most common species found at Franz Josef Land seems identical with *Pityophyllum Lindstrømi* Nath. also so common in the deposit at Advent Bay. The age of this deposit I have tried to define by stating that "the nearest approach to truth is made by counting the deposit as Uppermost Jurassic, to a horizon which is somewhat older than the Wealden."

The agreement between the fossil flora of Franz Josef Land and Advent Bay is, however, far from complete. Most remarkable is the absence, at Franz Josef

THE FOSSIL FLORA OF FRANZ JOSEF LAND.

List of species described in this paper.	Allied or identical species from other localities
Cladophlebis sp.	Belongs to the Jurassic Cladophlebis-Type.
Sphenopteris sp. a.	? *Asplenium petruschinense* Heer and *A. Czekanowskianum* Heer from the Siberian Jura.
Sphenopteris sp. b.	*Sphenopteris* (*Thyrsopteris*) *Murrayana* Brongn from the Jura of England, Siberia etc.
Sphenopteris sp. c.	*Sphenopteris* (*Thyrsopteris*) *Maakiana* Heer from the Siberian Jura and some other Jurassic forms.
Sphenopteris (*Adiantites*) sp. d.	*Adiantites Nympharum* Heer from the Jura of eastern Siberia.
Pterophyllum? sp.	
Podozamites? sp.	*Podozamites lanceolatus* Lindl. sp. from the Jura of Europe, Spitsbergen, Siberia etc.
Ginkgo polaris Nath.	*Ginkgo sibirica* Heer and *G. flabellata* Heer from the Siberian Jura.
Ginkgo polaris Nath. var. *pygmaea*.	
Ginkgo sp.	*Ginkgo pluripartita* Schimper sp. from the Wealden deposits.

List of species described in this paper.	Allied or identical species from other localities.
Czekanowskia cf. *rigida* Heer.	*Czekanowskia rigida* Heer from the Siberian Jura and from the Rhætic beds of Scania.
Phoenicopsis cf. *angustifolia* Heer.	*Phoenicopsis angustifolia* Heer from the Jura of Siberia and Spitsbergen.
Feildenia sp.	*Feildenia Nordenskiøldi* Nath. from the uppermost Jura of Spitsbergen.
Taxites cf. *gramineus* Heer sp.	*Taxites gramineus* Heer sp. from the Jura of Siberia and Spitsbergen.
Abietites? sp.	
Pityanthus sp.	
Pityostrobus sp. a.	
Pityostrobus? sp. b.	
Pityospermum cf. *Maakianum*, Heer sp.	*Pityospermum Maakianum* Heer sp. from the Siberian Jura.
Pityospermum cf. *cuneatum*, Nath.	*Pityospermum cuneatum* Nath. from the uppermost Jura of Spitsbergen.
Pityospermum Nanseni Nath.	
Pityospermum sp.	
Pityophyllum cf. *Staratschini*, Heer sp.	*Pityophyllum Staratschini* Heer sp. from the uppermost Jura of Spitsbergen.
Pityophyllum cf. *Lindstrømi* Nath.	*Pityophyllum Lindstrømi* Nath. from the uppermost Jura of Spitsbergen.
Carpolithes sp. a.	*Carpolithes* sp. c. from the uppermost Jura of Spitsbergen.
Carpolithes sp. b.	
Carpolithes sp. c.	
Carpolithes sp. d.	
Carpolithes sp. e.	?*Samaropsis* from the Siberian Jura.

Land, of *Elatides curvifolia* Dkr. sp., which both at Cape Staratschin and Advent Bay predominates to such a degree. *Baiera spetsbergensis* is also not found at Franz Josef Land, while at Advent Bay no *Ginkgo polaris, Phoenicopsis*, etc., appear to have been discovered. Under these circumstances it is not probable that the plant-bearing deposit of Franz Josef Land is quite contemporaneous with the plant-bearing strata of Cape Staratschin and Advent Bay, but it is difficult to decide whether it is to be considered older or younger. In favour of the former supposition there is the fact of the similarity or affinity of species in the fossil floras of Siberia and Cape Boheman (*Sphenopteris, Ginkgo polaris, Czekanowskia, Phoenicopsis, Pityospermum Maakianum*); and the most natural conclusion, in consequence, would be to consider the flora of Franz Josef Land as belonging to a period between the fossil floras of Cape Boheman and Advent Bay. The material at hand is, however, so incomplete, that a precise determination of the age of the deposit can only be made to an approximate degree. As regards its downward limits, as previously stated, it may be adduced with certainty that it must be younger than the Jurassic flora of Siberia and Cape Boheman. As these, as before stated, owing to the stratigraphical conditions must be younger than the Oxfordian, or belong to the uppermost part of it, the fossil flora of Franz Josef Land must in consequence, be still younger. How much younger, however, it is very difficult to decide. As regards its upward limits there is the difficulty that in the Polar regions no real Wealden flora is, as yet, described. There appears to be no agreement with the Urgonian flora of Greenland, and it must therefore be supposed that the fossil flora of Franz Josef Land is older than the Urgonian. The result of the age-problem can therefore only be thus defined: that the plant-bearing deposit was formed towards the close of the Jurassic or commencement of the Cretaceous Period, without our being able at present to settle which.

In order to avoid misapprehension, it is perhaps best, for me to mention that, together with many other authors, I reckon the Wealden as belonging to the Jurassic Period and not to the Cretaceous; a question in itself, of very slight importance.

It seems, however, as if the conditions at King Charles Land, as examined by myself in 1898, might possibly define with somewhat more precision the age of the deposit. Above the fossil-bearing marine strata which, according to

the determination of Dr. *J. F. Pompeckj* reaches up into the Neocomian, there is a plant-bearing deposit which shows affinity to the fossil flora both of the Wealden and Cape Boheman. This plant-bearing deposit cannot therefore, in consequence of its stratigraphical position, be older than the Wealden. It is covered by a basalt-bed, above which, at one point, I found fragments of a plant-bearing stratum which in every detail appeared to agree with the stratum between the basalt-beds of Franz Josef Land and which, in all probability, as is the case there, was covered by another bed of basalt. If these plant-bearing strata are identical, which cannot be fully proved owing to the condition of the material at present available, then, as a natural consequence, the fossil flora of Franz Josef Land must either belong to the Wealden, or be somewhat younger. This question will be further touched on in my work on the geology of King Charles Land when describing its fossil plants.

PLATE I.

PLATE I.

Figs. 1—42 are drawn in natural size.

Fig. 1. *Cladophlebis* sp.
2. *Sphenopteris* sp. a.
3. *Sphenopteris* sp. b.
4. *Sphenopteris* sp. c.
5 & 6. *Sphenopteris* (*Adiantites*) sp. d.
7. *Pterophyllum?* sp.
8—19. *Ginkgo polaris* Nath.
20 & 21. *Ginkgo polaris* Nath. var. *pygmæa.*
22—24. *Ginkgo* sp.
25—30. *Feildenia* sp.
31. *Podozamites?* sp.
32. *Feildenia?*
33. Male flower of *Ginkgo.*
34. *Czekanowskia?*
35. *Czekanowskia* cf. *rigida* Heer.
36—38. *Czekanowskia?*
39—41. *Phoenicopsis* cf. *angustifolia* Heer.
42. *Abietites?* sp.

Figs 43—57 are magnified drawings.

43. *Cladophlebis* sp. (Fig. 1).
44. *Sphenopteris* sp. a. (Fig. 2).
45. *Sphenopteris* sp. b. (Fig. 3).
46. *Sphenopteris* sp. c. (Fig. 4).
47 & 48. *Sphenopteris* (*Adiantites*) sp. d. (Figs. 5 & 6).
49. Male flower of *Ginkgo* (Fig. 33).
50. *Ginkgo polaris* Nath. var. *pygmæa.* (Fig. 20).
51. *Ginkgo polaris* Nath. (Fig 18).
52. *Ginkgo polaris* Nath. var. *pygmæa* (Fig. 21).
53. *Abietites* sp. (Fig. 42).
54. *Czekanowskia* cf. *rigida* Heer. (Fig. 35).
55. *Czekanowskia?* (Fig. 34).
56. Leaf of Taxites with parasitic fungus. 56 *a*, part of fig. 56 still more magnified.
57. *Pterophyllum?* sp. (Fig. 7).

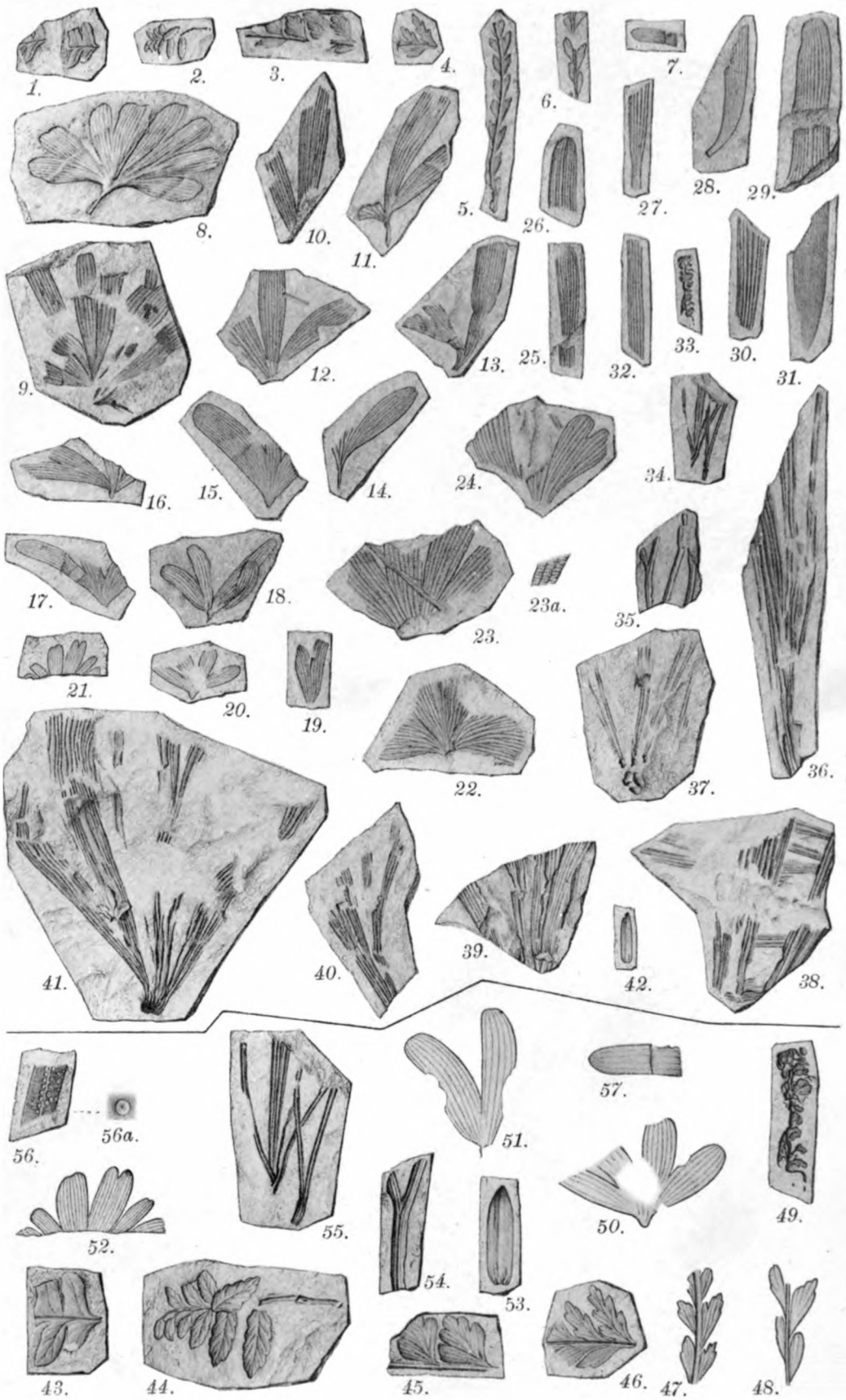
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PLATE II.

PLATE II.

Figs. 1—6. *Phoenicopsis* cf. *angustifolia* Heer. Figs 3a and 6a portions of figs. 3 and 6 magnified.

7, magnified 7a. *Pityanthus* sp.

8, magnified 8a. *Carpolithes* sp. a.

9 & 10, magnified 9a, 10a. *Pityostrobus* sp. a.

11, magnified 11a. *Pityostrobus?* sp. b.

12 & 13. *Pityospermum Nanseni* Nath.

14. *Pityospermum* cf. *cuneatum* Nath.

15, 16?. *Pityospermum* cf. *Maakianum* Heer sp.

17, 18, magnified 18a. *Pityospermum* sp.

19, magnified 19a. *Pityospermum?*

20—23. *Taxites* cf. *gramineus* Heer sp.

24, 25. *Pityophyllum* cf. *Staratschini* Heer sp?

26—34; 26a, 26b, 32a, 33a, 34a magnified portions. *Pityophyllum* cf. *Lindstrømi* Nath.

37. Transverse section of unknown leaf (*Pityophyllum* or *Czekonowskia?*) thrice magnified.

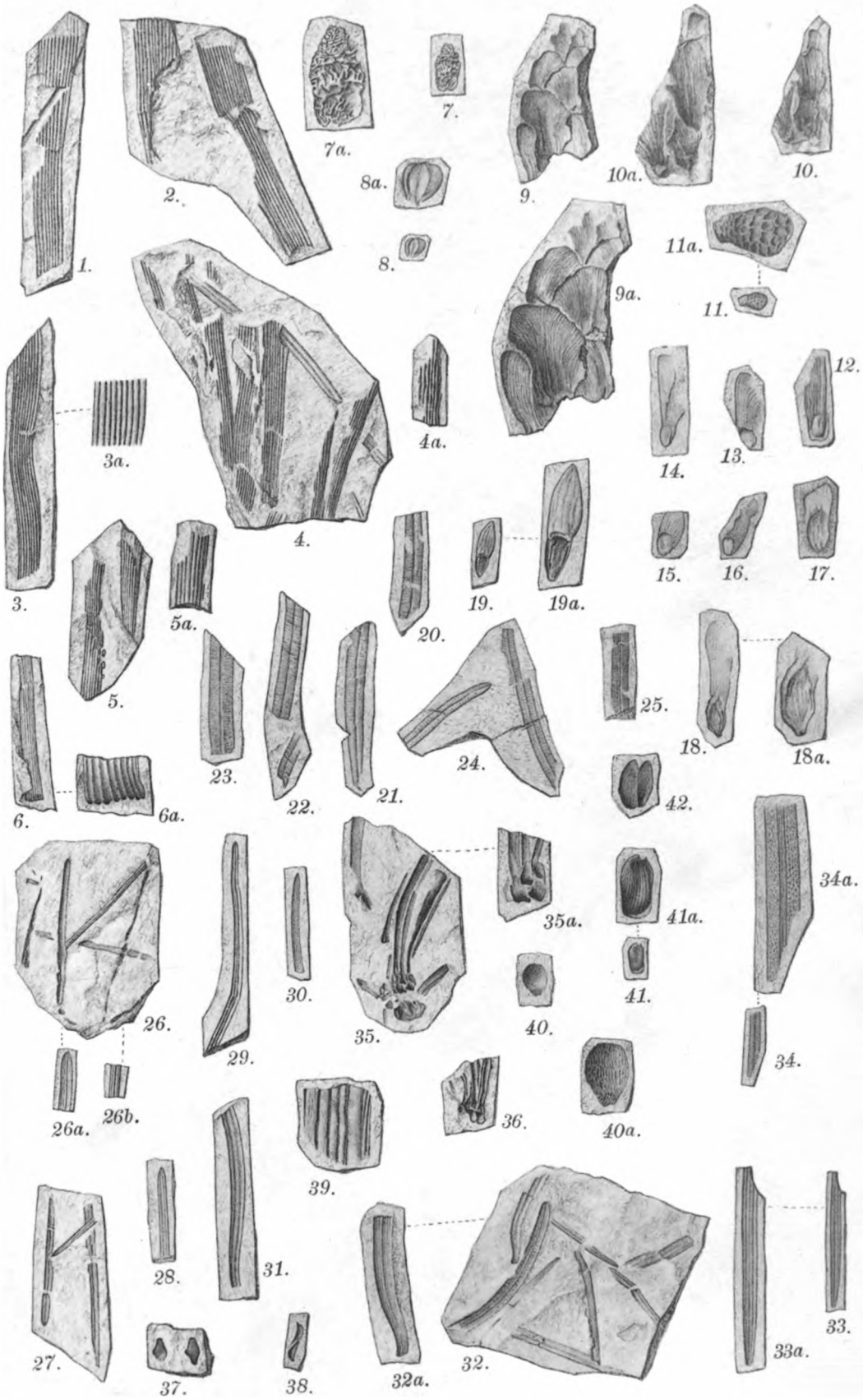
38. *Pityophyllum* cf. *Lindstrømi* Nath. Transverse section, twice magnified.

39. Impression of wood.

40, magnified 40a. *Carpolithes* sp. b.

41, magnified 41a. *Carpolithes* sp. c.

42, *Carpolithes* sp. d. Twice magnified.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