

**MEDDELELSER OM GRØNLAND**

UDGIVNE AF

KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND

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DE ØSTGRØNLANDSKE EXPEDITIONER TIL  
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I AARENE 1926—27 OG 1929—30

UNDER LEDELSE AF LAUGE KOCH

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**THE FOSSIL FLORA OF SCORESBY  
SOUND EAST GREENLAND**

PART 4: GINKGOALES, CONIFERALES, LYCOPODIALES  
AND ISOLATED FRUCTIFICATIONS

BY

**T. M. HARRIS**

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WITH 53 FIGURES IN THE TEXT AND 29 PLATES

KØBENHAVN

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BIANCO LUNOS BOGTRYKKERI A/S

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## INTRODUCTION

**T**his paper almost completes the descriptive part of my work and I hope soon to publish a final paper on the stratigraphic relations and age of the flora. The grouping of the Lycopods with the two families of Gymnosperms in this paper is the result of the need to postpone their investigation until bulk-macerations had been made of all available rock, and this maceration has only just been finished.

The previous papers on this flora are mentioned in the bibliography under the names of ROSENKRANTZ, KOCH, HARTZ and HARRIS.

### Ginkgoales.

Genus **GINKGOITES** SEWARD.

1919. *Ginkgoites* SEWARD, p. 10.

This genus is discussed on p. 47.

***Ginkgoites obovata* (NATHORST) SEWARD.**

Pl. 1, figs. 6, 12—14; Pl. 3, fig. 1, 2; Text-figs. 1, 2.

1886. *Ginkgo obovata* NATHORST, p. 93; Pl. 20, fig. 3.

1919. *Ginkgoites obovata* (NATH.) SEWARD, p. 12; Text-fig. 632 A.

#### *Occurrence in Greenland.*

Zamites R.

Astarte R., *Lepidopteris* Bed.

These beds belong to the *Lepidopteris* Zone.

*Description of the Greenland specimens.* A good many specimens were found; a few of the best are figured in Text-figs. 1, 2. The lamina is entire or almost entire, but varies greatly in size and also in relative width. The petiole is rather thick and sometimes shows the extensions of the thickening of the base of the lamina clearly (Pl. 1, fig. 13).

In the petiole there appears to be a single dark strand, which dichotomises just below the lamina. These strands soon dichotomise again, the outer half being rather stronger and dividing again at a lower

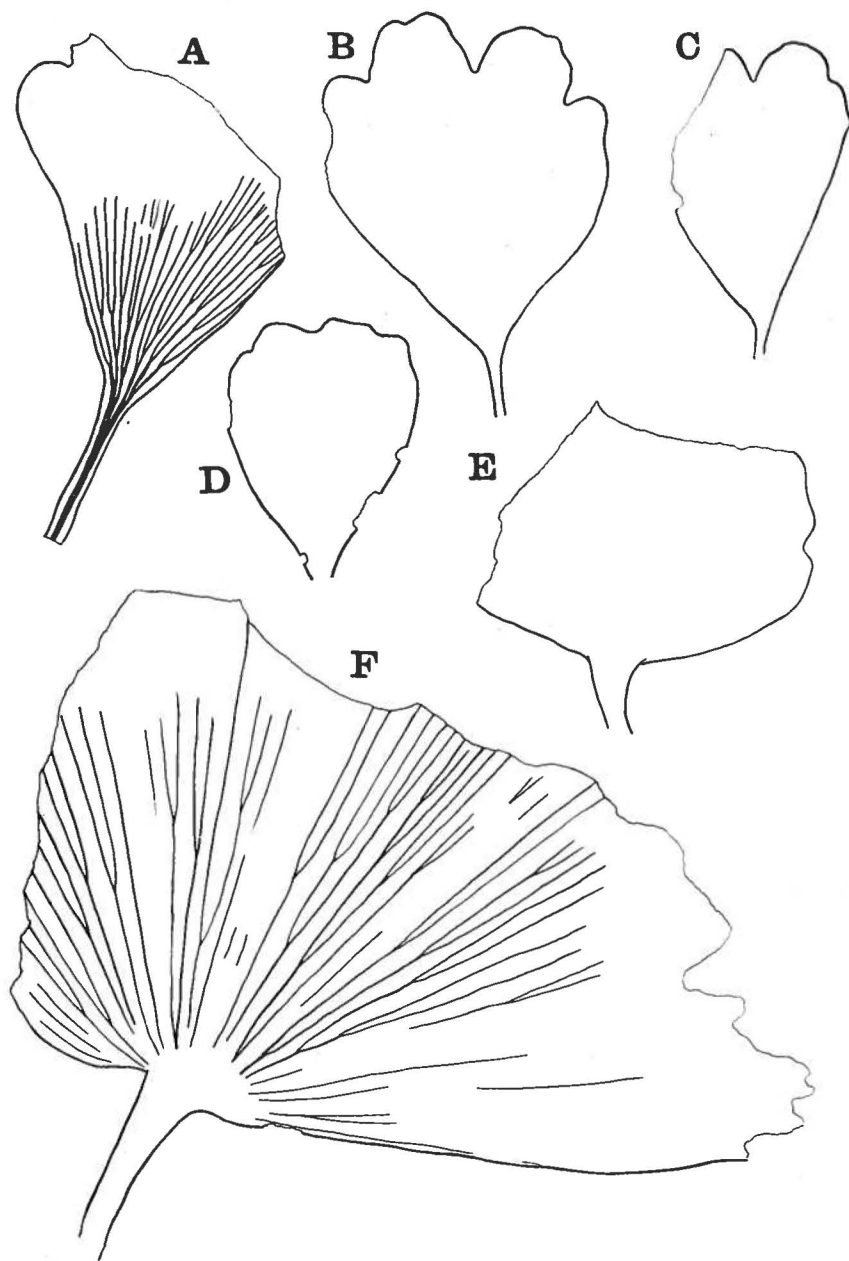


Fig. 1. *Ginkgoites obovata*.

A, leaf No. 2403, Slide 1908,  $\times 1$ . B, complete leaf, No. 2404,  $\times 1$ . C, small leaf, No. 2405,  $\times 1$ . D, small leaf, Slide 1907,  $\times 1$ . E, broad leaf (also shown in Pl. 1, fig. 12, 13), No. 2406,  $\times 1$ . F, lower part of large leaf, No. 2401,  $\times 1$ .

All the specimens were obtained from Astarte R., *Lepidopteris* Bed.,

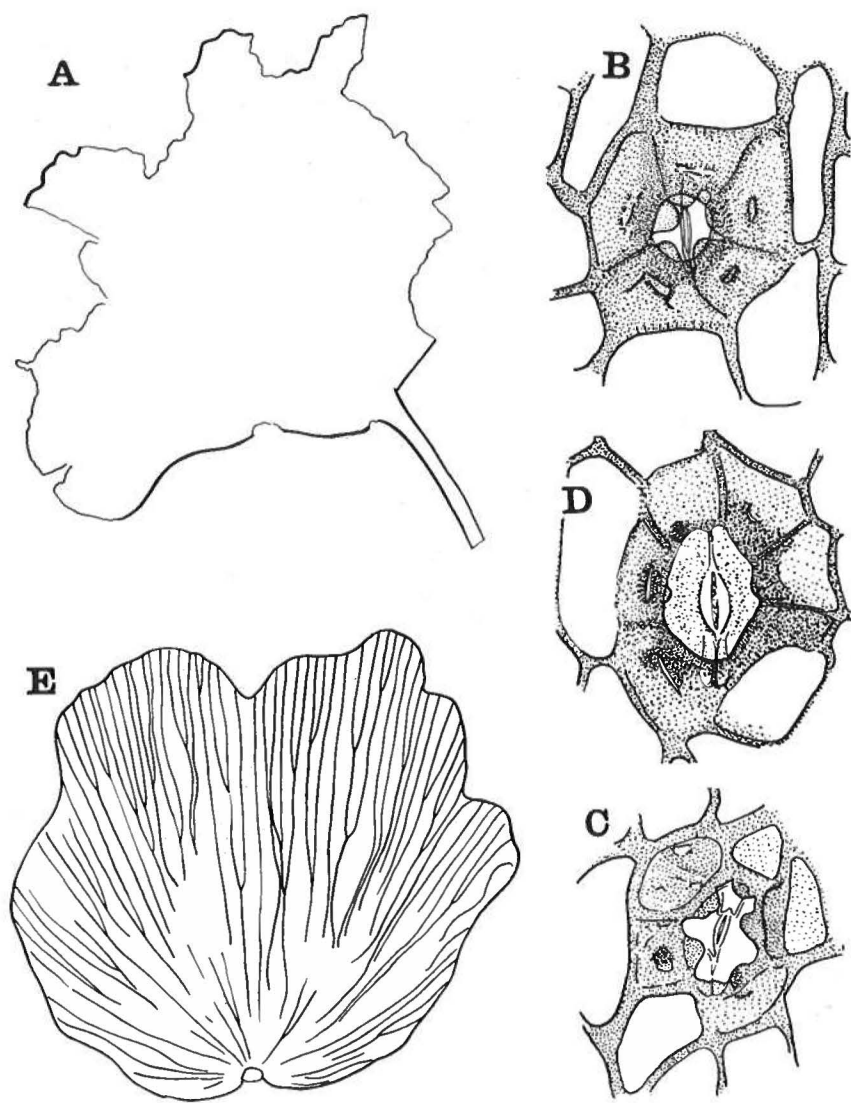


Fig. 2. *Ginkgoites obovata*.

A, outline of largest leaf found (also shown in Pl. 1, fig. 6), No. 2420,  $\times 0.5$ . B., C typical stomata on under surface, Slide 1900,  $\times 400$ . D, abnormal stoma from upper surface, Slide 1900,  $\times 400$ . E, leaf, No. 2402,  $\times 1$ .

All the specimens were obtained from Astarte R., *Lepidopteris* Bed, except No. 2420, which was obtained from Zamites R.

level that the inner half. The veins continue to branch and run at a concentration of 7.5 per cm in the lamina.

The substance of the leaf is thick. No characteristic "mesophyll" structure was recognised, apart from round or fusiform resin bodies which occur between the veins.

According to the state of preservation of the leaf, the veins and resin bodies may be conspicuous as ridges on the surface, or only visible by transmitted light. In some leaves they are invisible until after maceration, when the resin becomes conspicuous and the position of the veins can be recognised in the cuticle.

The cuticle is very thick on both sides. The upper has only a very few stomata. It shows nearly uniform cells with thick, straight walls and without papillae. The veins are scarcely distinguished. The lower has numerous stomata between the veins and occasional stomata along them. The epidermal cells are similar to those of the upper except that they sometimes show small papillae.

The stomata are surrounded by a round group of 4—7 subsidiary cells. The whole surface of the subsidiary cells is thickly cutinised, particularly near the stomatal aperture. The subsidiary cells bear papillae which project over the guard cells and may conceal them. The guard cells are sunken and thinly cutinised except round the aperture; the stomatal aperture is 15—27  $\mu$  long. The chief variation in the stomata is in the development of the papillae of the subsidiary cells, that shown in Text-fig. 2 D is abnormal.

*Discussion and Comparison.* The various types of leaf described here were identified with one another because they occur together and agree in their cuticles. The smallest Greenland specimens closely resemble the Swedish Type-specimen in form, venation and in resin bodies and are therefore identified with it.

*G. obovata* differs from most of the older Ginkgoalean leaves in its nearly entire lamina. *G. antarctica*, however, (see WALKOM, 1917; DU TOIT, 1927) is of similar shape but has more crowded veins. *Ginkgoidium nathorsti* YOKOYAMA (1889), a younger species, is rather similar in outline but has different venation (p. 49).

### ***Ginkgoites fimbriata* sp. nov.**

Pl. 1, fig. 11; Pl. 2, figs. 7, 8; Text-fig. 3 A—D.

The figures represent the Type-specimen.

*Occurrence.* Astarte R., *Lepidopteris* Bed, Bed C.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Leaf with lamina 1.5 cm long, estimated width near free margin 2 cm. Petiole 4.5 cm long, slender. Lamina deeply divided

into four lobes, lateral margins of lobes nearly straight, terminal margin bearing delicate pointed teeth 1.5 mm long and about 0.6 mm wide. Veins rather inconspicuous, except by transmitted light, ultimate branches ending in the marginal teeth. "Mesophyll" granular; fusiform resin bodies present between veins.

Cuticle not very thick. Upper cuticle the thicker, with a few stomata;

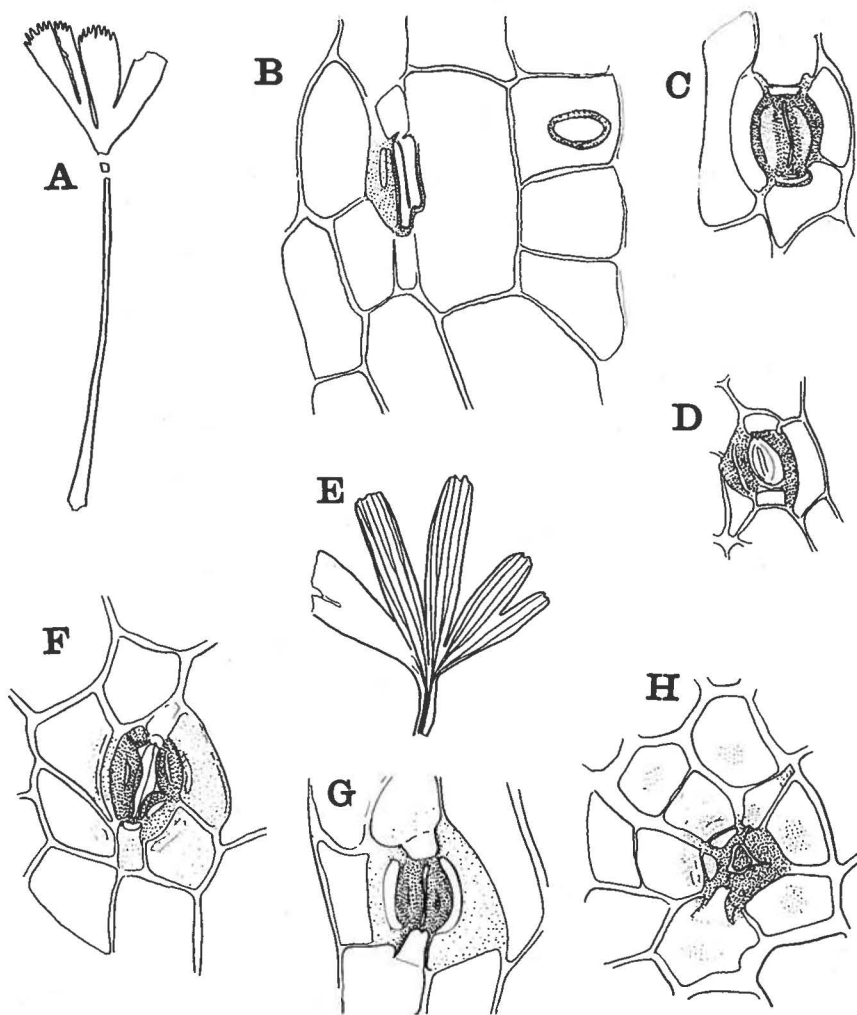


Fig. 3 A—D. *Ginkgoites fimbriata*. E—H, *G. acosmia*.

A, leaf, No. 2441,  $\times 1$ . The second segment of the left has been folded and only the upper half is seen; the margin of the segment on the right is missing. B, an unusually exposed stoma. C, D, typical stomata. B—D, drawn from Slide No. 1920,  $\times 400$ . E, *G. acosmia*, leaf,  $\times 2$ , No. 2454; F, G, typical stomata. Slide 1976,  $\times 400$ .

H, stoma on upper surface (aperture hidden by wax?), Slide 1976,  $\times 400$ .

composed of more or less rectangular cells with straight walls. Surface of cells bulging, often forming a hollow papilla. Cells along the veins not distinguished. Lower cuticle with isodiametric cells between the veins, elongated cells over the veins, cell walls straight or with minute zigzag projections. Occasional cells bearing a hollow papilla. About half of the stomata orientated longitudinally, the rest irregularly; stomata with 4—7 subsidiary cells — often with two large lateral ones and two smaller terminal ones. Surface of subsidiary cells of about the same thickness as other epidermal cells except near the stoma, where it is much thickened and forms an irregular ring round the stomatal aperture. Aperture of stoma 10—15  $\mu$  long, sunken, often concealed. Lateral encircling cells occasionally present.

*Discussion and Comparison.* *G. fimbriata* is only represented by the Type-specimen and a fragment of a second leaf identified by its cuticle. Although nothing is known about its range of form-variation, it seems so clearly distinguished by its fimbriate margin and bulging epidermal cells that it is worth description as a new species.

*G. fimbriata* agrees with *Baiera sp. a* and *B. kidoi* (YABE and OISHI 1933, OISHI 1933) in possessing hollow papillae on its epidermal cells, but it differs in its general form from both, and I therefore consider it a distinct species.

#### ***Ginkgoites acosmia* sp. nov.**

Pl. 1, figs. 3—5; Pl. 2, figs. 1, 2; Text-fig. 3 E—H; Text-fig. 4.  
Type-specimen, Text-fig. 4 I.

#### *Occurrence.*

Astarte R., Bed A.

?Ryders R., *Baiera* Bed.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Leaf composed of a petiole about 5 cm long  $\times$  1—2 mm thick bearing a lamina typically about 4 cm long  $\times$  6 cm broad (extreme specimens 6 cm long  $\times$  8 cm broad; 3 cm long  $\times$  2 cm broad; 7 mm long  $\times$  14 mm broad). Lamina always divided into halves, each half divided more or less deeply into three main lobes, the inner lobes being longer and broader than the outer ones. Main lobes usually deeply notched or divided in large leaves, slightly notched in small ones. Apex of lobes entire or irregularly notched, varying considerably even in a single leaf. Substance of leaf moderately dense; mesophyll showing fine granules, sometimes evenly scattered, sometimes showing a slight tendency to form transverse plates.

Fusiform resin bodies about 0.5—1.0 mm long and 0.2 mm wide always present between veins; resin bodies seldom visible on surface, but usually conspicuous by transmitted light and always found after

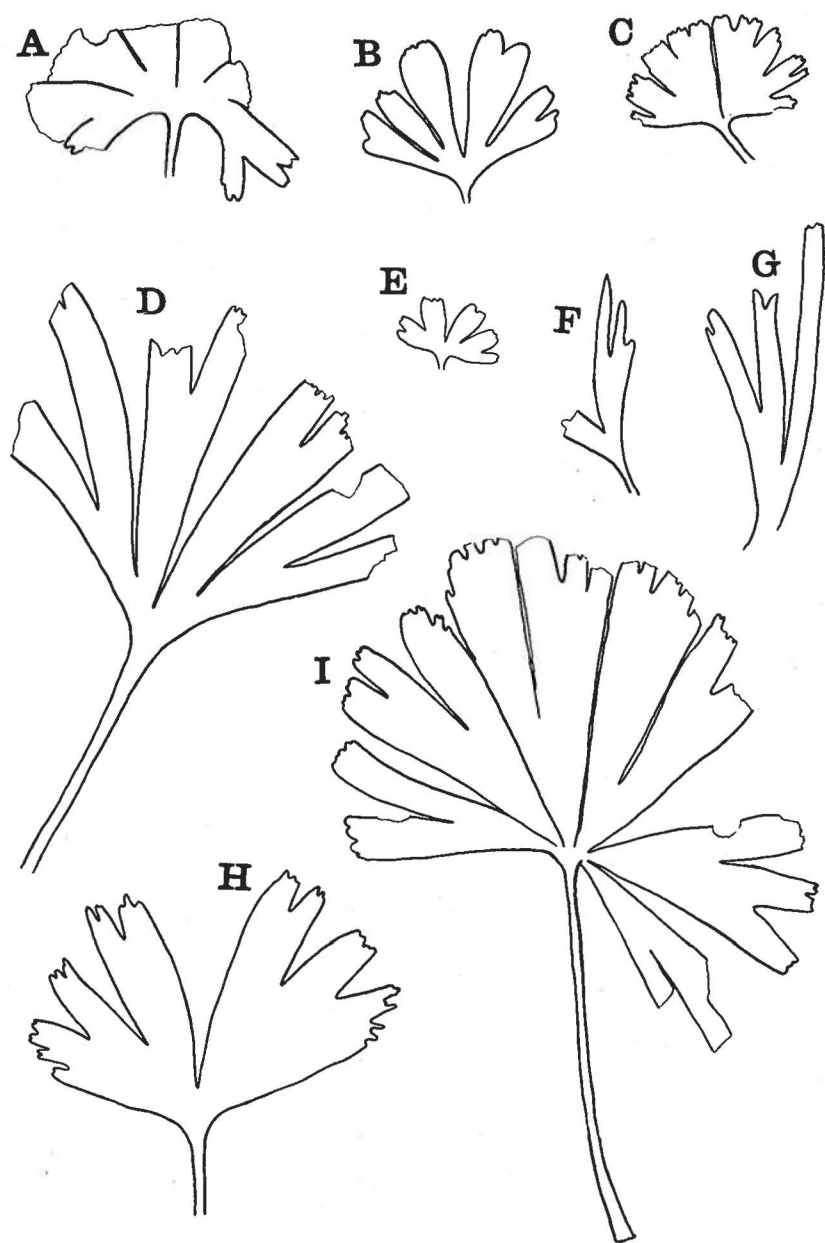


Fig. 4. *Ginkgoites acosmia*.

A, lower part of a leaf, No. 2458,  $\times 1$ . B, small leaf, No. 2461,  $\times 1$ . C, small leaf, No. 2459,  $\times 1$ . D, normal-sized leaf, No. 2455,  $\times 1$ . E, smallest leaf found, Slide 1950,  $\times 1$ . F, unusually narrow leaf, No. 2460,  $\times 1$ . G, left-hand half of a narrow leaf (the other half was folded underneath), No. 2458,  $\times 1$ . H, leaf which is less dissected than usual, No. 2456,  $\times 1$ . I, Normal sized leaf, Type-specimen, No. 2451.

maceration. Veins fine, often inconspicuous, dichotomising regularly and usually traversing lamina at a concentration of about 15 per cm.

Cuticle of medium thickness. Upper with very few or no stomata, either composed of uniform epidermal cells, or with those along the veins slightly elongated; cell walls straight, fairly thick, surface with an obscurely marked median papilla. Lower cuticle showing numerous scattered stomata between the veins, few or none along the veins. Epidermal cells along the veins considerably elongated, those between of rather irregular shape, sometimes transversely elongated. Cell walls straight; cells without papillae or with only exceedingly faint and indefinite papillae. Stomata irregularly orientated, but often placed longitudinally, sometimes with four subsidiary cells — two large lateral ones and two small terminal ones — but usually with a ring of about six. Whole surface of subsidiary cells usually rather thicker than that of ordinary epidermal cells, near the stoma the surface becoming thicker and forming an irregular ring round the aperture, or very broad papillae which often meet over the aperture. Stomatal aperture sunken, about  $14\mu$  long, poles of guard cells usually visible on surface. Walls of cells of lower side sometimes finely sinuous.

*Discussion and Comparison.* *G. acosmia* is the dominant species in certain layers of rock and shows a considerable range in the size of the leaf and in the angle made by the base of the lamina and the petiole, and in the dissection of the lamina. The branching of the leaf is, however, always of the same type (see p. 49); resin is constantly present and the structure of the cuticle is constant.

*G. fimbriata* is distinguished by its cuticle which shows characteristic hollow papillae on the epidermal cells.

It is compared with *G. taeniata*, a leaf of rather different form but a very similar cuticle on p. 23.

The leaves described by YABE and OISHI (1933) and by OISHI (1933) as *Ginkgoites* cf. *sibirica* resemble *G. acosmia* very closely indeed in cuticle and rather closely in general form; though differing in the apices of the lobes which are rounded instead of being irregularly notched, and I therefore regard them as specifically distinct.

There are a number of incompletely known specimens described under the names *G.* (or *Baiera*) *taeniata*, *sibirica*, *digitata*, etc. with which this leaf might possibly be identical.

The specific name is from  $\alpha$  not, and  $\kappa\omicron\sigma\mu\omicron\varsigma$  orderly, and refers to its very variable margin.



***Ginkgoites minuta* (NATH.) N. comb.**

Pl. 1, fig. 7; Text-fig. 5.

1878(a). *Baiera minuta* NATHORST, p. 12.1878(a). *Sphenopteris baieraeformis* or *Ginkgo minuta* NATHORST, pp. 28, 55; Pl. 1, fig. 3; Pl. 13, figs. 1—2.1886. *Ginkgo minuta* NATHORST, p. 93; Pl. 20, figs. 14—16.1918. *Baiera minuta* NATH., LUNDQVIST, p. 493, Pl. 9, Textfigs. 1—5.1926b. *Baiera Münsteriana* HARRIS (non PRESL), p. 101; Text-fig. 24.*Occurrence in Greenland.*Lepidopteris R., *Lepidopteris* Bed.

?Hare R., Lower plant bed (specimen lost).

Astarte R., *Lepidopteris* Bed, *Equisetites* Bed, Bed B (with seed); Bed C. Vardekløft, *Stachyotaxus* Bed.C. Stewart, *G. minuta* Bed.?Neill Cl., *Pterophyllum schenki* Bed (doubtfully determined fragment).

All of the above localities belong to the lower half of the *Lepidopteris* Zone. The specimens obtained by HARTZ and described by HARRIS were probably from Vardekløft and from C. Stewart.

*Description of the Greenland specimens.* A great many well preserved specimens were obtained from Astarte R., Bed B, where it is a dominant species. The great majority of these specimens agree in size and complexity with those shown in Text-fig. 5 A and D; those shown in B, C and E are selected on account of their abnormal size or form.

The venation agrees with that of the specimen figured by HARRIS; spindle-shaped resin bodies are invariably present between the veins. The "mesophyll structure" is not characteristic. The cuticle has been already described and figured by HARRIS (1926b); the cuticle of the present specimens agrees very well with these figures. Cell-papillae are very seldom recognisable and are never at all prominent. The cell-outlines are usually finely sinuous, but in other specimens they are straight, but with very fine zigzag thickenings.

*Discussion.* In 1926(b) I identified my specimens with *G. muensteriana*, but as a result of the collection of much better material, I have come to the conclusion that all the Greenland specimens would be better referred to *G. minuta*.

LUNDQVIST (1918) has discussed this species at some length. I am able to agree with nearly all his conclusions but differ in my interpretation of the variation in leaf form. This question is of some importance as it affects the separation of the form-genera *Ginkgoites* and *Baiera*. LUNDQVIST figured some leaves (with petioles) which are just like those shown in Text-fig. 5 and also some very narrow "leaves" (without petioles). I believe that these narrow specimens may not represent the

complete lamina but are fragments consisting of only a few lobes of the lamina of leaves which were originally quite normal. It is obvious that some of LUNDQVIST's specimens are broken in their upper part (it may be recalled that many of these had been removed bodily from the rock), it is therefore not unlikely that their bases also are incomplete. As far as my specimens show, this species seems to be rather uni-

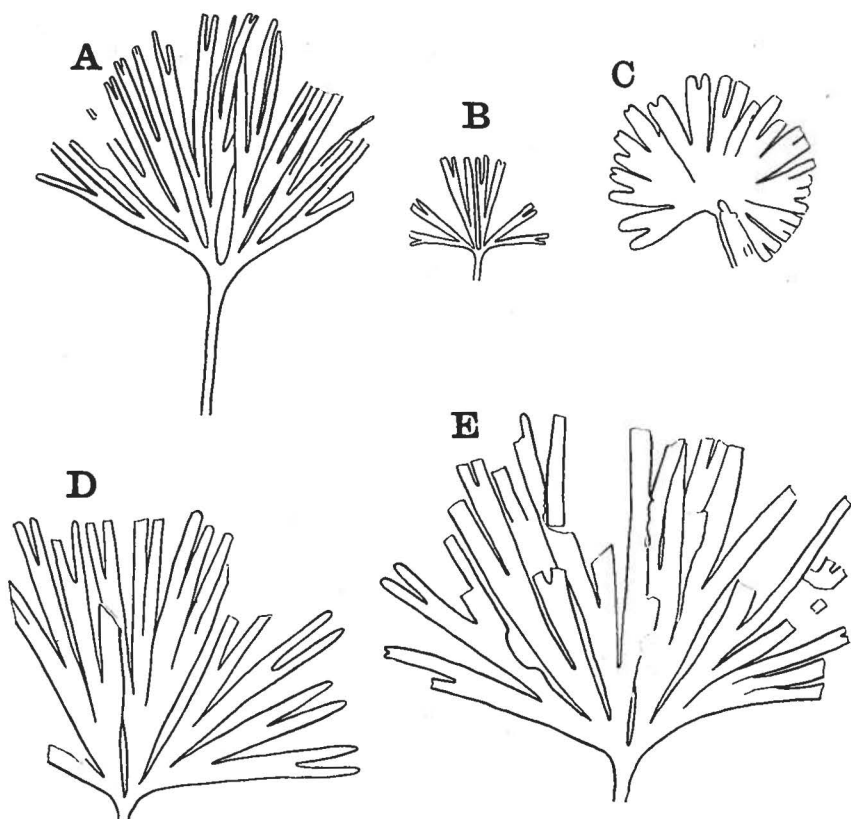


Fig. 5. *Ginkgoites minuta*.

A, D, normal leaves; B, C, abnormally small leaves; E, the largest leaf found: all  $\times 1$ . A, No. 2485; B, No. 2512; C, No. 2511; D, No. 2486; E, No. 2495. A and D were obtained from Astarte R., Bed B; B and C, from Astarte R., *Lepidopteris* Bed; E, from Vardekloft, *Stachyotaxus* Bed.

form; the leaf varies somewhat in size, but always possesses a broad, deeply divided lamina and a distinct petiole.

*Comparison.* *G. minuta* resembles *G. muensteriana* (see SCHENK 1867, GOTHAN 1914, ANTEVS 1919) so closely that it is only a number of well-developed leaves of the two species which can be definitely distinguished. A large leaf of *G. minuta* has a lamina 3.5 cm long  $\times$  5 cm broad; a

large leaf of *G. muensteriana* is 10 cm long  $\times$  10 cm broad — larger than the largest specimens of *G. minuta*. A lobe of the lamina (measured just above a dichotomy) is typically 1—2 mm broad in *G. minuta*, 1.5—3 mm broad in *G. muensteriana*. Small leaves of the two species are less distinguishable, but *G. muensteriana* seems nearly always to possess broader segments.

Through the kindness of Dr. FLORIN I was able to examine preparations of the cuticle of *G. muensteriana* from Germany and of *G. minuta* from Sweden. I was unable to recognise any difference between the cuticles of the two species, and they appear to show the same range of variation in wavyness of the cell walls. The cell papillae are usually quite obscure in both species. The cuticles of the Greenland specimens agreed well with the Swedish ones except that they seemed to be a little less thick.

*G. minuta* is only known from rocks of the *Lepidopteris* Zone, *G. muensteriana* in Europe is only known from the *Thaumatopteris* Zone but it has been determined in other parts of the world in beds which may be of rather different age (OISHI 1932a).

Several other species (at present included in *Baiera*, but which I would place in *Ginkgoites*) are rather like *G. minuta* but they all seem to differ in being less richly branched. Among these leaves may be mentioned:— *B. concinna* HEER (see for example KAWASAKI 1926), *B. gracilis* (see SEWARD 1900), *B. elegans* and *B. guilhaumati* (see OISHI 1932a) and *B. asadai* (see YABE and OISHI 1928). I have examined Dr. HAMSHAW THOMAS's preparations of the cuticles of a number of leaves of the *B. gracilis* type from Yorkshire, none of which show the sinuous cell-outlines characteristic of *G. muensteriana* and *G. minuta*.

The leaves described by YABE and OISHI (1933) and by YABE (1933) as *Baiera* cf. *gracilis*; *Baiera manchurica*, *Baiera kidoi* and *Baiera minima* all agree closely with *G. minuta* in general form, but are all distinguished by their cuticles, which usually show quite definite papillae on the upper surface and always have conspicuous hollow ones on the lower surface. *G. minuta* seldom shows more than the faintest indication of a papilla on either surface, and such papillae are solid.

### ***Ginkgoites hermelini* (HARTZ) N. comb.**

Pl. 1, figs. 8, 10; Pl. 2, figs. 5, 6; Text-fig. 6, 7, 8.

- 1896. *Ginkgo* (*Baiera*?) *Hermelini* HARTZ, p. 240; Pl. 19, fig. 1.
- ?1919. *Baiera taeniata* ANTEVS (non BRAUN), p. 44, Pl. 5, fig. 20—24; Pl. 6, fig. 43.
- 1922. *Baiera* cf. *longifolia* (non POMEL) JOHANSSON, p. 45; Pl. 3, figs. 7—11; Pl. 8, figs. 3, 4.
- ?1922. *Ginkgo* sp. JOHANSSON, p. 44; Pl. 3, fig. 6; Pl. 8, fig. 5.
- ?1922. *Ginkgo* cf. *sibirica* JOHANSSON, p. 43, Pl. 3, fig. 5; Pl. 8, figs. 7—9 (?non Pl. 6, fig. 26).

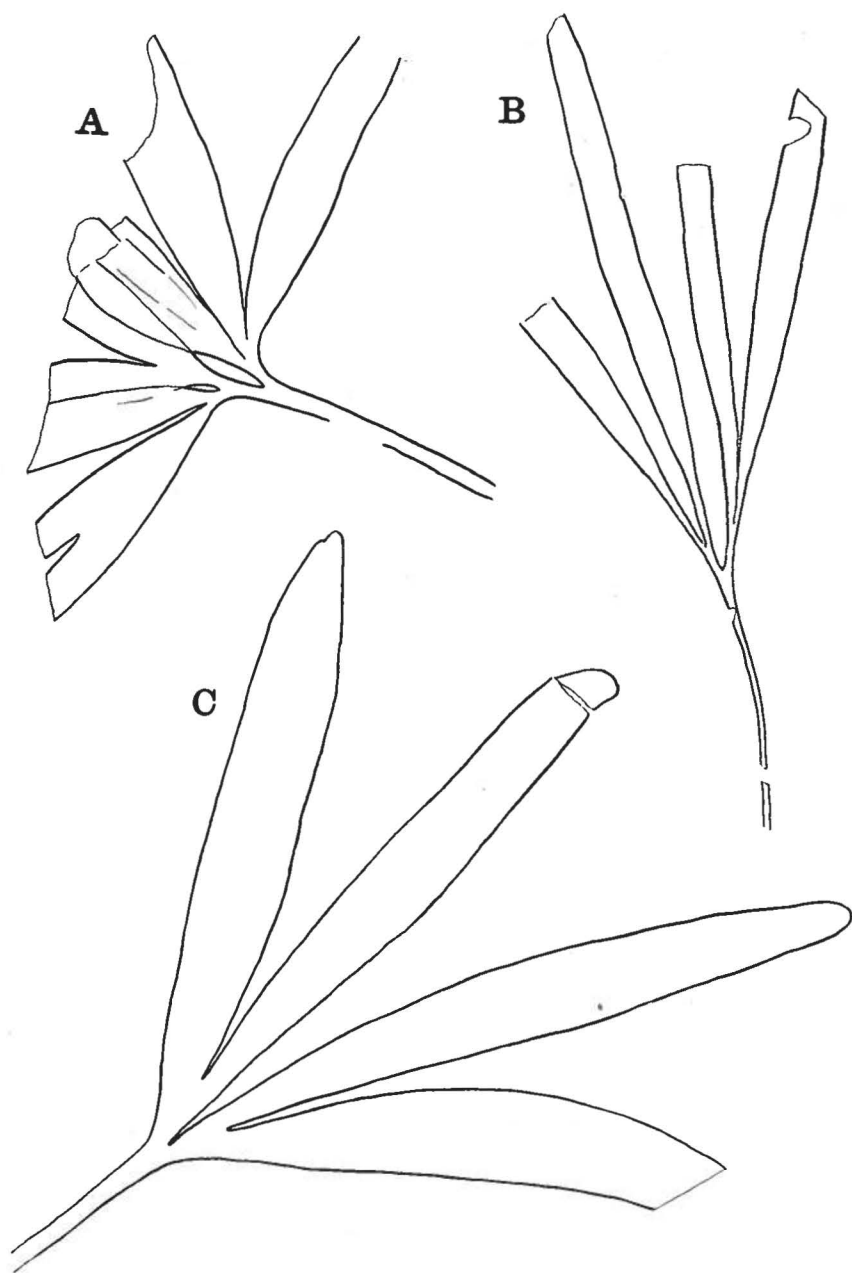


Fig. 6. *Ginkgoites hermelini*.

A, No. 2513,  $\times 1$ . B, No. 2542,  $\times 1$ . C, No. 2554,  $\times 1$ . A, was obtained from Storgaard R., B, from C. Stewart, *Todites* Bed, C, from Vardekloft, Liverwort Bed.

- ?1922. *Baiera* sp. JOHANSSON, p. 49; Pl. 3, fig. 12.  
 1924. *Ginkgo Hermelini* HARTZ, CHOW, p. 8, Pl. 1, figs. 13—15.  
 1924. *Ginkgo* or *Baiera* sp. CHOW, p. 9; Pl. 1, fig. 20; Pl. 2, fig. 7.  
 ?1924. *Baiera taeniata* CHOW (non BRAUN), p. 9; Pl. 1, figs. 16—18.  
 Non. *Ginkgo* cf. *Hermelini* SZE. 1931, p. 55; Pl. 8, fig. 3—4, and SZE. 1933(b), p. 28; Pl. 7, figs. 5, 6.

*Occurrence in Greenland.*

Lejr R., *Ginkgoites* Bed.  
 Ammonite Mountain, *Baiera* Bed.  
 Astarte R., *Thaumatopteris brauniana* Bed.  
 Vardekløft, Liverwort Bed.  
 Dinosaur R., *G. hermelini* Bed (just below *Marattiopsis* Bed).  
 Neill Cl., *Nilssonia undulata* Bed; Liverwort Bed.  
 Storgaard R.  
 C. Stewart, *Todites* Bed.

All of these beds belong to the upper half of the *Thaumatopteris* Zone. HARTZ's specimen was collected in Storgaard R.

*Description of the Greenland specimens.* This species proves to vary a good deal in form; the chief types found are figured. The commonest type of leaf is one with six rather narrow lobes. A nearly constant feature of all medium-sized or large leaves is that the leaf-lobes taper slightly near the apex and the apex itself is rounded, but in small leaves the apex is less constant. Veins occur in the lamina at intervals of 1.0—1.3 mm. Resin is absent in the majority of leaves from most localities, but in leaves from some localities (Astarte R.) it occurs in numerous round flecks between the veins. The "mesophyll structure" is characteristic and apparently does not vary, but is not always preserved. It consists of granules forming bars placed transversely to the veins.

The cuticle is of medium thickness. The upper (the thicker) usually has very few stomata, but in some leaves it has nearly as many as the lower. It shows nearly isodiametric cells between the veins, rather elongated ones over the veins; the cells have straight or nearly straight sides. In some leaves the cells have rather indistinct papillae, in others they have none. The lower cuticle shows isodiametric straight-walled cells between the veins, narrow ones along the veins. Most cells have no papillae, but occasional cells between the veins possess rather prominent, hollow papillae. In some specimens the cell-outlines are very faintly shown, particularly near a stoma, but usually they are clearly marked. The stomata occur between the veins, they are surrounded by 4—6 subsidiary cells each bearing a papilla which is often hollow. The papillae are very often situated near the middle of the subsidiary cells and point upwards and so do not project at all over the aperture, but in other leaves they point inwards and entirely conceal the guard cells.

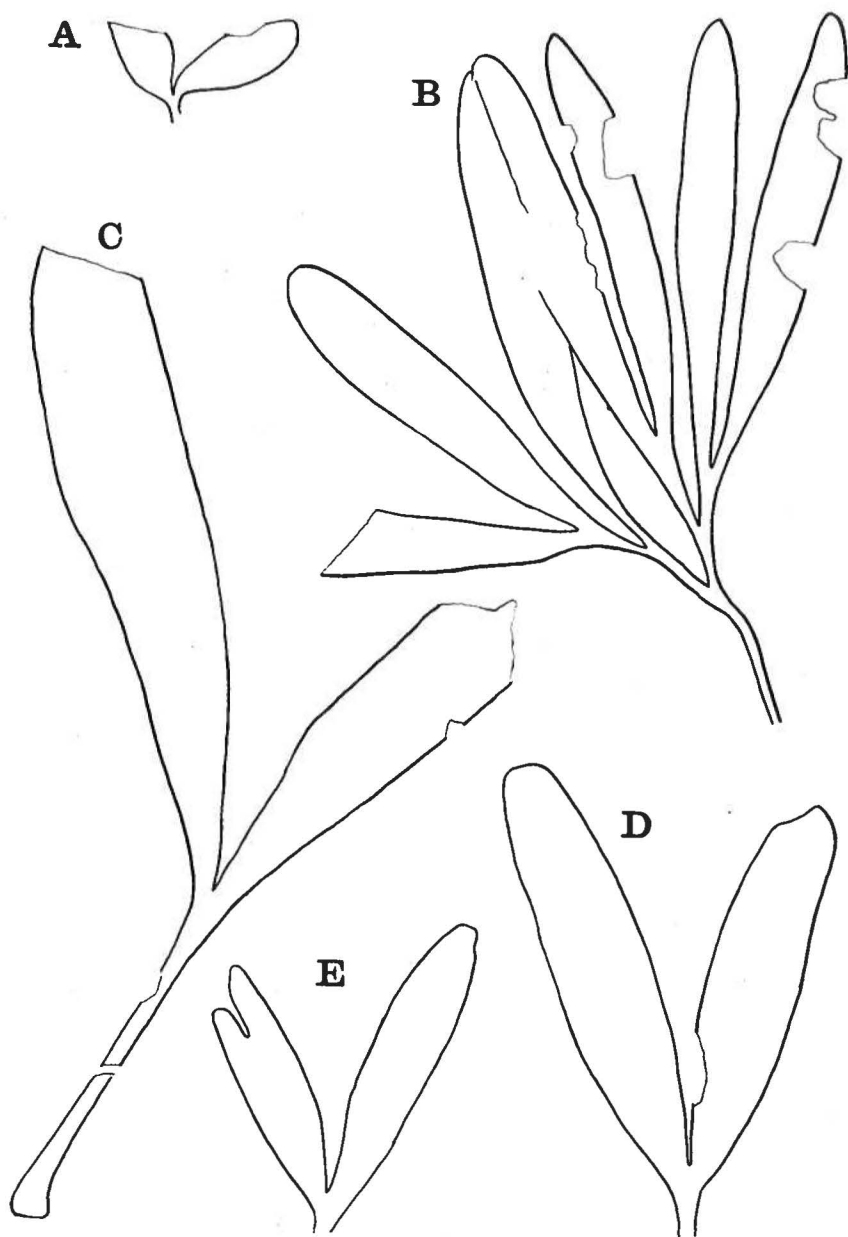


Fig. 7. *Ginkgoites hermelini*. Leaves, natural size.  
A, No. 2577; B, No. 2541; C, No. 2552; D, No. 2557; E, No. 2551. — A, was obtained from Ammonite Mountain, *Baiera* Bed, B, from C. Stewart *Todites* Bd, C—E, from Vardekloft, Liverwort Bed.

The guard cells are sunken and seldom seen distinctly; they are very thinly cutinised except for a narrow, slightly thickened strip along the aperture. The aperture has no constant orientation, its length is about  $13\ \mu$ .

*Discussion.* HARTZ's original specimen was poorly preserved, but I found some better specimens in the same bed which agree with it in form. As no other *Ginkgoites* leaf occurs here, the identity of the specimens

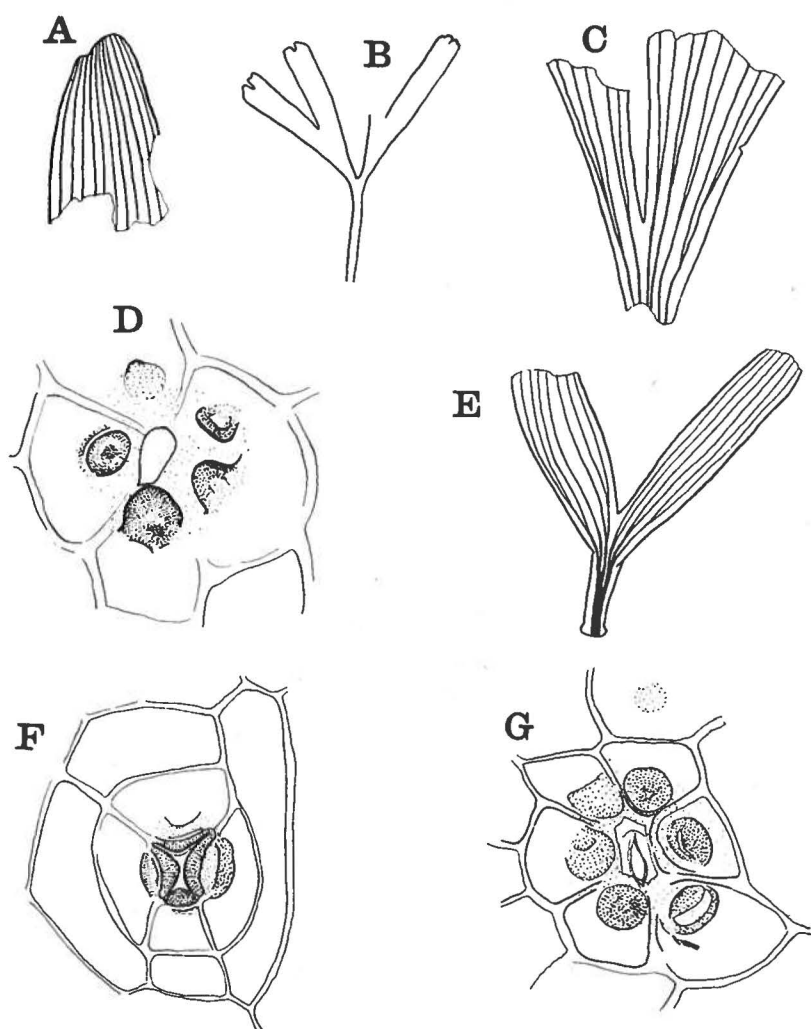


Fig. 8. *Ginkgoites hermelini*.

A, apex of lobe, Slide 2324,  $\times 2$ . B, abnormal leaf, No. 2524,  $\times 1$ . C, venation of part of lamina, Slide 2324,  $\times 2$ . D, stoma, Slide 1991,  $\times 400$ . E, venation of very small leaf, Slide 2325,  $\times 2$ . F, G, stomata, Slide 2521,  $\times 400$ . — The specimens shown in A, C, E, F, G were obtained from Vardekloft, that in B from Ammonite Mountain, that in D from Lejr R.

seems certain. Quite a large number of good specimens were also found in other places which are sufficient to indicate the range of variation of this species. The various types of leaf were identified because of their association with one another and agreement in cuticle—the cuticle of every specimen was examined. The considerable range of variation met in this species and in *G. taeniata* makes their separation rather difficult (see p. 23), particularly when small or imperfect leaves alone are available. I have nevertheless tentatively referred a number of Swedish specimens which had been determined as *G. taeniata* or as other species, to this species. This has only been possible through the kindness of Dr. FLORIN, who lent me slides of the cuticles of the Swedish specimens.

CHOW's (1924) specimens of "*B. taeniata*" as regards their form could belong to either species; his *Ginkgo* sp. (Pl. 2, fig. 7) is typical *G. hermelini*. The cuticles of these specimens agree very well with Greenland *G. hermelini* but differ slightly from Greenland *G. taeniata* in the large papillae round the stomata.

JOHANSSON's (1922) specimens determined as *B. cf. longifolia*, *G. cf. sibirica*, *G. sp.* and *B. taeniata* may all, as regards their form, belong to *G. hermelini*. Of these his *B. cf. longifolia* agrees perfectly with slender leaves of *G. hermelini*; his *B. taeniata* is certainly not typical of *G. hermelini*, but nor is it of *G. taeniata*, having leaf lobes with round apices. Of the cuticle preparations; his "*B. cf. longifolia*" seems typical of *G. hermelini*, the others agree fairly well with it, but the character of their stomata may be somewhat intermediate between it and *G. taeniata*. I conclude that *G. hermelini* is certainly represented from Stabbarp ("*B. cf. longifolia*") and it is likely that some at least of the specimens described as *B. sp.*, *G. sp.*, *B. taeniata*, *G. cf. sibirica* associated with them belong to the same species, most of which agree in having veins (as shown by Dr. FLORIN's cuticle preparations) about 1 mm apart. One specimen (FLORIN's Slide No. 205), however, has veins only about 0.5 mm apart and this may well be a distinct species. I offer no opinion about the identity of the solitary leaf of "*G. cf. sibirica*" from Skromberga.

The leaves described by YABE and OISHI (1933) and by OISHI (1933) as *Ginkgoites* cf. *sibirica* (which they identify with JOHANSSON's *G. sibirica*) are rather like small leaves of *G. hermelini* in their general form and in the appearance of their cuticles. They differ, however, from both the Swedish and the Greenland specimens in the details of their cuticles, which have less conspicuous stomata (owing to the slighter thickening of the subsidiary cells), but more conspicuous guard-cells. They also differ from all the Greenland specimens and from some of the Swedish ones in having twice as crowded veins. These differences (most of which



are not, however, definitely shown in JOHANSSON's figures) seem important enough to preclude the identification of the Swedish or Greenland specimens with those from Manchuria.

SZE's (1931, 1933(b)) specimens determined as *Ginkgo* cf. *hermelini* resemble the Greenland ones in the rounded apices of the leaf lobes, but differ in possessing more crowded veins, and on this account I consider them distinct.

### ***Ginkgoites taeniata* (BRAUN) N. comb.**

Pl. 1, figs. 1, 2, 9; Pl. 2, figs. 3, 4; Text-figs. 9, 10, 11.

1843. *Baiera taeniata* F. BRAUN, p. 21.

1867. *Baiera taeniata* BRAUN, SCHENK, p. 26; Pl. 5, figs. 1—4; Pl. 6, figs. 1, 2.

?1876. *Baiera taeniata* BRAUN, NATHORST, p. 68; Pl. 13, fig. 17.

?1878(b). *Baiera Geinitzi* NATHORST, p. 26; Pl. 13, fig. 17.

1914. *Baiera taeniata* BRAUN, GOTHAN, p. 150; Pl. 29, fig. 2; Pl. 31, 32, fig. 1.

cf. 1932a. *Baiera taeniata* BRAUN, OISHI, p. 350; Pl. 50, fig. 5.

?Non. *Baiera taeniata* of ANTEVS (1919), JOHANSSON (1922), CHOW (1924) — see p. 18 and p. 24.

#### *Occurrence in Greenland.*

Astarte R., *Thaumatopteris brauniana* Bed.

Dinosaur R., *Marattiopsis* Bed.

C. Stewart, *A. hartzi* Bed.

These beds belong to the middle and lower part of the *Thaumatopteris* Zone.

*Description of the Greenland specimens.* I found about a hundred leaves of this species. They vary a good deal in size and form, the commonest type is that illustrated in Text-fig. 9 H, I, but some of the other types illustrated are frequent. All normal sized leaves have a rather slender petiole and leaf lobes with irregularly notched apices, but the smallest ones have a short, wide petiole and a nearly entire lamina. In normal leaves the veins run at intervals of 1 mm and there are usually four in each lobe. The mesophyll substance sometimes shows a regular granular structure, but never forms transverse bars as in *G. hermelini*. Resin is often present: its occurrence is discussed below.

The cuticle is fairly thick; it is rather thicker on the upper side. The upper cuticle shows slightly elongated or isodiametric straight-sided cells, sometimes with an obscure median papilla. The cells along the veins are slightly more elongated. Stomata are very rare indeed. The lower cuticle shows isodiametric cells between veins, elongated ones along them. The cell-outlines are nearly straight, but sometimes show very slight zigzag thickenings. Faint median papillae are visible in certain specimens, but they are usually absent. The stomata are confined to the strips between veins; the guard cells are sunken and

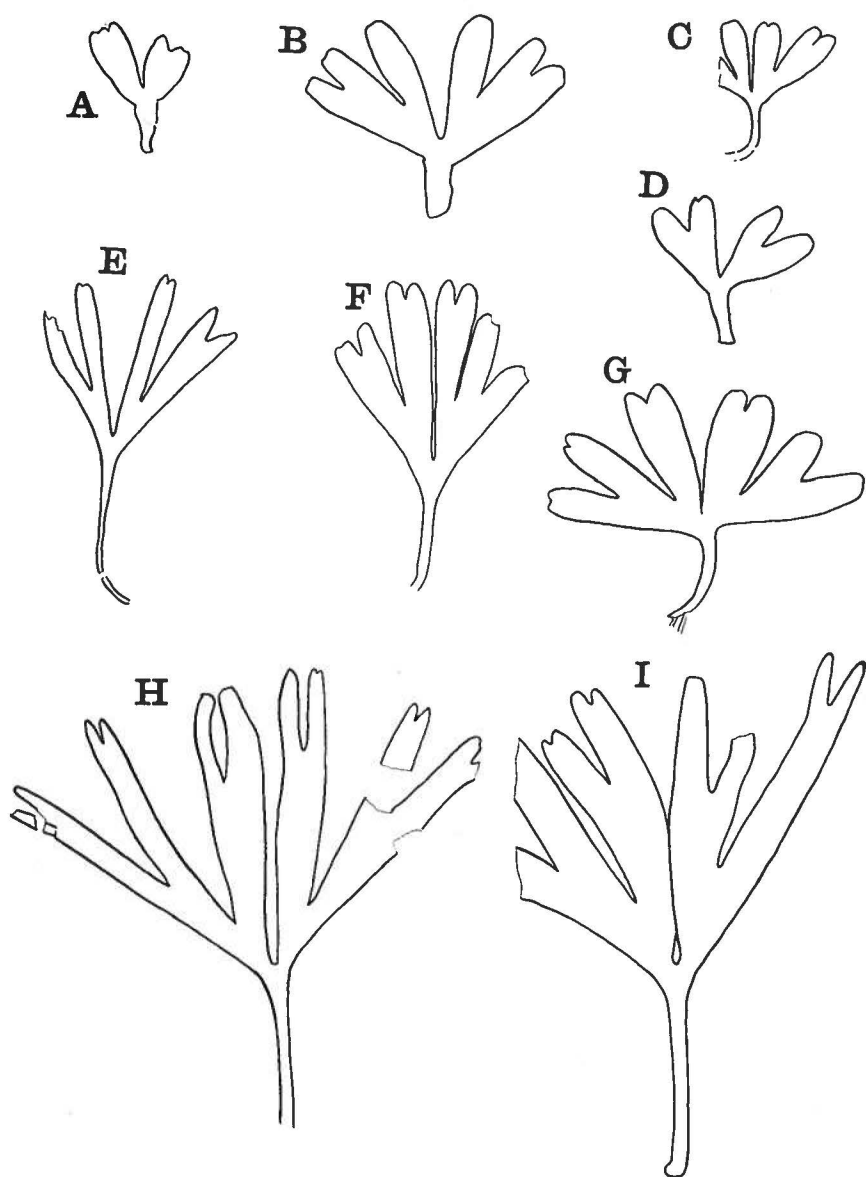


Fig. 9. *Ginkgoites taeniata*.

A, No. 2609; B, No. 2603; C, No. 2613; D, No. 2603; E, No. 2605; F, No. 2631; G, No. 2604; H, No. 2604; I, No. 2614. — The specimen shown in F was obtained from Dinosaur R., the rest from C. Stewart.

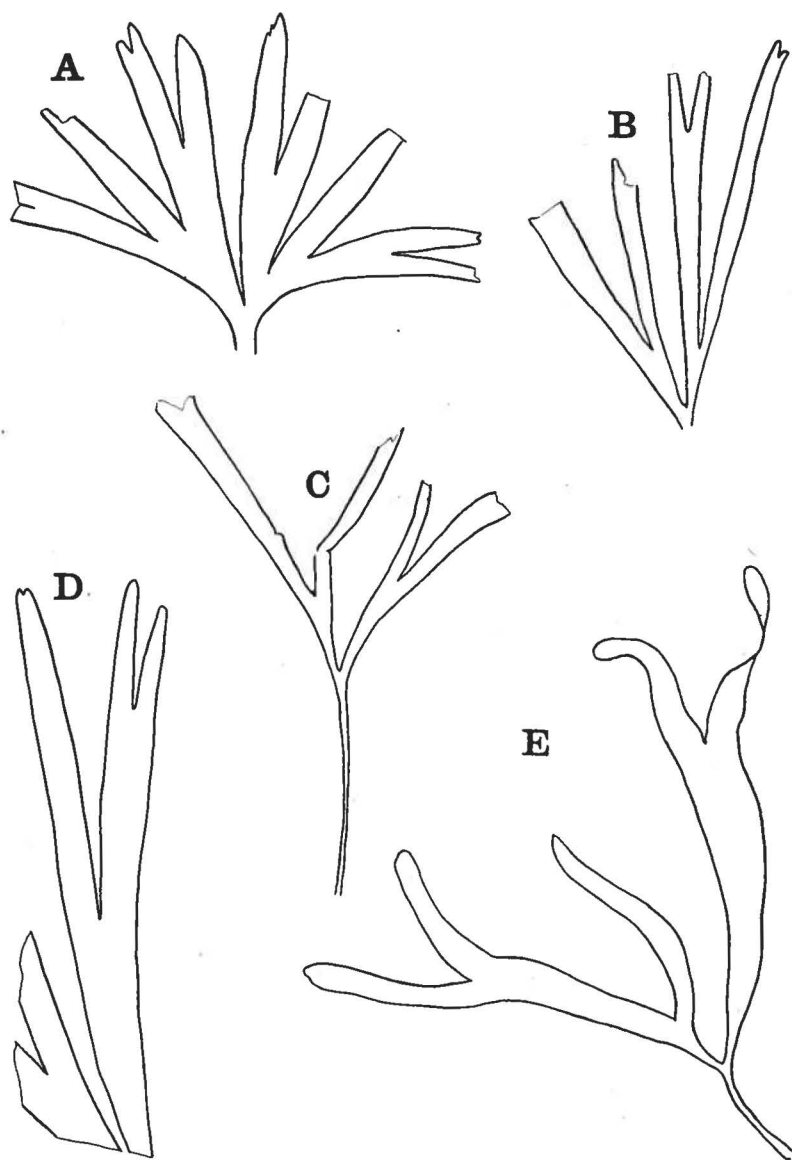


Fig. 10. *Ginkgoites taeniata*.

A, No. 2621; B, No. 2612; C, No. 2610; D, No. 2606; E, Nos. 2607, 2608. — The specimen shown in A was obtained from Astarte R., the rest from C. Stewart.

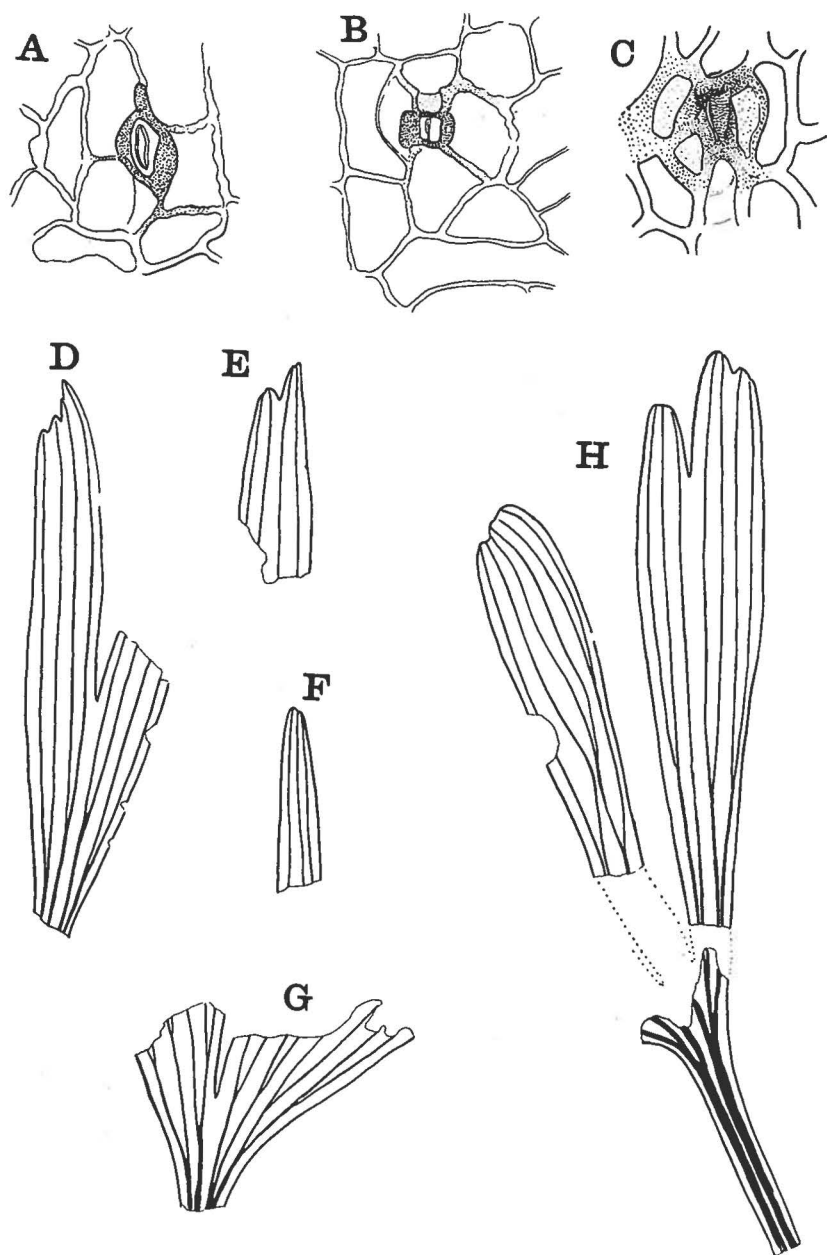


Fig. 11. *Ginkgoites taeniata*.

A—C, stomata; C, is rather unusual, Slide 2558,  $\times 400$ . D—H, fragments of leaves showing veins; all  $\times 2$ . D, Slide 2571. E, F, G, Slide 2557. H, Slide 2554. — The specimen shown in D was obtained from Astarte R., the rest from C. Stewart.

surrounded by about five scarcely specialised subsidiary cells. The subsidiary cells never possess definite papillae (as in *G. hermelini*) but the cuticle on the inner margin often projects as a rim (Text-fig. 11 A, B) and occasionally is lobed so as to form a rudimentary papilla, but this is exceptional (Text-fig. 11 C). The guard cells are only a little less thickly cutinised than the general epidermal cells, the stomatal aperture is 10—15  $\mu$  long.

*Discussion.* The various types of leaf were identified specifically because they agree in cuticle, because they are associated with one another and because they form an intergrading series. There is, however, an important difference in the occurrence of resin in the leaf in different localities.

Resin occurs as round or fusiform bodies in many leaves, but in others resin bodies are rare or absent. The resin bodies seem to be very persistent even in poorly preserved leaves, and when they occur at all they are quite conspicuous by transmitted light. The apparent rarity of resin in certain leaves is therefore probably an original feature and is not due to some peculiarity in preservation (see Pl. 1, fig. 1, 2). The majority of leaves were found to fall into two classes in respect of their resin content — those with at least one resin body per sq.mm, and those with only one in 20 sq.mm or more. Only a few leaves were intermediate.

Of 70 leaves from C. Stewart, 46 had much resin, 19 little and 5 none — that is 34 per cent. have little or none.

Of twenty-one leaves from Dinosaur R., one had much resin, four little and sixteen none — that is 95 per cent. have little or none.

Although the number of leaves investigated is not very large, it is sufficient to show that there is a real difference between the leaves of the two localities. Too few leaves were obtained from Astarte R., *T. brauniana* Bed for comparison.

In the absence of any other recognisable difference it is impossible to regard this difference in relative proportions as of specific value. A possible explanation of the difference is that *G. taeniata* includes two or more races (cf. biotypes) differing in the amount of resin in their leaves, and that the relative proportions of these races differs in different localities (cf. ecotypes), or at different times (the bed at C. Stewart is probably a little older). I know of no other evidence for the existence of this sort of variation in fossil plants, but it should be of common occurrence since it seems to be general in recent plants.

*Comparison.* The three Greenland species, *G. taeniata*, *G. hermelini* and *G. acosmia* are very like one another, and it is only fairly well developed leaves of each which can be distinguished with certainty.

*G. acosmia* and *G. taeniata* have very similar cuticles and similar mesophyll structure, but they differ in the relative width of the segments

of the leaf, those of *G. acosmia* being much broader and usually shorter. In *G. taeniata* the lower margins of the basal lobes of the lamina usually makes an angle of about  $130^{\circ}$  or more with one another; in *G. acosmia* it is  $90^{\circ}$  or less.

*G. hermelini* has a slightly different cuticle; occasional cells on the lower surface bear rather conspicuous papillae and the subsidiary cells nearly always bear well-marked papillae, while in *G. taeniata* they only bear a slight irregular rim of cuticle at the margins of the stomatal pit. Its mesophyll structure is distinct, and the lobes of the lamina are characteristic, tapering slightly towards the apex and having a rounded apical margin. In nearly every specimen of *G. taeniata* the apex is irregularly notched.

Our knowledge of the original specimens of *G. taeniata* is unsatisfactory, but if the details in SCHENK's figures can be relied on, they agree both in form and in cuticle with typical Greenland specimens.

As has been pointed out previously (p. 18 under *G. hermelini*) the Swedish leaves determined as *G. taeniata* are rather different and seem to me more like *G. hermelini*. Very few of the Swedish specimens show undamaged apices of the lobes except one figured by JOHANSSON (1922) in which they are rounded as in *G. hermelini*. Through the kindness of Dr. FLORIN I have been able to examine the cuticles of various Swedish leaves determined as *G. taeniata*. All of these show the conspicuous papillae round the stoma typical of *G. hermelini*, except one specimen from Hör which has some stomata without papillae, as in *G. taeniata*, but others have well developed papillae, such as I have never seen in Greenland *G. taeniata*. The "mesophyll structure" of the Swedish specimens has not been described.

The leaf from Pålshö described by NATHORST (1876) as *B. taeniata* and in 1878 as *B. geinitzi* agrees very well with a small leaf of *G. taeniata* in its form and as far as can be made out, the cuticle which is indifferently preserved, agrees also. Papillae are very feebly developed on the subsidiary cells.

The Japanese specimens described by OISHI (1932a, see above) agree fairly well with the Greenland ones except that the apices of the lobes are rounded as in *G. hermelini*. The apices of the lobes are poorly preserved in the specimens figured by GOTHAN (1914). The cuticles of these specimens have not been described.

There are a good other many Ginkgoalean leaves which more or less resemble *G. taeniata*, among which may be mentioned forms of *G. digitata* and *G. sibirica* figured by various authors, *B. bidens*, *B. ginkgoides* and *B. ipsviciensis* (WALKOM 1917, 1924), *B. phillipsi* and *B. gracilis* SEWARD 1900, KAWASAKI 1926, and various *Ginkgoites* leaves figured by HEER 1876, 1878, 1880.

Genus **BAIERA** BRAUN.1843. *Baiera* BRAUN, p. 20.

This genus is discussed on p. 47.

***Baiera spectabilis* NATH.**

Text-figs. 12, 13; Pl. 3, figs. 7, 8.

1906. *Baiera spectabilis* NATHORST, p. 4; Pl. 1, figs. 1—8; Pl. 2, fig. 1; Text-figs. 1—8.1908b. *Baiera spectabilis* NATHORST, p. 5; Pl. 1, figs. 1, 2.1922. *Baiera spectabilis* NATH., JOHANSSON, p. 45; Pl. 8, figs. 1, 2.1926b. *Baiera spectabilis* NATH., HARRIS, p. 99; Text-fig. 23 A—D.

The following may also belong to this species:—

1903. *Baiera pulchella*, MÖLLER, p. 26; Pl. 4, fig. 19.1903. *Baiera czekanowskiana* MÖLLER, p. 27; Pl. 5, fig. 3.1919. *Baiera* cf. *spectabilis* ANTEVS, p. 47; Pl. 5, fig. 27.1924. *Baiera* cf. *spectabilis* CHOW, p. 11; Pl. 1, fig. 19.*Occurrence in Greenland.*Ammonite Mountain, *Baiera* Bed.

Musk-Ox R., Plant Bed.

Astarte R., Bed F., *B. spectabilis* Bed.Vardekløft, *P. agardhianus* Bed; *Czekanowskia* Bed.Dinosaur R., *N. carcinoides* Bed.

Neill Cl., Liverwort Bed.

Storgaard R., Plant Bed.

C. Stewart, *Todites* Bed.C. Hope, *Czekanowskia* Bed.

All of these beds belong to the upper half of the *Thaumatopteris* Zone.

The specimens collected by HARTZ and described by me were obtained from Vardekløft.

*Description of the Greenland specimens.* A great many specimens of this leaf were examined; leaves selected as being respectively the largest, the smallest, the most divided and the least divided are represented in Text-figs. 12, 13, and give an idea of the range in form. Perhaps the commonest type of leaf is one 13 cm long having six deeply notched lobes.

The various types of leaf are all found associated and agree in structure and there is every reason to believe them specifically identical. They agree exactly with the Swedish specimens with which they are identified. The cuticle and venation of some Greenland specimens have been already described (HARRIS 1926b).

*Comparison.* Large, coarsely divided leaves of *B. spectabilis* are distinguishable from all other species, but the smaller and more finely

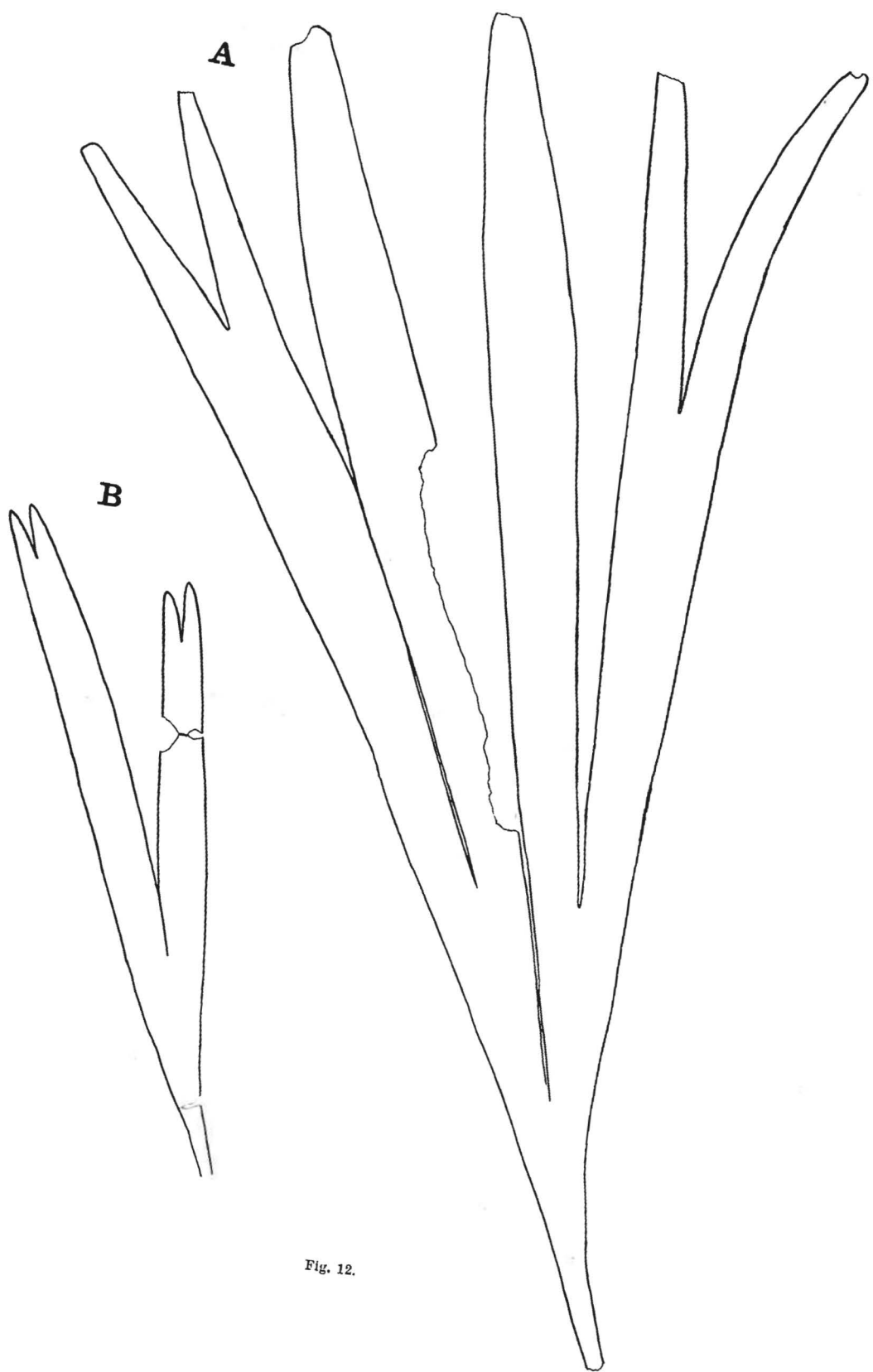


Fig. 12.



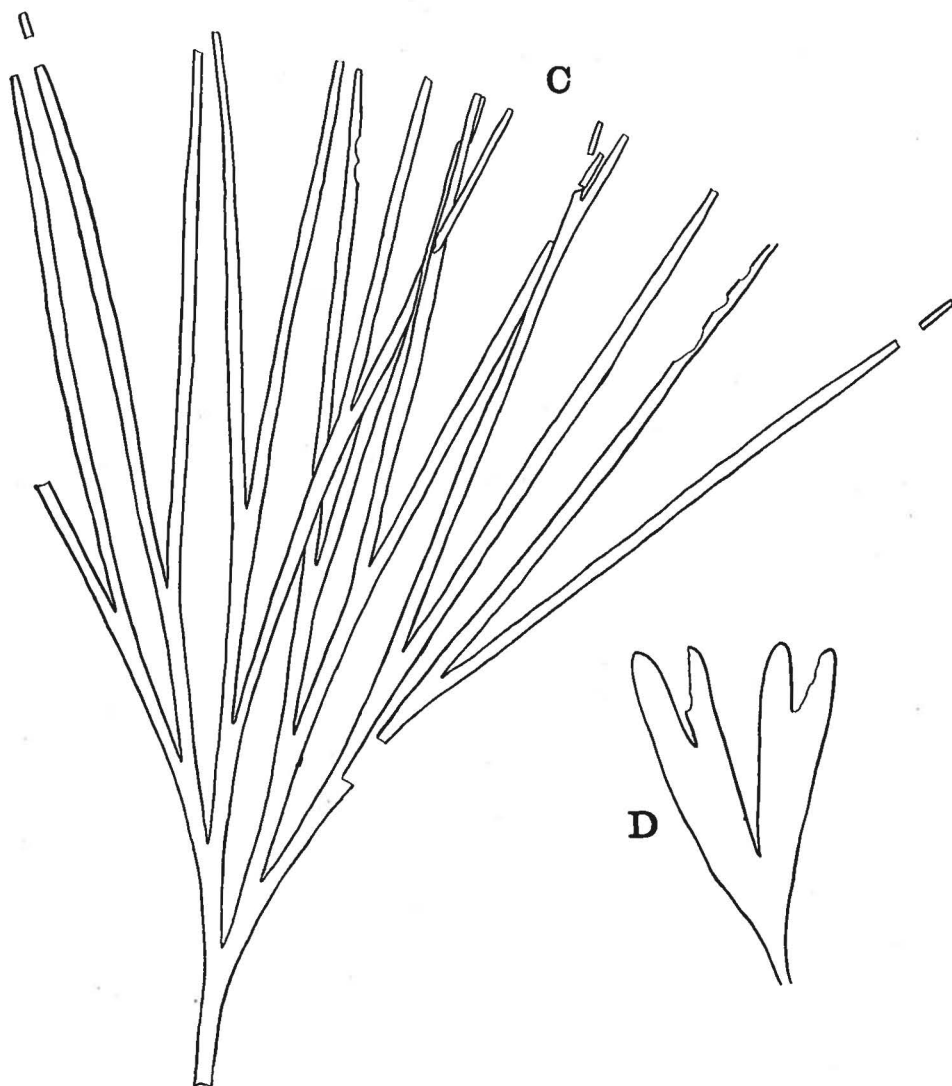


Fig. 13.

Figs. 12, 13. *Baiera spectabilis*.

A, full-sized leaf, No. 2675,  $\times 1$ . B, little divided leaf, No. 2651,  $\times 1$ . C, much divided leaf, No. 2672,  $\times 1$ . D, smallest leaf found, No. 2653,  $\times 1$ . — The specimens shown in A, C, were obtained from Vardekløft, *Czekanowskia* Bed, those in B, D, from Astarte R., *B. spectabilis* Bed.

divided ones scarcely differ in form from many leaves described as *B. longifolia* — see, for example THOMAS 1913b, Pl. 25, figs. 3, 4; KAWASAKI (1926). The cuticle is, however, distinct from that of the Yorkshire specimens at least — the stomatal group is elongated in *spectabilis*, round in *longifolia* and the veins are better marked on the upper side in *spectabilis*.

*B. multifida* FONTAINE (1883) resembles the finely divided forms of *B. spectabilis* but has even larger leaves.

***Baiera boeggildiana* sp. nov.**

Pl. 3, figs. 3, 4; Pl. 4, figs. 2, 6, 8; Text-fig. 14.

Type-specimen, Pl. 4, figs. 2, 8.

*Occurrence.* Astarte R., *Lepidopteris* Bed.

*Diagnosis.* Leaves borne on a shoot 3 mm thick. Leaf scar semi-circular, 1.5 mm wide. Leaf typically 3—4 cm long, 0.6—1.2 cm wide, base tapering, apex typically divided into two rounded lobes. No distinct petiole present, margins of leaf thickened in lower part and meeting on the upper surface of the leaf just above its base. No "interstitial vein" present, but round resin bodies occurring between the veins in some, but not in other specimens.

Cuticle fairly thick; upper thicker than the under, possessing few or no stomata, showing isodiametric or transversely elongated cells, cell-outlines prominent, straight but with fine jagged thickenings, no definite median papilla present. Cells along the veins not modified.

Lower cuticle with numerous stomata in the strips between the veins but only occasional stomata along the veins. Cells isodiametric, cell-outlines conspicuous, showing slight jagged thickenings (smaller than those on upper surface). Most cells in some specimens possessing a conspicuous median papilla, in others the papillae are rather small and confined to certain cells. Majority of stomata orientated longitudinally, surrounded by a ring of subsidiary cells, polar subsidiary cells usually not specialised, lateral ones slightly thickened all over and strongly thickened near the stoma. Lateral subsidiary cells usually bearing papillae projecting over the stomatal aperture. Guard cells situated at the bottom of an oval pit, surface thinly cutinised, aperture  $13\mu$  long. Surface of the subsidiary cells usually showing a thin strip, possibly representing the base of the papilla. Unspecialised encircling cells often found opposite the lateral subsidiary cells.

In some specimens occasional cells along veins have a bulging surface forming a very short hair.

*Discussion and comparison.* *B. boeggildiana* is represented by the Type-specimen consisting of a stem bearing several leaves, and by three specimens of isolated leaves.

It is a species of considerable interest because its leaves are intermediate in form between several of the Ginkgoalean leaf-genera — particularly *Ginkgoidium*, *Baiera* and *Eretmophyllum*. It seems to me most convenient to place it in *Baiera* because it agrees with typical species of *Baiera* (e.g. *B. spectabilis*) in everything but its nearly entire lamina — a difference which I consider of only specific value. It agrees

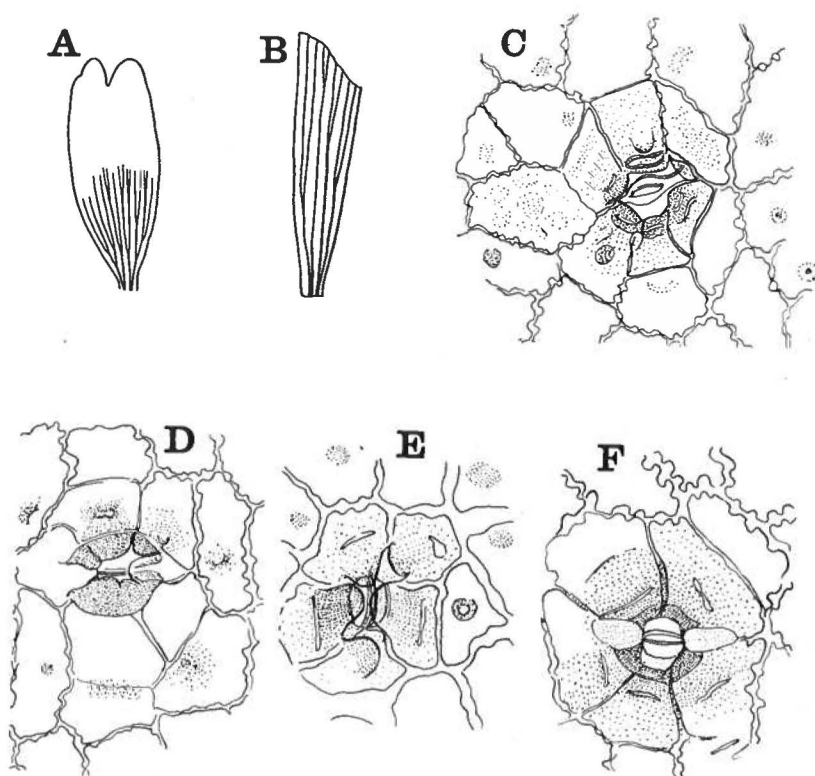


Fig. 14. *Baiera boeggildiana*.

A, leaf, No. 2702,  $\times 1$ . B, leaf, Slide 2381,  $\times 2$ . C—F, stomata,  $\times 400$ . E is drawn from Slide 2581; C, D, F from Slide 2583; F is a stoma of the upper surface, the rest of the lower surface.

exactly in form with the smaller leaves of *Ginkgoidium nathorsti* (YOKOYAMA 1889, THOMAS 1911) but differs in venation; it seems to agree with *Eretmophyllum* (THOMAS 1913, EDWARDS 1929) in venation but differs in its more distinctly notched tip. If placed in either of these genera, *B. boeggildiana* would remove the clear distinction between that genus and *Baiera*.

The cuticle of *Ginkgoidium* has not been described. The two Yorkshire species of *Eretmophyllum* have both quite thick cuticles; that of

*E. pubescens* shows much more obvious epidermal papillae than *B. boegildiana*; that of *E. whitbiense* is distinguishable by its smooth instead of jagged cell walls on the upper side.

This species is named after Professor BØGGILD.

***Baiera leptophylla* sp. nov.**

Pl. 5, figs. 6, 7; Text-fig. 15.

1926b. "*Baiera* sp. A" HARRIS, p. 103; Text-fig. 25 A—D.

*Occurrence.*

Zamites R.

Astarte R., *Lepidopteris* Bed, Bed A?, Bed C (fragment of cuticle).

Neill Cl., *N. hoerensis* Bed.

C. Stewart, *A. minor* Bed.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Leaves borne in bundles of about five. Leaf typically 10 cm long; about 1 mm wide near base, 2 or 3 mm wide at widest point near middle; branches 1 mm wide or less. Leaf usually forked twice, but some specimens probably more and others less branched than this. Veins rather variable; sometimes dividing at a considerable distance below a fork of the lamina (when two or four veins occur in most parts of the leaf); in other specimens dividing just below a fork of the lamina (when one or two at most occur in the leaf). Upper part of leaf variable, terminal branches often slender and acute and with only one vein, sometimes broader and bicuspid and with two veins, occasionally 2 mm broad and with four veins. Veins only conspicuous by transmitted light. Resin bodies present in lamina. Substance of leaf rather thin, mesophyll structure not characteristic.

Cuticle of medium thickness. One side slightly thicker and often with fewer stomata, but the two sides otherwise rather similar. Epidermal cells elongated over veins, shorter and often isodiametric between them, cell walls straight with or without exceedingly fine jagged thickenings. Middle of cells (particularly those between the veins) thickened to form a fairly large but rather indefinite papilla. Stomata most numerous between veins, occurring for the most part in short longitudinal rows of about six. Subsidiary cells little specialised, except that their papillae are usually strongly developed and often project over the guard cells but occasionally with feebly developed papillae forming a mere rim round the stoma, or not developed at all. Papillae usually thick walled, but hollow. Guard cells usually concealed by papillae of subsidiary cells; surface quite thinly cutinised except round aperture, where it is moderately thick. Stomatal aperture about  $10\mu$  long, orientation irregular.

*Discussion.* All the best specimens of *B. leptophylla*, which is a rather uncommon species, have been figured. All the more complete

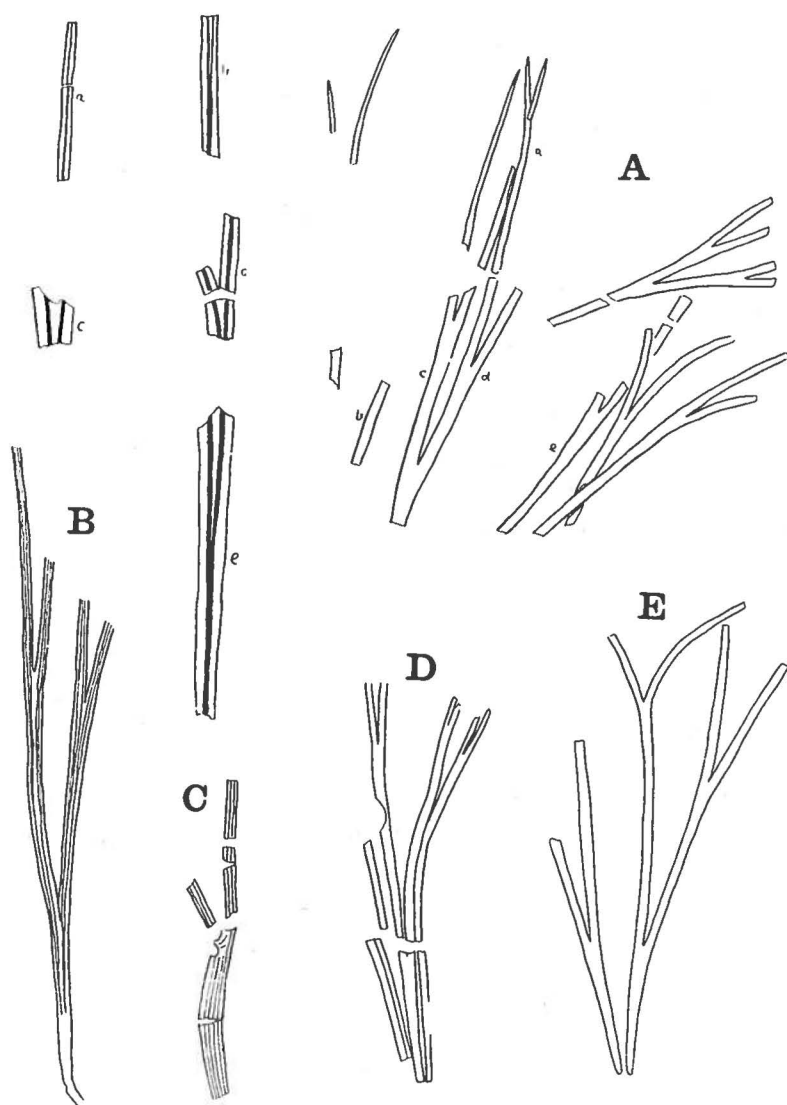


Fig. 15. *Baiera leptophylla*.

A, group of leaves, *a—e* refer to the places from which fragments were detached, No. 2732,  $\times 1$ . B, leaf, No. 2720 and Slide 2417,  $\times 1$ . C, leaf, Slide 468,  $\times 1$ . D, group of leaves, No. 2722,  $\times 1$ . E, two leaves, No. 2731,  $\times 1$ . *a—e*, fragments from 'A',  $\times 2$ , Slides 2402, 2403. — The specimens shown in A, E were obtained from Zamites R., the rest from C. Stewart. Slide 468 belongs to the collection made by HARTZ.

specimens of leaves branch twice; the evidence that the leaf may occasionally branch more or less than twice is provided by detached apices showing a single vein — which should belong to a leaf branched three times — and by apices with four veins, which should belong to a once-branched or unbranched leaf.

The various specimens were specifically identified on the characters of their cuticles, which are fairly constant, there only being a little variation in the relative length of the cells and in the development of the papillae and the jagged thickenings of the cell-walls.

*B. leptophylla* is compared with similar species on p. 37.

The specific name is from λεπτός — thin and weak.

### **Baiera amalloidea** sp. nov.

Pl. 3, figs. 5, 6; Pl. 4, fig. 1; Pl. 6, fig. 5; Text-figs. 16, 17.

Type-specimen, Text-fig. 16 A.

*Occurrence.* Astarte R. Bed C.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dwarf shoot typically 6 mm broad, 8 mm long, bearing about eight leaves. Leaf 15 cm or more long, usually forked twice. Base of leaf 1.5 mm broad; leaf gradually growing broader (4—7 mm broad just below the first dichotomy, 2.5—4 mm broad just below the second). Veins quite inconspicuous, but sometimes shown by transmitted light, dichotomising fairly freely; broad segments of lamina possessing 8 veins, the narrowest only two. Veins running at a concentration of 10 per cm in broad segments, rather more crowded in narrow segments.

Mesophyll showing no characteristic structure. Resin entirely absent.

Cuticle rather thin. Upper cuticle completely lacking stomata, composed of uniform elongated cells without median papillae and with well-marked straight walls. Veins seldom distinguishable. Lower cuticle thinner than upper, bearing numerous stomata, stomata confined to strips between veins, stomatal strips usually rather narrower than strips without stomata. Cells along veins like those of upper surface; cells along stomatal strips shorter and less thickly cutinised and with much less distinct outlines but typically with a rather conspicuous, solid, median papilla. Stomata surrounded by a more or less regular ring of subsidiary cells, subsidiary cells bearing conspicuous papillae but not otherwise specialised. Guard cells thinly cutinised, usually orientated longitudinally, aperture about  $10\mu$  long. In some specimens papillae only feebly developed on subsidiary cells and absent from surrounding epidermal cells.

*Discussion and Comparison.* Although *B. amalloidea* is abundant, and is the dominant species in part of Bed C, the shale was so rotten that I could not obtain any complete leaves.

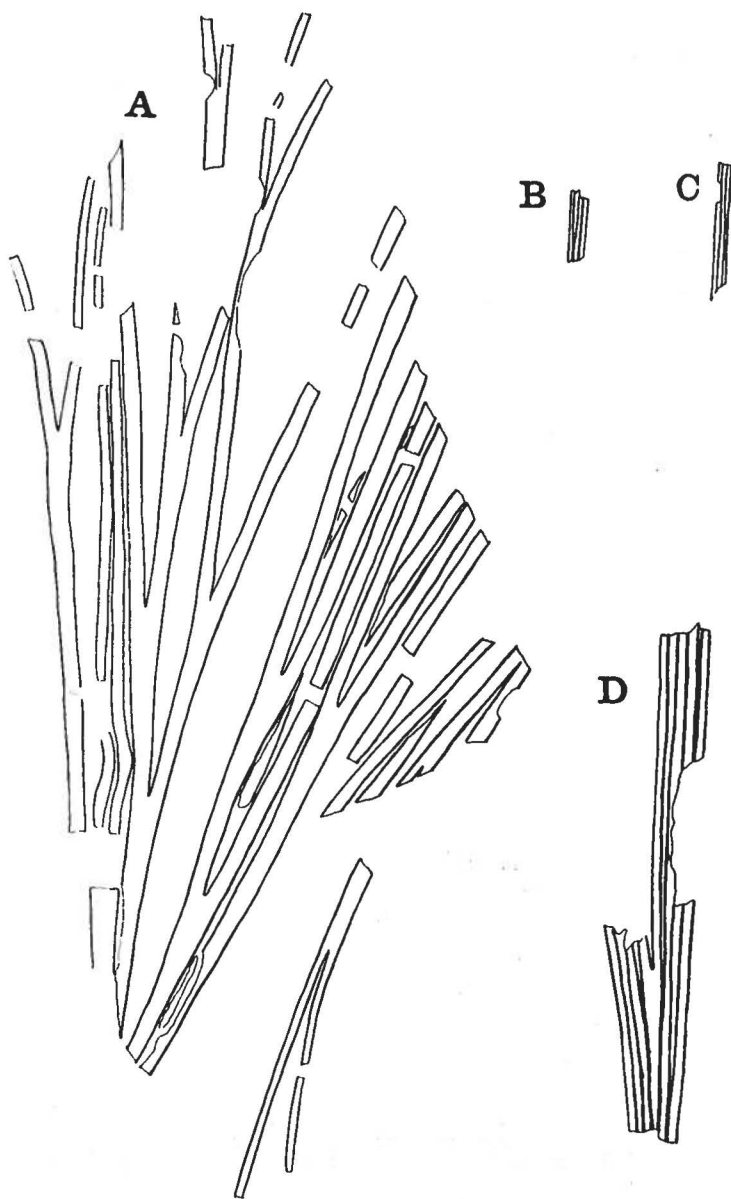


Fig. 16. *Baiera amalloidea*.

A, group of typical leaves (and part of another group to the right, Type-specimen, No. 2750,  $\times 1$ . B, C, D, fragments of leaves showing veins, Slides 2583, 2584, 2585,  $\times 2$ .

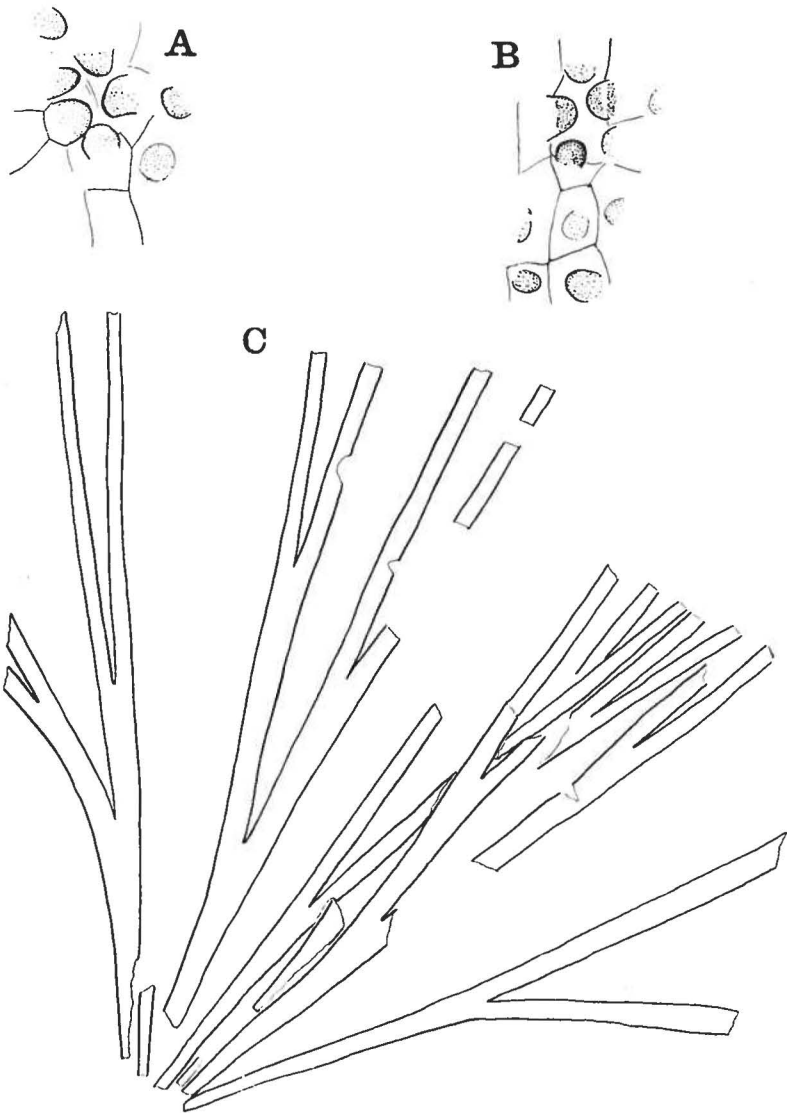


Fig. 17. *Baiera amalloidea*.

A, B, stomata, Slide 2581,  $\times 400$ . C, typical group of leaves, No. 2751,  $\times 1$ .

*B. amalloidea* resembles *B. paucipartita* (NATHORST 1886, OISHI 1932(a)) but has leaves quite twice as long which divide into narrower segments. It also resembles many leaves described under the name *B. angustiloba* by ANTEVS 1919, and other authors mentioned by him, none of which are adequately known for a full comparison. *B. cf. angu-*



*stiloba* JOHANSSON (1922) is a leaf of similar appearance with a rather similar cuticle, but is probably distinct as the subsidiary cells have no bulging papilla on their surface (see p. 37). The specific name *amalloidea* is from ἀμᾶλλα, a sheaf, and refers to the bundle of leaves.

### ***Stenopteris dinosaurens* HARRIS.<sup>1)</sup>**

Pl. 5, figs. 8, 9; Text-fig. 18.

1924. *Baiera* cf. *angustiloba* (? non HEER) CHOW, p. 10; Pl. 1, fig. 21.

?1919. *Baiera* cf. *angustiloba* (? non HEER) ANTEVS.

1932. *Stenopteris dinosaurens* HARRIS, p. 75.

#### *Occurrence in Greenland.*

Ammonite Mountain, *Baiera* Bed.

Astarte R., *Todites princeps* Bed.

Vardekløft, Liverwort Bed; *Czekanowskia* Bed.

Neill Cliff, *Nilssonina undulata* Bed; Coal Bed.

These beds belong to the *Thaumatopteris* Zone; Neill Cliff Coal Bed being transitioned between this and the *Lepidopteris* Zone.

*Description* (based on Greenland specimens). Leaf about 10 cm long, branched, up to 2.5 mm wide near the base, 1.5 mm wide in most parts, 1 mm wide near the apex. Segments of leaf in middle and upper parts possessing a single vein. Mesophyll granular, resin absent.

Cuticle thick, almost the same thickness on the two sides. Epidermal cells very similar on both sides, cell-walls straight, cuticle projecting rather strongly inwards along margins of cells. Stomata occurring in about equal numbers on two sides; almost evenly scattered, but tending to occur in short longitudinal rows. Position of vein not recognisable in cuticle. Surface of cells sometimes thickened forming a median papilla, but papillae often very feebly developed, being sometimes only just recognisable on one side of the leaf (? the lower) and absent from the other.

Stomata surrounded by five or six small subsidiary cells. Surface of subsidiary cells strongly thickened, projecting to form a very large hollow papilla, sometimes overhanging the guard cells, but often not doing so. Stomatal pit usually oval, about  $20\mu \times 16\mu$ . Aperture of the guard cells about  $20\mu$  long, most commonly orientated longitudinally. Surface of guard cells thinly cutinised except for a rather broad band flanking the aperture, which is moderately thick.

Through the kindness of Dr. FLORIN I have been able to examine the cuticles of CHOW's (1924) Swedish specimens determined as *B. cf.*

<sup>1)</sup> These specimens were thought to represent a new species of *Baiera*, but after this paper was in the press were discovered to belong to this species.

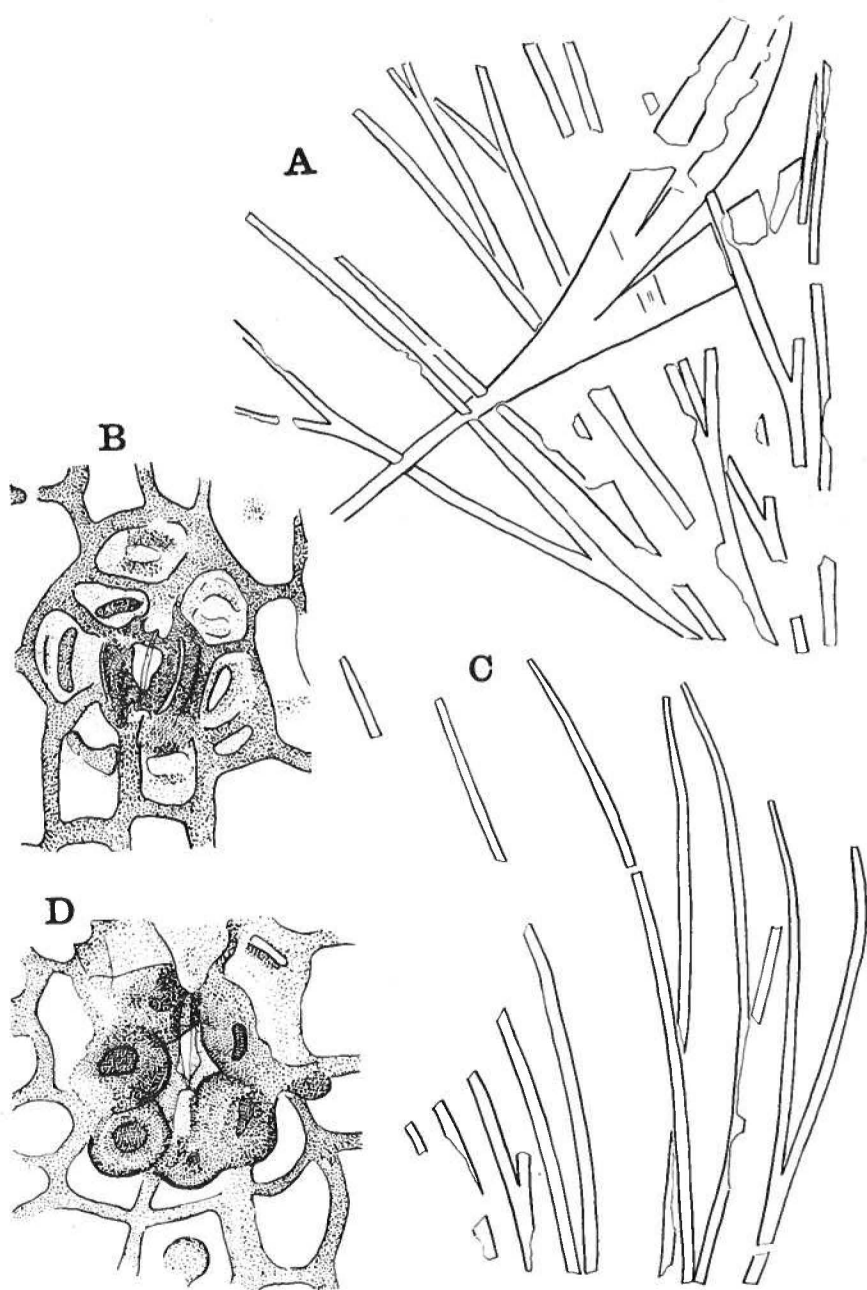


Fig. 18. *Stenopteris dinosaurens*.

A, leaf (and a specimen of *G. hermelini*), specimen No. 2780,  $\times 1$ . B, stoma with rather feebly developed papillae; D, stoma with better developed papillae, Slide 2561 (from No. 2785),  $\times 400$ . C, leaf, No. 2785,  $\times 1$ . — The specimen shown in A was obtained from Ammonite Mountain, *Baiera* Bed; that shown in B—D from Astarte R., *Todites princeps* Bed.

*angustiloba*. These specimens (from Sofiero) agree very well indeed with mine in the structure of their cuticles; papillae are not discernible in the cells as in many of my specimens, and I consider them to be specifically identical with mine.

*Comparison.* The four species, *Baiera furcata* (Keuper), *B. leptophylla*, *B. cf. angustiloba* JOHANSSON (Rhaetic) and *S. dinosaurens* (Basal Lias) are distinguishable by their cuticles, and their cuticles distinguish them with certainty. Unusually finely branched leaves of *B. amalloidea* and unusually much branched leaves of *Hartzia tenuis* might also be mistaken for any of these leaves, but typical specimens are obviously different.

*B. furcata* (LEUTHARDT 1903, KRÄUSEL 1923) has the thickest cuticle. The two sides show similar structure, the stomata are scattered and are remarkably large — the oval pit formed by the subsidiary cells being often  $50\mu \times 30\mu$ , and the stomatal aperture is  $30\mu$  long. Relatively small, widely spaced papillae usually project from the subsidiary cells over the edges of this pit; occasionally the papillae are lacking. The epidermal cells either have a small solid papilla, or no papilla at all, but their surface is sculptured with pits or striae — features absent in the other species.

*S. dinosaurens* also has a thick cuticle with scattered stomata on both sides. The stomata are smaller (the pit is  $20\mu \times 16\mu$  and the aperture is  $16\mu$  long. The subsidiary cells bear hollow papillae which are so large as to be almost in contact with one another. Epidermal papillae are usually faint or absent.

*B. cf. angustiloba* JOHANSSON (1922) has its stomata confined to definite bands on the lower side. The epidermal cells have no papillae, the subsidiary cells merely possess a rim of cuticle projecting over the guard-cells (as in *G. acosmia*, Text-fig. 3 F, G).

*B. leptophylla* (which alone has resin in the mesophyll) has rather more stomata on the lower surface, where they tend to avoid the veins. Large hollow papillae usually occur on the epidermal cells, and are especially conspicuous on the subsidiary cells. The cell-outlines often show very fine jagged thickenings. The stomata are quite small (aperture  $10\mu$  long).

*B. amalloidea* has stomata confined to narrow bands on the lower surface. The subsidiary cells have fairly conspicuous papillae, the other cells on the lower side have fainter papillae.

*Hartzia tenuis* has scattered stomata on both sides. It is readily distinguished by the elongated groups of subsidiary cells, cells without papillae but with jagged thickenings on their walls.

I am indebted to Dr. FLORIN for the loan of preparations of *B. furcata* (from Basle), and *B. cf. angustiloba* (from Sweden).

Genus **CZEKANOWSKIA** HEER.1876. *Czekanowskia* HEER, p. 65.

The genus is discussed on p. 48.

***Czekanowskia hartzi* HARRIS.**

Pl. 4, fig. 4, 5; Pl. 6, fig. 1, 9—11; Pl. 7, fig. 10; Text-fig. 19.

1896. *Czekanowskia rigida* and *C. setacea* HARTZ, p. 241.1926b. *Czekanowskia hartzi* HARRIS, p. 104; Pl. 4, figs. 1—3; Text-fig. 25 E—G.*Occurrence.*Lejr R., *Czekanowskia* Bed; *G. hermelini* Bed.

Hare R., Upper Plant Bed.

Primula R., Upper Plant Bed.

Musk-Ox R.

Vardekløft, *Czekanowskia* Bed; *P. agardhianus* Bed.Neill C., *Czekanowskia* Bed (N. of Tancredia R.); *Czekanowskia* Bed  
(over Liverwort Bed).

Storgaard R.

Lakse R.

C. Stewart, *Todites* Bed.C. Hope, *Czekanowskia* Bed, Coal bed.All of these beds belong to the upper half of the *Thaumatopteris* Zone.This is one of the commonest species in beds belonging to the upper half of the *Thaumatopteris* Zone. It appears to be nearly constant in form and in cuticle structure.

An interesting specimen (Pl. 4, fig. 5) was found consisting of a stem apparently bearing three short shoots. No isolated foliage leaves were found; they always occur in compact bundles of about eight on short shoots. In addition to the normal foliage leaves, occasional unbranched leaves 1—2 cm long occur. The base of the short shoot is usually covered with a number of small adpressed scales (only recognisable after maceration).

The cuticle is remarkably constant in structure in all the specimens examined (at the extreme base and tip of the leaf the cells are shorter than usual). The stomata of even a well preserved specimen are scarcely visible without fairly high magnification (Pl. 6, fig. 9—11). No other leaf I have examined has such a uniform-looking cuticle.

The bud-scales are evidently quite delicate and their cuticles are so thin that it was impossible to isolate a scale without injuring it. The cuticle shows the outlines of narrow, straight-sided cells, but no stomata (Pl. 6, fig. 1).

*Comparison.* The majority of specimens of *C. hartzi* can be distinguished from *C. nathorsti* by possessing fewer leaves on a dwarf shoot (about 8 instead of 12—16); by corresponding parts of its leaves

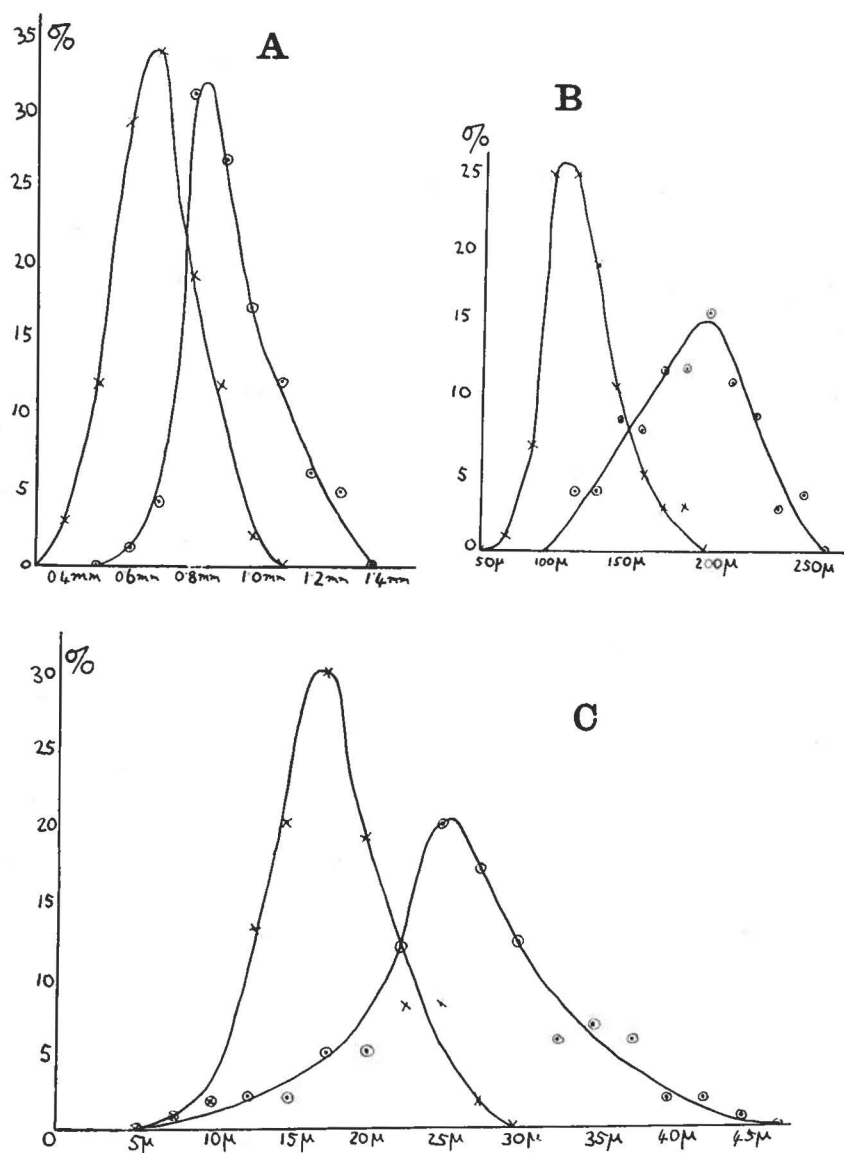


Fig. 19. *Czekanowskia hartzi* and *C. nathorstii*.

Graphs comparing the range and frequency of variation of each of three characters; in A the breadth of a leaf 1 cm. above the base, in B the width of ten adjacent epidermal cells, in C the length of the stomatal aperture. The points marked with x belong to *C. hartzi*, those marked with o belong to *C. nathorstii*. Dimensions are on the horizontal axis, percentages of specimens with any particular dimension on the vertical axis: thus 34 per cent. of the leaves of *C. hartzi* are 0.7 mm. wide, but only 4 per cent. of those of *C. nathorstii*.

being as a rule narrower — typically the leaf of *C. hartzi* is 0.7 mm wide just above the base while that of *C. nathorsti* is 1.1 mm wide. Its cuticle is thinner and has narrower cells; the stomata have a smaller aperture and the subsidiary cells are smaller. All these features are, however, subject to some variation in each species and specimens may be found which match the other species in one or another respect. The characters taken together do, however, distinguish it satisfactorily. The variation of the two species was investigated statistically and the results are expressed in graphs in Text-fig. 19.

A fructification which I attribute to *C. hartzi* is described later under the name *Leptostrobus longus*.

**Czekanowskia nathorsti** sp. nov.

Pl. 4, figs. 3, 7, 9; Pl. 5, figs. 1—5; Pl. 6, figs. 2—4, 6—8; Pl. 8, figs. 1, 2; Text-fig. 19.

Selected type-specimen: NATHORST 1906, Pl. 2, fig. 8.

1906. *Czekanowskia rigida* and *C. setacea* NATHORST (? HEER), p. 11; Pl. 1, fig. 9; Pl. 2, fig. 2—15; Text-fig. 16—18.

1922. *Czekanowskia rigida* JOHANSSON (? HEER), p. 49; Pl. 8, fig. 6; Text-fig. 5.

Many of the specimens described by various authors under the name *C. rigida* may belong to this species but until their cuticles are described it is impossible to say which of them do so. A useful list of such specimens is given by OISHI (1931b).

*Occurrence in Greenland.*

?Nathorst Mtn., *Czekanowskia* Bed (a few abnormal specimens).

Astarte R., Bed D, *Thaumatopteris brauniana* Bed, *Todites princeps* Bed. Vardekloft Liverwort Bed.

Dinosaur R., *Marattiopsis* Bed (abundant); *Pterophyllum subaequale* Bed. Neill Cliff, *Clathropteris* Bed.

C. Stewart, *A. hartzi* Bed.

These beds belong to the lower two thirds of the *Thaumatopteris* Zone; Astarte R., Bed D and Neill Cliff, *Clathropteris* Bed being at the base of this zone and transitional between this and the *Lepidopteris* Zone.

*Diagnosis.* Leaves borne in a bundle of about 15 on a dwarf shoot. Dwarf shoot bearing semicircular scales 2—3 mm in diameter, or naked. Leaves about 15 cm long, forked three or more times. Leaf typically 0.8 mm wide 1 cm above the base (extremes 0.6 and 1.4 mm wide), leaf segments typically 1.1 mm wide in the lower half of the leaf, 0.6 mm in the upper half. Apex of segments acute. Leaf considerably expanded at its point of attachment. Substance of leaf dense, resin bodies absent. Leaf segments possessing a single median vein which forks a little below the point where the lamina divides.

Cuticle thick, similar on the two sides except that one may have more stomata. Epidermal cells elongated, with straight, strongly marked

outlines. Surface of cells without any median papilla (in occasional specimens cuticle a little thickened towards middle of cell), but usually marked with longitudinal striations; striations sometimes faint, occasionally absent. Stomata forming short vertical rows. Subsidiary cells resembling other epidermal cells in size and shape, sometimes of the same thickness, but usually rather thickened. Guard-cells sunken, very thinly cutinised, stomatal aperture not often visible, about  $20\mu$  long, always orientated longitudinally. Pit formed by subsidiary cells over stoma usually about  $25\mu$  long,  $10\mu$  wide, often irregular and more or less covered by projections from the subsidiary cells.

*Discussion.* The various leaves described as *C. nathorsti* were identified with one another and with the Swedish specimens on their agreement in form and in structure.

They would ordinarily have been included in *C. rigida*; I have, however, made this new species because I consider that there are several distinct species of *Czekanowskia* which agree closely enough with HEER's figures of *C. rigida* to be identified on their form, but which are shown by their cuticles to be different from one another — *C. nathorsti*, *C. hartzi* and two undescribed species from the Lower Oolite of Yorkshire collected by Dr. HAMSHAW THOMAS.

Any one of these leaves, or none of them, may be identical with HEER's *C. rigida*. Pending a complete revision of the genus, it seems best to retain the names *C. rigida* and *C. setacea* as aggregate species where the cuticles are unknown.

*C. nathorsti* is compared with *C. hartzi* on p. 38.

An unnamed species of rather similar form occurring at Gristhorpe, Yorkshire (Lower Oolite) has a similar cuticle, but may be distinguished by its epidermal cells which often have a median thickening and are usually much shorter than those of *C. nathorsti*. Another Yorkshire species (from Whitby) is rather more like *C. nathorsti* in cuticle, but differs in its stomata, which do not form vertical rows. In neither Yorkshire species is the surface of the cells striated. I am indebted to Dr. HAMSHAW THOMAS for lending me preparations of these leaves.

*Variation.* The Greenland specimens vary slightly in all their characters, but these differences are probably merely fluctuations or individual variations for I could find no general difference between the specimens of different localities. The number of specimens was sufficient to allow certain of these variations to be investigated statistically (Text-fig. 19). The most striking variation in the cuticle, however, depends on the length of time of maceration; a densely staining layer becomes detached from the rest of the cuticle, disappearing from the ordinary epidermal cells more easily than from the subsidiary cells, giving the cuticle a remarkable appearance (Pl. 5, fig. 4, 5 and some

of NATHORST'S and JOHANSSON'S figures). The same effect is seen occasionally in other fossils with thick cuticles.

It will be seen from Text-fig. 19 that *C. nathorsti* varies a little more than *C. hartzi* in respect of each feature investigated. The width of individual cells is so variable in each that it could hardly be used to distinguish the two species, but the average width of a cell — expressed in graph B as the width of ten adjacent cells — shows a satisfactory difference between the two. In all the graphs the lower values are rather unreliable as the total number counted (between 100 and 200 in each case) is too small to give a smooth curve, but the numbers are high enough to show the position of the maxima reliably.

Genus **HARTZIA** gen. nov.

Type-species *H. tenuis* (HARRIS).

*Diagnosis.* Same as specific diagnosis, see below.

*Discussion.* Certain specimens of *H. tenuis* might be placed in *Baiera*, others in *Czekanowskia*, others in *Phoenicopsis*, while a new genus seems needed for the species as a whole. From *Baiera* it differs in the prevalence of narrow unbranched leaves; from *Czekanowskia* in the usual lack of branching and the occurrence of two or sometimes four veins in the leaf (instead of one); from *Phoenicopsis* in the frequent forking of the leaftip and the prevalence of leaves with only two veins.

The fruit ascribed to *H. tenuis* is described on p. 114 as *Staphidio-phora secunda*.

This genus is named after Dr. N. HARTZ, who collected the original specimens.

**Hartzia tenuis** (HARRIS) N. comb.

Text-fig. 20.

1926b. *Phoenicopsis tenuis* HARRIS, p. 107; Pl. 3, figs. 6, 7; Pl. 4, figs. 5, 6; Pl. 10, fig. 5; Text-fig. 26.

Type-specimen, HARRIS 1926b, Text-fig. 26 A.

*Occurrence.*

Vardekløft *Neocalamites* Bed; *Dictyophyllum* Bed; *Anomozamites* Bed. C. Stewart, *A. minor* Bed.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Dwarf shoot bearing about seven leaves and a number of semicircular scales. Leaves 5—15 cm long, unbranched except near apex, 1—2 mm wide in upper portion, narrower near base. Apex of leaf variable, often rounded (but with projections marking ends of veins) or forked into rather short branches. Veins only visible by transmitted light. Leaf typically with two veins throughout: occasional leaves with



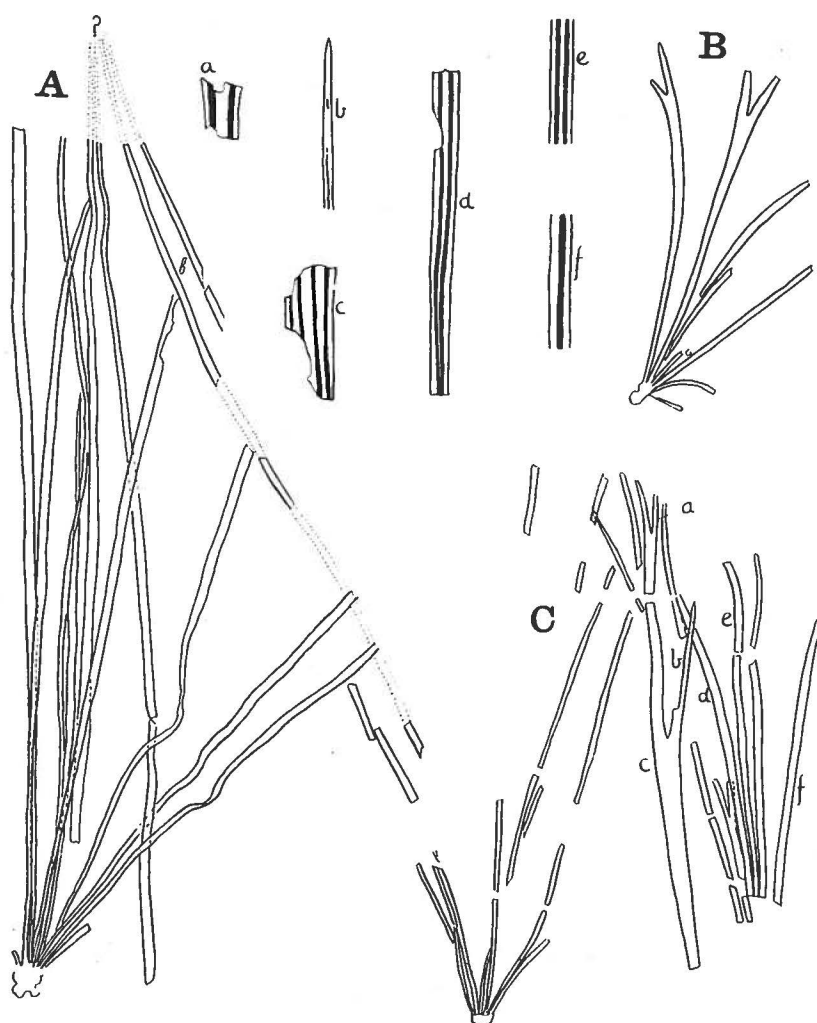


Fig. 20. *Hartzia tenuis*.

A, two groups of leaves (one group is restored by dotted lines, No. 2991,  $\times 1$ . B, group of leaves (rather short) on dwarf shoot, No. 2995,  $\times 1$ . C, two groups of leaves, No. 2993,  $\times 1$ . a, b, c, d, e, f, fragments of specimen C from the positions marked in the same way, viewed by transmitted light to show the veins.  $\times 2$ . —

All the specimens were obtained from C. Stewart, *A. minor* Bed.

two veins at the base branching to give four. Leaves very rarely with only one vein. Resin absent.

Cuticle fairly thick, one side slightly thicker and with rather more stomata, but two sides otherwise similar. Epidermal cells elongated, without papillae; lateral walls possessing fine jagged thickenings. Subsidiary cells forming an elongated group of 4—6 cells, surface rather thickened, bearing a ridge or flat papilla of cuticle projecting over the

guard-cells. Guard-cells thinly cutinised, aperture about  $15\mu$  long, orientated longitudinally.

*Discussion.* I obtained a specimen of *H. tenuis* in which the dwarf shoots were still attached to a main shoot (very much as in the specimen of *Czekanowskia hartzi* figured on Pl. 4, fig. 5) but the specimen was unfortunately rotted by frost and broke up in thawing. A number of typical shoots are figured in Text-fig. 20, some of which still bear the little round scale-leaves like those described previously (HARRIS 1926b, p. 108).

Genus **TORELLIA** HEER (= *Feildenia*).

1870. *Torellia* HEER, p. 44.

1878. *Feildenia* HEER (substituted for *Torellia*), p. 20.

Type-species *T. rigida* HEER.

The genus *Torellia* includes several species placed, in it by HEER, among which *T. rigida* alone is well-defined; another well-known species is NATHORST'S *T. nordenskioldi*. Only detached, unbranched leaves need be considered because HEER'S figures, which are supposed to show leaves attached to a stem, or forking leaves, are unconvincing.

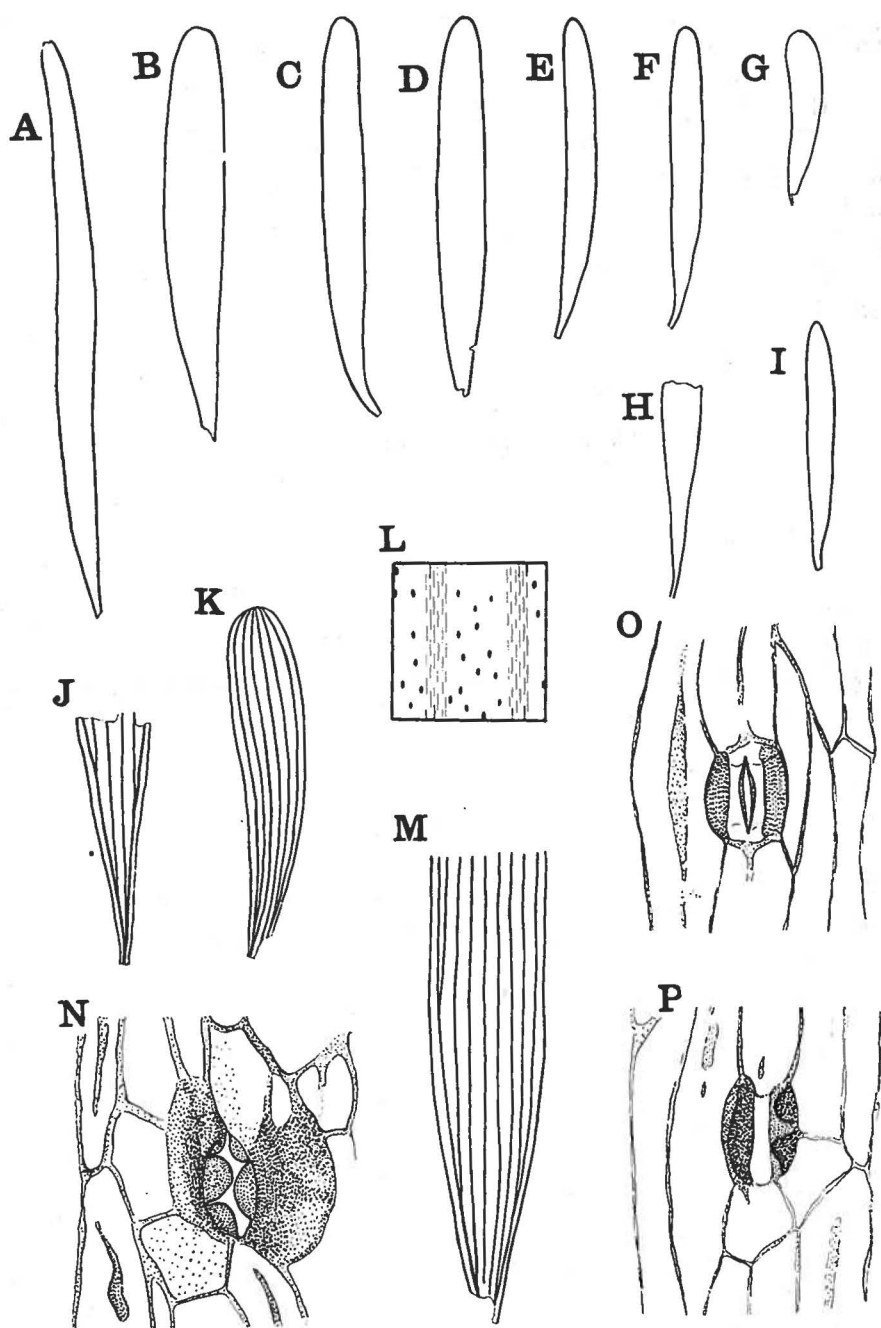
The macroscopic features and affinities of *Torellia* have been discussed by NATHORST 1897, SEWARD 1919, and NATHORST 1919. The present investigation of *T. ephela* provides information about its microscopic structure which makes a reconsideration of its position possible.

1. I have been able to confirm the previous accounts of the venation — at the base of the leaf there are two strong marginal veins which give off branches on their inner sides (as in *Ginkgoidium*). These branches run without further branching to the apex where they converge slightly, but seem to end separately at the terminal margin — an important character distinguishing the leaves of the Ginkgoales from those of most broad-leaved conifers (but see p. 89). On the other hand, I have not been able to recognise any marginal folds (SAHNI 1933) of the type met in certain Ginkgoales, at the leaf-base of *Torellia*.

2. The cuticle. The epidermal cells — with their longitudinal ridges — are more like those of certain conifers than of any known Ginkgoales, but the distribution of the stomata — occurring sparsely scattered in ill-defined bands — is typically Ginkgoalean. The stomata can be matched in either group.

Although some of the evidence is equivocal, the balance seems to me to favour the inclusion of *Torellia* in the Ginkgoales.

The genera which are confused with *Torellia* are *Phoenicopsis* and *Podozamites*. The species of *Phoenicopsis* so far investigated (PRINADA 1928, OISHI 1933) show comparatively short epidermal cells with papillae like those met in other Ginkgoales — not an elongated strip. The

Fig. 21. *Torellia ephela*.

A—I, leaves,  $\times 1$ . A, No. 3021, B, (Type-specimen) 3022, C, 3020, D, 3028, E, 3023, F, 3024, G, 3025, H, Slide 2844, I, 3026, 3027. J, lower part of leaf showing the veins, Slide 2845,  $\times 2$ . K, small leaf, shown in 'G', showing veins, No. 3025,  $\times 2$ . L, distribution of stomata on 1 sq.mm of the lower surface, Slide 2847. M, lower part of leaf shown in 'D'. N, stoma, Slide 2846,  $\times 400$ . O, P, stomata, Slide 2848,  $\times 400$ . In O, the guard cells are seen.

striations on the surface of the leaf of the other two species of *Torellia* may indicate that they also have ridges along their cells.

Confusion between isolated leaves of *Podozamites* and *Torellia* is most likely when the base of the leaf of one or other is mistaken for its apex — for example, the isolated leaf of *Podozamites agardhianus*, which has a rounded base and a tapering apex, has been described upside down, when it was said to resemble *Torellia*.

None of the species of the form-genus *Podozamites* which I have examined show the same scattered distribution of stomata.

***Torellia ephela* sp. nov.**

Pl. 8, figs. 7, 8, 12, 13; Text-fig. 21.

Type-specimen, Text-fig. 21 B.

*Occurrence.* Dinosaur R., *Marattiopsis* Bed.

*Diagnosis.* Leaf 2—8 cm long, 4—8 mm broad, straight or slightly curved. Base tapering, middle and upper part with nearly parallel margins (or tapering slightly towards apex), apex rounded. Petiole minute, less than 0.5 mm long. Petiole with a single vein which forks at the leaf base, main veins running near margins and giving off branches on their inner side in lower part of leaf, veins continuing parallel and without branching at a concentration of 11—16 per cm in greater part of leaf, converging somewhat at apex. Interstitial ducts, or oval interstitial bodies visible between veins — particularly near leaf apex — in some specimens. Veins by no means prominent. Surface of leaf covered with fine striations due to epidermal cells. Leaf substance rather delicate, "mesophyll" showing a regular granular structure between the veins in most specimens. Interstitial bodies, interstitial ducts and mesophyll granules all destroyed by maceration.

Cuticle rather thin. Upper without stomata, showing almost uniform elongated, straight-sided cells. Cells possessing a conspicuous median ridge. Veins scarcely recognisable on upper cuticle.

Lower cuticle showing similar elongated cells with a median ridge, cells rather narrower along veins, stomata confined to strips between veins. Stomata not occurring in definite rows, but scattered, not very numerous. Guard-cells sunken, surrounded by 4—7 subsidiary cells, terminal subsidiary cells little specialised, lateral ones thickened along the margins of the stoma, often bearing small solid papillae projecting over the aperture. Aperture always orientated longitudinally.

*Comparison.* Only two other species of *Torellia* need be considered for comparison (see above) — *T. nordenskiöldi* NATHORST (1897), which usually has rather smaller leaves than *T. ephela*; and *T. rigida* HEER, the specimens of which HEER figured in 1871 were like *T. ephela*, while

those figured in 1878 are distinguished by possessing a much larger leaf base. The cuticle of neither species has been described. The age of *T. nordenskiöldi* is Upper Jurassic, that of *T. rigida* is given as Miocene.

### Undetermined Ginkgoales.

In addition to the species described above, there are a considerable number in which either the structure or the general form are too imperfectly known for determination.

Among these may be mentioned a leaf resembling *G. acosmia* or *G. taeniata* in Astarte R., Bed D; fragments of a new species of *Czekanowskia* from Dinosaur R., *Marattiopsis* Bed; and fragments of three undescribed species, probably of *Phoenicopsis* or *Feildenia* found respectively in Vardekløft *Stachyotaxus* Bed, Vardekløft *P. agardhianus* Bed and C. Hope *A. minor* Bed. These four species represented by fragments have characteristic cuticles and are specifically distinct from anything previously described. Most of these fragments were obtained by the "bulk-maceration" method (HARRIS 1926a).

### General discussion of the Ginkgoalean leaves.

The Mesozoic form-genera which I include in the Ginkgoales are *Ginkgoites*, *Baiera*, *Eretmophyllum*, *Phoenicopsis*, *Ginkgoidium*, *Torellia*, *Czekanowskia* and *Hartzia*. These leaves agree in essential architecture — they are built up on a plan of repeated dichotomies which are shown by the veins, if not always by the lamina. Each vein ends separately at the apex instead of converging to a point as in broad-leaved Conifers. In many species the margins are thickened in the lower part of the leaf and the thickenings extend as ridges on to the upper side of the petiole (SAHNI 1933).

The cuticle is remarkably constant; its general characters are well summarised by OISHI (1933), while the details of the stomata are also given by FLORIN (1931). The stoma of *Phoenicopsis* has been described as having six guard-cells (PRINADA 1928), but it seems likely that these are six subsidiary cells, the guard-cells being concealed as in many other Ginkgoales.

Our knowledge of the reproductive organs is inadequate to form any basis for classification and the various species of leaves seem to form a number of almost perfectly intergrading series which can at present only be classified in rather arbitrarily defined form-genera. There is fair agreement about the limits of all these form-genera except, unfortunately the two largest — *Ginkgoites* and *Baiera*. About equal numbers of authors use two of the following bases (expressed or implicitly):—

- Leaf divided into several segments..... *Baiera*.  
 Leaf merely indented..... *Ginkgoites*.  
 and  
 Leaf with a distinct petiole — outline of lamina as a whole being  
     semicircular ..... *Ginkgoites*.  
 Leaf without a distinct petiole — leaf as a whole being wedge-  
     shaped ..... *Baiera*.<sup>1)</sup>

Other authors retain a species in the genus in which it first was placed, using in effect, a mixture of the two systems.

Two authors who have recently discussed this question come to nearly opposite conclusions — KRÄUSEL (1917) pointed out that the extent to which the leaf of *G. biloba* is divided varies greatly on one tree, making the extent of division an unsatisfactory basis for classification, while LUNDQVIST (1918) thinks that this is the best basis available and claims to have shown (in *G. minuta*) that the presence or absence of a petiole is "purely subjective". As has been pointed out before (p. 11), however, the specimens of *G. minuta* lacking petioles are probably only fragments.

My reason for preferring the second basis of classification — the presence or absence of a distinct petiole — is that I think that this varies less within the limits of a species and there happen to be very few species (as *B. boeggildiana*) in which the presence or absence of a petiole is "subjective". I admit, however, that fragments of the lamina, and also the minute leaves intermediate between foliage leaves and bud-scales formed in *G. biloba* at the end of a year's growth, and similar minute leaves found occasionally in the fossil species, are difficult to place on this basis. The determination of such fossil specimens is difficult anyhow.

A comparison of the cuticles of the *Ginkgoites* and *Baiera* species shows that its structure cannot be used as a basis for separating the two genera — (see also OISHI 1933, p. 251).

The leaves forming the genera *Baiera* and *Czekanowskia* also seem to intergrade. I have limited *Czekanowskia* to leaves in which the segments show only a single dark strand or "vein" for some distance above a dichotomy of the lamina, thereby excluding *B. furcata*, *B. leptophylla*, etc., in which the segments are broader and usually possess at least two veins. It must be admitted that this distinction is arbitrary, for certain leaves of these species are narrow and have only one "vein".

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<sup>1)</sup> The situation is complicated by the fact that the genus *Baiera* appears to be based on the finely divided leaf '*B. muenstenana*', though included with it are the coarsely divided leaves '*B. huttoni*' & *B. digitata*.

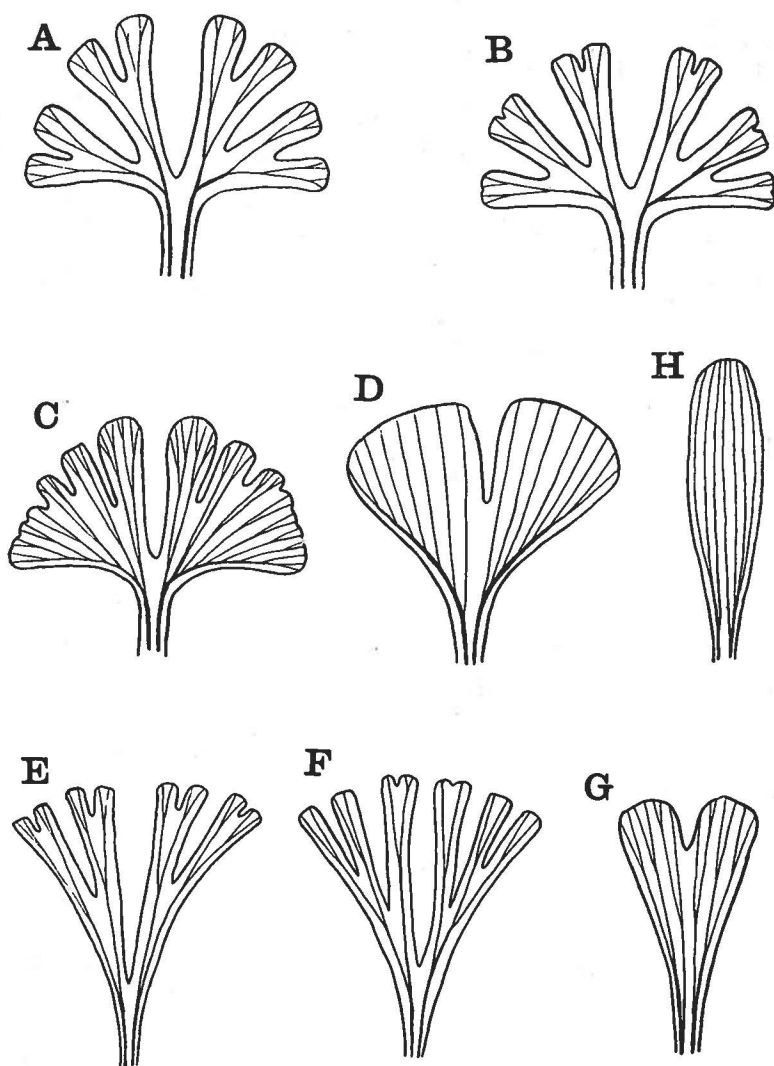


Fig. 22. Diagrams of the venation and branching of certain Ginkgoalean leaves. A—D, *Ginkgo*-series; A, dichotomy equal (approached by *G. minuta*); B, outer half the stronger (*G. acosmia*, *G. taeniata* etc.); C, outer half much stronger (*G. biloba*); D, outer half alone branched (*Ginkgoidium*). E—H, *Baiera*-series. E, dichotomy equal (*B. furcata*); F, outer half stronger (*B. spectabilis*); G, as F but leaf less divided (*B. boeggildiana*); H, outer half alone branched (*Torellia*).

The discovery, by FLORIN, that the "vein" of *Czekanowskia* may be composed of two separate vascular bundles also suggests that this distinction is not one that can be applied rigidly. I could find no absolutely reliable criterion in the structure of the cuticles for separating the two genera, though I agree with OISHI (1933) that *Czekanowskia* can usually be distinguished by its narrower cells end by other characters.

*Venation and branching of the lamina.* In all the specimens I have seen, the branching of the lamina seems merely to follow — after a longer or a shorter interval — the branching of the veins. The various Ginkgoalean leaves can be arranged in an interesting series with regard to their venation — ranging from repeated equal dichotomy to a sympodial system with strong veins running up the leaf margins giving off slender branches on their inner sides (Text-fig. 22).

Equal dichotomy is probably seen in *Czekanowskia*; in certain species of *Baiera* (e. g. *B. furcata*, *B. leptophylla*) and according to OISHI 1932(a), p. 353, in a leaf of the *Ginkgoites* type — *B. elegans* OISHI. Nearly equal dichotomy is seen in *Ginkgoites minuta* and in certain specimens of *Baiera spectabilis*.

Considerable inequality is seen in most species of *Baiera* and *Ginkgoites* (e. g. *G. taeniata*), in which each half of the leaf may appear to be divided into three nearly equal lobes; still further inequality in *G. biloba*, in which a marginal vein becomes apparent and the series reaches its culmination in *Torellia* and in *Ginkgoidium* with their strong marginal veins. The same stages are recognisable in leaves with a broad lamina (*Ginkgoites*, etc.) and with a wedge-shaped lamina (*Baiera*, etc.).

*Specific determinations.* I have found it unsatisfactory or impossible to identify my own specimens of Ginkgoalean leaves with one another without the help provided by the microscopic structure of their cuticles, and I have therefore considered it useless to identify them with other specimens whose cuticles are unknown. All the characters — including those of the cuticle — which are useful for specific determination vary within the limits of the species, but on the whole the cuticles seems rather more characteristic than any macroscopic character.

The characters I have used to distinguish species include:— the size, the shape and degree of dissection of the leaf; the form of the apex of the lobes, the concentration of veins, the distribution of resin bodies, the structure of the mesophyll, and in the cuticle the size and shape of the cells, the presence of a median papilla, the distribution of the stomata and the structure of their subsidiary cells. A fair number of specimens, enough to show the usual range of variation of these characters, is needed before any of them can be safely used. The microscopic and macroscopic characters should, of course, be used together and I have refrained from giving any description of certain Ginkgoalean leaves in this collection in which the cuticle is missing and also of fragments of characteristic cuticles in which the leaf-form is unrecognisable.

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## Coniferales.

The conifers are here divided for convenience into species with 1-veined leaves (*Elatocladus sensu lato*) and species with several-veined leaves (*Podozamites sensu lato*). I have no reason to suppose that either group constitutes a natural family.

The reproductive organs are described separately from the leaves and under different generic names (p. 99 *et seq.*) unless there happens to be proof of organic connection.

### 1. CONIFERS WITH 1-VEINED LEAVES.

#### Genus *STACHYOTAXUS* NATHORST.

1886. *Stachyotaxus* NATHORST, p. 98.

Type-species doubtful, see p. 55.

*Stachyotaxus* is one of the best known genera of fossil conifers, but its systematic position is uncertain. Most authors (e. g. KRÄUSEL 1926) have accepted NATHORST's view (1908c) that it is rather near to *Dacrydium* (Podocarpaceae); SAHNI (1920) has suggested it is nearer *Cephalotaxus*. As a result of the investigation of Greenland material I have come to the conclusion that it cannot be placed in any living Conifer family, without considerably altering its definition.

The facts which must be considered are:—

1. The leaves are dorsiventral and have sheathing bases; there are two stomatal bands on the under side of the leaf; the stomata are monocyclic and scattered; the subsidiary cells are small, unspecialised and have very feebly developed papillae.

Monocyclic stomata are rather exceptional in the living conifers but occur in most families (*Pherosphaera* and *Microcachrys* of the Podocarpaceae; *Amentotaxus* of the Cephalotaxaceae; *Arthrotaxis* of the Taxodiaceae, *Pinus* and *Larix* of the Abietineae; and in certain genera of the Cupressineae. Both *Dacrydium*, like most of the Podocarps, and *Cephalotaxus* have amphicyclic stomata which do not resemble those of *Stachyotaxus* closely.

2. The female cone is unique in appearance, but the individual cone scale might be compared with that of the Podocarpaceae e. g. *Dacrydium*, in which case the epimatium would correspond to the "cupule", or with that of *Cephalotaxus*, in which case the "cupule" would be wanting, or with the Abietineae, in which case the "cupule" would be represented by the bract scale.
3. The ovule has a nucellus which is free nearly to its base, a primitive feature unusual in the living conifers.
4. The male cone is a small catkin; the microsporophyll is bract-like

and bears two pollen sacs on its under side (as in Abietineae, Podocarpaceae) but differing from that of many conifers — e.g. *Cephalotaxus*. The pollen is round and wingless as in all conifers but the Podocarpaceae (save *Saxegothea*) and the Abietineae.

It will be seen from this summary that *Stachyotaxus* differs in important respects from each living conifer family. Its classification must await the erection of new families for the reception of the older fossil conifers.

### *Stachyotaxus elegans* NATHORST.

Pl. 10, figs. 1—3, 6—9, 11; Pl. 21, fig. 1—3; Pl. 27, fig. 7; Text-fig. 23.

For early references see below.

- 1878c. *Cyparissidium septentrionale* (AGARDH) NATHORST, p. 29; Pl. 4, figs. 8—14 (not cone in fig. 14). Probably also figs. 4—7, which were later referred to *C. nilssonianum*.
- ?1878c. *Carpolithes septentrionalis* (AGARDH) NATHORST, p. 32; Pl. 3, figs. 15—17 (AGARDH's Type-specimens refigured).
1886. *Stachyotaxus septentrionalis* (?AGARDH) NATHORST, p. 98; Pl. 22, fig. 22, ?20—23, 33, 34; Pl. 23, fig. 6; Pl. 25, fig. 9.
1896. *Stachyotaxus septentrionalis* (?AGARDH) HARTZ, p. 242; Pl. 19, figs. 2—4, 5?; Pl. 13, fig. 4a.
- 1908(c). *Stachyotaxus elegans* NATHORST, p. 13; Pl. 2, figs. 1—9, 12—24, 27 (not 10, 11, 25, 26); Pl. 3, figs. 10—12.
1922. *Stachyotaxus elegans* NATHORST, JOHANSSON, p. 51; Pl. 1, figs. 30, 31, 32?; Pl. 6, figs. 18, 19, 29?
- 1926(b). *Stachyotaxus elegans* NATHORST, HARRIS, p. 119; Pl. 10, figs. 2—4; Pl. 12, figs. 1, 2, 6; Pl. 13, fig. 5; Text-figs. 30 E, F, I, J.

(The magnification of the specimen shown in HARRIS, 1926b, Pl. 12, fig. 1, stated to be  $\times 8.3$  is actually  $\times 0.83$ ).

NATHORST (1886, p. 98) gives the older references to "*Caulerpa*", or "*Sargassum*" *septentrionalis* under which name both *S. elegans* and *S. septentrionalis* may have been described. I am indebted to Dr. FLORIN for some notes on the synonymy in this genus.

For discussion, see p. 55.

#### *Occurrence in Greenland.*

Lepidopteris R., *Lepidopteris* Bed.

Zamites R.

Hare R., Lower plant bed.

Astarte R., Bed A, Bed C, Bed D.

Vardekloft, *Neocalamites* Bed, *Dictyophyllum* Bed, *Stachyotaxus* Bed, *A. minor* Bed.

Neill Cliffs, *N. hoerensis* Bed.

C. Stewart, *E. muensteri* Bed; *E. laevis* Bed.

C. Hope, *A. minor* Bed.

All of these beds belong to the *Lepidopteris* Zone; except Astarte R., Bed D which is transitional between this zone and the *Thaumatopteris* Zone.

*Description.* Shoots and female cones of *S. elegans* are abundant in the Vardekløft *Stachyotaxus* Bed, and Astarte R., Bed D, but comparatively rare in the other localities. The shoots agree perfectly with those figured by NATHORST, 1908(c), and by other authors; I have figured two typical specimens, as well as smaller ones associated with them which resemble *S. septentrionalis*.

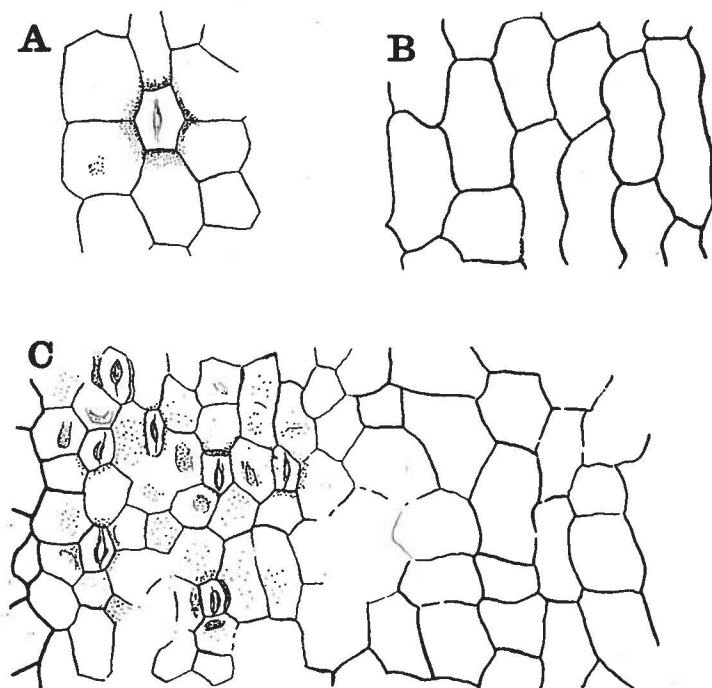


Fig. 23. *Stachyotaxus elegans*.

A, stoma, from leaf with rather large cells, Slide 3005,  $\times 400$ ; B, cells of upper epidermis, Slide 3004,  $\times 400$ . C, lower epidermis from leaf with rather small cells, the whole of a stomatal band is shown, the midrib of the leaf is to the right, Slide 3005,  $\times 400$ . The specimens were obtained from Astarte R., Bed D.

No new information was obtained about the structure of the female cone.

I have macerated a number of seeds and have been able to confirm my account of its structure. Pollen grains of the type already figured were found in the micropyles of several specimens; in one seed three sorts of pollen grains or fern spores were found, but the commonest type of pollen is usually the same as that occurring in the male cone of this plant.

A good many detached male cones from the Vardekloft *Stachyotaxus* Bed were identified by their resemblance to the attached, unripe male cone described by HARRIS (1926b). These male cones have shed their pollen and are often a little larger than the unripe cone, but are otherwise very similar. Few of these male cones show the structure of their microsporophylls, but pollen sacs are seen in certain transfers, though the indifferent preservation makes their interpretation not quite certain (Pl. 10, fig. 3, 8, 9). Each microsporophyll appears to consist of a stalk about 1 mm long bearing two oval pollen sacs 0.7 mm long on its under side and terminating in a lanceolate upturned portion about 1.4 mm long, 0.6 mm wide at its widest part. The pollen sacs dehisced by a large slit. The walls of the pollen sacs are quite delicate and are translucent.

The microsporophylls are only thinly cutinised, and their cuticle showed no characteristic features. The microsporangia, however, possess at rather tougher though quite thin, non-cellular finely granular cutinised membrane — resembling the membranes obtained from various other microsporangia. Although the sporangia have dehisced, they still contain plenty of spores resembling those obtained from the immature attached cone (and the micropyles of the seeds).

*Leaf of cuticle.* The cuticle is quite thin and only the best preserved leaves yielded satisfactory preparations. On the upper side the cells are uniform and placed in longitudinal rows. The walls are nearly straight and are fairly well marked. Median papillae are absent though the whole inner part of the cell may be slightly thickened. The lower side shows similar cells along the midrib and near the leaf margins, but in addition there are two narrow stomatal bands with rather smaller epidermal cells. The stomata are scattered (not forming definite longitudinal rows), the guard-cells are longitudinally orientated and very thinly cutinised. The subsidiary cells are unspecialised, except that their surface is somewhat thickened and bulges slightly on the side near a stoma. Encircling cells are absent. No marginal teeth or hairs of any kind are present on the leaf. NATHORST's (1908c) figures of the cuticle appear to show similar structure, though their magnification is rather low.

*Discussion and Comparison.* See also p. 56. *S. elegans* is a satisfactory zone fossil of the Rhaetic (*Lepidopteris* Zone), as the only species with which it can be confused (*S. septentrionalis*) is the same age. Its foliage — when well preserved — is characteristic and the female cone is unique. Shoots with scale-like leaves are not, perhaps, very characteristic, but as they are nearly always associated with normal foliage their identification should not be difficult. The specimens described by NATHORST (1878c) as *Cyparissidium nilssonianum* (as NATHORST later pointed out) are very probably *S. elegans*. The type of shoot with small

scale leaves is not as common in my collection as appears to be in Sweden.

It seems hardly possible to decide (from NATHORST's figure) whether the *Stachyotaxus* cone which is AGARDH's Type-specimen of "*Sargassum septentrionalis*" is identical with *S. elegans* NATH. or *S. septentrionalis* in the sense in which NATHORST used it later (1908c), as it seems more or less intermediate in size between the two, but the associated leaves seem to me to be more like typical "*S. elegans*" than "*S. septentrionalis*". If it could be shown from a critical re-examination of the Type-specimen that it is the same as NATHORST's "*S. elegans*", it would involve the re-naming of nearly all the specimens of *Stachyotaxus* that have been described. I will not make such an inconvenient change without seeing the specimens.

I have not in fact found any specimens in the localities with typical "*S. septentrionalis*" which gave any difficulty in determination, but in those where "*S. elegans*" is abundant, some specimens, or parts of specimens, approach *S. septentrionalis* closely (e. g. one of the top branches in the shoot shown in Pl. 10, fig. 1, and the whole of the specimens shown in Pl. 21, fig. 1, 2; Pl. 27, fig. 7. A complete series can be found in these localities connecting such specimens with typical ones of "*S. elegans*", of which I have no doubt that they are extreme forms. It will be seen that NATHORST's specimens of "*S. septentrionalis*" from Höganäs are much nearer to typical *S. elegans* than are these. No difference is known between the two species in their finer details; the cuticle of the Greenland specimens of "*S. septentrionalis*" is unknown.

The female cone in *S. elegans* is 8—10 cm long, that of *S. septentrionalis* 4—5 cm, and it is usually a little narrower and has a more slender axis. As the majority of specimens of cones are rather broken it is not usually possible to make full use of this difference. A valuable difference is provided by the seeds which seem to be rather constant in size and distinctly larger (3 mm in diameter) in *S. elegans* than in *S. septentrionalis* (2 mm). Their structure, however, is the same.

To summarise the position: *S. septentrionalis* is best distinguished by its smaller cone and smaller seeds; it is also distinguished by its much smaller leaves which are under 1 mm broad. Specimens with large leaves can thus be placed in *S. elegans* with certainty, while specimens with small ones may be *S. septentrionalis* or exceptionally small *S. elegans* — which they are can only be decided by the general character of the *Stachyotaxus* flora of the particular locality. Where the two species occur together it would be nearly impossible on our present knowledge to determine specimens intermediate in character. It must also be remembered that it is doubtful whether the two names as used since 1908 are rightly applied.

**Stachyotaxus septentrionalis** (? non AGARDH) NATH.

Pl. 9, figs. 11, 12, 14—17; Pl. 10, figs. 4, 5, 10, 12, 13.

1908(c). *Stachyotaxus septentrionalis* (?non AGARDH) NATHORST, p. 71; Pl. 3, figs. 1—9.

?1908(c). *Stachyotaxus elegans* NATHORST (ex parte), Pl. 2, figs. 10—11 only.

NATHORST (1886, p. 98) gives the older references to "*Caulerpa*" or "*Sargassum*" *septentrionalis* under which names this species and *S. elegans* may have been described. See p. 55.

*Occurrence in Greenland.*

Zamites R., Plant Bed.

Astarte R., *Lepidopteris* Bed.

These beds belong to the base of the *Lepidopteris* zone.

*Description of the Greenland Specimens.* *S. septentrionalis* is only represented by a few shoots and detached cones and isolated seeds in Zamites R., and a few shoots and seeds at Astarte R. All the cones are figured; they are poorly preserved but seem to agree in structure with those described by NATHORST (1908c).

The cuticle of the leaf is quite thin and it was not possible to obtain good preparations of the lower surface. The upper surface shows rectangular cells with straight rather faintly marked walls, and without median papillae. The lower epidermis shows cells rather less regular in shape and with still more faintly marked walls. Stomata were not seen.

Some well preserved detached seeds occur associated with the leaves and cones in both localities. They were identified by their resemblance to the seeds in the cones. These seeds closely resemble those of *S. elegans* in structure; the integument shows hexagonal cells with prominent lateral walls but in this species this membrane is often more delicate. The fused cuticles of the nucellus and inside of the integument is an easily recognisable membrane as is the megaspore membrane which is granular and non-cellular. In one specimen spores were present in the micropyle, but unfortunately this was destroyed in preparation.

*Discussion.* (See also p. 55). "*S. septentrionalis*" (in the sense in which it is used here) appears to differ from "*S. elegans*" in having smaller cones and smaller shoots, but the two have been a good deal confused and a thorough revision of the Swedish material is needed.

In both species the leaves vary greatly on almost every shoot, often being mere scales 1—2 mm long near the base of the shoot, attaining their full length and breadth in the middle region and being a little shorter and a good deal narrower near the apex. In "*S. elegans*" the leaves vary in length from 1—15 mm and in width from 0.7—1.8 mm, but the full-sized leaves on most shoots are usually at least 10 mm long and 1.2 mm wide. In "*S. septentrionalis*", the leaves vary from minute scales to 5 mm long, and in width from 0.4—0.9 mm. It will be seen

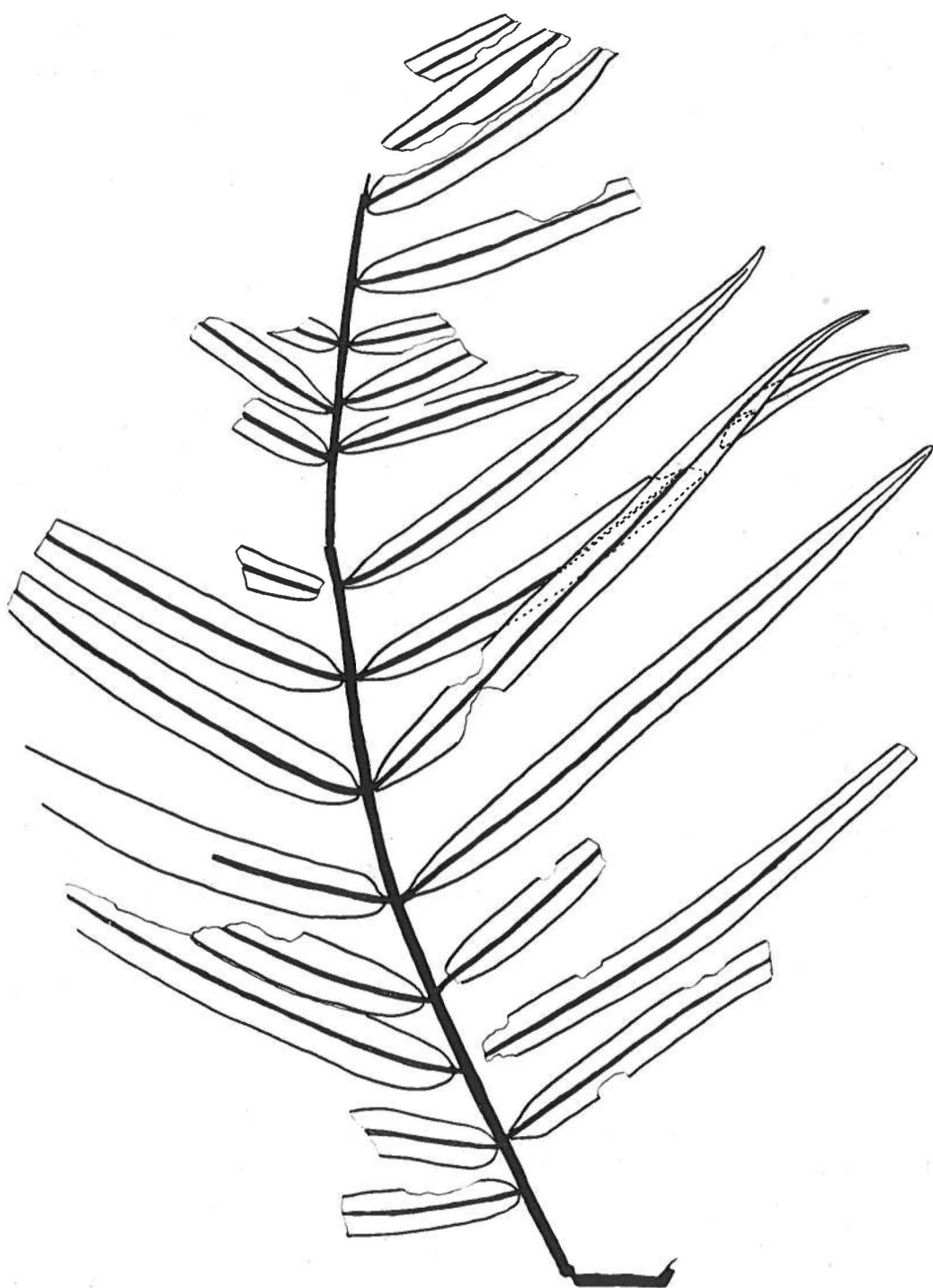


Fig. 24. *Storgaardia spectabilis*.  
Type-specimen, No. 3301,  $\times 1$ ; from Storgaard R.

from these figures, that in "*S. elegans*", they are about twice as big as in "*S. septentrionalis*", and this difference is sufficient to distinguish normal sized specimens of the two species.

*S. septentrionalis* is rare in Greenland, only occurring the two of the lowest beds of the *Lepidopteris* Zone where *S. elegans* happens to be absent. In Sweden, however, it occurs in beds which are probably slightly younger than some with *S. elegans*.

### **STORGAARDIA** gen. nov.

Type-species, *S. spectabilis*.

For diagnosis, see *S. spectabilis* below.

### **Storgaardia spectabilis** sp. nov.

Pl. 11, fig. 17; Pl. 12, fig. 7, 8; Pl. 16, fig. 1, 2; Text-fig. 24—26.

Type-specimen, Text-fig. 24.

?1919. "*Problematicum* 3" *ANTEVS.* p. 55; Pl. 6, figs. 24, 25.

#### *Occurrence.*

Astarte R., *B. spectabilis* Bed.

Neill Cliff Liverwort Bed.

Storgaard R.

C. Stewart *Czekanowskia* Bed.

These beds belong to the upper half of the *Thaumatopteris* Zone.

*Diagnosis.* Conifer with unbranched deciduous shoots at least 20 cm long; probably very much longer. Leaves borne in pairs at intervals of 1—2 cm and at an angle of 30°—90° to the axis; very shortly stalked, lanceolate, about 10 cm long, 5—10 mm wide; apex acute. Leaf pairs probably decussating but all leaves brought into horizontal plane by the twisting of the petioles. Midrib of leaf prominent, but no other veins present; lamina quite delicate, showing a conspicuous "mesophyll" structure of transverse striations probably representing transfusion tissue. Resin not recognised.

Cuticle rather thin, upper side slightly the thicker. Upper cuticle without stomata; cells along midrib rectangular with straight, rather prominent walls; cells of lamina about twice as long (in direction parallel with midrib) as broad, lateral walls rather strongly curved. Middle of cell sometimes very slightly thickened to form an indefinite median ridge, but usually without any thickening.

Lower cuticle with stomata confined to two narrow bands 0.5 mm wide at the sides of the midrib. Cells along midrib and on lateral parts of lamina like those on upper side, but median ridge slightly more prominent. Cells of stomatal bands smaller, with fairly prominent papillae. Stomata placed irregularly, but with a tendency to be arranged



in longitudinal rows, surrounded by 5—6 subsidiary cells; part of cuticle of subsidiary cells strongly thickened, forming a very conspicuous ring of more or less con crescent papillae round the stomatal pit. Guard-cells thinly cutinised, aperture longitudinal. Encircling cells absent.

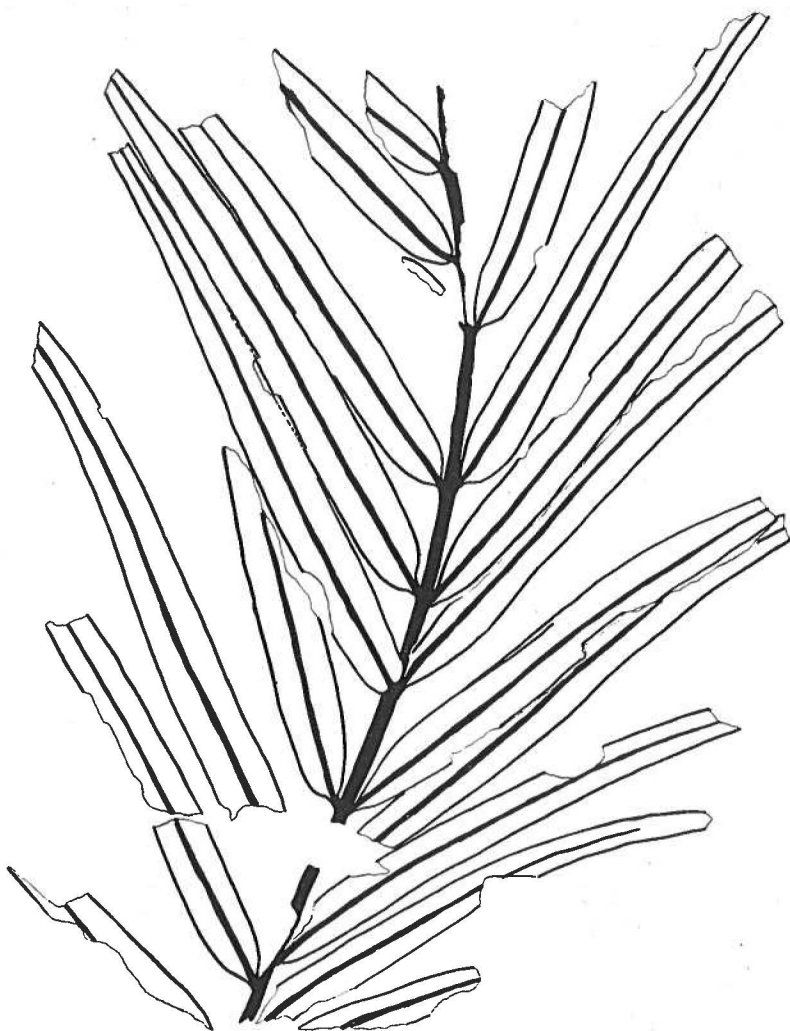


Fig. 25. *Storgaardia spectabilis*.

Shoot with leaves inserted at a rather small angle, No. 3311,  $\times 1$ ; obtained from C. Stewart.

*Discussion and Comparison.* This striking fossil recalls *Podocarpus* subgenus *Eu-Podocarpus* in the form of its leaves, but subgenus *Nageia* in their insertion and the genus *Taxus* in the general appearance of its cuticle, although the stomata differ in detail in being monocyclic.

The narrowness of the stomatal band in relation to the width of the leaf is remarkable.

*Comparison.* The only specimens which resemble *S. spectabilis* are the very ill preserved ones figured by ANTEVS (see above) but some of the fragmentary leaves called *Pityophyllum longifolium*, which have been figured by various authors might represent unusually narrow

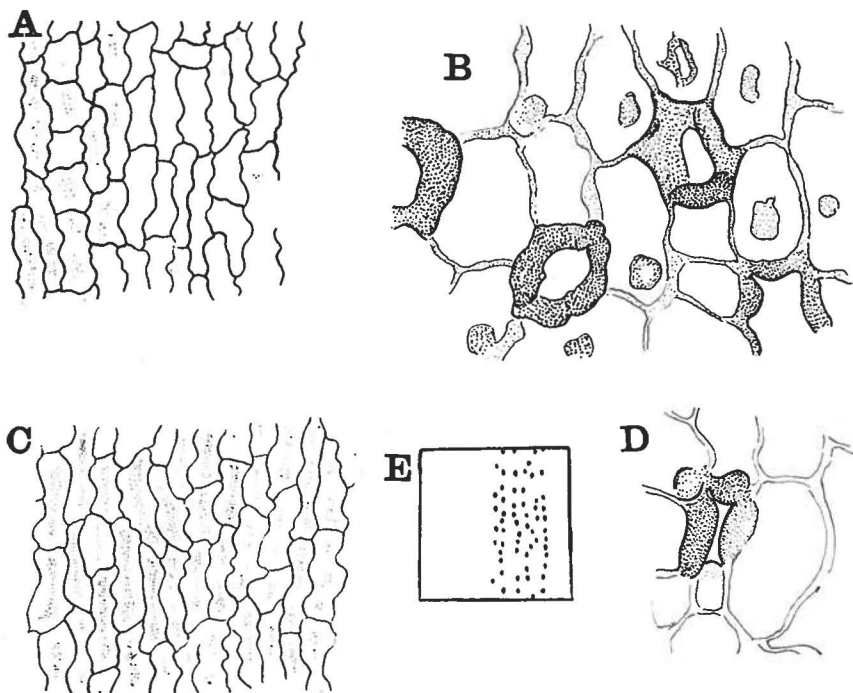


Fig. 26. *Storgaardia spectabilis*.

A, cells from upper, and B from lower epidermis outside the stomatal band, Slide 3061,  $\times 100$ . C, part of stomatal band, Slide 3061,  $\times 400$ . D, a stoma, Slide 3062,  $\times 400$ . E, distribution of the stomata in 1 sq. mm of the lower surface, Slide 3061.

The specimens were obtained from C. Stewart.

leaves of this species. It is also possible that pinnae of *Marattiopsis*, *Laccopteris* or of *Thaumatopteris* when so badly preserved that they had lost all trace of the lateral veins might be confused with *S. spectabilis*.

*Storgaardia* is named after Mgr. EINAR STORGAARD.

#### Form-genus **ELATOCLADUS** HALLE.

1913. *Elatocladus* HALLE, p. 82.

Until the fossil conifers have been thoroughly revised it seems to me best to refer all sterile conifer twigs with small needles to *Elatocladus*. I have grouped the species on the characters of their cuticles (see p. 80).

**Elatocladus patens** sp. nov.

Pl. 11, figs. 4, 10, 11, 16, 19; Pl. 15, fig. 3; Text-fig. 29 A—C.

Type-specimen Pl. 15, fig. 3.

*Occurrence.*

Astarte R., Bed D.

Dinosaur R., *Marattiopsis* Bed (Type-specimen).

These beds belong to the *Thaumatopteris* Zone, Bed D being transitional between the *Thaumatopteris* and *Lepidopteris* Zones.

*Diagnosis.* Sparingly branched twigs with an axis 2 mm thick, showing elliptical leaf scars and faint furrows along the sides of the leaf cushions. Leaves inserted spirally, but probably all lying in the horizontal plane as a result of the twisting of their bases; often inserted almost at right angles to the axis. Leaf dorsiventral, 7—12 mm long, 1—2 mm wide, apex acute, base contracted to a minute stalk 0.5 mm long. Lamina frequently bent, with leaf apex pointing backwards. Midrib conspicuous, lamina smooth, showing no characteristic "mesophyll".

Cuticle thin, upper side composed of uniform elongated cells with straight walls; surface of cell unpitted and without any median papilla. Lower cuticle showing two stomatal bands  $180\mu$  wide. Cells of most of under surface just like those of upper; cells of the stomatal bands small, surface very slightly thickened to form a very indistinct papilla. Stomata arranged in a few vertical rows, but occurring rather irregularly in their rows; subsidiary cells unspecialised and irregularly placed but their surface slightly thickened round the stomatal pit. Guard-cells orientated longitudinally. Encircling cells absent.

*Discussion.* *E. patens* is represented by seven twigs from Astarte R. with badly preserved cuticles and one fragment of a twig (the Type-specimen) from Dinosaur R. with a well preserved cuticle. The identification of the specimens from Astarte R. is not quite certain, but the part of the diagnosis which refers to the character of the axis is based on them.

In its general appearance *E. patens* resembles *Taxus*, *Tsuga*, and other living conifers though it differs in its cuticle, which is peculiar among conifers with petiolate leaves in having monocyclic stomata with little specialised subsidiary cells. The specific name refers to the spreading leaves

**Elatocladus pachyteichus** sp. nov.

Pl. 14, figs. 7, 10; Pl. 15, fig. 2; Text-fig. 30 D—F.

Type-specimen, Pl. 15, fig. 2.

*Occurrence.* Astarte R., *Gutbiera* Bed.This bed belongs to the lower half of the *Thaumatopteris* Zone.

*Diagnosis.* Slender twigs bearing spirally arranged leaves. Bases of leaves overlapping and covering surface of stem. Leaves typically

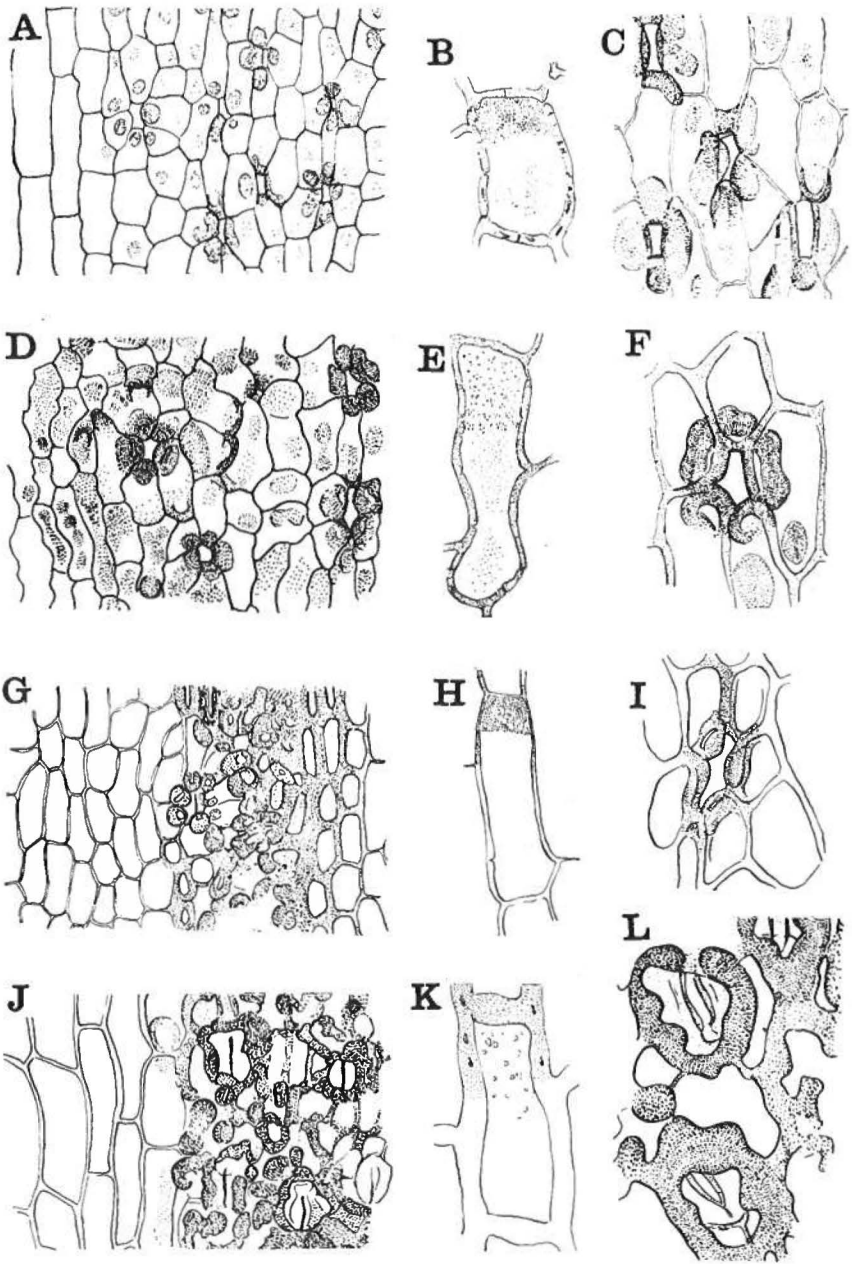


Fig. 27. *Elatocladus* spp.

A—C, *E. nitidus*, Slide 3131; D—F, *E. tuberculatus*, Slide 3151; G—I, *E. oligostomus*, Slide 3143, H. I. Slide 3142; J—L, *E. punctatus*, Slide 3121 (from Astarte R.). The figures on the left represent the lower cuticle,  $\times 200$ ; the middle figures a cell of the upper surface,  $\times 400$ ; the figures on the right represent stomata,  $\times 400$ . In all figures shading by dots (stippling) represents a thickened part, while rings, etc. represent pits.

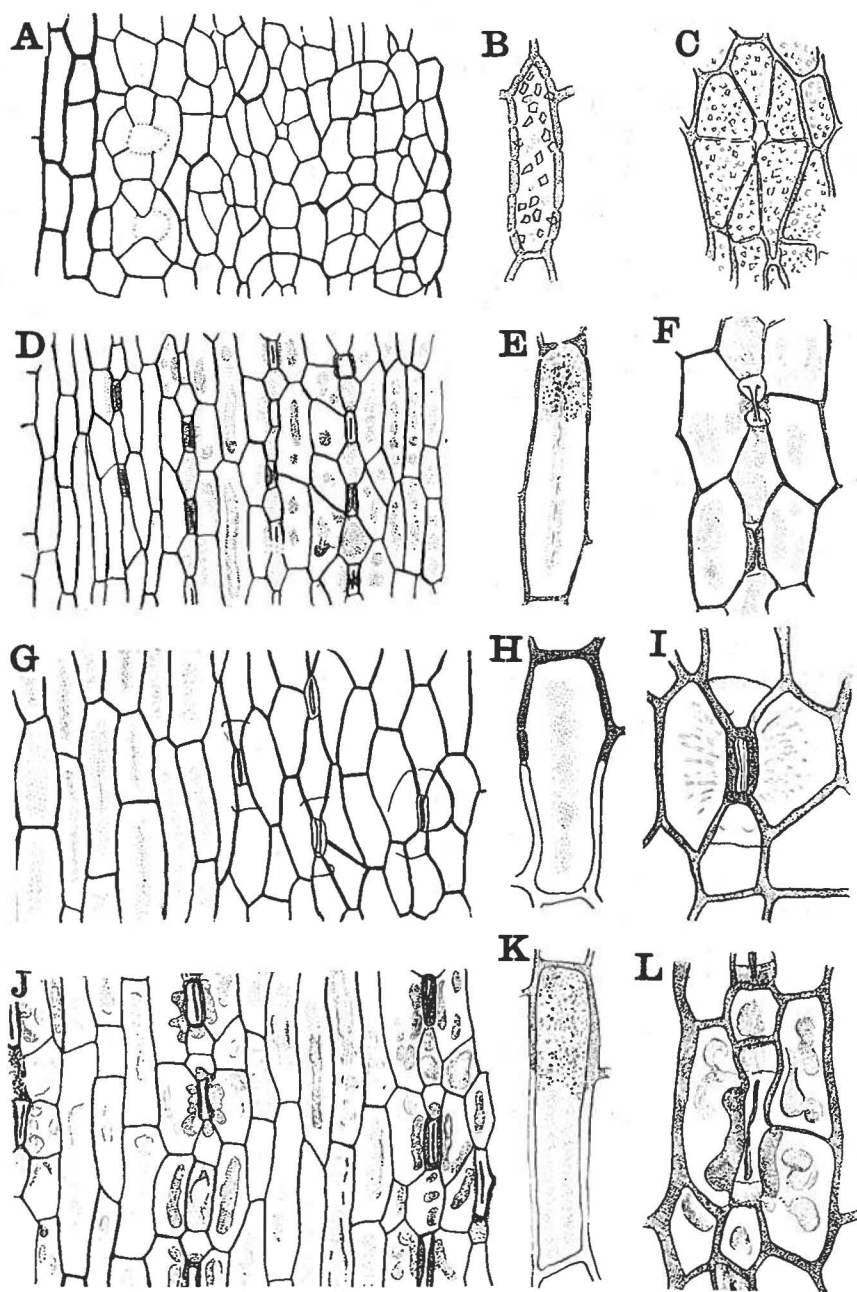


Fig. 28. *Elatocladus* spp.

A—C, *E. perforatus*, Slide 3161; D—F, *E. polystomus*, Slide 3201; G—I, *E. stenostomus*, Slide 3171; J—L, *E. stenocytus*, Slide 3192 (from Astarte R., Bed C). The figures on the left represent the lower cuticle,  $\times 200$ ; the middle a cell of the upper surface,  $\times 400$ ; the figures on the right a stoma,  $\times 400$ . In all figures shading by dots (stippling) represents a thickened part while rings, etc. represent pits.

5 mm long  $\times$  0.7 mm wide, but often shorter and forming small scales pressed to the stem. Base of leaf not at all contracted, apex acute, mid-rib rather inconspicuous, surface showing the outlines of short cells.

Cuticle moderately thick, upper side showing uniform square or slightly elongated straight-sided cells. Lateral cell walls rather thick, surface of cell bearing very fine and inconspicuous pits but usually appearing unpitted. Lower surface showing somewhat elongated cells with remarkably thick, but ill-defined lateral walls. Stomata occurring in bands  $150\mu$  wide, cells of stomatal band shorter and their walls a little more definite than the other cells of the under side, but otherwise very similar. Stomata orientated longitudinally, scattered, but with a tendency to occupy longitudinal rows. Stomatal pit an elongated slit. Subsidiary cells unspecialised but sometimes slightly thickened near the stomatal pit to form a very indefinite papilla which may project over the sides of the pit. Encircling cells absent.

*Discussion.* *E. pachyteichus* is represented by the Type-specimen and a number of similar shoots and a few leaf fragments obtained by the maceration of the rock in which the Type-specimen occurs. The cuticles of the different specimens are very similar to one another.

The name is from  $\pi\alpha\chi\upsilon\varsigma$ , thick, and  $\tau\epsilon\iota\chi\omicron\varsigma$ , a wall, and refers to the very thick-walled cells of the lower side.

### ***Elatocladus perforatus* sp. nov.**

Pl. 13, figs. 1, 2; Text-fig. 28 A—C (Type-specimen).

*Occurrence.* Astarte R., Bed C.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral leaf 1.0 mm broad; probably elongated. Cuticle moderately thick; upper showing uniform elongated cells with conspicuous, straight walls; surface of cell not locally thickened, but covered with conspicuous angular pits. Lower cuticle exactly like the upper but bearing two stomatal bands  $250\mu$  wide. Cells among stomata rather shorter and less regular than the others, also without papillae; stomata for the most part placed in regular longitudinal rows. Subsidiary cells usually forming a definite ring round the stoma, surface without any trace of a papilla, but often projecting to some extent over the stomatal aperture; stomatal pit rather small, of variable shape, but frequently a narrow slit. Guard cells very thinly cutinised; orientated longitudinally. Encircling cells absent from most stomata, but sometimes found opposite the lateral subsidiary cells.

*Discussion.* *E. perforatus* is only represented by the Type-specimen. Its name refers to the strongly pitted cuticle which appears almost to be perforated.

**Elatocladus stenostomus** sp. nov.

Pl. 13, figs. 3, 4; Text-fig. 28 G—I (Type-specimen).

*Occurrence.* Astarte R., Bed C.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral leaf 0.6 mm broad, length unknown. Cuticle moderately thick, upper showing uniform elongated cells with conspicuous, nearly straight walls, cuticle projecting inwards along margins of cells to an unusual extent. Surface of cell unpitted; showing an extremely faint median thickened ridge. Lower cuticle like the upper, but bearing two stomatal bands  $150\mu$  wide: cells among stomata shorter than the others and differing also in possessing no trace of a median ridge or papilla. Subsidiary cells without papillae, but surface usually marked by pits radiating from the stoma. Pit over stoma usually reduced to a minute slit. Encircling cells usually absent, but occasionally found opposite lateral subsidiary cells. Stomata orientated longitudinally, forming rather regular longitudinal rows.

*Discussion.* *E. stenostomus* is only represented by the Type-specimen.

The line crossing the polar subsidiary cells shown in the Text-figure might be taken to mark the boundary of subsidiary and encircling cells; but it seems to me to be a plate of cuticle extending into the epidermis along the wall between the guard cell and polar subsidiary cell. Such a plate is not usual in the conifers, but in this species the cuticle extends inwards along all cell walls to an unusual extent.

The name *stenostomus* refers to the narrowness of the stomatal pits.

**Elatocladus lacunosus** sp. nov.

Pl. 14, figs. 3, 4; Text-fig. 29 F (Type-specimen).

1926b. *Taxites* sp. A HARRIS, p. 123, Text-fig. 30 A—D (Type-specimen).

*Occurrence.* Vardekløft *Dictyophyllum* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral leaf 1.8 mm broad, length unknown. Cuticle fairly thick; upper side composed of uniform elongated cells with strongly marked, nearly straight lateral walls. Surface of cell slightly thickened to form an obscure median ridge and covered with minute pits. Cells constricted at the ends. Lower cuticle showing two well-defined stomatal bands  $320\mu$  broad. Epidermal cells along midrib rather narrow; those near margins resembling those of the upper surface, but with a much more conspicuous median ridge; those of stomatal band nearly isodiametric, possessing very prominent irregular ridges or papillae. Stomata arranged irregularly, but orientated longitudinally, surrounded by unspecialised subsidiary cells, papillae of subsidiary

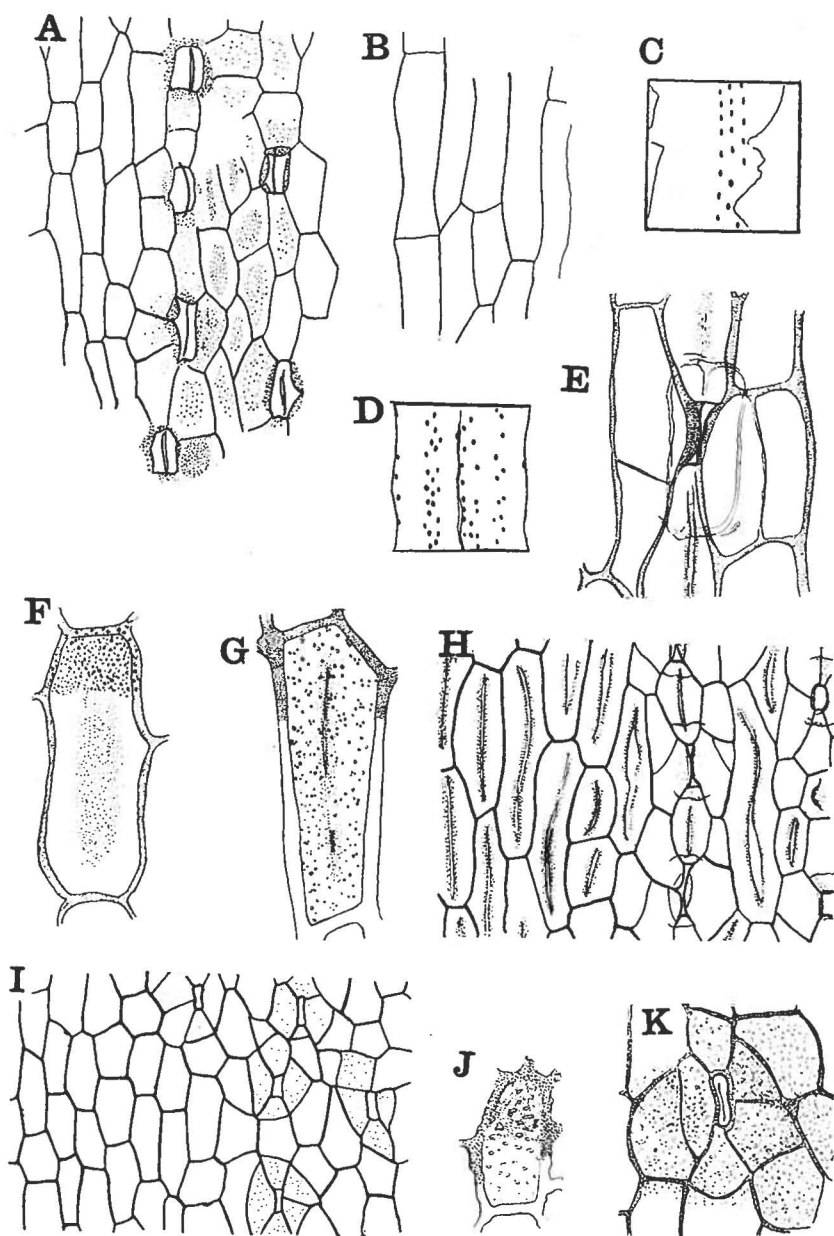


Fig. 29. *Elatocladus* spp.

A, *E. patens* lower cuticle, Slide 3111,  $\times 200$ . B, *E. patens* upper cuticle, Slide 3111,  $\times 200$ . C, *E. patens* distribution of stomata on lower cuticle; the square is 1 sq.mm. D, *E. polystictus* distribution of stomata on both sides of leaf (a slight amount of the cuticle was torn off from the margins in preparation), Slide 3210,  $\times 10$ . E, *E. molopicus* stoma, Slide 3251,  $\times 400$ . F, *E. lacunosus*, a cell of the upper side, Slide 481 (HARTZ Collection),  $\times 400$ . G, *E. molopicus*, cell of the upper side, Slide 3251,



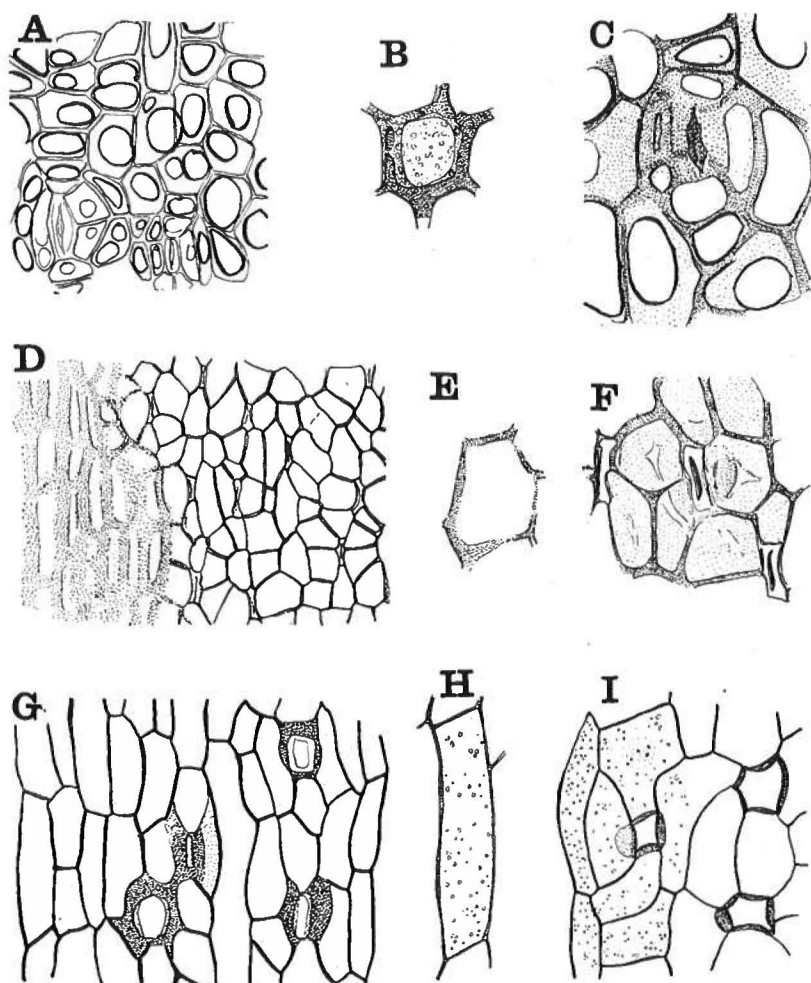


Fig. 30. *Elatocladus* spp.

A—C, *E. physetus*, Slide 3230 (Type-specimen). The stoma shown in C belongs to the upper surface. D—F, *E. pachyteichus*, Slides 3242, 3241; G, *E. eurystomus*?, Slide 3220,  $\times 200$ . H, I, *E. eurystomus* Type-specimen. — Figures A, D, G represent the stoma-bearing surface,  $\times 200$ ; B, E, H a single cell of the upper surface,  $\times 400$ ; C, F, I, stomata,  $\times 400$ .

$\times 400$ . H, *E. molopicus*, lower cuticle, Slide 3251,  $\times 200$ . I, *E. polystictus*, lower cuticle, Slide 3210,  $\times 200$ . J, *E. polystictus*, a cell of the upper side, Slide 3210,  $\times 400$ . K, *E. polystictus*, a stoma, Slide 3210,  $\times 400$ . — The specimen of *E. patens* was obtained from Dinosaur R., that of *E. polystictus* is the same as the one figured in Pl. 14, fig. 8, and was obtained from Astarte R., Bed C.

cells often overhanging the stomatal pit, but sometimes leaving the guard cells entirely exposed. No encircling cells present. Guard cells thinly cutinised.

*Discussion.* *E. lacunosus* is represented by a few fragments which very likely belong to a single leaf. The name *lacunosus* refers to the appearance of large gaps in the stomatal band; these gaps are apparently stomata which are unprotected by the papillae of the subsidiary cells. I have not seen anything similar in any other cuticle.

***Elatocladus punctatus* sp. nov.**

Pl. 12, figs. 5, 6; Text-fig. 27 J—L (Type-specimen).

*Occurrence.*

Lepidopteris R., *Lepidopteris* Bed.

Astarte R., Bed C (Type-specimen).

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral leaf 1.4 mm broad, length unknown. Cuticle fairly thick; upper side composed of uniform rectangular cells with broad, straight lateral walls. Surface of cells without any sign of a papilla but covered with small pits. Lower cuticle showing two well-defined stomatal bands  $200\mu$  broad, cells along the midrib narrow; those near margins like those of the upper surface but showing a very obscure median ridge; those of stomatal bands quite short, surface bulging to form a prominent hollow papilla of varied appearance which more or less obscures the cell outlines. Stomata arranged irregularly but orientated longitudinally. Subsidiary cells irregularly placed, papillae strongly developed, usually forming a more or less continuous thickened ring round the stomatal pit. Encircling cells probably absent.

*Discussion.* *E. punctatus* is represented by two very similar fragments. The specific name refers to the dotted appearance of the cells due to the small but conspicuous pits.

***Elatocladus nitidus* sp. nov.**

Pl. 12, figs. 1, 2; Text-fig. 27 A—C (Type-specimen).

*Occurrence.* C. Hope, *Anomozamites minor* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral conifer leaf 1.0—1.5 mm broad, length unknown. Cuticle fairly thick; upper side composed of uniform square or slightly elongated cells with conspicuous, nearly straight, pitted lateral walls. Surface of cell thickened to form a large indefinite papilla and covered with minute pits. Lower cuticle showing two well defined stomatal bands about  $150\mu$  broad. Epidermal cells of lower side about twice as long as broad, otherwise resembling those of upper side, cells of

stomatal bands small, bearing one or two well marked round, solid papillae. Stomata arranged irregularly, but with a tendency to form short vertical rows, surrounded by irregularly placed subsidiary cells, papillae of subsidiary cells forming a ring round the stomatal pit. Encircling cells occasionally present opposite lateral subsidiary cells, but more often absent.

*Discussion.* *E. nitidus* is represented by a good many leaf-fragments from C. Hope, which show almost uniform structure. The specific name refers to the neat appearance of the cuticle; the cells of the stomatal band being small and with unusually clearly marked walls and papillae.

***Elatocladus oligostomus* sp. nov.**

Pl. 12, figs. 9, 10 (Type-specimen); Pl. 18, fig. 9; Text-fig. 27 G—I.

*Occurrence.* Astarte R., *Gutbiera* Bed.

This bed belongs to the lower half of the *Thaumatopteris* Zone.

*Diagnosis.* Twigs slender, about 1 mm thick, bearing spirally arranged leaves, surface of stem marked with prominent decurrent leaf bases. Leaves usually inclined to the stem at an angle of about 70°, but sometimes irregular. Leaf 7—11 mm long, 0.9 mm wide in the lower part, tapering slightly towards the apex; apex acute, base contracted to a petiole 0.4 mm wide, nearly 1 mm long. Midrib rather conspicuous, surface covered with longitudinal cell-striations and also showing transverse wrinkles due to the "mesophyll".

Cuticle moderately, but not very thick, upper side showing uniform elongated cells with straight walls. Surface of cells without any median papilla, either apparently unpitted or (after long maceration) showing innumerable very fine dots. In some specimens whole of interior of cell slightly thickened. Lower side showing two well defined narrow stomatal bands about 60  $\mu$  wide. Epidermal cells of stomatal bands small and with a more or less bulging surface forming a hollow papilla, those of the rest of the lower surface like those of the upper surface. Stomata arranged irregularly, surrounded by a fairly definite ring of about six subsidiary cells which resemble the other cells of the stomatal band. Encircling cells often present round the scattered stomata at the base of the leaf, but absent from those of the stomatal bands.

*Discussion.* *E. oligostomus* is represented by several leafy twigs and a good many fragments from macerations. The specific name refers to the fewness of its stomata which are confined to remarkably narrow bands.

***Elatocladus tuberculatus* sp. nov.**

Pl. 12, figs. 3, 4; Text-fig. 27 D, E, F (Type-specimen).

*Occurrence.* Lejr R., *Ginkgoites* Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis.* Dorsiventral leaf about 3 mm broad; of unknown length. Cuticle fairly thick; upper side composed of uniform elongated cells with undulating lateral walls, surface finely pitted without any definite median thickened ridge. Lower side possessing similarly shaped cells, but with their surface thickened to form a row of papillae or else a continuous ridge, cells among stomata small, with prominent irregular papillae. Stomatal band well defined,  $500\mu$  broad, stomata scattered, but with a tendency to form longitudinal rows. Subsidiary cells small, with very strongly developed papillae forming conspicuous rings round the stomata. Encircling cells absent.

*Discussion.* *E. tuberculatus* is represented by one leaf fragment but it seems never the less to be sufficiently distinct to merit description. It most resembles *Storgaadia spectabilis*, but differs in being a narrower leaf with a thicker cuticle. Its cells have more strongly developed papillae or ridges.

The name *tuberculatus* refers to the irregular papillae on the cells round the stomata.

***Elatocladus amblus* sp. nov.**

Pl. 16, fig. 8, 9; Pl. 19, figs. 15, 16, 18, 19; Text-fig. 31 F, G.

Type-specimen, Pl. 19, fig. 18.

*Occurrence.*

Dinosaur R., Coal Bed (frequent).

C. Hope, Coal Bed (rare).

Neill Cliff, Coal Bed (rare).

These beds of coal belong to the *Thaumatopteris* Zone; the Neill Cliff Bed being transitional between this and the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral leaf 1.2—1.5 mm broad, length unknown. Margin finely serrate (nearly smooth in certain specimens), apex rounded. Cuticle thick; upper side showing uniform rectangular cells with thick, nearly straight lateral walls. Surface of cell rather coarsely pitted, but with no trace of a median thickened papilla. Lower surface showing one median or two lateral bands of stomata; stomatal bands well-defined,  $200\mu$  wide. Cells of lower surface like those of upper surface, but often less coarsely pitted, usually without any distinct median thickening, but in some specimens the cells near the stomatal groves showing an ill-defined median thickened ridge. Cells of stomatal band smaller, often nearly square; surface occasionally almost unthickened, but often showing more or less conspicuous papilla. Stomata not forming definite longitudinal rows, subsidiary cells resembling other cells of stomatal band in size, but with much more strongly developed thickenings which unite to form a conspicuous ring round each stoma. Surface of subsidiary cells often showing a very thin strip just outside the thickened

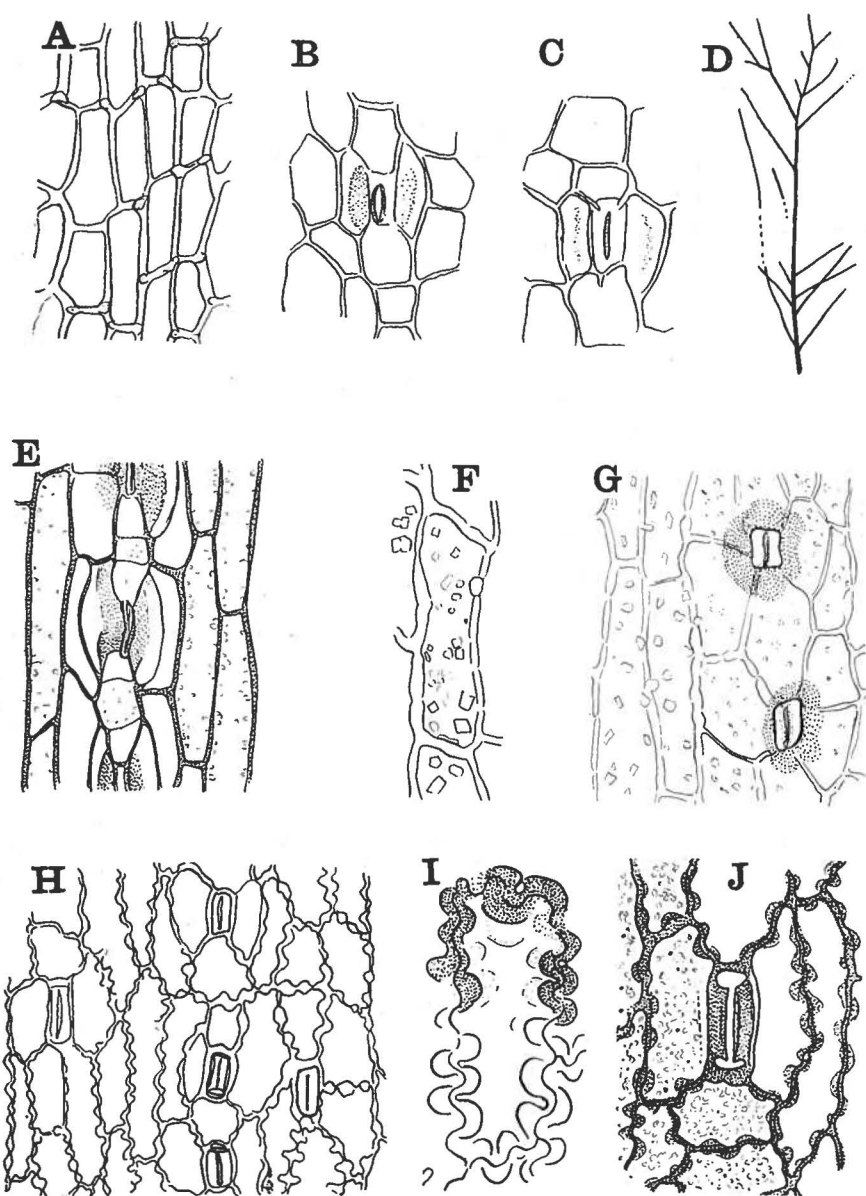


Fig. 31.

A—D, *Ontheodendron sternbergi*. A, upper cuticle, Slide 3082,  $\times 400$ . B, C, stomata, Slide 3082,  $\times 400$ . D, diagram of the branches (leaves omitted) of a large specimen No. 3372,  $\frac{1}{10}$  natural size. E, *Elatocladus* sp. B, Stomata, Slide 3271,  $\times 400$ . F, *E. amblus*, cell of upper surface, Slide 3281,  $\times 400$ . G, *E. amblus*, Stomata, Slide 3281,  $\times 400$ . H, *E. sp. A*, lower cuticle, Slide 3281,  $\times 200$ . I, *E. sp. A*, cell of upper surface, Slide 3281,  $\times 400$ . J, *E. sp. A*, stoma,  $\times 400$ . — The specimen shown in A—C was obtained from Ryder R., *Clathropteris* Bed; that in D from Vardekloft *Dictyophyllum* Bed.

ring round the stoma. Guard-cells very thinly cutinised, stomatal aperture about  $10\mu$  long, but seldom visible. Encircling cells absent.

*Discussion.* *E. amblus* is a rather variable species; the most remarkable variation being in the number and position of the stomatal bands. Complete intergradation is, however, shown in the other variable characters — the development of marginal teeth, and of the papillae in the stomatal band, and it does not seem to me possible to make any specific distinction between the leaves with one, and those with two stomatal bands.

***Elatocladus stenocytus* sp. nov.**

Pl. 13, figs. 7, 8 (Type-specimen); Text-fig. 28 J, K, L.

*Occurrence.*

Astarte R., *Lepidopteris* Bed, Bed C.

C. Stewart *A. minor* Bed.

C. Stewart *Ginkgo minuta* Bed.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Conifer leaf about 2 mm broad, of unknown length. Cuticle fairly thick, upper showing uniform elongated straight-sided cells. Surface of cells covered with fine pits and showing an obscure median ridge. Lower surface showing similar cells, but median ridge more obvious. Stomata occurring in two bands  $400\mu$  broad, each stomatal band composed of three or four uniseriate rows of stomata. Stomata orientated longitudinally, arranged very regularly in their rows, usually possessing two large lateral subsidiary cells and two small terminal ones. Stomatal aperture well-marked, about  $30\mu$  long, subsidiary cells possessing several conspicuous, irregularly arranged papillae, some of which usually form a thickened rim to the stomata.

*Discussion.* *E. stenocytus* is represented by several closely similar fragments. The specific name refers to the narrowness of the epidermal cells which, owing to the presence of a median ridge, appear very narrow indeed.

***Elatocladus polystomus* sp. nov.**

Pl. 13, fig. 9, 10; Text-fig. 28 D, E, F (Type-specimen).

*Occurrence.* Astarte R., Bed C.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral leaf probably about 2 mm broad, length unknown. Cuticle fairly thick; upper showing uniform elongated cells with straight sides. Surface finely pitted and often showing a faint longitudinal ridge of thickening on which the pits may be replaced by a longitudinal slit. Lower surface showing similar elongated cells, surface showing a rather more conspicuous ridge or row of papillae. Stomatal

bands very broad; stomata orientated longitudinally, arranged regularly in numerous, crowded longitudinal rows. Stomata usually possessing two small terminal subsidiary cells and two large lateral ones. Lateral subsidiary cells possessing a number of papillae, some of which often overhang the guard-cells. Encircling cells absent.

*Discussion.* *E. polystomus* is represented by two fragments, neither of which shows the whole width of the leaf. It is therefore not impossible that the fragments may belong to a much broader leaf than stated in the diagnosis.

The name *polystomus* refers to its relatively numerous stomata.

***Elatocladus molopicus* sp. nov.**

Pl. 14, fig. 1, 2; Text-fig. 29 E, G, H (Type-specimen).

*Occurrence.* Astarte R., Bed C.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral conifer leaf about 2 mm broad. Cuticle fairly thick; upper side composed of uniform rather large elongated cells with straight, conspicuous walls. Surface of cell bearing a number of small but conspicuous pits and in addition a rather obscure thickened ridge down the middle of the cell. Lower cuticle showing epidermal cells of similar shape but with a very much more conspicuous median ridge down the middle of which is a thin strip where the cuticle often splits. Stomata probably occurring in two broad, rather ill-defined bands; cells among the stomata irregular, the smaller ones having relatively feeble ridges, the larger ones strong ridges. Stomata occurring in short vertical rows, the stomata of a row being spaced regularly and separated from one another by a single terminal subsidiary cell. Subsidiary cells rather small, the lateral without but the terminal with median ridges. Stomatal pit elongated, often reduced or obliterated by papilla-like ingrowths of the lateral subsidiary cells. Encircling cells usually, but not invariably occurring opposite the lateral subsidiary cells, but very irregular in size and position. Cuticle of guard cells often rather conspicuous — particularly at the poles of the stoma.

*Discussion.* *E. molopicus* is only represented by the Type-specimen; it is quite a small fragment which does not even show the whole width of the leaf, but the character of its cuticle seems sufficiently remarkable to merit description. *E. molopicus* is rather like *E. stenostomus* (in which there is a tendency for the stomata to be arranged in similar vertical rows and in which lateral encircling cells are occasionally found) but the cells of the under side differ in having a much more obvious median ridge and pits. *E. lacunosus* has similar epidermal cells, but the distribution of its stomata is quite different.

The specific name *molopicus* is from *μολωπικός*, covered with weals, and refers to the weal-like marks on the cells of the under side.

**Elatocladus sp. A.**

Pl. 20, fig. 6, 7; Text-fig. 31 H, I, J.

*Occurrence.* Astarte R., Bed A.

This bed belongs to the *Lepidopteris* Zone.

*Description.* The only specimen is a minute fragment of cuticle which does not show the whole width of the leaf. The cuticle is rather thick on both sides. The upper which is without stomata, shows elongated cells with sinuous walls with prominent zigzag thickenings which extend some way over the surface of the cell. No median papillae occur, and the surface of the cell shows no definite pits — apart from the relatively thin places between adjacent thickenings of the lateral wall. The lower cuticle is slightly thinner than the upper; its cells are similar, except that the cell walls have rather less sinuous outlines and have less prominent jagged thickenings, and the surface of the cells shows small and rather obscure pits.

The relation of the distribution of the stomata to the vein or veins is unknown, but they are orientated longitudinally and occur in longitudinal rows, though they are not quite regularly spaced in their rows. The subsidiary cells are almost exactly like the other epidermal cells; most frequently there are two lateral ones and two terminal ones. Encircling cells often, but no means always, are recognisable opposite the subsidiary cells.

A peculiar feature which I attribute to bad preservation is that a sharply defined thin area in the cuticle occurs round many of the stomata (Pl. 20, fig. 7). The outline of this thin area has no relation to that of the cells and is omitted in the Text-figure.

*E. sp. A.* is interesting because it shows a nearer approach to the cuticle of many of the Abietineae (e. g. *Abies*, *Picea*) than any other Greenland Conifer.

**Elatocladus sp. nov. 'B'.**

Pl. 16, fig. 18; Text-fig. 31 E.

*Occurrence.* Astarte R., *Lepidopteris* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Description.* ?Dorsiventral leaf probably over 1 mm broad. Cuticle fairly thick, upper side unknown; lower side showing stomata in well-marked rows. Epidermal cells elongated, rectangular, with straight sides, surface rather obscurely pitted, occasionally showing very indistinct median thickened ridges. Cells near stomata sometimes showing a number of irregular, indistinct papillae. Subsidiary cells regularly placed (except



where two stomatal rows are very close to one another laterally), typically consisting of two lateral ones and two terminal. Surface of the subsidiary cells — especially the lateral ones — strongly thickened near the stomatal pit. Terminal encircling cells always present, lateral encircling cells usually present. Stomatal pit forming an elongated slit; guard-cells orientated longitudinally.

*Discussion.* *E. sp. B* is only represented by a fragment of the lower cuticle, which, although quite distinct, shows too little of the form of the leaf to be worth a specific name.

***Elatocladus polystictus* sp. nov.**

Pl. 14, figs. 8, 9; Text-fig. 29 D. I—K.

Type-specimen Pl. 14, fig. 9.

*Occurrence.*

Astarte R., Bed C.

C. Hope, *A. minor* Bed (Type locality).

Neil Cliffs *N. hoerensis* Bed.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Conifer leaf 0.7—0.9 mm wide, sometimes at least only about 3 mm long, apex acute, base probably uncontracted. Margins bearing minute teeth near the leaf apex. Cuticle fairly thick, only very slightly thicker on one side (? the upper side) than on the other. Epidermal cells nearly uniform, isodiametric or slightly elongated with straight, rather prominent walls. Surface pitted, usually without any median papilla but occasionally with a large ill-defined median thickening. Stomata varying in their distribution, sometimes occurring in two fairly broad ill-defined bands on the under side and two narrower bands on the upper, sometimes scattered over the under surface and only occurring rarely on the upper. Stomata orientated longitudinally, showing a slight tendency to form vertical rows, but irregularly spaced in the rows. Subsidiary cells slightly thicker than the other cells and often less pitted, surface of subsidiary cell sometimes slightly thickened to form a rather indefinite papilla, but usually without any local thickening, apart from a thickening along the side of the stomatal pit. Stomatal pit more or less rectangular, elongated longitudinally. Encircling cells almost always present opposite all of the subsidiary cells; an outer ring of encircling cells occasionally present.

*E. polystictus* is represented by five fragments. As indicated in the diagnosis and by the two photographs on Pl. 14 these differ in structure to some extent, but the differences seem to be of little importance as they are shown between the top and bottom of one specimen.

The name *polystictus* is from πολύ, many, and στικτός, punctured, and refers to the numerous pits in the cuticle.

**Elatocladus physetus** sp. nov.

Pl. 14, fig. 5, 6; Text-fig. 30 A, B, C.

The figures represent the Type-specimen.

*Occurrence.* Vardekloft *Stachyotaxus* Bed.This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Dorsiventral conifer leaf 1.5 mm broad. Upper cuticle moderately thick bearing a few stomata near the margins, lower cuticle rather thin, bearing numerous rows of stomata over its whole surface. Cells of the middle region of the upper surface nearly isodiametric, outlines straight, not very conspicuous, surface of middle of cell bulging strongly as a large dome-shaped hollow papilla, surface of papilla only thinly cutinised, covered with minute dots or pits. Margins (which bear stomata) resembling the under surface. Cells of under surface like those of upper surface, but outlines fainter and surface bearing a rather smaller, but equally conspicuous hollow papilla, surface of papilla scarcely cutinised at all. Stomata occurring for the most part in fairly definite longitudinal rows surrounded by a definite ring of subsidiary cells and by a complete ring of encircling cells. Cuticle of subsidiary cells bearing hollow papillae which are much less strongly developed than those of the ordinary epidermal cells, stomatal pit fairly wide; encircling cells unspecialised. Stomata of upper surface with rather narrower stomatal pits.

*E. physetus* is only represented by the Type-specimen.

The specific name *physetus* is from φυσήτος, inflated, and refers to the bulging epidermal cells.

**Elatocladus eurystomus** sp. nov.

Pl. 16, fig. 13; Text-fig. 30 G—I.

All figures but Text-fig. 30 B represent the Type-specimen.

*Occurrence.* Astarte R., Bed C.This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Needle-shaped conifer leaf 0.8 mm broad, of unknown length. Cuticle moderately thick, epidermal cells elongated, nearly rectangular and straight-sided except among the stomata where they are often quite short and may have irregularly curved sides. Surface of cell marked with a number of fairly small, but conspicuous pits, as a rule showing no trace of a median papilla. Stomata occurring in four to six fairly narrow bands, rather irregularly scattered in the stomatal band but with a tendency to be placed in longitudinal rows. Guard-cells, where visible, orientated longitudinally. Subsidiary cells forming an irregular ring, pit over stoma remarkably wide, often as wide as long, margins of pit slightly thickened, pit occasionally constricted by ingrowths

from one or more of the subsidiary cells. Encircling cells very often present opposite one or more of the lateral subsidiary cells but never forming a definite ring.

*E. eurystomus* is represented by two fragments — the type which is figured and another which has rather thicker cell walls, less irregular cells among the stomata and rather more frequent encircling cells round the stomata.

The specific name *eurystomus* is from εὐρύς, wide, and *stomus*, and refers to the wide stomatal pits.

### ELATOCLADUS sp. C.

Text-fig. 32.

*Occurrence.* C. Stewart, *Todites* Bed.

This bed belongs to the top of the *Thaumatopteris* Zone.

*Description.* The only specimen found is represented in Text-fig. 32. The leaves are preserved as a delicate brown film in which the midrib is conspicuous but no regular mesophyll structure can be seen. The cuticle is quite thin and it was only possible to obtain preparations from the midrib where the cells are elongated and have thin, straight walls. The distribution of the stomata is unknown, but in the unmacerated

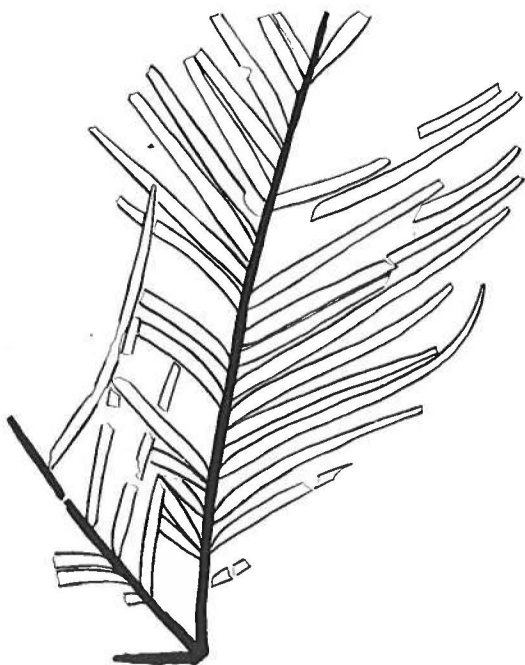


Fig. 32. *Elatocladus* sp. C.  
Specimen No. 3441,  $\times 1$ .

leaf there is a rather narrow band of dark bodies which may be stomata on either side of the midrib and close to it.

*Comparison.* *E. sp. C* differs from *Storgaadia* in having much narrower leaves, and it has a much thinner cuticle than any of the preceding species of *Elatocladus* except *E. patens*. Isolated one-veined leaves which might belong to this species have been described from various floras under such names as *Taxites longifolius* and *Pityophyllum sp.* Although *E. sp. C* seems quite distinct, too little is known about its cuticle to make it worth describing as a new species.

### Genus **ONTHEODENDRON** SAHNI and RAO.

1931 (or 1933). *Ontheodendron* SAHNI and RAO, p. 199.

Type-species *O. florini* SAHNI and RAO, p. 200.

#### **Ontheodendron sternbergi** (NILSSON) N. Comb.

Pl. 11, figs. 5, 12—15, 18; Pl. 15, figs. 1, 4—11; Text-fig. 31 A—D.

1831. *Abies Sternbergi* NILSSON, p. 350; Pl. 3, figs. 1, 2.

1878c. *Palissya Brauni* NATHORST (non ENDL.), p. 28; Höganäs, Pl. 4, figs. 1—3 (NILSSON's Type-specimen).

1886. *Palissya Sternbergi* (NILSSON) NATHORST, p. 107; Pl. 23, figs. 8—12; Pl. 24; Pl. 25, figs. 5—8.

#### *Occurrence in Greenland.*

Lepidopteris R., *Lepidopteris* Bed (shoots).

Ryder R., *Clathropteris* Bed (shoots).

?Hare R., Lower Plant Bed (field record of shoot).

Astarte R., Bed D (shoots and cones).

Vardekløft *Dictyophyllum* Bed (shoots and cones).

These beds belong to the *Lepidopteris* Zone except Astarte R., Bed D, which is transitional between this and the *Thaumatopteris* Zone.

#### *Description of the Greenland specimens.*

1. The Shoots. This conifer is often abundant and is represented by large specimens — e.g. that represented in Text-fig. 31 D is nearly 50 cm long. Nearly all the shoots retain their leaves. The size of the leaves varies somewhat; see Pl. 15, where extreme forms are shown.

The cuticle of the leaf is thin and badly preserved. The upper shows uniform, slightly elongated straight-walled cells, the surface of which is unpitted and without papillae. The lower cuticle probably has two rather broad and ill-defined bands of stomata; the stomata are scattered but are orientated longitudinally. The epidermal cells are like those of the upper side but their walls are less distinct. The subsidiary cells are unspecialised — except that the lateral ones may show a faint longitudinal ridge on their surface; there are no encircling cells (unless the

ridge interpreted as being on the subsidiary cells really marks a division between them and encircling cells).

2. The Cone. Typical cones are shown on Pl. 11, fig. 15. As will be seen, their length varies and also the curvature of the cone scales which are sometimes adpressed, sometimes recurved. Each cone scale consists of a basal part 3 mm wide  $\times$  5 mm long (bearing the seed), and a part 1 cm long beyond the seed tapering from 2 mm to an acute apex. The substance of the cone scale is quite thin. The seeds are oval, 3 mm long  $\times$  2 mm broad and are borne singly in a median position on the cone scales. The cone scales have a thin cuticle showing rectangular straight-walled cells.

The seed possesses a rather thickly cutinised megaspore membrane which is finely pitted but shows no other structure. One end of the megaspore is invested in a rather delicate cuticle (probably the nucellus) showing elongated cells with fine, straight walls. The fact that this only occurs near the end of the seed suggests that the nucellus is fused with the integument to near the apex. Outside this are traces of an exceedingly delicate cuticle (probably the inner cuticle of the integument). The outer cuticle of the integument and the micropyle were broken away in maceration and were not recognised.

The cone scales were never found detached and probably were never shed from the cones, but as most of the cones yielded very few seeds when macerated, it is probable that the seeds had dropped out on ripening.

No ligule was recognised, and the orientation of the seed on the cone scale is unknown.

#### Discussion.

1. Specific Identification. The Greenland shoots were identified with one another on their macroscopic characters — the cuticle was too poorly preserved to give much assistance. The various cones were identified with one another on their macroscopic characters and on the seeds they yielded on maceration. Both shoots and cones were identified with the Swedish ones on their macroscopic characters. The cones had already been referred to the same plant as the shoots by NATHORST (on the grounds of association). This is supported by their association in Greenland and by the specimen shown in Pl. 15, fig. 4, in which a cone is still attached to a twig typical leaves of *O. sternbergi*.

No cone is known which is likely to be confused with *O. sternbergi* (*O. florini* has much larger seeds and *Ourostrobos* — see p. 116, is more slender), but the foliage cannot at present be distinguished satisfactorily from that of *Palissya sphenolepis* (= *P. brauni*) (see SCHENK 1867, NATHORST 1908c), though the cones are quite different. NATHORST has discussed the difference between the appearance of the leaves of the

two plants and admits that they are very similar; I am unable to distinguish between them. The two conifers, however, seem to have different cuticles, *P. sphenolepis* having a narrower and *O. sternbergi* a broad stomatal zone, but unfortunately neither is adequately known. The foliage of the two species has thus little stratigraphic value at present, though from the cones it appears that *P. sphenolepis* is confined to the *Thaumatopteris* and *O. sternbergi* to the *Lepidopteris* Zone.

2. Affinities. I have identified this cone with the genus *Ontheodendron*, because it agrees perfectly with the diagnosis, though I admit that the identification is not quite reliable as in neither species is much known about the seeds. The chief apparent difference is in the ridge on the cone scale of *O. florini* (interpreted as a ligule), a feature which has not been recognised in *O. sternbergi*.

SAHNI and RAO concluded that *O. florini* stands nearest to the Araucariaceae though they point out the differences in the shape of the scales and in the fact that the seeds were dropped from the scales. The cone of *O. sternbergi* is even less Araucarian in form and the foliage too is different; but I agree that *Ontheodendron* should be tentatively referred to the Araucariaceae.

## Comparison of the Greenland needle-leaved Conifers.

### General Comparison.

1. Stomata restricted (so far as is known) to two bands on the lower surface.
  - A. Stomata not regularly spaced in rows. (The stomata are normally monocyclic in all this group).
    - a Stomatal pit surrounded by a conspicuous ring of papillae:—
 

|                            |                               |
|----------------------------|-------------------------------|
| <i>Elatocladus nitidus</i> | <i>E. oligostomus</i>         |
| <i>E. lacunosus</i>        | <i>E. tuberculatus</i>        |
| <i>E. punctatus</i>        | <i>E. amblus</i>              |
|                            | <i>Storgaadia spectabilis</i> |
    - β Stoma not surrounded by well-marked papillae:—
 

|                           |                                 |
|---------------------------|---------------------------------|
| <i>Elatocladus patens</i> | <i>E. stenostomus</i>           |
| <i>E. pachyteichus</i>    | <i>Ontheodendron sternbergi</i> |
| <i>E. perforatus</i>      | <i>Stachyotaxus elegans</i>     |
  - B. Stomata regularly spaced in definite rows.
    - a Stomata normally monocyclic:—
 

|                               |                      |
|-------------------------------|----------------------|
| <i>Elatocladus stenocytus</i> | <i>E. polystomus</i> |
|-------------------------------|----------------------|
    - β Stomata normally amphicyclic:—
 

|                              |                  |
|------------------------------|------------------|
| <i>Elatocladus molopicus</i> | <i>E. sp. B.</i> |
| <i>E. sp. A.</i>             |                  |

2. Stomata not restricted to two bands; some usually occurring on the upper surface.

All have rather irregularly spaced stomata.

*a* Stomata monocyclic:—

*E. eurystomus*

*β* Stomata amphicyclic:—

*E. physetus*

*E. polystictus*

3. Cuticle structure not known:—

*Stachyotaxus septentrionalis*, *Elatocladus* sp. *C* (imperfectly known in *Ontheodendron sternbergi*).

### Specific Comparison.

Group      *Specific feature* (other features are mentioned in the diagnosis).

- 1 A *a*. Cell walls undulating;

leaf 3 mm wide, cuticle thick..... *E. tuberculatus*

leaf 8 mm wide, cuticle thin..... *Storgaadia spectabilis*

Cell-walls nearly straight, surface coarsely pitted;

cells among stomata bulging..... *E. punctatus*

cells among stomata nearly flat..... *E. amblus*

Cell-walls nearly straight, surface finely pitted, or unpitted;

cells with a median ridge..... *E. lacunosus*

cells with a small, definite papilla..... *E. nitidus*

cells with no conspicuous ridge or papilla, stomatal

groove very narrow ..... *E. oligostomus*

- 1 A *β*. Cuticle thick;

cell-outline very thick..... *E. pachyteichus*

cell-surface coarsely pitted, without a ridge.. *E. perforatus*

cells unpitted, with a median ridge..... *E. stenostomus*

Cuticle thin (seldom appearing in bulk-macerations);

very small stomata..... *Stachyotaxus elegans*

narrow stomatal band, leaf petiolate ..... *E. patens*

?broader stomatal band, leaf-base uncontracted

*Ontheodendron sternbergi*

- 1 B *a*. Crowded stomatal rows ..... *E. polystomus*

Sparse stomatal rows..... *E. stenocytus*

- 1 B  $\beta$ . Cells with median ridge..... *E. molopicus*  
 Cells without median ridge;  
     cell walls sinuous..... *E. sp. A.*  
     cell walls straight ..... *E. sp. B.*
- 2 *a.* ..... *E. eurystomus*
- 2  $\beta$ . Cells bulging..... *E. phyetus*  
 Cells not bulging ..... *E. polystictus*

*General discussion of the Greenland needle-leaved Conifers.*

Twenty-five species have been found — a number which greatly exceeds that in any other flora, but as four-fifths of these species are very rare and have only been obtained by a method (bulk-maceration) which has not been applied to any other flora, there is no reason to think that the Greenland flora is particularly rich in such conifers.

It would be interesting to compare the cuticles of these fossil conifers with those of the living ones, but in our present state of ignorance about the fossil conifers in general, any comparison I would be able to give would certainly be worthless. It is a striking fact that many of the best known conifers of the Older Mesozoic — *Cheirolepis*<sup>1</sup>), *Stachyotaxus*, *Voltzia*, *Palyssia*, *Cycadocarpidium* (*Podozamites*) are difficult, and in some at least impossible, to fit into existing families; there is every reason to think that many of the less well-known will ultimately prove to be equally different from any living conifer.

While it is possible to match the cuticles of some of the fossils fairly closely with living genera (see FLORIN 1931), there is an interesting general difference between them. Most of the fossils (17 out of 23) have monocyclic stomata; but the majority of recent conifer genera have amphicyclic stomata.

Broad-leaved Conifers.

Form-genus **PODOZAMITES** BRAUN.

1843. *Podozamites* BRAUN in MÜNSTER, Heft VI, p. 36.

*Podozamites* is the most abundant genus in Greenland and in two respects it is the least satisfactory:— it is not clear that it is a natural genus and it is nearly impossible to delimit the species. Both difficulties are very probably due to the extreme delicacy of the cuticle. In any locality, it is true, all the leaves usually seem to belong to one or two types which could be regarded as species were it not that the types characterising other localities seem seldom, if ever, quite the same — the range of variation and what may be termed the average differs though selected specimens may be quite indistinguishable. Under these

<sup>1</sup>) Knowledge of this genus has recently been greatly advanced by HÖRHAMMER (1933) and HIRNER and HÖRHAMMER (1934).



circumstances it has seemed to me best to distinguish the more definite types as species and to leave those which are less distinct without any definite specific name. I have only been able to obtain satisfactory preparations of the cuticle from exceptionally well-preserved specimens, and in the absence of reliable evidence about structure I have been forced to rely on characters which I regard as less satisfactory, such as the details of venation (which varies somewhat within the limits of a species) and on the fine surface markings of the lamina and the nature of the interstitial ducts between the veins (which vary somewhat in appearance according to the preservation).

I had hoped to be able to use the sporophylls (*Cycadocarpidium*) as a guide to the species of the associated *Podozamites* leaves, but, as will be seen from the table on p. 101, this is very difficult.

Affinities. Although it is likely that the Greenland species of *Podozamites* may belong to several natural genera; they agree sufficiently to be considered together. Evidence is provided by:—

1. The gross morphology of *Podozamites*.
2. The structure (the cuticle only is known in certain species).
3. The female reproductive organs (*Cycadocarpidium*), and possibly also *Swedenborgia*.

1. *Podozamites* has been regarded as a pinnate leaf, but later, as a result of NATHORST's discovery that the leaves of certain species are attached spirally, it has been regarded as a leafy stem; it was therefore first regarded as a Cycad, then as a Conifer. The considerable majority of Greenland species have spirally arranged leaves like NATHORST's specimens; in a few they are arranged in two ranks, but in these too they appear to be more like leaves than the segments of a leaf in their method of attachment. To judge from their irregular arrangement, the leaves of the majority of Rhaetic and Jurassic *Podozamites* shoots are attached spirally; but in the Cretaceous species (as for example those figured by VELENOVSKY and VÍNIKLAR) they look more like segments of a leaf.

2. The cuticle, which is known in two species, appears to be of the usual Gymnosperm type (i.e. agreeing in essentials with nearly all Gymnosperms but the Bennettitales). In detail, it appears in both species to be of a type which can be matched in the Conifers, but which is rather different from anything known in the recent Cycads.

SEWARD (1919, p. 453) discussed the possibility that the isolated Jurassic leaves determined as *Podozamites*, whose cuticle has been described by HOLDEN (1915, p. 223) may belong to *Phoenicopsis*.

3. The megasporophyll, *Cycadocarpidium*, has been compared with the megasporophyll of *Cycas*, *Dioon*, etc., but I prefer the view which

regards it as being essentially like the cone-scale of the Abietineae — that is to say that it consists of a single stalk bearing a large “bract scale” with an “ovuliferous scale” on its upper surface (see p. 99). The organisation of the whole cone does not appear to provide any conclusive evidence.

The female cone *Swedenborgia* which I think may belong to other species of *Podozamites*, is of a coniferous type and is very like that of *Cryptomeria*.

On the evidence given above, it is clear that *Podozamites* must be removed from the Cycads and it may be provisionally referred to the Conifers which it resembles more closely than any other group. If a Conifer, it certainly belongs to a distinct family. I am disinclined to refer it to an intermediate position between the Conifers and the Cycads (which SCHUSTER has suggested), for this important position would seem to depend not so much on any proof that its leaves and its sporophylls are intermediate between those of the two classes as on our ignorance of their essential nature. *Podozamites* cannot be intermediate unless we are prepared to admit the morphological homology of a leafy shoot of *Agathis* and a leaf of *Zamia* and also the cone scale of *Cycas* and *Pinus* (I admit, however, that the genus *Podozamites* may be unnatural and include species with purely Cycad affinities).

It is possible to classify the Greenland species of *Podozamites* in two groups — the species with spirally arranged leaves (recognisable even in poorly preserved specimens by the apparent irregularity of their insertion) and species in which they are arranged distichously.

#### 1. Species with spirally arranged leaves.

##### ***Podozamites stewartensis* HARRIS.**

Pl. 13, figs. 5, 6; Pl. 16, figs. 15, 16; Text-fig. 33/34, 37 D, E, G.

1926b. *Podozamites stewartensis* HARRIS, p. 113; Pl. 6, fig. 4; Pl. 13, fig. 3; Text-fig. 28 A—G.

SZE 1931, p. 20, gives a useful list of figures of specimens, many of which resemble *P. stewartensis* rather closely.

##### *Occurrence.*

Vardekloft *Dictyophyllum* Bed (abundant); *Anomozamites minor* Bed.

Tancredia R., *Lepidopteris* Bed (abundant).

C. Stewart *Equisetites muensteri* Bed.

These beds belong to the *Lepidopteris* Zone.

*Description.* Owing to the comparative thickness of its cuticle, this species is more satisfactory to determine than any other in Greenland.

*P. stewartensis* is abundant and often well preserved and I am thus enabled to amplify my description. The previously described specimens

(HARRIS 1926b) which were collected by HARTZ prove to be typical of the species, but none of them indicate the very large size often attained by the shoot.

The leaves are evidently twisted so as to lie in the horizontal plane, but their bases are attached spirally, the phyllotaxis of the specimen shown in Text-fig. 33/34 being almost exactly  $\frac{2}{5}$  in the lower part, but apparently changing in the upper part to approximately  $\frac{1}{3}$ . In this and other well preserved specimens ridges marking the boundaries of the decurrent leaf-bases on the stem are fairly conspicuous and can sometimes be traced for as much as 10 cm.

The foliage leaves vary in size from large ones like those shown in the Text-figure down to  $2.5 \times 0.4$  cm. These exceptionally small leaves are borne on stems of quite normal size. The leaves are nearly always inclined to the axis at an angle of less than  $45^\circ$ ; their shape is uniform and I have nothing to add to my description of the veins except that the smallest leaves may have as few as six veins. I have been able to confirm my previous account of the cuticle, and of the "interstitial ducts" occurring between the veins.

I have found that in certain specimens (e.g. that shown in Pl. 13, figs. 5, 6; Text-fig. 37) the cuticle is rather thicker than usual, and the subsidiary and other cells have less well developed papillae than is usual in this species. This specimen shows an interesting feature — which I have been able to confirm in other specimens — that a small proportion of the stomata are orientated transversely. In the other species of *Podozamites* whose cuticle is adequately known (p. 93), the majority of the stomata are placed transversely, and papillae are entirely absent, but such a specimen as the one figured here suggests that the two types of cuticle are not so entirely different as to preclude the two species belonging to the same family.

*Comparison.* Owing to the moderate thickness of its cuticle, *P. stewartensis* is a satisfactory species though nearly all the species which it most resembles are extremely indefinite.

From the Type-specimen of *P. lanceolatus* and other Yorkshire specimens of this species it may be distinguished by the shape of its leaf — broadest near the middle, instead of near the base, and by its much less crowded veins. From *P. mucronatus* and the Greenland specimens at least, of *P. distans* it is distinguished by the spiral insertion of its leaves, its less crowded veins and its conspicuous interstitial ducts. Its cuticle also seems to be different in structure and is certainly much thicker. From *P. punctatus* it is distinguished by its smooth stem and uninterrupted interstitial ducts.

As previously stated, however (HARRIS 1926b), it is not possible to distinguish it satisfactorily from certain of the very numerous specimens

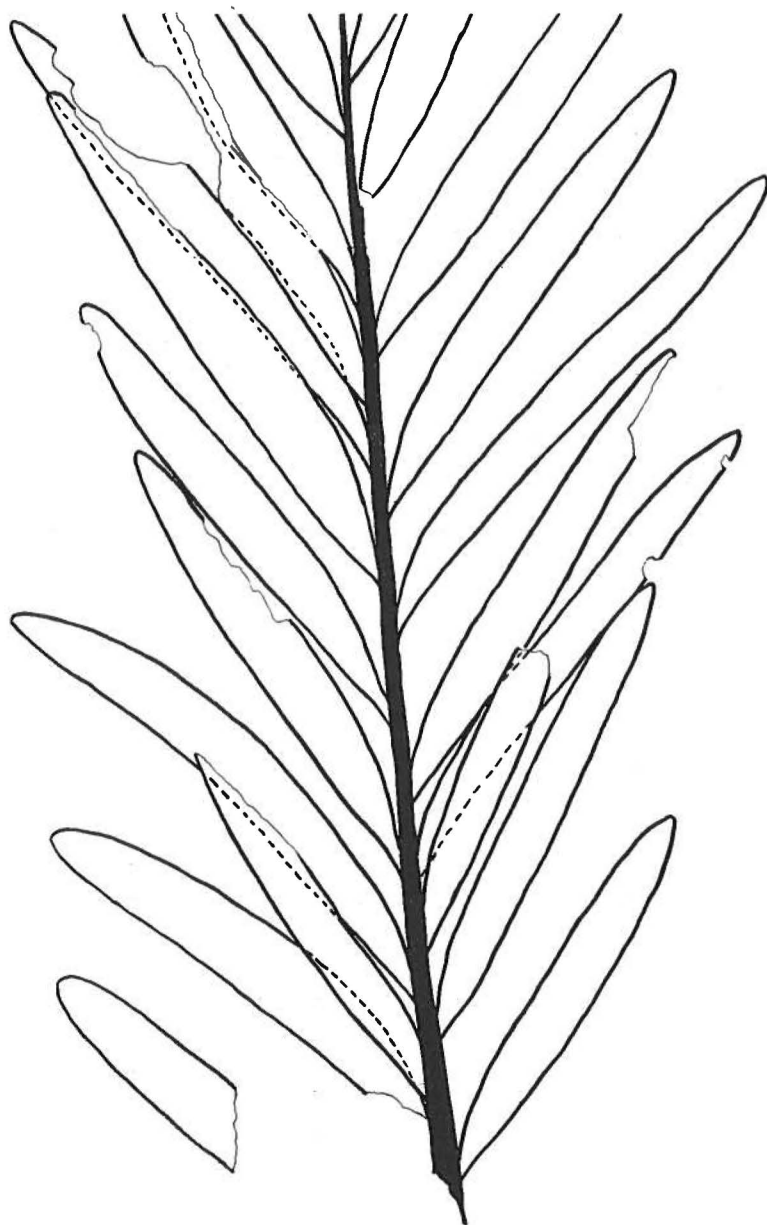


Fig. 33.

Figs. 33, 34. *Podogamites stewartensis*.

A well developed specimen (No. 3501, 3502),  $\times 1$ . The specimen was obtained from Tancredia R., *Lepidopteris* Bed.



Fig. 34.

referred to *P. lanceolatus* and *P. distans* in which the finer details of the cuticle and the interstitial ducts are unknown; I do not, however, mean by this statement that it is specifically identical with them (see SZE 1931).

***Podozamites astartensis* sp. nov.**

Pl. 16, fig. 17; Text-fig. 35.

Type-specimen, Text-fig. 35 E.

*Occurrence in Greenland.* Astarte R., Bed A, Bed B.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Axis up to 4 mm thick, bearing leaves which are probably inserted spirally but with their bases twisted into the horizontal plane. Leaves ovate-acuminate, 7—10 cm long, 1.3—2 cm wide at the middle, the widest point, base of leaf rounded, apex acuminate. Veins slender and inconspicuous, branching in the leaf base to give about 26 in a typical leaf, converging slightly towards the apex, but some of them ending in the lateral margins. Interstitial ducts present, but only recognisable by transmitted light.

Surface almost smooth between the veins, finely striated along the veins. Cuticle very delicate, showing straight sided cells, with no other feature recognisable.

*Discussion and Comparison.* *P. astartensis* is represented by three specimens of stems with attached leaves and by a good many detached leaves. They are fairly well distinguished from the other species of *Podozamites* in the Greenland flora by their size, shape and venation.

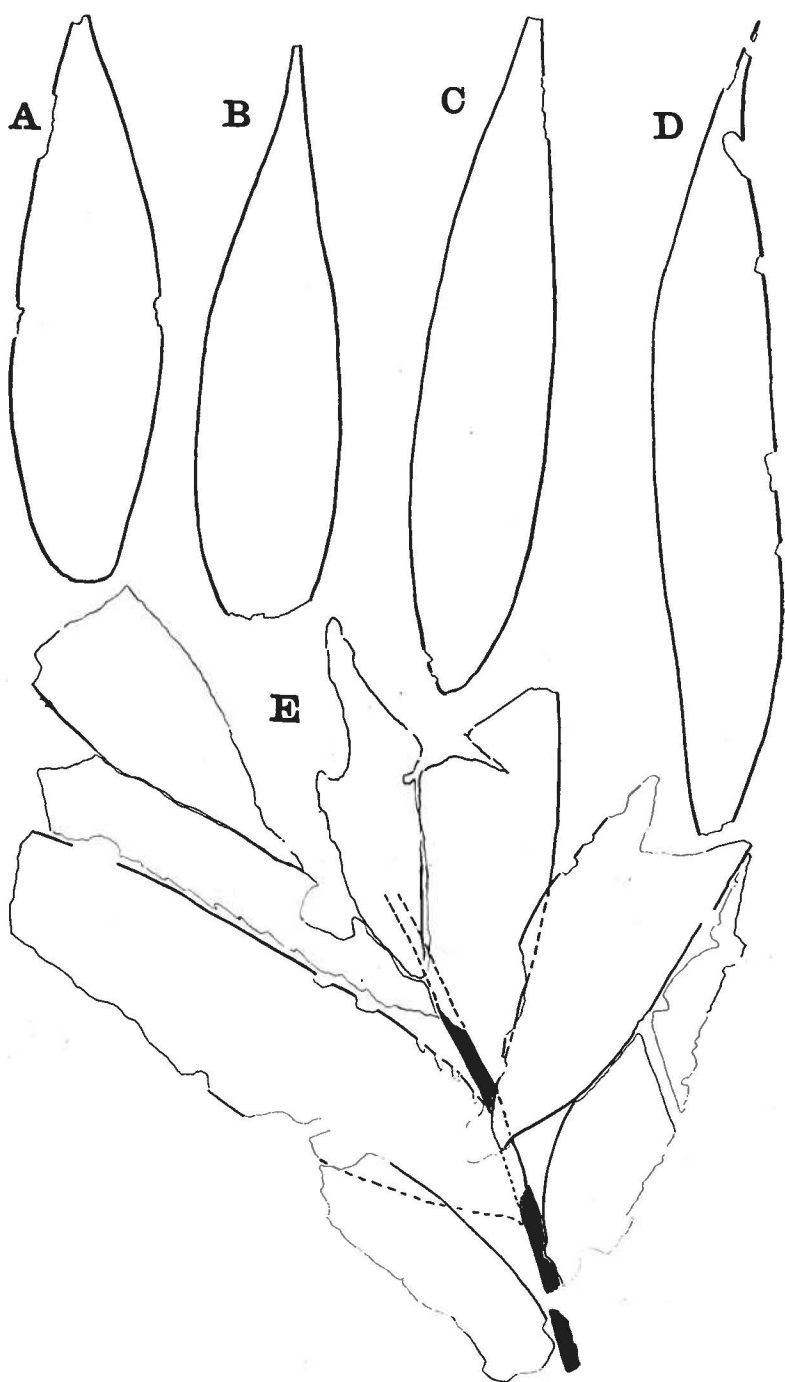


Fig. 35. *Podozamites astartensis*.

A—D, detached leaves Nos. 2651—2654, all  $\times 1$ . E, shoot bearing several imperfectly preserved leaves, No. 3553. — The specimen shown in E was obtained from Astarte R., Bed B, the others from Astarte R., Bed A.

There are very few leaves in the older Mesozoic with which *P. astartensis* could be confused, though it is possible that the leaf-fragments described by NATHORST 1878a—1886 as *Anthrophyopsis tenuinevis* may be the same.

***Podozamites punctatus* sp. nov.**

Pl. 18, fig. 5; Text-fig. 36, 37 B, C.

Type-specimen, Text-fig. 36 E.

*Occurrence.* Dinosaur R., *Marattiopsis* Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis.* Axis 1—2 mm thick, attaining a length of at least 10 cm, surface of axis marked with rather conspicuous transverse wrinkles. Leaves apparently borne spirally, but all twisted at the base into the horizontal plane. Leaf 5—10 cm long (typically 9 cm)  $\times$  4—12 mm wide (typically 7—10 mm). Leaf widest just above the base from where it tapers towards the apex; apex rounded in broad leaves, rather more acute in narrow ones but never really sharp. Leaf base often extending for about 2 mm as a short petiole.

Veins fine, running in the middle of the leaf at a concentration of about 26 per cm, converging slightly towards the apex, a few ending in the lateral margins but most of them ending separately at the tip. Leaf surface nearly smooth. Round secretory bodies present between the veins (visible by transmitted light); secretory matter somewhat resistant to maceration.

Cuticle thin; upper side showing faint indications of polygonal cells without papillae. Lower side showing elongated cells over the veins; shorter cells, apparently in rows between the veins. Stomata orientated transversely to the veins, flanked by large lateral subsidiary cells, without any papillae, but sometimes slightly more cutinised than the rest of the lower surface. Guard cells very thinly cutinised.

*Discussion.* *P. punctatus* is represented by a good number of well-preserved specimens. They are distinguishable from the other Greenland species by the secretory bodies between the veins.

It would seem just possible to place *P. punctatus* in the Cretaceous genus *Nageiopsis* (see SEWARD 1919 for references), because the veins converge less than usual in *Podozamites* but on the other hand they converge much more than in most species of *Nageiopsis*.

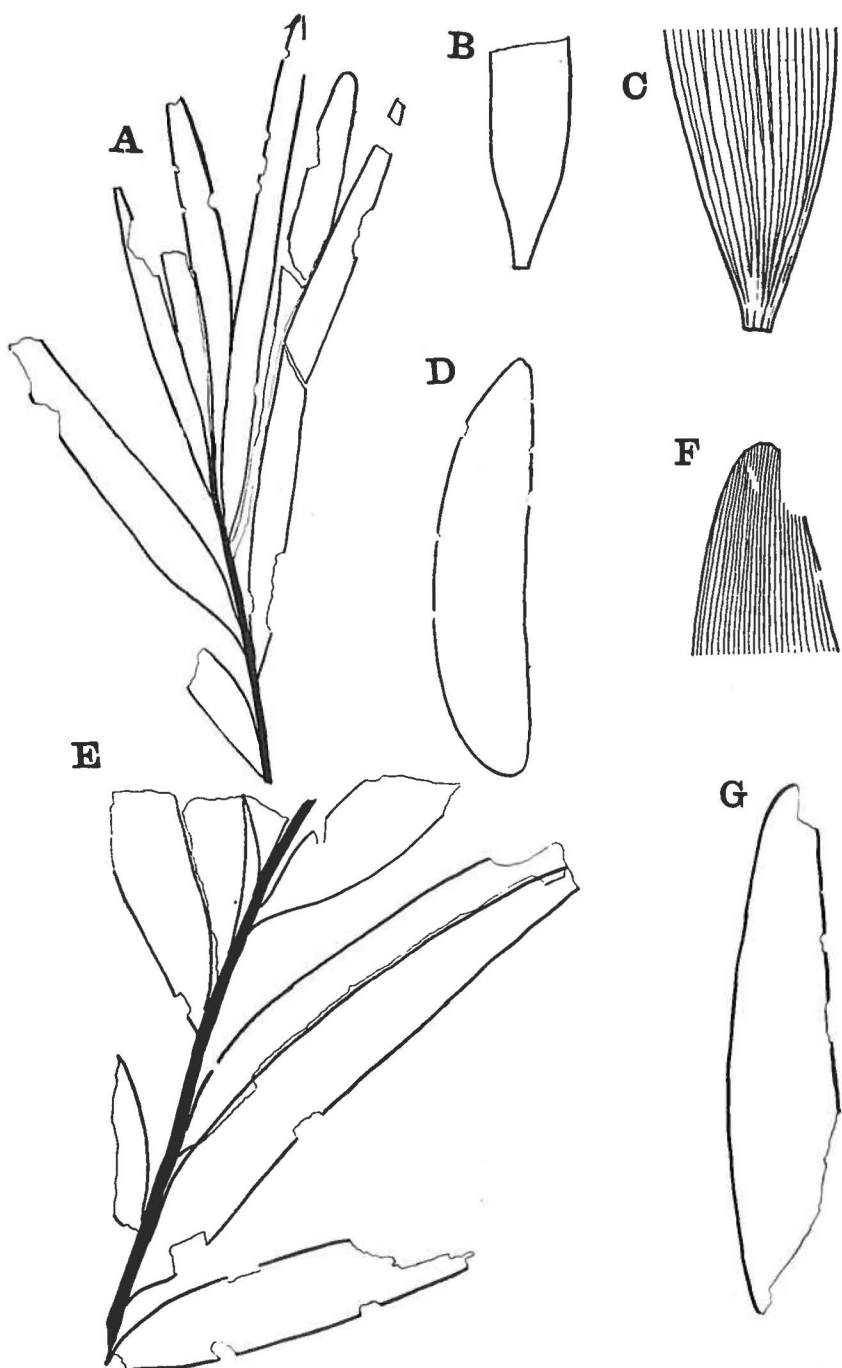
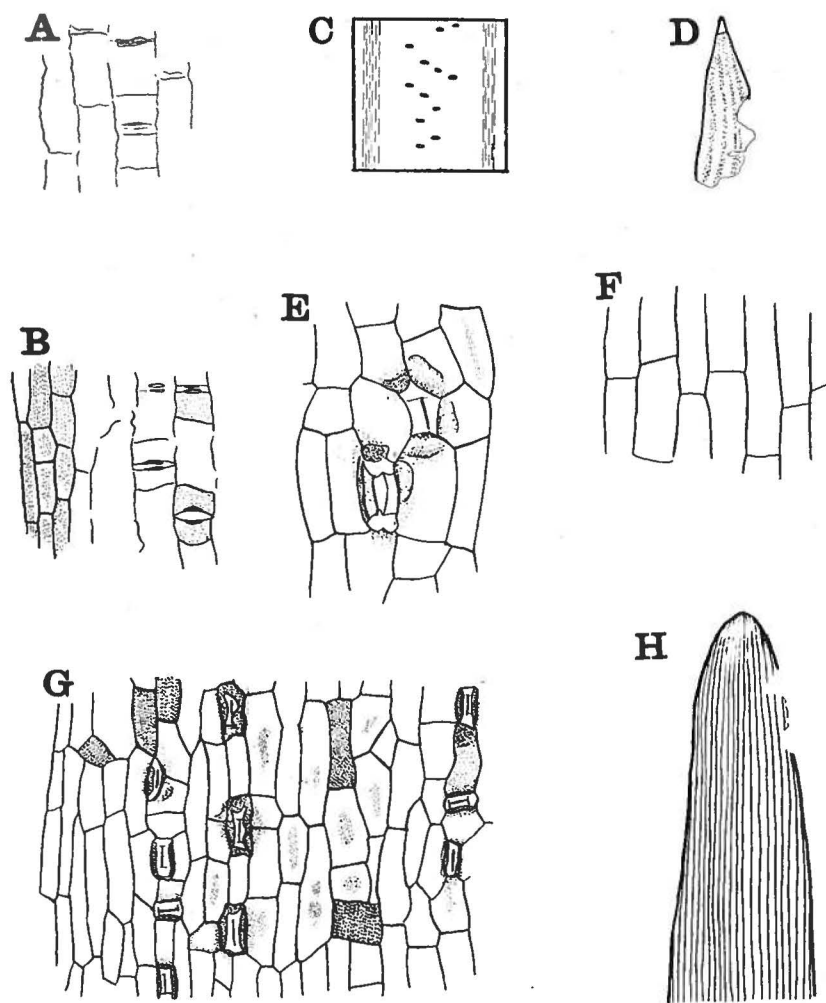


Fig. 36. *Podozamites punctatus*.

A, shoot with narrow leaves, No. 3593,  $\times 1$ . B, leaf base, No. 3592,  $\times 1$ . C, same leaf-base,  $\times 2$ . D, unusually short, broad leaf, No. 3594,  $\times 1$ . E, shoot with normal leaves, Type-specimen, No. 3591,  $\times 1$ . F, leaf apex, No. 3595,  $\times 2$ . G, same-specimen as F,  $\times 1$ .



Fig. 37. *Podozamites* spp.

A, *P. distans*, lower cuticle with stomata (?), Slide 491 (HARTZ Collection),  $\times 200$ . B, *P. punctatus*, lower cuticle, Slide 3361,  $\times 200$ . C, *P. punctatus*, distribution and orientation of stomata in 0.3 mm sq. of the lower surface. More stomata probably occur than are shown. D, *P. stewartensis*, leaf apex showing the stomatal bands (dotted); Slide 3355,  $\times 4$ . E, *P. stewartensis*, stomata,  $\times 400$ , Slide 3355. F, *P. stewartensis* upper cuticle,  $\times 200$ . G, *P. stewartensis*, lower cuticle of same leaf showing parts of two stomatal bands,  $\times 200$ . H, *P. distans*, apex of leaf, No. 3620,  $\times 2$ . — The specimen shown in A was probably obtained from C. Stewart *A. minor* Bed; that in B was obtained from Dinosaur R., that in C—G from Vardekloft *A. minor* Bed; that in H from Vardekloft *Stachyotaxus* Bed.

**Podozamites spp. indet.**

(*Podozamites schenki* — *agardhianus* group).

Pl. 18, fig. 7; Pl. 20, fig. 8; Text-fig. 38.

HARTZ 1896, p. 237—240; Pl. 13, 14, 18 (*P. schenki*, *P. lanceolatus*).

HARRIS 1926b, p. 112 (as *P. agardhianus*), p. 115 (as *P. schenki*).

SZE 1931 gives a useful list of references to many narrow-leaved specimens of *Podozamites*.

*Occurrence* of the *P. schenki-agardhianus* group (i.e. narrow leaved species of *Podozamites*) in Greenland. (Only localities where specimens are abundant are mentioned). T = bed of the *Thaumatopteris*, L of the *Lepidopteris* Zone.

Type 1. Stem slender; leaves  $7 \times 0.6$  cm, widest near base. Veins 8—10 (15 per cm).

This is the *P. agardhianus* of HARRIS 1926b, p. 112; Pl. 8, fig. 3, and Text-fig. 27 E—G.

Astarte R., *B. spectabilis* Bed (T).

Vardekloft, *P. agardhianus* Bed (T).

Storgaad R., Lower part of Plant Bed (T).

Dinosaur R., *Marattiopsis* Bed (T).

Type 2. Stem slender; leaves  $6 \times 0.5$  cm, broadest below middle, veins 10—15 (20—30 per cm). HARTZ (1896) has figured typical specimens as *P. lanceolatus* and *P. Schenki*; see also Text-fig. 38 and Pl. 18, fig. 7, in this paper.

Lejr R., *Thaumatopteris* Bed (T).

Dinosaur R., *Marattiopsis* Bed (T).

Storgaad R., Upper part of Plant Bed (T).

Neill Cliffs, Liverwort Bed (T).

Astarte R., Bed B (L).

C. Stewart *A. hartzi* Bed (T); *Todites* Bed (T).

Type 3. Stem rather thick (up to 2.5 mm); leaves  $10 \times 4.5$  mm, margins parallel in middle region; veins conspicuous, about 10 (20—30 per cm). Pl. 20, fig. 8.

Astarte R., Bed A. (L).

Primula R., Lower Plant Bed (L).

Type 4. Stem fairly slender; leaves  $6 \times 0.2$ — $0.4$ , margins parallel in middle region; veins inconspicuous, 4—8 (20 per cm). This is the *P. schenki* of HARRIS 1926b, p. 115.

Ryder R., *Clathropteris* Bed (L).

Astarte R., *Lepidopteris* Bed (L), Bed A (L); Bed B (L); *Thaumatopteris* Bed (T).

Neill Cliffs Liverwort Bed (T).

C. Stewart *A. minor* Bed (L); *E. muensteri* Bed (L); *A. hartzi* Bed (T).

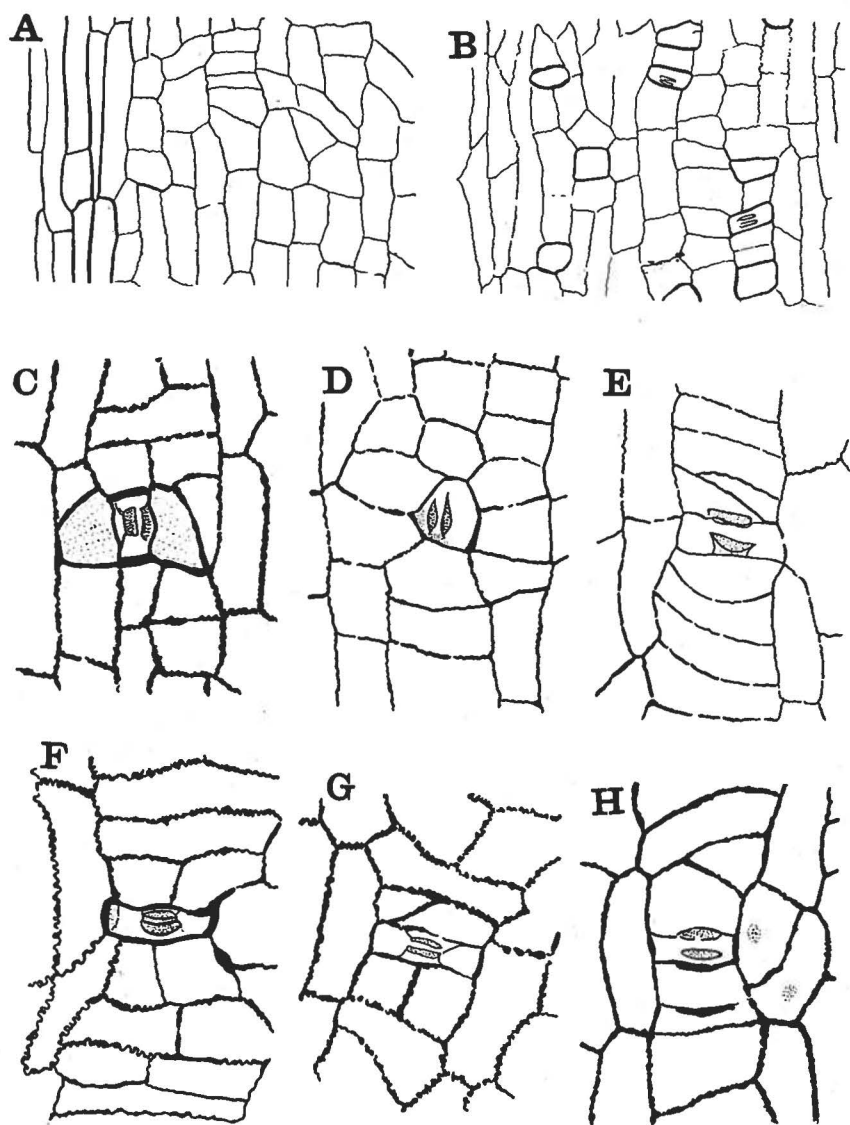


Fig. 38. *Podozamites* sp. indet. Type 2.

A, upper cuticle,  $\times 200$ . B, lower cuticle,  $\times 200$ . C, D, vertically orientated stomata (abnormal),  $\times 400$ . E—H, normally orientated stomata,  $\times 400$ . — All the specimens were obtained from Lejr R., *Thaumatopteris* Bed and are in Slide 3395.

*Description.* Although I am convinced from my observations in the field that there are several different narrow-leaved species of *Podozamites* in Greenland, I was quite unable to divide them into satisfactory species, and I do not suggest that the four groups into which I have divided them are entirely natural. In any case *P. schenki* sensu

*lato* like *P. lanceolatus sensu lato* has little zonal significance since both types are found throughout the older Mesozoic.

The leaves of "Type 2" in Lejr R (Pl. 18, fig. 7) are preserved in an exceedingly fine grained coaly shale and gave exceptionally good preparations of their cuticle, although this cuticle is exceedingly delicate. Typical pieces of cuticle are figured in Text-fig. 38; the cell-outlines are sometimes quite conspicuous, but more often are indistinct; but they always have fine jagged thickenings. Median papillae occur in certain cells, but never in the subsidiary cells. The great majority of the stomata are placed transversely and have lateral subsidiary cells lying along the whole length of the guard-cells — as in the Bennettitales — and suggesting a common origin from a single mother cell. Sometimes, however, the stomata are irregularly oriented, and in these and other stomata, the subsidiary cells occasionally are placed irregularly and must have arisen from different mother cells from those which formed the guard-cells. I conclude that the more normal arrangement of the subsidiary cells in this species opposite the guard-cells has no special significance, but arises as in certain recent Conifers with transverse stomata by the differentiation of certain members a rather regular row of embryonic cells.

No satisfactory cuticles were obtained from any other specimens, and as a result of a re-examination of my preparations I think that the apparent stomata figured of Type 4 as "*P. schenki*" (HARRIS 1926b, Text-fig. 29 A—D) may be due to irregularities of the matrix. The cells are, however, different in outline from those of "Type 2" described in this paper.

The great majority of specimens are too opaque to show interstitial ducts even if they are present; but in some of those from Storgaad R. and Neill Cliffs (Type 2) continuous ducts are quite conspicuous. On the other hand, they are quite definitely absent from the specimens (Type 2) from C. Stewart, which appear quite suitably preserved to have shown them if they were present, and I have not observed them in any of the specimens grouped under the heading Type 1, Type 3 or Type 4.

## 2. Leaves attached distichously.

### **Podozamites** cf. **distans** (PRESL) BRAUN.

Pl. 16, figs. 3, 6; Text-fig. 37 A, H.

1926b. *Podozamites distans* (PRESL) BRAUN, HARRIS, p. 110; Text-fig. 27 A—D. SZE (1931) gives a most useful list of specimens described under various names, which more or less resemble the present specimens.

#### *Occurrence in Greenland.*

#### 1. Doubtfully determined specimens:—

Ryder R., *Clathropteris* Bed.

Astarte R., Bed A, Bed B.

Vardekløft *Neocalamites* Bed, *Dictyophyllum* Bed.

2. Specimens definitely identified with those described by HARRIS 1926b.

Vardekløft *Stachyotaxus* Bed.

C. Stewart *A. minor* Bed.

*Description.* "*P. distans*" is abundant at Vardekløft *Stachyotaxus* Bed, where it is represented by specimens which agree with the ones previously figured from this locality. The arrangement of the leaves is constant — they are borne alternately, and in the best preserved specimens they are seen to be attached laterally to the axis and their bases twist, bringing the laminae into the horizontal plane.

The venation seems to be constant. The base of a leaf has been previously figured (HARRIS 1926b, Text-fig. 273) where the magnification ( $\times 3$ ) was incorrectly stated to be  $\times 6$ .

The apices of a number of leaves are shown in Pl. 16, figs. 3, 6, and in Text-fig. 37 H. In all specimens examined, a considerable number of veins end in the margins. The margins of the leaf are sometimes slightly recurved near the apex, and in one specimen (Pl. 16, fig. 3) they are sufficiently strongly recurved to give the leaf a superficial resemblance to *P. mucronatus*. I have not, however, seen any specimens from the localities previously mentioned which have really mucronate tips.

The cuticle is very delicate and I could obtain no good preparations of it. I have re-examined my previous specimens and have come to the conclusion that what I took to be stomata may have been shrunken cells surrounded by a group of locally thickened cells — a pathological feature often observable in cuticles and that what may more probably be stomata are shown in Text-fig. 37A. They seem to be transversely placed and to occur in rows between the veins.

### ***Podozamites* sp. B. cf. *P. distans*.**

*Occurrence.* Primula R., Lower Plant Bed.

This bed belongs to the *Lepidopteris* Zone.

*Description.* A number of almost uniform *Podozamites* shoots were found in Primula R. which resemble the Vardekløft specimens of *P. distans* in the shape of their leaves and in their distichous insertion, but which differ in having much smaller leaves 1.5—3 cm long (usually 2.5 cm long)  $\times$  5—6 mm broad. The veins branch exactly as in *P. distans* and behave in the same way in the distal part of the leaf. The concentration of veins in the middle of the leaf varies between 24 and 28 per cm, which is about the same as in *P. distans*.

The only difference is thus in the size of the leaf; had only one specimen been found I would have included it with the "doubtfully determined specimens" but the occurrence of several small and no normal specimens suggests a specific difference.

**Podozamites mucronatus** sp. nov.

Pl. 16, figs. 4, 5, 7, 10—12, 14; Text-fig. 39.

Type-specimen, Text-fig. 39 A.

*Occurrence in Greenland.* Astarte R., Bed D.

This bed is transitional between the *Lepidopteris* and *Thaumatopteris* Zones.

*Diagnosis.* Stem up to 2 mm thick and 7 cm long, swollen and covered with scales at the base, bearing distichously arranged leaves at an angle of  $45^\circ$ . Leaves typically 5 cm long, 9 mm wide but varying a good deal in size (dimensions of selected specimens in cm:  $3.0 \times 1.3$ ,  $7.0 \times 0.6$ ,  $6.0 \times 0.5$ ,  $5.5 \times 1.0$ ,  $4 \times 0.7$ ,  $3.5 \times 0.8$ ,  $2 \times 0.6$ ,  $1.6 \times 0.6$ ); the shorter leaves being borne near the bases of stems. Leaf widest at or a little below the middle, base tapering to form a petiolar portion 3 mm long. Apex of leaf varying between two extremes of a blunt apex with a mucronate tip of variable size, and a rather sharply pointed acute apex; rounded apices occur rarely. Veins fine but rather conspicuous; usually sunken, branching near the leaf base and traversing the middle at a concentration of about 30 per cm; a few of them ending in the lateral margins in the leaves with acute tips, but all of them reaching the apex in leaves with rounded or mucronate tips.

Surface showing fine striations due to longitudinal rows of cells. No interstitial ducts or secretory bodies visible.

Cuticle very thin; upper side showing uniform rectangular cells with indistinct outlines, lower very thin indeed, cell outlines scarcely visible at all. Stomata possibly placed transversely.

Base tapering and forming a petiolar portion 3 mm long, apex (in broad leaves) rounded but usually with a very distinct mucronate point; apex of narrow leaves more pointed and mucro consequently less evident.

Veins branching near the leaf base and running at a concentration of 30 per cm in the middle; all of them usually converging at the apex, or with the outermost alone ending in the margins near the apex.

*Discussion and Comparison.* *P. mucronatus* is represented by a great many well preserved specimens. It is very like *P. distans*, from which it can only be definitely distinguished by the apex of the leaf. In *P. distans* the apex is never really mucronate and a large number of the veins end in the lateral margins below the apex; in *P. mucronatus* the apex of broad leaves is nearly always mucronate, and nearly all the veins reach the mucro. The veins of *P. mucronatus* are slightly more crowded than in *P. distans* (30 per cm instead of 25 per cm).

In the shape of the apex of the leaf, it resembles *P. ovalis* (non HEER) NATHORST 1878b, p. 24; Pl. 13, fig. 5, but it cannot be identical with it as the veins in the Greenland specimens are always at least twice as crowded.

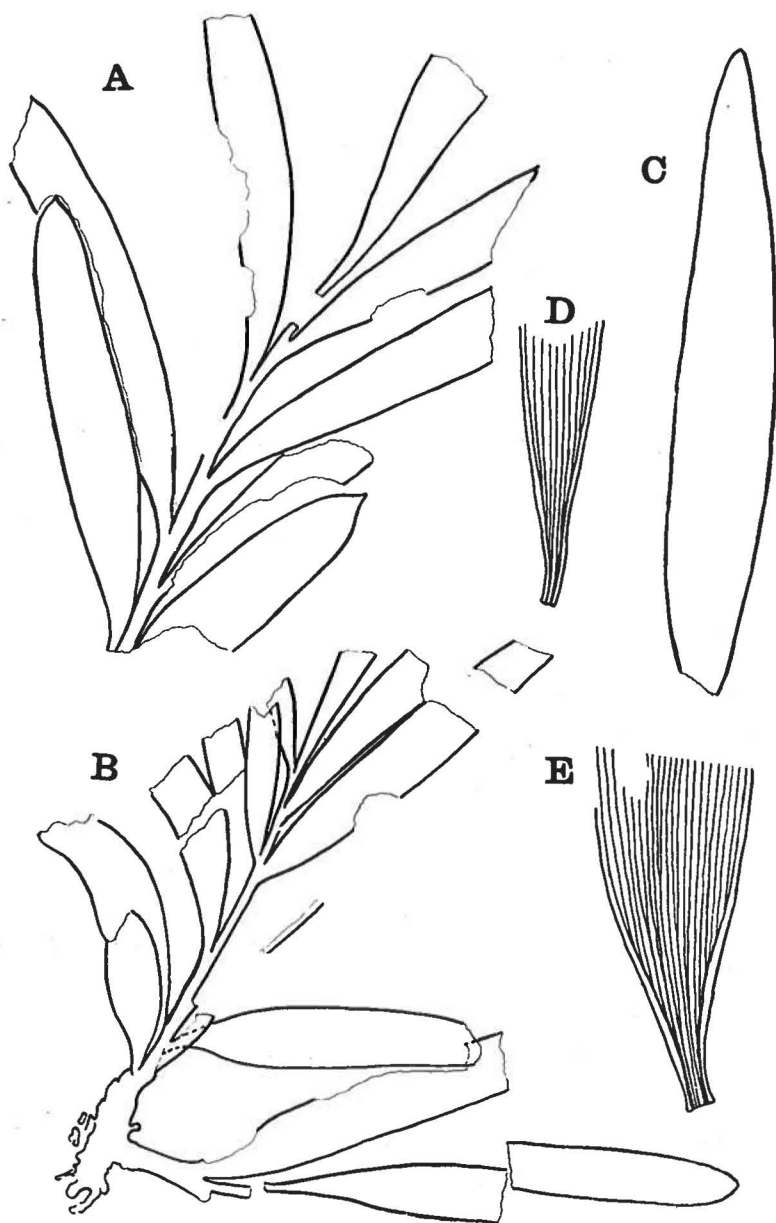


Fig. 39. *Podozamites mucronatus*. A, Type-specimen, No. 3701,  $\times 1$ . B, specimen No. 3703, 3704 (drawn from part and counterpart),  $\times 1$ . C, exceptionally large leaf, No. 3702,  $\times 1$ . D, venation of base of a small leaf, No. 3706,  $\times 2$ . E, venation of a large leaf, No. 3720,  $\times 2$ .

## Leaves Incertae Sedis.

Form-genus **DESMIOPHYLLUM** LESQUEREUX.

1878. *Desmiophyllum* LESQUEREUX, p. 322.

1904. *Desmiophyllum* LESQ. emend., SOLMS-LAUBACH, p. 6 *et seq.*

Isolated Mesozoic ribbon-shaped leaves with parallel veins have been described under many names; for example, *Cordaites*, *Podozamites* or *Phoenicopsis*, which indicate generic identity with well known genera, and under various names implying Monocotyledon affinity — *Yuccites*, *Bambusinum*, *Flabellaria*, etc.

If such leaves about which nothing else is known are to be described at all, they should certainly be included in a single form-genus and *Desmiophyllum* seems to be generally accepted; though as the first species of *Desmiophyllum* described was probably a species of *Cordaites*, the next probably a *Phoenicopsis* and as various earlier names of ribbon-shaped leaves exist, e. g. *Bambusinum*, its validity is rather doubtful. *Desmiophyllum* would be a useful name to keep as a *nomen conservandum*.

I consider that the three types described below are undoubtedly distinct, but in the absence of any information about their cuticles (which is too delicate to prepare) it is useless to give them specific names.

### **Desmiophyllum Type 1.**

*Occurrence of leaves of this general type.*

Vardekløft *P. agardhianus* Bed.

Storgaad R., Plant Bed.

C. Stewart, *Todites* Bed.

These beds belong to the *Thaumatopteris* Zone.

*Description.* Leaf of unknown length, about 1.5 mm wide; margins parallel; apex and base unknown. Veins one (or two close together) near middle of leaf. Cuticle unknown.

### **Desmiophyllum Type 2.**

Pl. 17, fig. 15.

*Occurrence of leaves of this general type.*

Primula R., Upper Plant Bed.

Hare R., Upper Plant Bed.

Astarte R., *B. spectabilis* Bed.

Dinosaur R., *Marattiopsis* Bed.

Neill Cliff, Liverwort Bed.

C. Stewart, *Todites* Bed.

C. Hope, *Czekanowskia* Bed.



All of these beds belong to the upper part of the *Thaumatopteris* Zone.

*Description.* Leaves of this type are over 27 cm long and vary in width from 2—6 mm; the usual width being 3—4 mm. The leaf tapers very gradually towards the apex which is rather acute; the base was not definitely recognised. The veins vary in number from 8 in the broadest leaves to three in the narrowest ones, near the apex. The number seems to be reduced on passing up the leaf by the marginal vein fusing with the one next it. It was found impossible to prepare any cuticle even from the best preserved specimens.

### **Desmiophyllum Type 3.**

1926b. “? *Podozamites* sp. A” HARRIS, p. 117; Pl. 12, figs. 3, 4.

*Occurrence.* Vardekloft *Dictyophyllum* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Description.* I found a few specimens which agree closely with the leaf I previously described.

## **Isolated Fructifications.**

A number of isolated male and female fructifications which I considered to belong to the same families or species as the leaves which were under description have been described in my previous papers. The fructifications described in this paper include some of a Coniferous or Ginkgoalean type, and others which cannot be assigned to any family.

### **1. SEED-BEARING FRUCTIFICATIONS.**

#### **Genus CYCADOCARPIDIUM NATHORST.**

1886. *Cycadocarpidium* NATHORST, p. 91.

Type-species *C. erdmanni* NATHORST.

I found about a hundred specimens of this fossil which had always seemed a rather rare one; it is probably quite abundant in Greenland, but it is inconspicuous because it looks like a small detached leaf of *Podozamites* until its base has been cleared of rock.

*Morphology.* The structure of the sporophyll is shown more clearly in *C. erdmanni* than in *C. swabi*, but it is evident from the best preserved of my specimens that the structure of the two is essentially similar. This had been inferred from NATHORST's (1911) figures by SCHUSTER (1911), who gives restorations of both species. The main part of the sporophyll is generally regarded as a leaf, since it is like a single leaf of *Podozamites*, but the little projections at its base which bear the seeds have been variously

regarded as reduced lateral pinnae (as in the Cycad megasporophyll) or as an ovuliferous scale (as in the Abietineae).

I consider that the evidence available favours the view that the projection is like a conifer ovuliferous scale, since (as is shown in SCHUSTER's figure) it seems to be a single organ situated in front of the base of the sporophyll. Its surface texture is different from that of the rest of the sporophyll, being irregularly wrinkled instead of showing fine, regular cell striations.

The seed is rather delicate, evidently having a far thinner testa than the associated *Stachytaxus* seeds, and its cutinised membranes too are delicate and difficult to investigate. The integument is covered by a thin cuticle and in part of the seed at least it encloses some more delicate cuticles which may represent the nucellus a possibly the megaspore (see also *Allicospermum obscurum* on p. 125).

The cone axis is a rather striking fossil. I found two types — both apparently bearing sporophylls of the *C. swabi* type. There is a long naked stalk bearing a 'cone' 2—5 cm long which consists of alternating whorls of four (or two in the other type) short outgrowths to the ends of which the sporophylls appear to have been attached, though in all but one specimen they have been shed before preservation.

*Cycadocarpidium* has been referred by nearly all authors to *Podozamites*; the evidence being the great resemblance of the lamina of the sporophyll to the leaf of *Podozamites* and its association with *Podozamites* in every locality. This association (which has been noticed in seven new localities in Greenland), appears to provide a sufficient weight of circumstantial evidence for identifying them.

I had hoped to be able to clear up some of the difficulty in distinguishing the species of *Podozamites* with the help of the associated fructifications, but as will be realised from the table on p. 101, the results are disappointing, and I have been forced to conclude that both *C. swabi* and *C. erdmanni* — like *P. distans*, *P. schenki* or *P. lanceolatus* when used in a 'broad' sense, include more than one natural species.

The available evidence indicates that the Rhaetic species at least of *Podozamites* (with *Cycadocarpidium*) are essentially different from any Cycad (see p. 83); whether the evidence is held to be sufficient for referring it definitely to the Conifers is more doubtful but in my opinion is nearly as good as it is for many of the other Rhaetic plants referred to the Conifers. It is, however, clear that it cannot belong to any one of the existing families of Conifers.

Two fossils which to some extent resemble *Cycadocarpidium* are *Fraxinopsis* (see OISHI 1931a) and *Dioonitocarpidium* (v. LILIENSTERN 1928), though the great difference between the foliage attributed to

these fructifications and *Podozamites* suggests that they may be unrelated and of essentially different morphological nature.

Record of the occurrence of *Cycadocarpidium* and of associated *Podozamites* leaves.

| Locality and author                 | Sporophyll              | Cone axis    | Associated <i>Podozamites</i>                              |
|-------------------------------------|-------------------------|--------------|------------------------------------------------------------|
| 1. Sweden (NATHORST 1911)           |                         |              |                                                            |
| Bjuf .....                          | <i>C. erdmanni</i>      | —            | <i>P. spp.</i>                                             |
| Hyllinge .....                      | <i>C. erdmanni</i>      | —            | species not stated                                         |
| Hyllinge .....                      | <i>C. swabi</i>         | —            | species not stated                                         |
| Pålsjö .....                        | <i>C. redivivum</i>     | very slender | <i>P. spp.</i>                                             |
| 2. Indo-China (COUNILLON, 1914)     | <i>C. erdmanni</i>      | —            | —                                                          |
| 3. China (SZE, 1931)                |                         |              |                                                            |
| Szechuan .....                      | <i>C. erdmanni</i>      | —            | <i>P. lanceolatus</i>                                      |
| Annam .....                         | <i>C. erdmanni</i>      | —            | —                                                          |
| Hunan .....                         | <i>C. erdmanni</i>      | —            | —                                                          |
| 4. Japan                            |                         |              |                                                            |
| Kusaigawa (OZAWA, 1925) ..          | <i>C. swabi</i>         | —            | —                                                          |
| Ojigase (OISHI, 1932a) .....        | <i>C. swabi</i>         | —            | { <i>P. schenki</i><br><i>P. distans</i>                   |
| 5. Greenland                        |                         |              |                                                            |
| Vardekloft, <i>Neocalamites</i> Bed | <i>C. erdmanni</i>      | —            | { <i>P. cf. schenki</i><br>Type 4<br><i>P. distans</i>     |
| Astarte R., Bed D* .....            | <i>C. erdmanni</i>      | —            | <i>P. mucronatus</i>                                       |
| — <i>Lepidopteris</i> Bed* .....    | <i>C. erdmanni</i>      | —            | { <i>P. cf. schenki</i><br>Type 4                          |
| — — — .....                         | <i>C. swabi</i> (small) | —            | { <i>P. cf. schenki</i><br>Type 3<br><i>P. astartensis</i> |
| — Bed A* .....                      | <i>C. swabi</i>         | slender      | { <i>P. distans</i><br><i>P. cf. schenki</i><br>Type 4     |
| Vardekloft <i>Stachyotaxus</i> Bed  | <i>C. swabi</i>         | stout        | { <i>P. sp. B. cf. distans</i><br><i>P. distans</i>        |
| Primula R .....                     | <i>C. swabi</i>         | —            | { <i>P. sp. B. cf. distans</i><br><i>P. distans</i>        |
| C. Stewart .....                    | <i>C. swabi</i>         | stout        | { <i>P. sp. B. cf. distans</i><br><i>P. distans</i>        |

The Greenland localities marked \* contain other conifer cones which are equally likely to belong to *Podozamites*.

*C. minor* from Kirghiz (Turutanova-Ketova 1930) is associated with *P. lanceolatus* and *P. lanceolatus* v. *minor*.

### *Cycadocarpidium swabi* NATHORST (*sensu lato*).

Pl. 17, figs. 3, 5, 6, 8; cone axis of two types; Pl. 17, figs. 1, 5, 11—14, 16;

See also *Allicospermum obscurum*, p. 125.

1911. *Cycadocarpidium Swabii* NATHORST, p. 5; Pl. 1, figs. 11—15.

1911. *Cycadocarpidium Swabii* NATHORST, SCHUSTER; p. 453, fig. 26.

1925. *Cycadocarpidium Swabii* NATHORST, OZAWA, p. 94; fig. 1 (I have not seen this paper).

1932(a). *Cycadocarpidium Swabii* NATHORST, OISHI, p. 66; Pl. 10, figs. 10, 10a.

*Occurrence of C. swabi (sensu lato) in Greenland.*

Cone-scale.

Primula R., Lower Plant bed.

Astarte R., *Lepidopteris* Bed; Bed A.

Vardekloft, *Stachyotaxus* Bed.

C. Stewart, *A. minor* Bed.

Cone axis.

Type A, Vardekloft, *Stachyotaxus* Bed, C. Stewart *A. minor* Bed.

Type B, Astarte R., Bed A.

All of these beds belong to the *Lepidopteris* Zone.

*Description and discussion.* As I have already indicated, *C. swabi* must probably be regarded as an aggregate species.

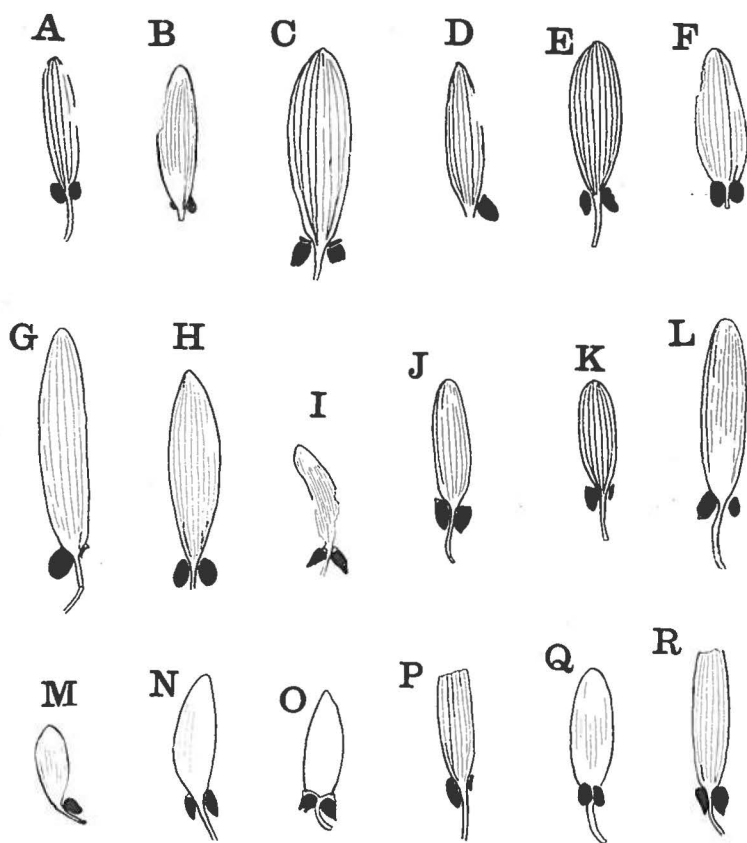


Fig. 40. *Cycladocarpidium swabi (sensu lato)*. Nat. size.

A—H, specimens from Astarte R., Bed A; I, from Primula R.; J—Q, from Astarte R., *Lepidopteris* Bed; R, from C. Stewart, *A. minor* Bed. A, No. 4203; B, 4204; C, 4201; D, 4204; E, 4202; F—H, 4201; I, No. 4221; J, 4231; K, 4232; L, 4234; M, 4233; N, 4235; O, 4236; P, 4237; Q, 4238; R, 4251.

The range of form-variation in the specimens of each locality are shown in Text-figs. 40, 41. I have figured every fairly complete specimen (apart from those from Vardekloft, which are too numerous) in order to give the variation in form and dimensions in each locality. It will be seen that while nearly every specimen from Vardekloft is larger than every one from Astarte R., *Lepidopteris* Bed, the specimens from

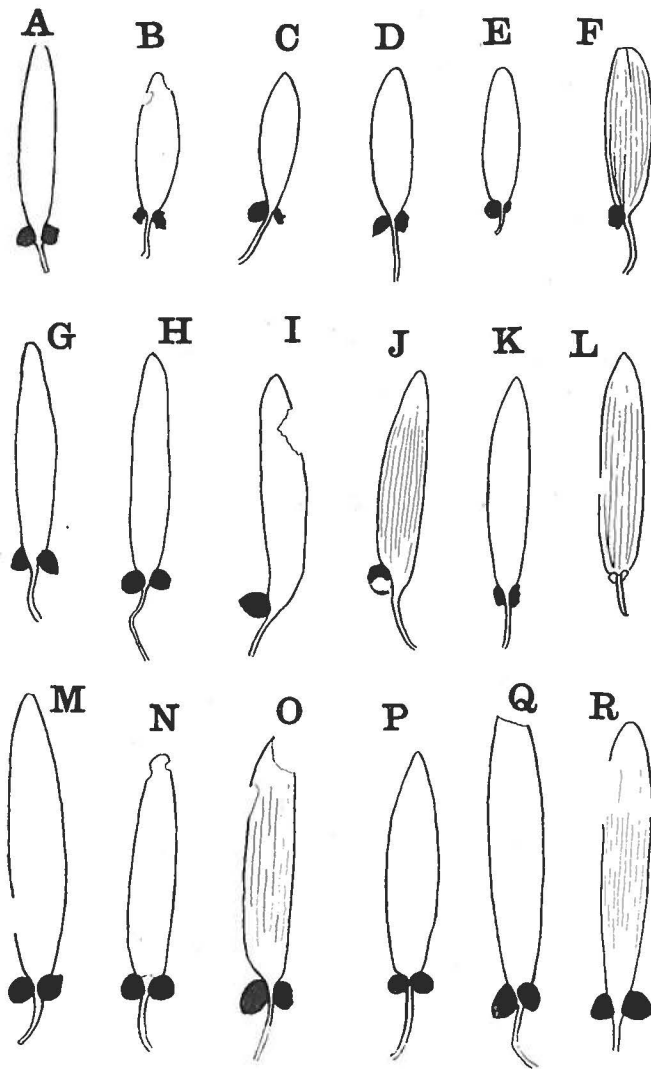


Fig. 41. *Cycadocarpidium swabi*, sensu lato. Nat. size.

A, No. 4267; B, 4264; C, 4268; D, 4261; E, 4267; F, 4266; G, 4269; H, 4265; I, 4264; J, 4263; K, 4267; L, M, 4261; N, 4264; O, 4268; P, 4261; Q, 4268; R, 4270.

All the specimens were obtained from the Vardekloft *Stachyotaxus* Bed.

other localities are intermediate and make a satisfactory specific distinction between them impossible.

The veins are figured in all the specimens in which they could be seen in surface view. It is interesting to note that in none of my specimens have as many as ten been observed, while this number is typical of NATHORST'S specimens.

The veins were examined by transmitted light in some transfers when they are rather more conspicuous. They are slender; most of them arise from strong veins which run up the lateral margins, but occasionally one of the innermost veins was observed to dichotomise also. No interstitial ducts or resin bodies occur between the veins.

The cuticle of the sporophyll was badly preserved.

*The cuticle of the seed.* I obtained some moderately well preserved cuticles from the specimens from Astarte R., Bed A. These specimens provided a fragile, but not very thin cuticle of the integument and some much more delicate cuticles from the interior of the seed, the nature of which could not be investigated very fully, but it is very probable that they consist of a cutinised nucellus investing a cutinised megaspore membrane. The integument shows the very obscurely marked outlines of almost straight-sided cells, the surface of the cells being irregularly marked in a way which obscures the cell outlines.

In size, shape and structure as far as it is known the seed of *C. swabi* agrees with the isolated but better preserved seed described later as *Allicospermum obscurum* and I think their identity almost certain, but as this species of seed is based on isolated specimens it has been described under a different name.

### Cone Axis. Type 'A'.

#### *Occurrence.*

Vardekløft, *Stachyotaxus* Bed (abundant).

C. Stewart, *A. minor* Bed (rare).

These beds belong to the *Lepidopteris* Zone.

*Description.* Complete specimens consist of a stalk 2—3 mm wide, 12 cm long, which is naked below but with its upper 4 cm covered with lateral appendages forming a sort of strobilus. The appendages are about 6 mm long, and 2 mm thick and arise at right angles to the cone axis. They appear to be borne in alternating whorls of four, the distance between successive whorls is about 2.5 mm. The distal ends of the appendages are slightly expanded and form shallow cups.

In one specimen only (Pl. 17, fig. 5) are *C. swabi* "sporophylls" still attached to the appendages; the preservation of this specimen is unfortunately too poor to make out any details.

The cuticle of the cone axis is delicate and was very poorly preserved.

For comparison, see Cone axis Type 'B'.

### Cone axis. Type 'B'.

Pl. 17, figs. 1, 11, 16.

*Occurrence.* Astarte R., Bed A. (*Lepidopteris* Zone).

*Description.* The long naked stalk seen in complete specimens of Cone axis Type 'A' is not preserved in any of the specimens, which consist of the upper 'cone' part only. The appendages are 3.5 mm long  $\times$  1.5 mm wide and also stand at right angles to the axis. They are borne in alternating pairs (i.e. decussately). The distance between successive pairs is about 2 mm. As in Type 'A', the distal ends of the appendages are slightly expanded. In no specimen are any *Cycadocarpidium* sporophylls attached but from a comparison with Cone axis Type 'A', it seems very probable that the associated *Cycadocarpidium swabi* sporophylls were borne on them.

Cone axis Type 'B' only differs from Type 'A' in its slightly shorter appendages which are borne in twos instead of in fours. It somewhat resembles "*Stenorachis lepida*" (HEER); see SEWARD 1919 for references, and it seems possible that *S. lepida* is of similar morphological nature. It is, however, readily, distinguished by its shorter and stouter appendages.

### *Cycadocarpidium erdmanni* NATHORST (*sensu lato*).

Pl. 17, figs. 2, 4, 7, 9, 10; Text-fig. 42.

- 1886. *Cycadocarpidium Erdmanni* NATHORST, p. 91; Pl. 26, figs. 15—20.
- 1902. *Cycadocarpidium Erdmanni* NATHORST, p. 8; Pl. 1, figs. 5, 6.
- 1911. *Cycadocarpidium Erdmanni* NATHORST, p. 3; Pl. 1, figs. 1—10.
- 1914. *Cycadocarpidium Erdmanni* NATHORST, COUNILLON, p. 15; Pl. 5, figs. 6, 6a (I have not seen this paper).
- 1933(b). *Cycadocarpidium Erdmanni* NATHORST, SZE, p. 22; Pl. 2, figs. 10, 11.
- 1933(b). *Cycadocarpidium Erdmanni* NATHORST, mention of HALLE's work in SZE, p. 22.

#### *Occurrence.*

Astarte R., *Lepidopteris* Bed; Bed D.

Vardekløft, *Neocalamites* Bed.

These beds belong to the *Lepidopteris* Zone; Astarte, Bed D being transitional between this zone and the *Thaumatopteris* Zone.

*Description.* I obtained a few specimens which are just like NATHORST's figures of *C. erdmanni*, and associated with these I found many other less typical specimens which seem to grade into *C. swabi*. All of the specimens are figured, as well as all of the small specimens which have been referred to *C. swabi*. It will be seen that there is quite con-

tinuous variation in size from the largest form of *C. swabi* and the smallest of *C. erdmanni*, and though *C. swabi* usually possesses more veins, it does not always. The little triangular scales situated above the seed in typical specimens of *C. erdmanni* distinguish it at once from *C. swabi* (in which they are much smaller), but in certain specimens which agree in other respects with *C. erdmanni* these scales are quite as small as in *C. swabi*.

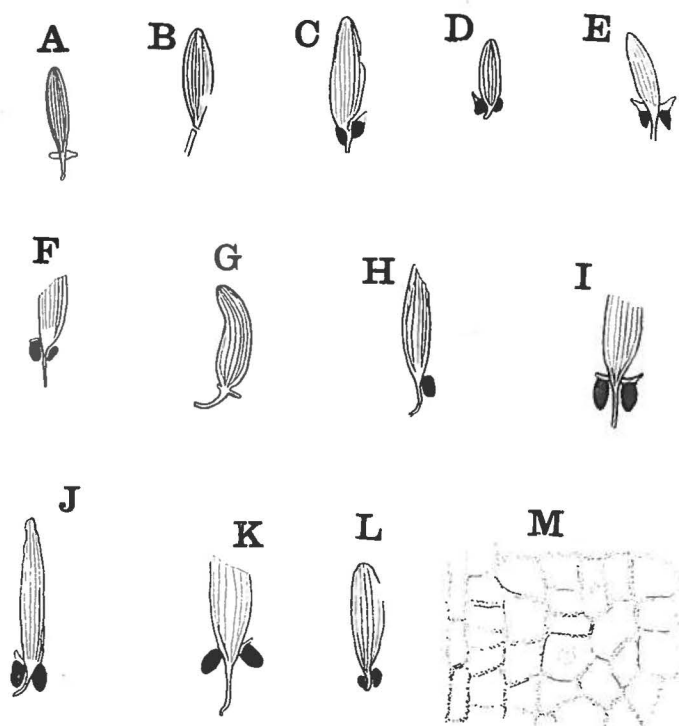


Fig. 42. *Cycadocarpidium erdmanni*, *sensu lato*.

A, No. 3706; B, 4301; C, 4302; D, 4303; E, 4321; F, 4331; G, 4332; H, 4333; I, 4334; J, 4335; K, 4336; L, 4337; M, cuticle of integument of seed; Slide No. 3405,  $\times 200$ . The specimens shown in A—D and M were obtained from Astarte R., Bed D; that in Fig. E from Astarte R., *Lepidopteris* Bed; those in F—L from Vardekløft *N. hoerensis* Bed. Figs. A—L natural size.

The cuticle of the sporophyll could not be prepared. The seeds of the specimens from Astarte R. Bed D yielded fragments of the cuticle of the integument. This cuticle is just like that of *C. swabi* except that the cells are about half the size.



Genus **SWEDENBORGIA** NATHORST.1876. *Swedenborgia* NATHORST, p. 66 (1878b, p. 30).Type-species *S. cryptomerioides* NATH.

SAPORTA (1884, p. 525) has discussed *Swedenborgia* at some length and most of his conclusions still hold good.

The cones are caducous, and all that have been examined so far seem to be ripe and to have shed nearly all their seeds. The axis is slender and bears spirally arranged cone-scales but no other appendage. Each cone-scale has a slender stalk which becomes broader at the distal end and divides palmately into five almost equal rigid lobes. The lower surface is concave and a small outgrowth from the stalk, the bract scale, projects into the base of the concavity. On the ventral (upper) surface, which is convex, at the base of each of the five lobes are small upgrowths where the seeds were probably attached. In all specimens seen there are five of these upgrowths, and therefore conclude that the scale normally bore five seeds. The seed is oval and probably flat, the base is slightly hollowed, the margins bear a delicate wing, 0.5 mm wide, which ceases just below the apex leaving a notch which is occupied by the projecting micropyle. The seeds were inverted, the micropyle facing the cone-axis. A good deal of the irregularity in the branching of the cone-scale observed by previous authors is probably due to cleavage of the rock in a different plane from the one in which the sporophyll branches.

The cuticle is rather delicate; it shows occasional stomata surrounded by an irregular ring of unspecialised subsidiary cells.

The chief features recognised for the first time are the bract-scale and the five (seed-bearing?) upgrowths of the ovuliferous scale.

*Swedenborgia* has always been found detached and its foliage is unknown; but assuming that it belongs to a Conifer, there is evidence of association for suggesting that it may belong to certain narrow-leaved species of *Podozamites* of the *P. schenki*-*P. agardhianus* group.

In its two Swedish localities *Swedenborgia* is associated with several conifers besides *Podozamites*; but in Greenland the three closely similar species are known from seven localities, in all of which narrow-leaves species of *Podozamites* are abundant. In three of these localities no other conifer leaf occurs, in the other three *Storgaadia* occurs and in addition a single specimen of an undetermined conifer — *Elatocladus* sp. C; in one *Podozamites mucronatus*, *Stachyotaxus* and *Ontheodendron sternbergi*. It is not likely that *Swedenborgia* belongs to *Storgaadia* as its stomata are very different; its stomata match those of two or three species of *Podozamites* fairly well but too little is known about the cuticles of the Greenland species of *Podozamites* for this agreement to have much weight.

Previous authors have pointed out that *Swedenborgia* resembles *Cryptomeria* in its cone; the present investigation shows that the agreement is rather close, the main difference being that the cone-scale of *Cryptomeria* is more solid and its parts more intimately fused. It thus supports the suggestion which has been put forward by various authors that the lobing of the cone-scale of *Cryptomeria* is a primitive feature. It also resembles *Cheirolepis* (HÖRHAMMER 1933), a conifer of the same age, and the Palaeozoic genus *Voltzia* (WALTON 1929) in its lobed cone-scale, though it is readily distinguished from both — and indeed from nearly all conifers — by its long stalked cone-scales. Moreover in *Voltzia*, the lobing of the cone-scale is more elaborate; while in *Cheirolepis* the seeds are embedded in the scale. The resemblance is, however, important from an evolutionary point of view; it suggests that there was a large group of ancient conifers with cone-scales of elaborate structure, and it seems to me preferable to classify it with these fossil genera than with the modern Taxodineae or Podocarpaceae. If I am right in supposing that its leaves may be of the *Podozamites* type, any very close affinity with any known genus seems to be precluded.

#### *Swedenborgia cryptomerioides* NATH.

Pl. 18, figs. 8, 10—18, 21, 22; Pl. 19, figs. 5—8, 20—22.

1876, 1878(b). *Swedenborgia cryptomerioides* NATHORST, p. 66 (1876), p. 30 (1878b); Pl. 16, figs. 6—13.

1884. *Swedenborgia cryptomerioides* NATH., SAPORTA, p. 528; Pl. 70, figs. 1—4.

1919. *Swedenborgia cryptomerioides* NATH., ANTEVS, p. 48; Pl. 70, figs. 1—4.

#### *Occurrence in Greenland.*

Astarte R., Bed D (uncommon).

?Vardekloft, *P. agardhianus* Bed — field record; specimen lost.

Neill Cliff, Liverwort Bed — abundant.

These localities belong to the *Thaumatopteris* Zone; except Astarte R., Bed D, which is transitional between the *Thaumatopteris* and *Lepidopteris* Zones.

*Description.* I found a great many cones and seeds which agree with those figured by other authors. I made a good many transfer preparations and was able to recognise the bract-scale on the lower side, and five small upgrowths which probably bore seeds on the upper side of the scale, though as a rule neither feature is visible in an untreated specimen. The seeds seem to be rather delicate and I was unable to investigate their internal structure, though it was possible to see the slightly projecting micropyle and the marginal wing in transfer preparations. Although a few scales still have one or two seeds attached, I was unable to make out any details of their attachment.

*S. cryptomerioides* is distinguished from the other two species

described here by its size; its cone-scale is about 12 mm long, and the five lobes into which it divides are about 3 mm long.

**Swedenborgia major** sp. nov.

Pl. 18, figs. 19, 20; Pl. 19, figs. 10—12; Text-fig. 44 A.

Type-specimen, Pl. 18, figs. 19, 20.

*Occurrence in Greenland.*

Astarte R., *B. spectabilis* Bed.

Storgaad R.

C. Stewart, *Todites* Bed.

These beds belong to the top of the *Thaumatopteris* Zone.

*Diagnosis.* Cone scale agreeing with *Swedenborgia cryptomerioides* in form, but differing in being larger; total length of scale 2.2 cm, stalk of scale 1.0—1.5 mm thick, terminal branches 0.8—1.0 cm long, seeds similar in form and size.

*Discussion.* *S. major* is represented by a fair number of detached cone scales, some of which are figured. Although it is very similar to *S. cryptomerioides*, it is sufficiently distinguished by its larger size and in particular by the branches, which are considerably longer and appear to be less stiff.

The Type-specimen is preserved as dust filling a cavity in sandstone; on removing the dust the casts of the bract-scale and the seed-bearing outgrowths became visible.

**Swedenborgia minor** sp. nov.

Pl. 19, figs. 13, 14, 17.

Type-specimen, Pl. 19, fig. 17.

*Occurrence.* C. Stewart *A. hartzi* Bed.

This bed belongs to the lower half of the *Thaumatopteris* Zone.

*Diagnosis.* Cone agreeing with *S. cryptomerioides* in form but differing in being smaller. Length of cone about 2 cm; cone-scales 6—7 mm long; stalk of scale 0.6 mm thick; terminal branches 1.8—2.0 mm long. Associated seeds like those of *S. cryptomerioides* but smaller, about 2.8 mm × 1.9 mm.

*Discussion and Comparison.* *S. minor* is represented by several indifferently preserved cones and by a number of detached but associated seeds. It is readily distinguished from *S. cryptomerioides* by its much smaller size, and, in particular, by the very short terminal branches of the scale. The material gave very poor transfer preparations and I was unable to find out anything about the structure of the scale beyond what is visible in the hand-specimens, but there is no reason to suppose that it differs essentially from the other two species.

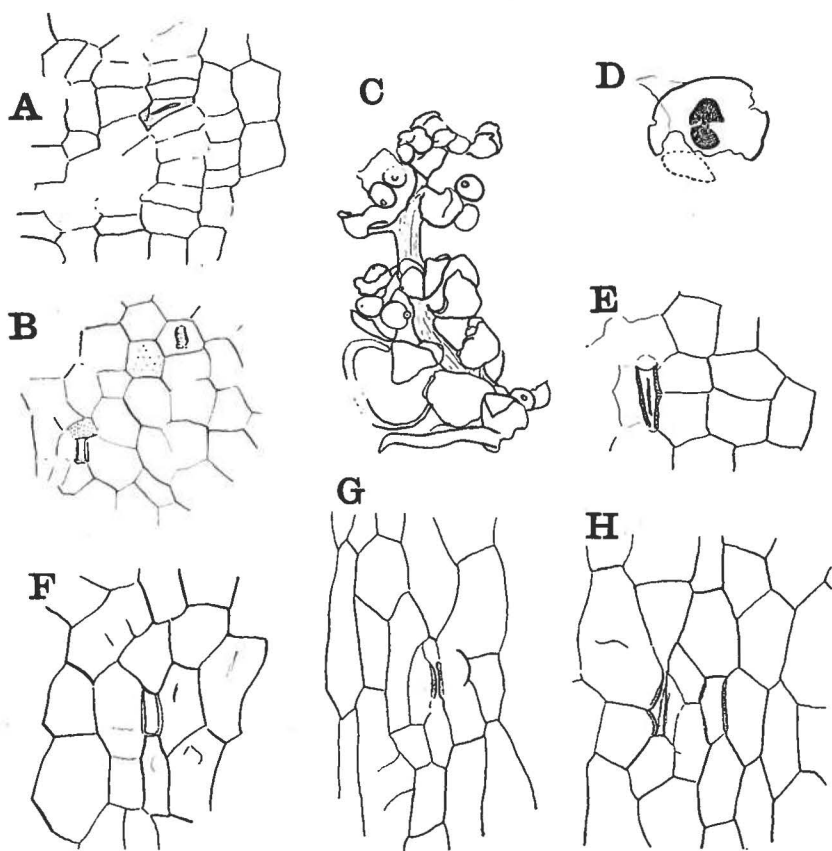


Fig. 43. A, *Swedenborgia major*, Slide 3440,  $\times 200$ . B, *Araucarites charcoti* cuticle showing what may be a stoma, Slide 3501,  $\times 200$ . C, *Callipitys leptoderma*, drawing of Type-specimen (for comparison with the photographs on Pl. 19). D, *C. leptoderma*, seed showing the outline of the integument (thick line) and of the megaspore membrane (stippled). One part of the integument which was detached is indicated in position by dotted lines, No. 3486,  $\times 8$ . E, *Swedenborgia major*, stoma, Slide 3440,  $\times 200$ . F, G, H, *C. leptoderma*, stomata. Slides 3483, 4, 5,  $\times 400$ .

Genus **CALLIPITYS** gen. nov.

Type-species *C. leptoderma*.

For diagnosis, see below.

**Callipitys leptoderma** sp. nov.

Pl. 19, figs. 1—4; Pl. 21, figs. 4—7.

Text-fig. 44 C, D, F—H. The figures represent the Type-specimen.

*Occurrence.* Neill Cliff, Liverwort Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis* (based on Type-specimen only). Cone 2 cm long, 8 mm

broad, consisting of an axis about 1 mm thick, bearing a few leaves at the base and spirally arranged cone scales above. Leaves about 8 mm long, 1 mm broad, sharply pointed, midrib inconspicuous. Cone-scales delicate, broadly lanceolate, 4 mm long, 3 mm wide, distal part curved upwards. Upper surface bearing two round ovules 1.5 mm in diameter with upwardly directed micropyles.

Lowest cone scales rather larger than the others.

Cuticle of leaf very thin, especially on one side. Both sides showing elongated straight-walled cells with fine, rather faintly marked outlines and without papillae or surface pitting. Stomata occurring on the thinner side; orientated longitudinally, distribution doubtful, but not forming conspicuous bands. Guard-cells sunken, stomatal pit more or less rectangular, surface of subsidiary cells very slightly thickened round the stomatal pit, but otherwise unspecialised. Encircling cells usually absent.

Cuticle of cone scale a little thicker than that of leaf but quite delicate, cells varying in shape, more or less isodiametric in some parts, elongated and forming rows in others. Lateral walls straight and faintly marked, papillae and surface pitting absent. Stomata infrequent.

Cuticles of seed also delicate, integument showing small hexagonal cells; megaspore membrane thicker but very soft, forming a sac 0.5 mm in diameter; apparently no other cuticle is present between the integument and megaspore.

*Discussion.* *Callipitys* (which is only represented by the indifferently preserved Type-specimen) is most similar to *Stachyotaxus septentrionalis*, but can be distinguished by the absence of a cup at the base of the ovules and by the relatively minute size of the ovules. The cuticle of the integument — which shows much smaller cells, and the smaller size of the megaspore, also distinguish them.

Among recent conifers, *Callipitys* resembles *Cephalotaxus* in the way the ovules are borne, though it differs from it in the cuticle of the leaf.

Although there is insufficient evidence on which to classify *Callipitys*, it is interesting as an example of an early conifer in which the ovules are apparently borne directly on a simple cone scale.

The specific name refers to the thinness of the cuticle.

#### Genus **ARAUCARITES** PRESL.

1838. *Araucarites* PRESL, p. 205.

(I have not been able to examine this reference).

*Discussion.* *Araucarites* was first used to denote conifer twigs, for example *Araucarites* (now *Pagiophyllum*) *peregrinum*, but it has come to be restricted to isolated cones and cone scales. The validity of the name is thus doubtful; and I know no definite generic difference

between many of the cone scales referred to *Araucarites*, *Dammarites* and (apart from the preservation) *Protodammara* — see SEWARD 1919, pp. 244—270 for references.

The fossil described below resembles other specimens described as *Araucarites* and it is therefore included in this genus, though I cannot,

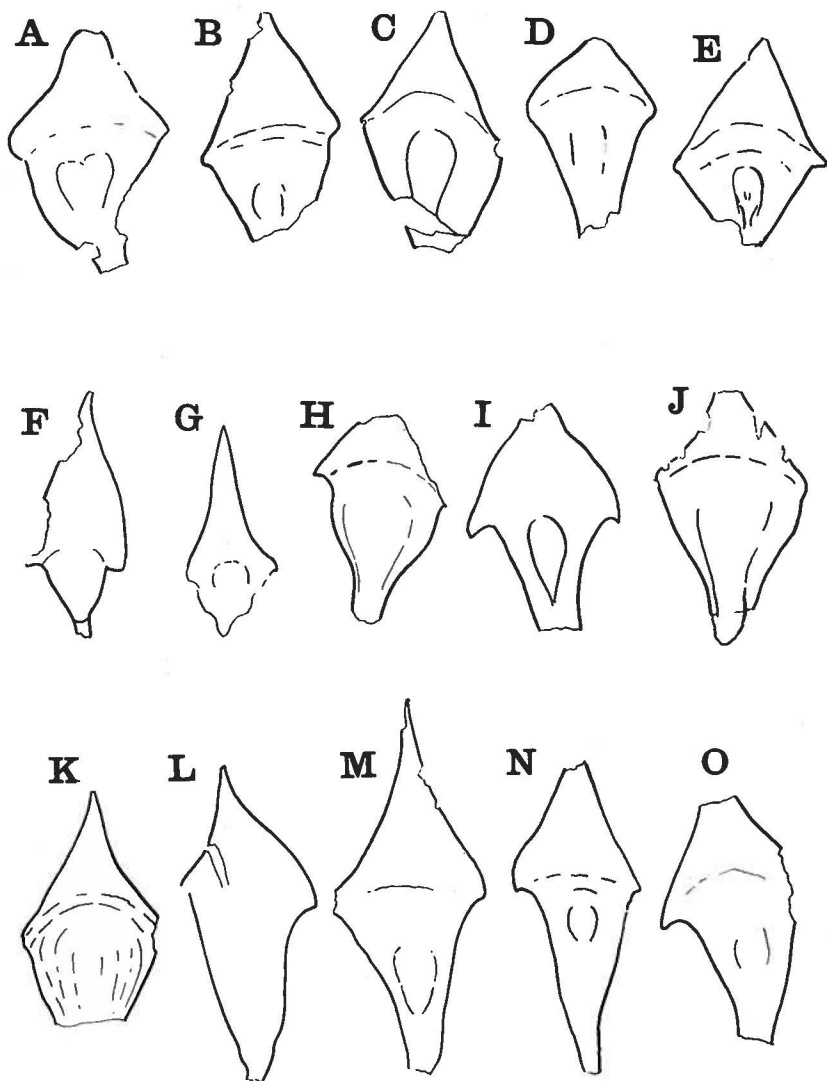


Fig. 44. *Araucarites charcoti*.

In this figure all the best preserved, isolated cone-scales are shown. — A, No. 4450; B, No. 4451; C, No. 4452; D, No. 4453; E, No. 4454; F, No. 4455; G, No. 4456; H, No. 4460; I, No. 4470; J, No. 4471; K, No. 4472; L, No. 4473; M, No. 4474; N, No. 4475; O, No. 4476. — All the specimens are  $\times 2$ . Those shown in A—H were obtained from Astarte R., Bed A; the others from Astarte R., *Lepidopteris* Bed.

however, regard the evidence for referring it to the Araucariaceae as entirely satisfactory. A 'ligule' is definitely absent and nothing is known about the seed apart from a depression on the scale which suggests its position. In these features it resembles *Agathis* but in shape it rather resembles *Araucaria*. Foliage of the *Pagiophyllum* type (which is often identified with *Araucarites* cones) is absent in Greenland, the only conifer foliage associated with it is various species of the form-genus *Podozamites*.

The Araucarian type of cone-scale is known from rocks much older than Rhaetic and from many parts of the world, but it does not become common until the Middle Jurassic and it is rare in the Arctic regions. The discovery of *A. charcoti* in the Rhaetic of E. Greenland is thus of some interest.

***Araucarites charcoti* sp. nov.**

Pl. 20, figs. 1—5, 9—13; Text-figs. 43, 44.

Type-specimen, Pl. 20, fig. 1—4.

*Occurrence.* Astarte R., *Lepidopteris* Bed; Bed A.

Both of these beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Cone cylindrical, 6 cm long, 2.5 cm thick, borne on a peduncle 5 mm thick. Surface of peduncle showing longitudinal ridges suggesting decurrent leaf bases, but no leaves or bracts actually attached. Cone scales rather loosely arranged; typically 2 cm long, 8 mm wide; divided by a somewhat curved transverse furrow into a proximal and a distal half; both halves triangular; proximal half composed of a moderately thick layer of carbonaceous matter. Distal half quite delicate, tapering to an acute point; base of distal half projecting towards the cone axis for 1—2 mm, forming a small hook at each side of the scale. One surface of proximal half of scale (probably the under) showing near its base a longitudinal ridge 1—2 mm wide; the other surface showing an ill-defined oval imprint which suggests the position of a single median ovule. Cuticle present on one, or both sides of scale, but delicate and ill-preserved. Cells with straight, finely marked walls; in some places cells isodiametric, in other places cells elongated. Surface of occasional cells thickened in the middle to form a papilla. Stomata not recognised with certainty.

*Discussion.* *A. charcoti* is represented by one complete cone and by a great many detached scales, the best preserved of which are figured. Transfers were made from several detached scales, but I found no trace of a seed, apart from the large impression which I regard as the scar left by a detached seed.

*A. charcoti* probably differs from most species of *Araucarites* in the rather delicate texture of its cone scales. In shape it resembles

certain specimens of *A. jeffreyi* BERRY (1908), a Cretaceous species, but is distinguishable by the apical region of the scale which is nearly triangular and forms marginal 'hooks' instead of tapering rapidly and then extending as a filiform process. As in *A. charcoti*, the seeds of *A. jeffreyi* dropped from the scales before preservation.

*A. charcoti* is named after Dr. CHARCOT, the explorer.

Genus **STAPHIDIOPHORA** gen. nov.

Type-species *S. secunda*.

*Diagnosis.* Slender axis bearing small, sessile seeds. Seeds possessing a cutinised integument and a cutinised megaspore membrane and traces of an intermediate cutinised membrane. Stomata sunken, surrounded by an irregular ring of subsidiary cells.

The name is from σταφίδιον a small raisin and φερα bearing, and refers to its resemblance to a bunch of raisins.

**Staphidiophora secunda** sp. nov.

Pl. 8, figs. 3, 4, 9, 10, 11; Text-fig. 45.

All the figures represent the Type-specimen.

*Occurrence.* Vardekloft, *N. hoerensis* Bed (*Lepidopteris* Zone).

*Diagnosis.* Seed-bearing fructification consisting of an axis naked below, bearing a few seeds in its upper part. Axis about 1 mm thick, tapering towards the apex. Seeds sessile, probably borne alternately

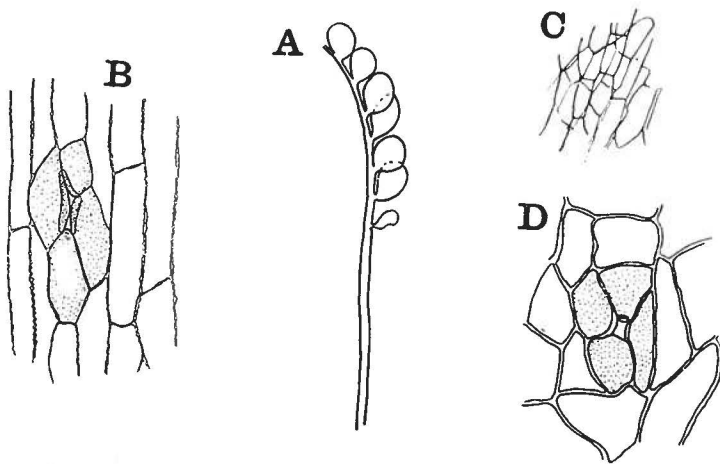


Fig. 45. *Staphidiophora secunda*.

A, Type-specimen, No. 3011,  $\times 1$ . B, stoma from the axis, Slide 2861,  $\times 200$ . C, inner cuticle of seed (fused cuticles of cuticle of nucellus and of inside of integument), Slide 2864,  $\times 200$ . D, stoma from the integument of a seed, Slide 2864,  $\times 200$ .



but all situated on one side as a result of twisting of the axis. Seeds nearly circular, 4 mm in diameter, composed of a rather thin layer of coaly matter.

Axis possessing a single dark (vascular) strand. Cuticle of axis moderately thick, showing elongated straight-sided cells without median papillae but showing faint longitudinal striations. Side walls of cells with fine jagged thickenings. Stomata fairly frequent. Subsidiary cells forming an elongated group. Guard cells sunken, subsidiary cells possessing a rim of cuticle overhanging the stomatal pit. Seed possessing three cutinised membranes: (1) the outer cuticle of the integument, a delicate cellular membrane, (2) the adherent cuticles of the inside of the integument and the outside of the nucellus and (3) the cuticle of the megaspore membrane.

Outer cuticle of integument moderately thick; showing isodiametric, straight-sided cells without median papillae and straight lateral walls without jagged thickenings. Stomata frequent, resembling those on axis except that the group of subsidiary cells is round. Fused cuticles of inside of integument and of nucellus very delicate, both showing very thin walled polygonal cells. Cuticle of megaspore membrane thick and brownish, but soft, rather coarsely granular. Seed possessing no considerable stony layer and no resin bodies.

*Discussion.* *S. secunda* is only represented by the Type-specimen. The interpretation of this fossil as a seed-bearing fructification is based on the internal structure of the round, seed-like bodies which show cuticles which match those of typical recent and fossil seeds — the cuticle of the outside and inside of the integument, of the nucellus, and an innermost non-cellular, granular cuticle — the megaspore membrane. It is doubtful whether the occurrence of the seeds on one side of the axis is an original feature; the cuticle of the axis shows signs of twisting below each seed and if allowance is made for this, it is clear that the seeds must have been borne alternately, or perhaps in a very loose spiral.

*Attribution.* There is strong evidence from its structure and its association that it belongs to *Hartzia tenuis*. The cuticle of the axis of *S. secunda* shows exactly the same characters as the cuticle of the leaf of *Hartzia* — except that stomata are a little less numerous. There is no other plant in the Greenland flora with which this cuticle could be confused — the most similar are *Czekanowskia nathorsti* (from which it is easily distinguished by the fine zigzag thickenings on the cell walls) and *Ginkgoites minuta*, in which the group of subsidiary cells is more rounded. No non-Ginkgoalean plant is known with a similar cuticle.

It occurs associated with *Hartzia* in the bed in which this leaf is most abundant. The only other Ginkgoalean leaf in this bed (*G. minuta*)

is rare; *Czekanowskia nathorsti* does not occur in this bed, or indeed in this zone.

The specific name refers to the second arrangement of the seeds.

**Staphidiophora (?) exile** sp. nov.

Pl. 19, fig. 9 (Type-specimen).

*Occurrence.* C. Stewart A. *minor* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Cone 2 cm long, consisting of an axis 0.5 mm wide bearing pairs of seeds at intervals of 2 mm. Seeds sessile, inclined to the axis at about 45°, all borne in the same plane, base pointed, apex blunt. Substance of seed not very thick; surface showing no obvious markings. Seed, on maceration, yielding a delicate outer cuticle showing fine but fairly conspicuous outlines of straight-walled cells 70  $\mu$  long, 10  $\mu$  wide, and containing a rather thicker, non-cellular cuticle, the megaspore membrane.

*Description.* This species is represented by the Type-specimen only. Transfer-preparations were made both of the part and the counterpart, but it was found that the fossil was almost entirely situated in the plane of rock-bedding and as a result neither transfer showed any feature not seen in the photograph on Pl. 19, fig. 9. It was, however, possible to remove fragments of the seeds for maceration, but the preservation was too poor to permit any detailed investigation to be made.

*S. exile* differs from *S. secunda* in its minute size and in its crowded, opposite or sub-opposite seeds. It also differs in the cells of the integument, which are much narrower.

The specific name *exile*, literally without guts and hence meaning puny, refers to its small size and delicate substance.

Genus **OUROSTROBUS** gen. nov.

Type-species *O. nathorsti*.

*Diagnosis.* See below.

The name is from οὐρα, a tail, and στροβος a cone.

**Ourostrobos nathorsti** sp. nov.

Pl. 23, figs. 3, 6, 7, 11; Pl. 27, fig. 11.

1878b. *Amentum masculum coniferarum* NATHORST, Pl. 16, fig. 4.

*Occurrence in Greenland.*

1. Cones.

Lejr R., *Czekanowskia* Bed.

Vardekloft *Podozamites agardhianus* Bed.

Dinosaur R., *Marattiopsis* Bed.

Storgaard R.

C. Stewart *Todites* Bed.

These beds belong to the upper half of the *Thaumatopteris* Zone.

2. Isolated seeds resembling that of *O. nathorsti*.

Lejr R., *Czekanowskia* Bed.

Astarte R., *T. brauniana* Bed.

Vardekløft, *P. agardhianus* Bed.

Dinosaur R., *Marattiopsis* Bed.

All of these beds belong to the *Thaumatopteris* Zone.

*Diagnosis.* Seed-bearing cone 4—7 cm long, 1.0—1.3 cm wide, composed of a central axis 1—2 mm wide, thickly covered with overlapping, upward pointing cone scales. Cone scales about 1.5 cm long, 2 mm wide near the base, tapering to an acute apex. Cuticle of cone scale very delicate indeed.

Each scale bearing a seed on its upper side, near its point of attachment. Seed attached to the scale by its whole length, about 1.5 mm long  $\times$  0.5 mm broad, with a very delicately cutinised integument but a more resistant megaspore membrane forming an oval sac typically  $1.5 \times 0.6$  mm (extremes  $1.0 \times 0.5$  and  $2.5 \times 1.0$  mm). Surface of megaspore covered with minute granules, and in most specimens showing very obscure impressions of longitudinally elongated cells. In some specimens megaspore loosely enveloped in a very delicate cuticle showing indications of straight-sided cells.

*Discussion.* *Ourostrobos nathorsti* is represented by a dozen cones and a large number of isolated seeds from bulk-macerations. In spite of the abundance of material it has been impossible to investigate its structure in much detail, owing to the delicacy of its cuticle.

It differs from *Ontheodendron sternbergi* in the much smaller size of all its parts and in its more delicate cuticle, and I think it would be a mistake to place it in that genus. It agrees perfectly in its appearance with NATHORST's cone cited above, which from its appearance he identified as a male cone. It is surprising that such a delicate cone should be a female cone, yet from nearly every specimen I was able to obtain seeds.

Genus **MICROCHEIRIS** gen. nov.

Type-species *M. enigma*.

*Diagnosis* and *Discussion* — see below. The name is from μικρός, small and χείρις, a glove, and refers to its general shape.

**Microcheiris enigma** sp. nov.

Pl. 8, figs. 5, 6.

*Occurrence.* Vardekløft Czekanowskia Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis.* Flattened scale 5 mm long, 5 mm broad, of oval shape, upper margin divided into five rounded lobes 1.5 mm wide. Megaspore-membranes of seeds situated in the substance of the scale about 1 mm below the top of each lobe. Megaspore membrane oval, 1.5 mm  $\times$  0.8 mm, composed of a delicate, densely staining cuticle showing no cell-outlines but covered with granules up to  $2\mu$  wide. Cuticle of one side of scale (termed the under) rather thin, showing the outlines of straight-sided cells  $30\mu \times 20\mu$ , cuticle of upper side very delicate but probably of similar structure. Stomata and trichomes not recognized. Definite masses of microspores situated on the upper surface 0.4 mm to the proximal side of each embryo sac.

*Discussion.* *M. enigma* is only represented by the Type-specimen, which was obtained by dissolving some sandstone in Hydrofluoric acid. It is rather delicate but fairly well preserved. Its most remarkable feature is certainly the mass of pollen grains just below each embryo-sac. These masses of pollen grains are so definite and occur in a constant relation to the embryo-sacs that there can be no doubt that they owe their existence to some original structural feature of the scale and not to their accidental assemblage. The most likely cause would be a pollenation drop, though owing perhaps to the delicacy of the cuticles on this side of the scale there is no sign of any special structure at this point.

There is no doubt that the embryo-sacs are situated above the relatively thick cuticle of the lower side of the scale and that they are situated underneath such remnants as there are of the delicate cuticle of the upper side of the scale. I conclude, therefore, that they are entirely enclosed in the tissue of the scale.

There is no trace of a cuticle corresponding to the nucellus of the seeds, or to their integuments unless the general cuticle of the scale is so regarded. At the distal end of the megaspore, it is true, there seems to be a small mass of dark material but this shows no structure at all.

The spores on the upper surface belong to several types, but two predominate. Both of these are smooth-walled oval spores with a longitudinal fold, one is  $70\mu \times 40\mu$ , the other  $30\mu \times 20\mu$ .

This fossil is obviously of a very peculiar type and thus of considerable interest. Two morphological interpretations seem to be possible. On the one hand, it may be essentially similar to a coniferous cone scale bearing five deeply embedded seeds (cf. *Cheirolepis*, HÖRHAMMER 1933),

though it differs from *Cheirolepis* in having no 'bract scale' and the seeds lack any cellular cutinised membranes near their micropyles. On the other hand, it may be like a *Caytonia* 'fruit' containing five seeds, though it again differs in having no cutinised integumentary membranes round its megaspore membrane and in the absence of a single definite 'stigma'. This difference in the stigma would not, however, exclude the possibility that *Microcheiris* might belong to the Caytoniales, because in each of the species of the Caytoniales studied the stigma is obviously a complex structure consisting of alternate denser and lighter portions which seem to correspond in number to the seeds and which I think may represent separate stigmatic canals. On this view *Microcheiris* would illustrate the Caytonialean 'stigma' in a simpler form.

The specific name refers to its puzzling nature.

### Genus **TMEMATOSTROBUS** gen. nov.

Type-species *T. eremus*.

For diagnosis and discussion see below. The name is from *τμήμα*, a shred, and *στροβός*, a cone.

### **Tmematostrobos eremus** sp. nov.

Pl. 23, fig. 5; Pl. 28, fig. 6.

Type-specimen, Pl. 23, fig. 5.

#### *Occurrence.*

Primula R., Lower plant Bed.

Hare R., Lower plant Bed.

Astarte R., Bed A.

Tancredia R., *Lepidopteris* Bed.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Cone typically 5 cm long and 2 cm wide, consisting of an axis up to 2 mm thick bearing spirally arranged 'sporophylls'. 'Sporophylls' spatulate, typically 10 mm long and 2.5 mm broad just below the apex; apex rounded. Surface of 'sporophylls' showing about three conspicuous longitudinal ridges or grooves. Sporophylls on maceration yielding a number of very delicate cuticles and also some resistant strands up to 7 mm  $\times$  0.4 mm, consisting of a central core of structureless resin surrounded by a few layers of resin-casts of elongated cells.

*Discussion.* The morphological nature of *Tmematostrobos* is very doubtful as the only resistant parts — the resin strands — though very characteristic, give no information. The delicate cuticles consist of fragments probably belonging to the outside, showing straight-walled cells 75  $\mu$   $\times$  12  $\mu$ ; fragments consisting of a double cuticle, showing the superimposed outlines of two sets of straight-sided cells (cf. fused cuticles

of nucellus and inside of integument), and fragments of a delicate non-cellular, granular cuticle (like the megaspore membrane of a seed). Very few microspores of any sort were found, and I conclude that it cannot have been a pollen-bearing organ.

In some cases the spatulate 'sporophyll' contains rock matrix and appears to be open at the apex.

The available evidence suggests that *Tmematostrobos* was a seed rather than a pollen-bearing cone, consisting of an axis and simple, spirally arranged 'sporophylls' which enclosed one or more seeds and shed them through apical openings. There is no reason to identify *Tmematostrobos* with any particular leaf, and it is at present impossible to classify it.

*Comparison.* *T. eremus* is very like *Androstrobos borealis* NATHORST (1878c) and may prove to be generically identical. It is distinguishable by the smaller size of its 'sporophylls'. It somewhat resembles species of *Stenorachis*, particularly *S. dubius* ANTEVS (1919), but differs in its unbranched 'sporophylls'.

The specific name *eremus* is from ἐρημος, deprived of what was there, and refers to the emptiness of most of the sporophylls.

## 2. ISOLATED SEEDS.

I propose to classify the seeds in the Greenland flora as follows:—

1. Seeds which, though isolated, can be attributed to certain fruits or to certain species of leaves with fair certainty, have been described with these fruits or leaves under the same generic names — e.g. seeds of *Caytonia*, *Vardekloeftia*, *Wielandiella*, *Stachyotaxus*, *Nilssonia*, *Lepidopteris*. In the case of *Lepidopteris* and *Nilssonia* it would have been better to have used different generic names, since they have not actually been found attached. This I propose to do in my next paper.

2. Seeds which cannot be attributed to leaves with the same certainty.

A. More or less oval seeds of unknown structure. . . . . *Carpolithus*.

This group may include uncutinised seeds, isolated 'stones' of seeds and possibly bodies which are not seeds at all.

B. Seeds of characteristic external form under various generic names, e. g. . . . . *Samaropsis*.

C. Seeds showing (cuticular) structure:—

1. Small orthotropous seeds with thinly cutinised integument and a relatively thickly cutinised nucellus.

a. with a short micropylar canal (as *Caytonia*)

*Amphorispermum* HARRIS.

b. with a long micropylar canal. . . *Bysmatospermum* gen. nov.

2. Larger orthotropous seeds with a thickly cutinised integument and a thinly cutinised nucellus which is cutinised (i.e. free) down to a considerable distance from the apex of the seed. Megaspore membrane present.

*Allicospermum* gen. nov.

3. Orthotropous seeds as *Allicospermum*, but with the nucellus only cutinised at its apex..... *Chitospermum* gen. nov.

It may be pointed out that the seeds of most Gymnosperms would be placed either in *Allicospermum* or in *Chitospermum*, both of which are likely to include species belonging to several families.

### Form-genus **ALLICOSPERMUM** gen. nov.

Typical species *A. xystum*.

Round or oval orthotropous seed. Integument thick, cutinised; nucellus free in its upper part, surface of nucellus and of inside of integument thinly cutinised; megaspore membrane cutinised, granular.

The form-genus *Allicospermum* would include among recent plants, the seeds of *Ginkgo*, Cycads and some Conifers, and among fossils, the seeds of *Nilssonina*, *Lepidopteris*, and *Stachytaxus*.

The name is from ἄλλιξ, an outer garment, referring to the loose-fitting integument, and σπέρμα, a seed.

### **Allicospermum xystum**

Pl. 9, figs. 1—10, 13, 18; Text-fig. 46.

Type-specimen, Pl. 9, figs. 13, 18.

#### *Occurrence.*

Astarte R., *Thaumatopteris brauniana* Bed (common).

Dinosaur R., *Marattiopsis* Bed (rare).

C. Stewart *A. hartzi* Bed (rare).

These beds belong to the *Thaumatopteris* Zone.

*Diagnosis.* Circular (globular) seed 11 mm diameter. Surface quite smooth — apart from folds due to crushing and fine pitting due to epidermal cells. Micropyle and chalaza not projecting and scarcely recognizable without maceration. Cuticle of integument very thick, thickest near micropyle, becoming thinner near chalaza, showing isodiametric cells with straight, strongly marked side walls. Cells often arranged in packets formed by the subdivision of larger cells. Surface of cells slightly thickened in certain specimens, but seldom forming a definite papilla. Micropyle a round hole 0.5 mm wide, cells of integument at apex of seed arranged in rows pointing towards the micropyle. Cuticle near chalaza delicate and with larger cells, but otherwise resembling cuticle of rest of seed. Stomata rather sparsely scattered over all

parts of integument, guard-cells sunken, thickened only round the aperture, possessing 4—6 subsidiary cells forming an irregular ring, subsidiary cells without papillae, pore between subsidiary cells oval or round, surface of subsidiary cells, in certain specimens, very heavily cutinised. Space between outer and inner cuticles of integument (representing the flesh and stone of seed) 2—3 mm wide, stone remarkably resistant to maceration, yielding many round or elliptical resin bodies about  $1.0 \times 0.5$  mm long.

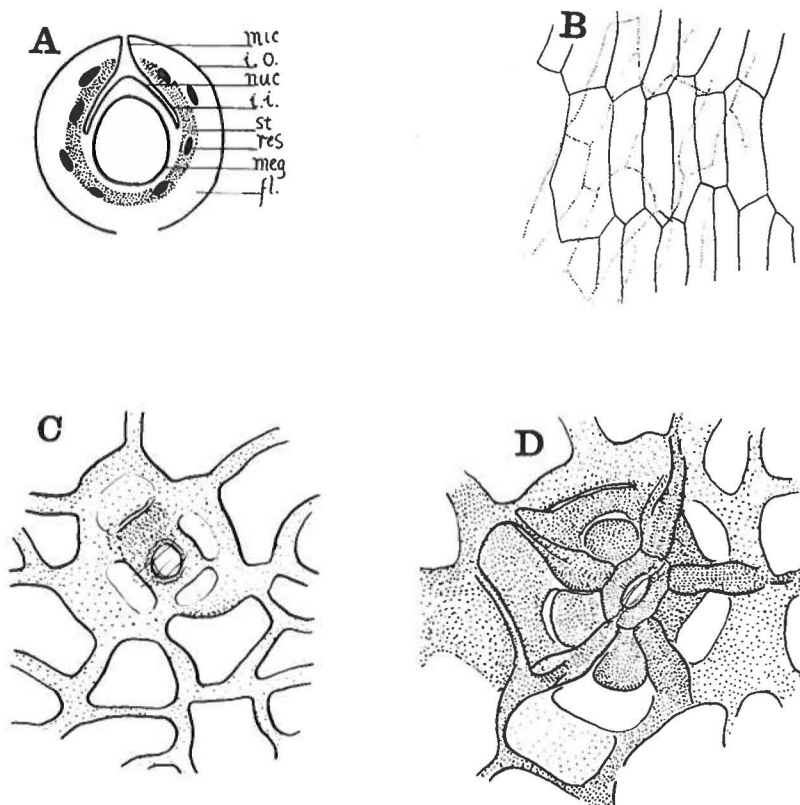


Fig. 46. *Allicospermum xystum*.

A, restoration of the seed in median longitudinal section showing the micropylar canal (*mic*), the outer cuticle of the integument (*i.o.*), the free part of the nucellus (*nuc*); the inner cuticle of the integument (*i.i.*); the stone (*st*); resin bodies (*res*) more or less embedded in the stone; the megaspore membrane (*meg*) and the flesh of the integument (*fl.*). The thickness of the layers outside the megaspore is slightly exaggerated for the sake of clearness. B, inner cutinised membrane of seed coat consisting of inside of integument (cells with continuous walls) and of outside of nucellus (cells with finely moniliform walls), Slide 2892,  $\times 100$ . C, a stoma on integument, Slide 2901,  $\times 400$ . D, a stoma, much more heavily cutinised than in C, Slide 2913,  $\times 400$ . The specimen shown in B was obtained from Dinosaur R.; that in C from C. Stewart; that in D from Astarte R.



Cuticle of nucellus and of inside of integument only present in upper third of seed. Cuticle of inside of integument rather thick in region of micropyle; cells resembling those of outside of integument, becoming much more delicate below and cells becoming larger. Cuticle of nucellus delicate, cells large, lateral walls sometimes finely dotted and thus being distinguishable from those of the inside of the integument.

Megaspore membrane fairly thick, without any definite indication of cells but with a finely granular texture.

*Discussion and Comparison.* *A. xystum* is represented by a great many specimens from Astarte R., and by a single specimen from each of the other localities. The various specimens agree closely with one another. No specimens were found attached; a few specimens were found occurring in pairs, suggesting attachment to a stalk as in *Ginkgo*, but in none of these specimens could I obtain evidence that the two seeds are organically connected.

In addition to the specimens figured on Pl. 9; a few rather smaller seeds were found with the others, which seem to represent the isolated stones of seeds from which the cuticle and flesh of the integument had disappeared. The specimens were macerated and yielded no thick outer cuticle, but gave satisfactory preparations of a megaspore membrane and the delicate cuticle showing two sets of cells agreeing with the corresponding membranes of *A. xystum*.

There are strong reasons from association and agreement in structure for regarding *A. xystum* as the seed of *Ginkgoites taeniata*. *A. xystum* occurs in the three localities where *G. taeniata* occurs and is found nowhere else. The stomata on its integument are very similar to those of the leaf of *G. taeniata* except that they are sometimes rather larger and more heavily cutinised, and the two fossils agree in the presence of resin. The very close resemblance of *A. xystum* to the seed of *Ginkgo biloba* is in agreement with this view.

Of the other associated plants, a good many have entirely different cuticles and cannot possibly have belonged to *A. xystum*; but *Nilssonia incisoserrata* (occurring in two of the localities), and *Ginkgoites hermelini* (occurring in one of them) should be mentioned as their stomata are of the same general type as those of *A. xystum*, though less similar in detail.

*Comparison.* *A. xystum* somewhat resembles the seed referred to *Nilssonia incisoserrata* but differs from it in being rounder and much more substantial (owing to its thicker stone); in being smoother — the resin bodies do not form bulges on the surface and in having only the upper third of the nucellus cutinised (i. e. free).

From *A. striatum* it is distinguished by its unstriated surface (because its integument cells are not elongated and do not form definite rows).

The specific name *xystum* is from ξυστος, polished, and refers to the appearance of the surface.

***Allicospermum* (?) *striatum* sp. nov.**

Pl. 11, fig. 6 (Type-specimen); Text-fig. 47 B.

*Occurrence.* Astarte R., Bed A.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Oval seed 10 mm  $\times$  7 mm; substance thick, surface marked with fine longitudinal cell-striations. Cuticle of integument moderately thick, cells more or less vertically elongated and often arranged in vertical rows. Stomata infrequent, surrounded by several irregularly placed subsidiary cells. Cuticle of inside of integument and of nucellus not definitely recognized. Cuticle of megaspore membrane rather thick, granular. Resin not found.

*Discussion and Comparison.* Only a few seeds of *A.*(?) *striatum* were found, and none of these yielded satisfactory preparations of the nucellus. The general resemblance of this seed to *A. xystum* is, however, so close that it most probably has essentially similar structure. It is only distinguishable by the absence of resin, and by the cuticle of the integument, which is thinner and has longer cells.

*Allicospermum*(?) *striatum* may be the seed of *Ginkgoites acosmia*. The two fossils are found associated and neither occurs elsewhere. They agree quite well in their stomata; the only other associated leaf with at all a similar stoma is *Baiera leptophylla*, which is very rare in this bed.

*Comparison* — see *A. xystum*.

***Allicospermum* (?) *Sp. A.***

Pl. 11, fig. 9.

*Occurrence.* Vardekløft Liverwort Bed.

*Description.* A few specimens which closely resemble the one figured were found associated with *G. hermelini*. They consist of an internal cast of a seed covered with a brittle layer of carbonaceous matter. No satisfactory cutinised membranes were obtained by maceration. Although these seeds are scarcely determinable, their close resemblance to some similarly preserved specimens which seem to be the isolated stones of the seed of *A. xystum* is noteworthy. *S. xystum* is attributed on evidence of association and agreement in structure to *G. taeniata*, and the occurrence of this specimen provides a certain amount of additional circumstantial evidence supporting the suggestion that *Ginkgoites* possessed this type of seed.

***Allicospermum hartzi* sp. nov.**

Pl. 27, figs. 8, 9.

Selected Type-specimen HARRIS 1926b; Text-fig. 31 E, F, H.

'Seed B' HARRIS, 1926b, p. 126; Text-fig. 31 E—H.

*Occurrence.*Neill Cliff, *Neocalamites* Bed.?Vardekløft, *Wielandiella* Bed.These beds belong to the *Lepidopteris* Zone.

The specimens collected by HARTZ and described by HARRIS (1926b) were probably obtained from Vardekløft.

*Diagnosis.* Elliptical seed 4 mm long, 3 mm wide with a micropyle 0.3 mm wide projecting upwards 0.3 mm. Cuticle of integument moderately thick, especially in the upper part. In micropylar region cuticle composed of small narrow cells; in upper part of seed composed of cells  $90\mu$  long,  $35\mu$  broad with very prominent lateral walls, especially at the corners of the cells, the cells in consequence often appearing rounded. In lower part of seed, cells longer ( $200\mu$  long,  $15\mu$  broad), outlines less distinct. In all parts of seed surface of cells unpitted and without any median thickening. Stomata absent.

'Stone' of seed probably not very thick.

Inner cellular cuticle (of inside of integument and of nucellus) delicate, extending from the micropyle to the base of the seed, showing the outlines of two sets of similar elongated cells  $300\mu \times 40\mu$ . Outlines of both sets of cells rather finely and faintly marked, one being rather fainter than the other.

Megaspore membrane an oval sac 2.5 mm long, 1.8 mm broad, composed of a brown non-cellular membrane covered with very minute and rather indistinct granules or pits.

*A. hartzi* is represented by a fair number of closely similar seeds, all of which were obtained by bulk-macerations. There is no reason to attribute it to the same plant as any particular type of leaf. It is named after Dr. N. HARTZ, who collected the first specimens.

***Allicospermum obscurum* sp. nov.**

Text-fig. 47 A, G—J.

Type-specimen, Text-fig. 47 J.

(This is probably the isolated seed of *Cycadocarpidium swabi*).*Occurrence.* C. Hope, *A. minor* Bed.This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Oval seed 3.5 mm long  $\times$  2.5 mm wide. The following cutinised membranes are present:—

1. Outer cuticle of integument; a fairly thick membrane, usually showing scarcely any indication of cells, but occasionally showing rows

of more or less square cells  $70\mu$  wide with finely marked undulating walls. Surface of cells rather unevenly thickened and thus obscuring the cell-outlines. Micropylar opening unspecialised, about  $60\mu$  wide, situated at the more pointed end of the seed.

2. Cuticle lining the micropyle not preserved. Inner cuticle of

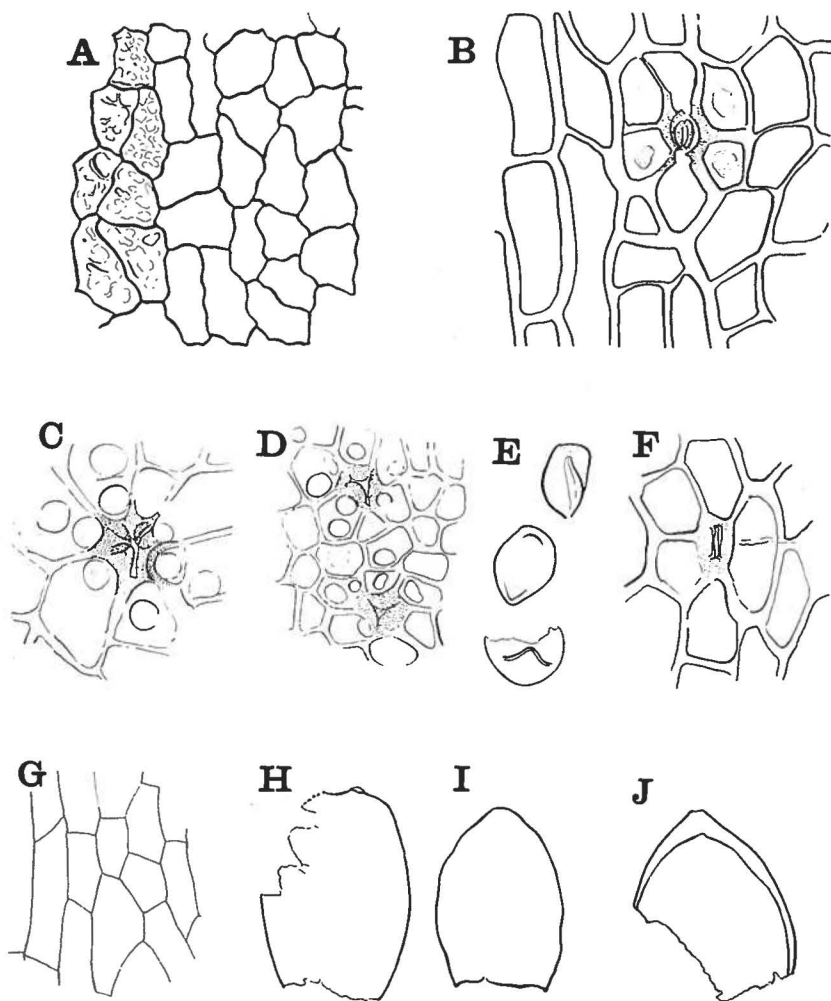


Fig. 47. *Allicospermum* and *Samaropsis*.

A, *A. obscurum*, integument, the surface markings are omitted from most cells, Slide 2953,  $\times 100$ . B, *A. striatum*, integument, Slide 2932,  $\times 200$ . C, *S. scirrhodes*, stoma on integument (near micropyle), Slide 2975,  $\times 400$ . D, *S. scirrhodes*, cuticle of integument near micropyle, Slide 2975,  $\times 200$ . E, *S. scirrhodes*, pollen grains found in micropyle, Slide 2975,  $\times 400$ . F, *S. scirrhodes*, cuticle of integument at some distance from micropyle, Slide 2975,  $\times 200$ . G, *A. obscurum*, nucellus, Slide 2954,  $\times 100$ . H, I, J, *A. obscurum*, outline of integument of seeds; in J, the Type-specimen, the nucellus is shown in place; Slides 2951, 2952,  $\times 8$ .

integument and cuticle of nucellus, rather thin membrane extending from near the apex to near the base, where it is transversely truncate. It shows the faintly marked outlines of one set of vertically elongated cells (probably nucellus cells)  $150\mu \times 40\mu$  with straight walls. In places there appears to be an indication of a second set of fainter outlines and at the apex of the seed the nucellus is invested in a very delicate cuticle — the inner cuticle of the integument.

3. Megaspore membrane, a delicate cuticle almost filling the nucellus. It appears to be almost homogeneous; no definite pitting being visible.

*Discussion.* *A. obscurum* is represented by eight specimens, all of which were obtained by bulk-maceration. It is distinguished from most seeds in the Greenland flora by its shape and dimensions; while from *A. hartzi* and the seed of *Stachyotaxus* it is distinguished by the cells of the integument.

*A. obscurum* agrees perfectly in its structure (so far as is known) with the seed of *Cycadocarpidium swabi* — see p. 101 and it is probably identical with it.

The name *obscurum* refers to the obscure cell outlines on the integument.

***Allicospermum fragilis* sp. nov.**

Text-fig. 48 S.

1926b. 'Seed D' HARRIS, p. 128, Text-fig. 32 A—D.

*Occurrence.*

Primula R., Lower Plant Bed.

Vardekløft *Dictyophyllum* Bed, *Stachyotaxus* Bed, *A. minor* Bed(?).

*Diagnosis.* Seed 16 mm long  $\times$  10 mm broad with a rounded base and pointed apex. Surface smooth, substance very thick.

On maceration yielding the following structures:—

1. The cuticle of integument (missing in most specimens). A fairly thick cuticle showing vertically elongated straight-walled cells  $30\mu$  wide. Cell outlines very obscure and often scarcely visible, but surface of cells provided with broad transverse or oblique thickenings.

2. A thick 'stone' layer, present in all specimens and forming the outside of most of them. Resin is absent.

3. The fused cuticles of the nucellus and the inside of the integument, extending the whole length of the seed, and forming a somewhat thin, though resistant membrane. Cells belonging to integument typically  $150\mu$  long  $\times$   $50\mu$  broad (but occasionally transversely elongated) with straight, very strongly marked lateral walls; cells belonging to nucellus typically vertically elongated,  $100\mu \times 30\mu$  with straight, rather faintly marked walls. Surface of both sets of cells unspecialised.

4. Megaspore membrane, a non-cellular cuticle covered with even-sized granules about  $1.5\mu$  wide.

*Discussion.* *A. fragilis* is represented by a dozen specimens. In my previous description of this seed, which was based on rather scanty material, I described some fragments of cuticle which I have now recognised as the inner lining of the integument as its outer cuticle; the actual outer cuticle is only present in one specimen. In other respects my previous account is correct.

The specific name refers to the fact that the substance of this seed, which usually has lost its outer cuticle, breaks up very readily.

***Allicospermum ooides* sp. nov.**

Text-fig. 48 H—L, R, T.

*Occurrence.* C. Stewart *Todites* Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis.* Seed 7 mm long  $\times$  5 mm broad, of almost elliptical shape, but one end slightly sharper than the other. Surface almost smooth, or in some cases showing folds due to crushing, substance fairly thick.

On maceration yielding the following membranes:—

1. Outer cuticle of integument, a fairly thick cuticle showing vertically elongated straight-sided cells typically  $200\mu \times 30\mu$  with conspicuous lateral walls. Surface of cell either unthickened or else uniformly thickened along the sides but leaving a thin strip down the middle.

2. Fused cuticles of nucellus and inside of integument, a delicate membrane showing a set of isodiametric or somewhat elongated cells typically  $50\mu$  wide and a second fainter set of narrower cells. Cell outlines straight, and very faintly marked. This membrane does not appear to be very extensive.

3. Megaspore membrane. A thin, non-cellular cuticle with an exceedingly finely granular structure.

*Discussion.* *A. ooides* is represented by the five specimens figured. None of them are particularly well preserved. It resembles *A. hartzi* and *A. obscurum* in size but is distinguished from *A. hartzi* by its oval shape and from *A. obscurum* by the very different cells of the integument.

Form-genus **SAMAROPSIS** GOEPPERT.1865. *Samaropsis* GOEPPERT, p. 177.**Samaropsis nathorstiana** sp. nov.

Pl. 18, figs. 1—4.

Type-specimen, Pl. 18, figs. 1, 2.

*Occurrence.* Tancredia R., *Lepidopteris* Bed.This bed belongs to the *Lepidopteris* Zone.*Diagnosis.* Nearly circular seed 2.7 cm in diameter, consisting of a hollow dome-shaped base supporting a nearly circular disc of carbonaceous matter, surrounded except at the base by a very delicate wing nearly 1 cm wide. Wing showing faint radial striations. Substance delicate, even in the central and basal parts.*Discussion.* *S. nathorstiana* is evidently an extremely delicate fossil; the associated remains of *Lepidopteris* and *Anomozamites* appear far more robust. It is represented by only four specimens; there is no reason for identifying it with any type of leaf.*S. nathorstiana* differs from *S. zignoana* (NATHORST 1886, p. 110, Pl. 25, figs. 10—14) in possessing a wing which surrounds the top as well as the sides of the seed, instead of the sides only. It is thus rather more like the seed of *Welwitschia* (with which NATHORST compared *S. zignoana*) but I do not suggest that the resemblance indicates any affinity between them.**Samaropsis chalcos** sp. nov.

Pl. 29, figs. 9, 10; Text-fig. 48 N, O.

Type-specimen, Pl. 29, fig. 9.

*Occurrence.* C. Stewart, *A. minor* Bed; *E. muensteri* Bed.These beds belong to the *Lepidopteris* Zone.*Diagnosis.* Circular seed 2.5 mm in diameter divided by two longitudinal furrows into a central 'nut', 0.7 mm wide, and marginal 'wings'. Micropyle apical, scarcely projecting at all. Surface covered with longitudinal striae due to epidermal cells of integument. Substance rather thin.

On maceration yielding the following cutinised membranes, all of them very thin indeed:—

1. Outer cuticle of integument, showing elongated cells with straight, distinctly marked walls.

2. A delicate cuticle showing two sets of cell-outlines (cuticles of nucellus and inside of integument stuck together in preservation). Both sets of cells have straight, faintly marked walls.

3. A very delicate non-cellular cuticle showing exceedingly fine granules — the megaspore membrane.

*Discussion.* *A. chalcos* is represented by about twenty very similar specimens. It is well distinguished by its minute size from other winged seeds in this flora.

Its name is from *χάλκος*, a minute coin.

***Samaropsis scirrhodes* sp. nov.**

Pl. 11, fig. 1—3; Text-fig. 47 C—F.

The figures represent the Type-specimen.

*Occurrence.* Neill Cliff Liverwort Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis* (based on Type-specimen only). Platyspermic seed 11 mm long  $\times$  7 mm broad, consisting of a central nutlike part 8 mm long  $\times$  3 mm broad enclosed in a wing formed by the flattened integument. Substance of seed rather thin; 'nut' without any considerable stony layer; resin absent from all parts of seed.

Cuticle of integument rather thick, almost uniform except at the base, where it is somewhat thinner; showing uniform isodiametric cells  $20\mu$  wide with rather thick straight walls. Surface of cells usually flat, but some of the cells in the apical region bearing round, hollow papillae  $7\mu$  in diameter at the base and probably less than  $5\mu$  high; cuticle of papilla slightly thinner than the rest of the cell surface. Cells not arranged in rows or in packets except just round the micropyle. Micropyle not projecting, opening about  $50\mu$  wide, surrounded by somewhat thickened cuticle.

Stomata moderately frequent near apex of seed, rare or absent elsewhere, consisting of an irregular ring of about six subsidiary cells with greatly thickened inner walls which meet and obliterate the opening of the stomatal pit. Guard-cells not observed, presumably sunken and thinly cutinised. Encircling cells absent, or if present, irregular and unspecialized.

Inner cuticles of seed consisting of the megaspore membrane and some delicate cellular cuticles confined to the apex of the seed.

The following layers were recognized:—

1. Inner cuticle of integument, a delicate membrane extending about 4 mm from the micropyle and forming a conical cap over the megaspore, showing the outlines of straight-sided cells  $20\mu \times 20\mu$  with moderately thick walls in the upper part;  $60\mu \times 15\mu$  and with very fine walls in the lower part. Surface of cells without papillae or other sculpturing, walls of cells straight.

2. Cuticle of nucellus, extending about 2.5 mm from 1.5 mm below



the micropyle to 1.5 mm beyond the top of the megaspore, and forming a dome-shaped investment of the seed apex. Apex of main nucellar dome forming rounded 'beak'  $200\mu$  wide,  $150\mu$  high. Cuticle rather thin, showing outlines of straight-sided cells  $30\mu \times 10\mu$ .

3. Cuticle of doubtful nature, closely investing the top of the megaspore. No definite cell outlines seen.

4. Megaspore membrane forming a sac  $5.5\text{ mm} \times 3\text{ mm}$ . Cuticle thick and very densely staining, structureless, without any trace of cell outlines or of surface granules or pits.

*Discussion.* *S. scirrhodes* is only represented by the Type-specimen, which is well preserved. The inner membranes are unusually complex and their interpretation is difficult. The inner lining of the integument shows two specialised regions, both above the nucellar beak. The cells along the middle line are vertically elongated, and just above the beak a transversely placed group of cells have rather thickened walls. I consider that the longitudinal line of cells probably represents the actual micropylar canal, the cuticle on the outside being a lateral extension due to the flattening of the seed. The 'micropylar canal' contains a great many pollen grains, apparently all of one type, just above the apex of the nucellus. They are oval,  $17\mu \times 10\mu$ , with smooth, fairly thick walls and a longitudinal fold. Most of them have burst.

A few similar grains are scattered over the surface of the nucellus; I do not know whether these were originally present, or owe their presence to manipulation.

There is no sign of any break in the nucellar beak such as would be caused by a pollen chamber; nor do any pollen grains seem to be situated inside the nucellus.

The nature of the rather indefinite cuticle inside the nucellus is doubtful; it might represent an inner cutinised layer of the nucellus abutting on the megaspore during life, but later separated from it by the shrinkage of the megaspore.

There is no reason to identify *S. scirrhodes* with any particular leaf; its stomata appear to agree with those of the Ginkgoales and several other families of Gymnosperms. The specific name is from *σκιρροδης* indurated, and refers to the thickly cutinised integument.

#### Genus **BYSMATOSPERMUM** gen. nov.

Type-species *B. macrotrachelum*.

*Diagnosis* — see below.

*Bysmatospermum* resembles *Amphorispermum* in appearance but differs in its more strongly developed micropylar canal, in the absence of a resistant megaspore membrane and in the nature of the inner cutin-

ised membrane of the seed which shows the outlines of two sets of cells. The much larger space occupied by the stone, etc. between the two cutinised layers also differentiates it.

There is no reason to refer it to any type of leaf; there being no species which is common to all the localities where it occurs. While its classification must remain open its general resemblance to the Bennettitalean type of seed seems worthy of note.

The name is from  $\beta\upsilon\sigma\mu\alpha$ , a plug, and refers to the plugged micropyle.

***Bysmatospermum macrotrachelum* sp. nov.**

Pl. 29, fig. 12; Text-fig. 48, A—G, M, P, Q.

Type-specimen, Text-fig. 48 G.

*Occurrence.*

Astarte R., Bed A, Bed C.

C. Hope, *A. minor* Bed.

C. Stewart, *A. hartzi* Bed.

The bed at C. Stewart belongs to the lower half of the *Thaumatopteris* Zone; the other beds to the *Lepidopteris* Zone.

*Diagnosis.* Orthotropous seed, varying in size from 2.1 mm  $\times$  1.5 mm, to 1.7 mm  $\times$  0.7 mm, shape usually oval but in some cases upper end narrowed some way below the apex; yielding the following resistant layers on maceration:—

1. Cuticle of integument. A moderately thin, or a very thin membrane showing the outlines of cells 15—40  $\mu$   $\times$  15  $\mu$  with thin straight walls. Trichomes consisting of a round cell 30  $\mu$  in diameter with a rather thickened surface and a central thin portion 15  $\mu$  wide occurring scattered over the surface, their frequency varying in different specimens. Cells at apex and at base of seed rather smaller.

2. Cuticle lining micropylar canal. This is typically 300  $\mu$  long and 40  $\mu$  wide and is composed of a thicker cuticle than the integument. It shows the outlines of narrow, straight-walled cells 3  $\mu$  wide, 30  $\mu$  long. Occasionally the whole canal is filled with dark-staining structureless material, but more often this is confined to its lower third, where it is invariably present. Cellular tissue probably present at base of micropyle but obscured by the brown resinous matter. The brown resin extends slightly below the base of the micropyle where it ends sharply.

3. Cuticle forming inside of seed (? inside of integuments and nucellus). A moderately thick cuticle (considerably more resistant than the outer cuticle of the integument) varying in size from 1.3  $\times$  0.8 mm to 1.1  $\times$  0.4 mm, showing two sets of cell outlines — one set of very conspicuous longitudinally elongated cells typically 150  $\mu$   $\times$  15  $\mu$  with conspicuous, nearly straight walls, and the other of isodiametric cells

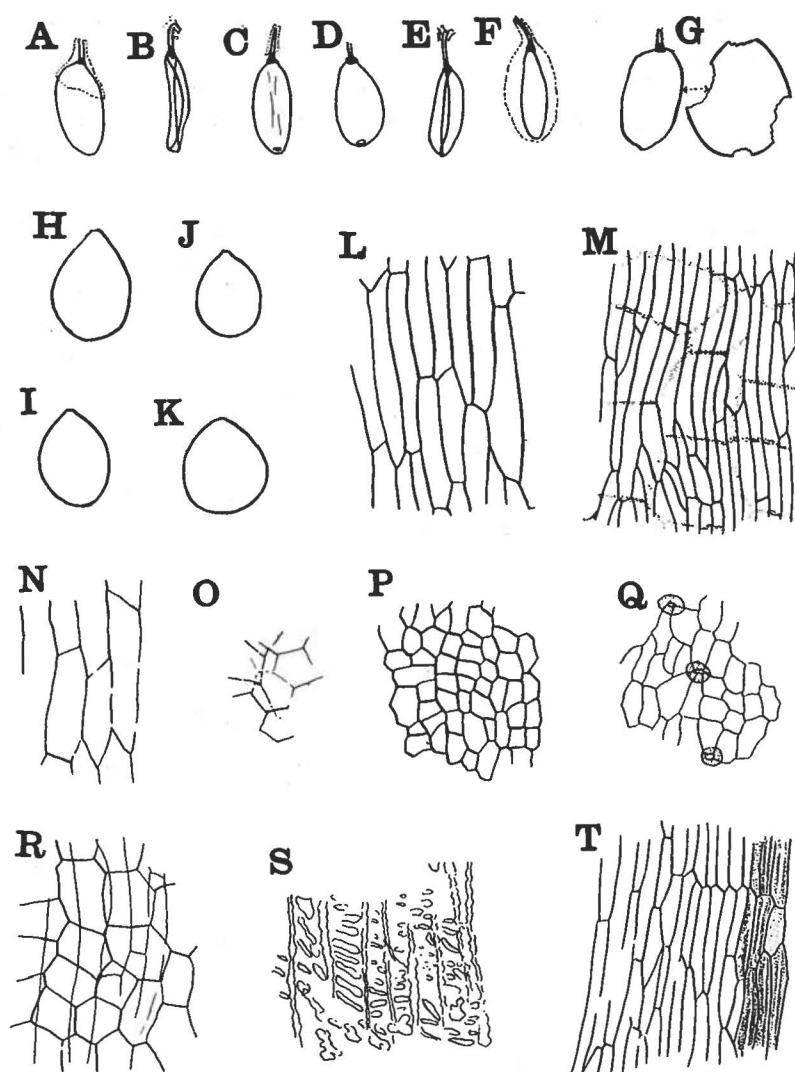


Fig. 48. Seeds.

A—E, *Bysmatospermum macrotrachelum*, the nucellus and micropylar canal are indicated by a firm line, the integument, when present, by a dotted line, Slide 2857,  $\times 8$ . F, *B. macrotrachelum*, Slide 2858,  $\times 8$ . G, *B. macrotrachelum*, Type-specimen showing the nucellus, etc. to the left and the remains of the integument to the right, Slide 2850,  $\times 8$ . H—K, *Allicospermum ooides*, outline of seeds, Nos. 3100—3102, K is the type-specimen, all  $\times 2$ . L, *A. ooides*, cuticle of integument from a part where the cells are not thickened, Slide 2965,  $\times 100$ . M, *B. macrotrachelum*, cuticle of nucellus, etc. showing two sets of cell-outlines, Slide 2851,  $\times 100$ . N, *Samaropsis chalcos*, integument,  $\times 200$ . O, *S. chalcos*, nucellus, etc.,  $\times 200$ . P, *B. macrotrachelum*, integument, Slide 2851,  $\times 100$ . Q, *B. macrotrachelum*, integument, showing trichomes, Slide 2857,  $\times 100$ . R, *A. ooides*, nucellus, etc. showing two sets of cell-outlines, Slide 2965,  $\times 100$ . S, *A. fragilis*, cuticle of integument showing sculpturing of cells, Slide 2963,  $\times 100$ . T, *A. ooides*, integument from a part where the cells are thickened. — The specimens shown in A—E, Q, were obtained from Astarte R., Bed A; that in F from C. Stewart; those in G, M, P from C. Hope; that in N, O from C. Stewart; that in S from Primula R.

100  $\mu$  in diameter with straight, obscurely marked walls which in some specimens can hardly be discerned.

Chalzal opening round, 50  $\mu$  in diameter, cells round it and also at the base of the micropyle smaller and more thickly cutinised.

Space between the inner and outer cuticles of seed (occupied by stone, etc.) 250—400  $\mu$  wide.

Megaspore membrane absent, but blocks 20  $\mu$  in diameter of slightly resistant material sometimes occurring inside some of the least macerated specimens — possibly representing the contents of prothallial cells.

*Discussion.* *B. macrotrachelum* is represented by about thirty specimens which were all obtained by bulk-maceration. Though they vary somewhat in the size of the inner cuticle, this variation appears to be largely due to shrinkage and is of no diagnostic importance. They all agree closely in the structure of their micropyles. The variation which seems to occur in the number of trichomes on the integument is possibly more important, but unfortunately the integument is preserved in too few specimens for this to be fully investigated.

The specific name is from μακρος, large and τραχηλος, a neck, and refers to the long micropylar tube.

Form-genus **CHITOSPERMUM** gen. nov.

Typical-species *C. stereococcus*.

*Diagnosis.* Orthotropous oval seed; integument thick, cutinised; nucellus only cutinised at the apex of the seed; megaspore membrane cutinised, granular.

The name is from χιτων an inner garment, referring to the closely adherent integument and σπερμα a seed.

**Chitospermum stereococcus** sp. nov.

Type-specimen HARRIS 1926b, Text-fig. 32 E, F.  
Pl. 29, fig. 13.

1926(b). 'Seed F' HARRIS, p. 129.

*Occurrence.*

Astarte R., Bed C.

Vardekløft, *A. minor* Bed.

C. Hope, *A. minor* Bed.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Orthotropous seed 1.5 mm long  $\times$  1.0 mm broad; shape ovoid with the micropyle projecting slightly at the more pointed end; on maceration yielding the following membranes:—

1. Cuticle of integument, a somewhat thin membrane showing the outlines of almost uniform elongated cells 150  $\mu$  long  $\times$  20  $\mu$  broad.

Cell outlines straight, rather finely marked but quite distinct. Surface of cells unthickened. Micropyle projecting about  $100\mu$ , base about  $200\mu$  broad, opening about  $100\mu$  broad. Cells in region of micropyle shorter and with thicker walls than elsewhere.

2. Cuticle of megaspore membrane, a thick, hard yellowish cuticle forming an egg-shaped sac 1.0—1.3 mm long, situated  $100$ — $150\mu$  below the top of the micropyle and separated from the integument by a space  $100\mu$  wide. Apex of megaspore flattened, or slightly concave, base rounded, apex bearing a trace of a very delicate cuticle (nucellus or micropylar canal). Megaspore membrane very fine, almost invisible granules and also obscure impressions of elongated cells  $15\mu$  wide; and usually filled with a brown, resinous substance which occasionally shows indications of rounded cells  $30\mu$  in diameter.

*Discussion.* *C. stereococcus* is represented by a large number of specimens obtained by bulk-maceration from Vardekloft and a few from the other localities. There is no reason to refer it to any species of leaf. I found a good many isolated megaspores of similar appearance, but different size, and I think it probable that they may belong to similar seeds, but as their integuments are unknown they hardly seem worth description.

The name *stereococcus* is from  $\sigma\tau\epsilon\pi\epsilon\omicron\varsigma$ , hard, and  $\kappa\omicron\chi\chi\omicron\varsigma$ , a kernel, and refers to the thick megaspore membrane.

### 3. ISOLATED MALE CONES.

The investigation of the male cones in this collection has only been possible with the help of the transfer-method, and even so they have proved difficult owing to their extreme delicacy. The great majority of specimens were evidently fully ripe, for almost all the sporangia had shed their pollen and only contained scattered grains. This causes uncertainty in recognizing the type of pollen that belongs to a cone and in some cases it was not even possible to be certain that the saclike bodies were, in fact, microsporangia.

It is even harder to refer detached male cones to their leaves than detached fruits because their cuticles are usually so thin that they provide no evidence of agreement in epidermal structure. One can then only use the evidence of their association which when unsupported is unreliable. Previous authors have relied to a large extent on the general agreement of male cones with those of recent genera in referring them to families. This method seems to me undesirable; it inevitably delays progress in the recognition of new types of reproductive organs.

Genus **LEPTOSTROBUS** HEER.1876. *Leptostrobus* HEER, p. 72.Selected Type-species, *L. laxiflora* HEER, p. 72.

*Emended diagnosis.* Fructification consisting of an elongated slender axis, covered at its base by semicircular scales and bearing cup-shaped organs in a very loose spiral in its upper part. Each cup-shaped organ consisting of a very short stalk bearing a widely open cup pointing forwards and outwards; cup divided by deep furrows into five or six lobes free at the apex but continuous below. Cuticle of axis moderately thick, showing straight-sided cells without papillae, stomata occasional, sunken, surrounded by an elongated group of slightly specialised subsidiary cells, stomatal pit vertically elongated. Cuticle of outer surface of cup rather thin, showing isodiametric straight-sided cells with occasional stomata. Subsidiary cell group rounded.

*Discussion.* HEER and subsequent authors have regarded *Leptostrobus* as the seed-bearing cone of a Conifer like *Voltzia*, basing this view on the scale leaves at the base of the shoot and a bulge, looking like a seed, on the surface of some of the supposedly palmate 'sporophylls'. The Greenland specimens look so like HEER's that I cannot doubt their generic identity, but show that the 'sporophylls' are not palmate, but form an open cup and suggest that the bulge on the surface of HEER's specimen was probably one of the lobes of the cup. They also provide a good deal of evidence for believing that *Leptostrobus* is a reproductive organ of *Czekanowskia*, not of a Conifer; but unfortunately they do not show conclusively whether it was a seed- or a pollen-bearing fructification.

Part of the evidence used by HEER for referring *Leptostrobus* to the Conifers may, I think, be better used the other way. It is quite true that the little scale leaves at the base of *Leptostrobus* look like the top of a short-leaved Conifer shoot terminating in a female cone; but it is striking that no such Conifer shoots occur in HEER's flora. On the other hand, identical scale leaves occur at the base of the short-shoots of *Czekanowskia* species of which occur in extraordinary abundance in association with *Leptostrobus*. The two fossils appear to be associated in two localities in Angara Land; and in both localities in Greenland where *Leptostrobus* occurs, *Czekanowskia hartzi* is abundant.

The cuticle of the axis of *Leptostrobus longus* agrees perfectly with that of the leaf of *Czekanowskia hartzi* — they are, indeed, indistinguishable except for the rather smaller number of stomata on *Leptostrobus*. There is no cuticle in the Greenland flora with which either could be confused; the least different is another *Czekanowskia* — *C. nathorsti*, which is, however, distinct and does not occur at quite such high horizons as *L. longus*.

The evidence is therefore — association in four localities; agreement between the scale-leaves and agreement between the cuticles, the last being the most important.

*Morphology.* The 'cups' of *Leptostrobus* might either be seed-bearing cupules which have lost their seeds, or pollen-bearing cupules composed of a ring of large pollen-sacs dehiscing on their inner side. In favour of the first view is the fact that the cuticle shows stomata — which would be more usual on the wall of a cupule, but certainly do not exclude the possibility that the cup produced pollen. In favour of their being pollen sacs is the occurrence of large quantities of pollen inside the cup, but unfortunately this is not all of one type. Most specimens yielded great numbers of winged spores  $100\mu$  in diameter, other spores being rare, but one specimen from C. Stewart yielded large numbers of oval wingless spores  $30\mu$  in diameter, only a few of the winged spores being present. Similar winged spores were found among the scale leaves of *C. hartzi* from other localities, and I think that there is a considerable likelihood, though no proof, that they belonged to this plant. The question can only be decided by the investigation of better preserved and less fully mature specimens which would provide the contents of the cup — whether it is a seed, or as I think more probable, winged pollen grains.

If *Leptostrobus* is a seed-bearing organ it might be compared in its branching with the female organ of *Ginkgo*, or more closely with *Staphidiophora*; but its strongly lobed cupule would be different from anything known in the Ginkgoales.

If it is a pollen-bearing organ it would obviously be more comparable to an amentum, e. g. the male cone of *Ginkgo* (because of its spirally arranged parts) than to a pinnate leaf. The cups or 'sporophylls' themselves differ from those of *Ginkgo* in being almost sessile and in bearing a group of sporangia partly fused in a cup instead of two free ones. Its differences from *Stachyopitys* (a fossil with a strong claim to be regarded as a Ginkgoalean male cone — see SEWARD 1919) are rather less, for in this genus there is a crowded ring of numerous sporangia. From such a type one can indeed picture the origin of *Leptostrobus* by the shortening of the stalk; the change in the direction in which the free parts of the sporangia point from backwards to forwards, and their partial fusion with one another. Such differences do not seem fundamental, but they enlarge the range of Ginkgoalean morphology in a very interesting way, and suggest a possible connection between the Ginkgoales and the Pteridosperms with microspore-bearing cupules.

The name *Leptostrobus* has been applied to several types of fossils besides ones like *L. laxiflora*; thus HEER (1880) described some leaves (of the *Pityophyllum* or *Czekanowskia* type) and some winged seeds (of

the *Samaropsis* type) under this name, and in this he was followed by FONTAINE, who also described an almost indeterminable, but probably different cone as *Leptostrobus* (?) *multiflorus*. *Leptostrobus* should certainly be limited to specimens like *L. laxiflora*.

***Leptostrobus longus* sp. nov.**

Pl. 7, figs. 1—5, 11—17, ?also figs. 6—10; ?Pl. 24, fig. 8; Text-fig. 49, 50 I.

Type-specimen Pl. 7, figs. 11—15; Text-fig. 49 C.

*Occurrence.*

Storgaard R.

C. Stewart, *Todites* Bed.

These beds belong to the top of the *Thaumatopteris* Zone.

*Diagnosis.* Axis of cone 15 cm or more long, 1.5 mm thick in the lowest part examined, bearing cup-shaped lateral organs at an angle of 60° in a very loose spiral; each 'cup' borne on a stalk 1 mm long, widely open at the apex, divided by deep furrows into about six lobes 3 mm long, 1.5 mm wide near the free end; apex of each lobe rounded.

Cuticle of axis moderately thick, showing cells 150  $\mu$  long  $\times$  20  $\mu$  wide with straight walls and without papillae. Stomata occasional, orientated longitudinally. Guard-cells sunken and thinly cutinised, subsidiary cells forming an elongated group, little specialised but sometimes with a slightly thickened surface. Stomatal pit 20  $\mu$  long, 4  $\mu$  wide, often partly closed by a rim of cuticle projecting inwards from the lateral subsidiary cells. Encircling cells absent.

Cuticle of outer surface of 'cup' rather thin, showing the outlines of straight-walled polygonal cells and scattered stomata. Subsidiary cells forming a round or irregular ring, rather smaller and more thickly cutinised than the other epidermal cells. Cuticle continuous over the whole surface of the 'cup' in the lower part, but separating along the line of division of the lobes in the upper part; extending over the apices of the lobes and for a short way down their inner side, and then ceasing abruptly. No cuticle present on most of the interior of the 'cup'.

*Discussion.* *Leptostrobus longus* is represented by three large, but incomplete specimens from Storgaard R., and fragments from C. Stewart. In no specimen is the base preserved and it is therefore unknown whether scale leaves were present. The preservation is indifferent and it has not been possible to make out the structure of the cups very fully, but it is certain that they are widely open at the apex — in most cases they contain quite a lot of rocky matrix, and that they are composed of several lobes which are, however, joined as their cuticle is continuous over their outer sides in the lower part of the cup.

Nearly all the cups available were macerated and they all yielded a great many scattered spores, but these are of not of one, but two main



types. One type (Pl. 7, figs. 6—10) agrees in shape with the spores of the Caytoniales, though it is very much larger; this type predominates in the cups from Storgaard R. and was also found among the scale leaves of *Czekanowskia hartzi* at Storgaard R., and at C. Hope. Similar spores



Fig. 49. *Leptostrobus longus*.

A, B, C, outline drawings of the three best specimens, Nos. 2981, 2982,  $\times 1$ . C, is the Type-specimen. — All the specimens were obtained from Storgaard R.

occur in the C. Stewart specimens; but one of the C. Stewart specimens yielded an enormous number of small oval spores of an entirely different type (Pl. 24, fig. 8).

As there is doubt which, if either, type of spore belongs to *Leptostrobus*, it is useless to discuss them; the oval wingless spore is more like that of *Ginkgo biloba* (SEWARD 1919).

*Comparison.* The species with which *L. longus* has to be compared are *L. laxiflora*, *L. crassipes* and *L. microlepis* HEER 1876, 1880. Of these species *L. microlepis*, the least known, differs in its much smaller 'cups' and *L. crassipes* in its very much thicker axis. The specimens of *L. crassipes* described in 1876 have similar 'cups', but in those described in 1880 seem different and may belong to *Schizolepis*.

*L. longus* is very closely similar to *L. laxiflora* HEER (which has also been figured by KRYSHTOFOVICH 1933) and the two species cannot at present be satisfactorily distinguished as the general form of the one, and the fine structure of the other is chiefly known, but I think that they should probably be distinguished as *L. longus*, which is probably a good deal older, has a rather more slender, but considerably longer axis (15 cm or more long instead of 7—10 cm).

#### Genus **BERNETTIA** GOTHAN.

1914. *Bernettia* Gothan, p. 146.

Type-species *B. inopinata* GOTHAN.

*Emended diagnosis.* Microspore bearing cone consisting of a thick axis covered with semicircular scale leaves in its lower part and bearing microsporophylls in a crowded spiral in the upper part. Microsporophylls cylindrical; exposed distal end strongly cutinised, protected inner part delicate, bearing numerous elongated microsporangia containing great numbers of oval microspores. Resin bodies present in microsporophylls. Cuticle of exposed parts of fossil rather thick, composed of thick-walled isodiametric cells with median papillae; stomata with thinly cutinised, sunken guard-cells, surrounded by an irregular ring of subsidiary cells with promined papillae; encircling cells occasionally present.

#### **Bernettia phialophora** sp. nov.

Pl. 22; Pl. 23, figs. 1, 2, 8—10, 12—14.

Type-specimen, Pl. 22, figs. 1, 2, 13, 15.

#### *Occurrence.*

Astarte R., *Baiera spectabilis* Bed.

Vardekløft, *Baiera spectabilis* Bed.

C. Stewart, *Todites* Bed.

These beds belong to the upper part of the *Thaumatopteris* Zone.

*Diagnosis.* Cone about 7 cm long; basal scale leaves semicircular, 8 mm broad. 'Microsporophylls' 7 mm long, distal end convex, but with a cup-shaped depression 2 mm in diameter; proximal part of micro-

sporophyll delicate, marked with irregular furrows and bearing numerous microsporangia.

Cuticle of outer side of scale leaves thick, showing vertical rows of straight-sided, isodiametric cells with conspicuous lateral walls and usually with conspicuous papillae. Presence of veins not indicated in the cuticle. Stomata infrequent, resembling those of microsporophylls, or else more heavily cutinised and more protected guard-cells. Cuticle of inner side of scale quite delicate and poorly preserved; cells similar in shape but walls thinner; stomata probably more numerous than on exposed side. Veins of scale leaves not observed; 'mesophyll' containing round resin bodies 0.3—0.8 mm in diameter.

Cuticle of distal end of 'microsporophyll' rather thick, showing uniform polygonal cells with conspicuous walls and a conspicuous median papilla; surface showing fine pits after long maceration. Structure in region of apical cup the same as elsewhere; towards the sides of 'microsporophyll' cells becoming elongated, and cuticle becoming much thinner; cuticle of proximal part very delicate indeed. Stomata rather numerous on distal end of 'microsporophyll'; guard-cells occasionally exposed, showing a stomatal aperture  $20\mu$  long; but usually sunken and surrounded by a ring of subsidiary cells with conspicuous papillae; papillae of subsidiary cells frequently overhanging and concealing guard-cells. Encircling cells sometimes present, but never forming a complete ring. Resin bodies 0.4—1.0 mm in diameter present in considerable numbers in substance of 'microsporophyll'.

Sporangia about 1.5 mm long, 0.4 mm wide, crowded over part of stalk of 'microsporophyll', precise arrangement of sporangia and their distribution on stalk unknown. Sporangia perhaps possessing a delicate outer cuticle showing elongated cells (or this may belong to the stalk of the 'microsporophyll'); possessing in addition a delicate, non-cellular, very finely granular cuticle containing the spores. Spores borne in large numbers in each sporangium.

Spores oval  $40\mu \times 25\mu$  wall smooth, thinly cutinised, showing a longitudinal thin strip but no other markings.

*Discussion.* *B. phialophora* is represented by a good many specimens, some of them excellently preserved.

1. *Generic identification.* *B. phialophora* resembles *B. inopinata* in the general appearance of its 'microsporophylls' and of its scale leaves and the generic identification depends on this resemblance. *B. inopinata* has not been macerated, its cuticle is unknown and the existence of microsporangia is unproved.

2. *Morphology.* *B. phialophora* seems to be very similar to the male cones of the Cycadales, though the precise arrangement of its sporangia is not fully known. The very conspicuous cup-shaped impression on the

head of the microsporophyll appears to be of no morphological importance but has its counterpart in the sculpturing seen on the female cone scales of the Conifers or on the male or female cone scales of certain Cycads. The pollen is of an unspecialised type found among most Gymnosperm families; the stomata are of an essentially Gymnospermous type.

3. *Attribution.* On the grounds of association and agreement in structure I attribute this cone to *Baiera spectabilis*. At Vardekloft, where it is very common, it is associated with *B. spectabilis* and *Czekanowskia hartzi* only; at Astarte R. with the same two leaves, *Podozamites agardhianus*, *Swedenborgia* cones and some *Desmiophyllum* leaves; at C. Stewart with all the above mentioned fossils and in addition *Storgaadia* and *Pterophyllum subaequale*; *Czekanowskia hartzi* and *Ginkgoites hermelini* occur in another part of the same bed.

The structure of the cuticle of the scale leaves and of the heads of the 'microsporophylls' of *B. phialophora* agrees very well with the Ginkgoalean type in general and in particular with that of the leaf, *Baiera spectabilis*, only differing in fact in being rather thinner and having smaller and shorter epidermal cells. Near the base of the leaf of *B. spectabilis*, however, these differences disappear and the two are almost identically similar. The resin bodies of the two fossils also agree.

None of the other leaves associated with *B. phialophora* have very similar cuticles. Among leaves in the *Thaumatopteris* Zone of Greenland not actually associated with *B. phialophora*, but with moderately similar cuticles are *Ginkgoites hermelini* and *G. taeniata*, neither of which is as similar as *B. spectabilis*, and among rather more different cuticles are those of the various species of *Nilssonia*, all of which are far thinner.

It is impossible to say to which, if any, of the plants associated with it, *B. inopinata* GOTHAN may belong.

As far as I know, no fossil cone so like a Cycad male cone has been described. It may therefore seem rather strange that it should be referred to another group, but it must be remembered that the male organs of hardly a tenth of the Mesozoic seed plants are known, and a still lower proportion of those of the Ginkgoales. It is thus only to be expected that wide differences will be found in such a group, and I see no reason why the reproductive organs of the Ginkgoales should not be just as varied as those of the Conifers.

4. *Comparison.* *B. phialophora* is well distinguished from *B. inopinata* GOTHAN by the cup-shaped impression on the heads of the sporophylls.

The specific name is from φιάλη, a cup, and φερα, bearing, and refers to the cup-shaped impression on the heads of the microsporophylls.

Genus **SPHAEROSTROBUS** gen. nov.Type-species *S. clandestinus*.

*Diagnosis.* Elongated, relatively slender axis bearing lanceolate, parallel-veined bracts with small almost spherical male cones in their axils. Surface of male cones covered with the overlapping distal ends of the microsporophylls; pollen grains small and oval.

**Sphaerostrobos clandestinus** sp. nov.

Pl. 29, figs. 1—4, 6, 11; Text-fig. 50 C, D.

*Occurrence.* Astarte R., Bed A.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Axis up to 4 mm thick and of considerable length, bearing lanceolate bracts with small round male cones in their axils. Surface of axis showing fine longitudinal striations; bracts occurring opposite one another, very probably in decussating pairs; consisting of a very short basal stalk which expands into a lanceolate-acuminate lamina. Lamina of bract 7 mm broad  $\times$  15 mm long, transversed by about eight veins of equal size which run parallel in the middle and converge somewhat towards the apex, some of them probably ending in the lateral margins just below the apex. Cones circular, about 3.5 mm in diameter, borne on a stalk 2 mm long in the axil of a bract and often concealed by it. Surface of cone formed by triangular overlapping scales about 1 mm broad; details of sporangia unknown. Axis and bracts and cone scales all yielding exceedingly delicate cuticles showing straight-sided cells; cone yielding small oval pollen grains  $26\mu \times 16\mu$  with a longitudinal fold and a rather thin, finely granular wall.

*Discussion.* *S. clandestinus* is represented by six specimens, the best of which are figured. I know of no fossil which it resembles.

Although it is not known what plant bore this male cone, I think that it may well have belonged to the form-genus *Podozamites*, several species of which are associated with it. The general resemblance between the bracts of *Sphaerostrobos* and the associated leaves of *Podozamites astartensis* in shape and venation is striking. Unfortunately it is impossible to tell whether they agree in structure, as the cuticles of both are too delicate to yield satisfactory preparations. I do not wish to assert definitely that it belongs to *Podozamites*, but only to call attention to the possibility in the hope that further evidence will be obtained from other floras. It may be recalled that *Cycadocarpidium* was originally referred to *Podozamites* on similar evidence and later workers have found the two associated in numerous places.

The specific name refers to the fact that the cones are often hidden by the bracts.

Genus **STENOMISCHUS** gen. nov.Type-species *S. athrous*.

*Diagnosis.* Male cone consisting of a slender axis bearing crowded sporophylls consisting of an extremely slender stalk terminating in a delicate lanceolate lamina, lamina-bearing at its base two or three pendulous sporangia. Pollen grains probably small, rounded.

*Stenomischus* differs from *Ixostrobus* in its delicate sporophylls, pendulous sporangia and the expanded distal lamina and from *Sorosaccus* in its less numerous sporangia and expanded distal lamina.

The name is from στενός, narrow, and μίσχος, a leaf stalk and refers to the very slender stalks of the sporophylls.

**Stenomischus athrous** sp. nov.

Pl. 24, figs. 1, 2, 9, 10; Text-fig. 50 J.

The figures represent the Type-specimen.

*Occurrence.* Neill Cl., Liverwort Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis.* Cylindrical male cone 2 cm long, 12 mm wide consisting of an axis 0.7 mm wide near the base, bearing crowded microsporophylls. Microsporophylls attached perpendicularly to the axis in the lower part, but at a decreasing angle towards the apex. Microsporophyll consisting of a stalk about 3 mm long, 0.1 mm wide bearing at its distal end an expanded lamina and a number of pollen sacs. Lamina about 2 mm wide, 2 mm long, more or less rhomboidal in outline; distal margin irregularly toothed. Texture very delicate, apparently composed of only one layer of cells near the distal margin but somewhat thicker below, groups of cells forming the marginal teeth. Marginal cells elongated, about  $10\mu$  wide. Sporangia oval, about 1 mm long  $\times$  0.8 mm wide, attached to the stalk of the sporophyll at the base of the expanded lamina; more than one (probably two or three) present on each sporophyll. Texture of sporangia very delicate indeed. Substance of stalk of sporophyll very delicate, a central dark strand (?group of tracheids)  $20\mu$  wide recognizable. Cuticle of all parts of male cone very delicate; sporangia yielding a structureless cuticle. Pollen grains probably round or oval,  $30\mu$  long,  $20\mu$  broad with a longitudinal fold or slit. Cuticle of wall smooth and moderately thick.

*Discussion.* *S. athrous* is represented by the Type-specimen alone, and this was made into a transfer preparation and part of it was afterwards macerated. The sporangia have all dehisced but contain a considerable number of pollen grains. The great majority of these pollen grains are of the type described, but two oval ones  $80\mu$  wide with lateral

wings were found (like the ones found in *Leptostrobus*). As with that cone I hesitate to refer the pollen grains to it definitely.

*Stenomischus* agrees in its general characters with the type of male cone most usual in the living Conifers; in detail it perhaps agrees most closely with that of *Cunninghamia*. It differs from them all, however (even *Cunninghamia*) in the extraordinarily long and slender stalks of its microsporophylls. I know of no fossil which it resembles at all closely.

### Genus **SOROSACCUS** gen. nov.

Type-species *S. gracilis*.

*Diagnosis.* Elongated cylindrical male cone consisting of a rather slender axis bearing very slender sporophylls. Sporophylls consisting of a horizontal portion 2—5 mm long, bearing a cluster of about eight microsporangia and then bending upwards and ending as a filiform process. Sporangia more or less pendulous, oval, dehiscing by a longitudinal slit up one side. Pollen grains moderately large, oval.

*Discussion.* HEER (1876, p. 53; Pl. IX, figs. 8—11) has described some fossils which are obviously of exactly the same nature as *Sorosaccus gracilis* as the male flowers of *Baiera longifolia*; their reference to that plant being based on their general agreement with the male organs of *Ginkgo* and on their association with the leaves. On the whole, the occurrence of *Sorosaccus* in Greenland may be said to be in agreement with what should be expected on HEER's view that it belongs to species of *Ginkgoites* or *Baiera*, but as will be seen from the table given on p. 150 the evidence from association is not at all clear and they might equally well belong to *Podozamites*. The association of *Sorosaccus* in Greenland with Ginkgoalean leaves is nowhere at all striking. It has been impossible to obtain evidence from the structure of the cuticle of *Sorosaccus* as it is too delicate; the microspores are of a type which occurs in the Ginkgoales and many other Gymnosperms. I have not been able to elucidate any new facts about the general structure of *Sorosaccus*, which is very well shown in HEER's figures.

For comparison see *Stenomischus*, above.

The name is from *σῶραξ*, a pile, and *σακκος*, a sack, and refers to the clustered microsporangia.

### **Sorosaccus gracilis** sp. nov.

Pl. 24, figs. 3—7, 11, 12; Pl. 28, fig. 11; Text-fig. 50 E, F, H.

Type-specimen, Pl. 24, figs. 5, 6.

#### *Occurrence.*

Neill Cliff, Liverwort Bed.

Dinosaur R., *Marattiopsis* Bed.

Both of these beds belong to the *Thaumatopteris* Zone.

*Diagnosis.* Cone typically 3 cm long  $\times$  8 mm wide, consisting of an axis less than 1 mm thick bearing crowded 'sporophylls'. Sporophylls consisting of a very slender basal stalk 2—4 mm long arising at right angles to the main axis and bearing at its distal extremity a group of about six pollen sacs, and then bending upwards and continuing as a filiform apical process 2—3 mm long; but apical process often broken off. Pollen sacs oval, about  $1.1 \times 0.8$  mm, wall exceedingly delicate, opening by a longitudinal slit extending the whole length of the sporangium. Wall of sporangium showing faint indications of elongated, straight-sided cells  $10\text{--}15\ \mu$  wide.

Cuticle of all parts very delicate. Pollen-grains oval,  $90\ \mu \times 60\ \mu$  with very thin, very finely granular (almost smooth) walls and a longitudinal fold.

*Discussion.* *S. gracilis* is represented by a good many specimens, almost all of which were made into transfers. They agree very closely with one another. One specimen provided some undehiscent sporangia and from this I obtained the pollen mentioned in the diagnosis.

#### **Sorosaccus minor** sp. nov.

Pl. 27, fig. 2 (Type-specimen).

*Occurrence.* C. Stewart *Todites* Bed. This bed belongs to the *Thau-matopteris* Zone.

*Diagnosis.* As *S. gracilis*, but differing in being more slender owing to its smaller sporophylls (basal region 2 mm long) and smaller sporangia ( $0.7 \times 0.5$  mm).

*Discussion.* *S. minor* is represented by three specimens, which are not very well preserved and show their structure less clearly than does *S. gracilis*, but as far as can be made out are constructed on exactly the same plan.

#### **Genus IXOSTROBUS** RACIBORSKI.

1892. *Ixostrobus* RACIBORSKI, p. 12.

Type-species *I. siemiradzskii* RACIB.

*Emended diagnosis.* Male cone up to 7 cm long and 1.3 cm broad, consisting of a rather slender axis up to 2.5 mm broad, bearing microsporophylls in whorls 1—2 mm apart, or sometimes possibly, bearing them irregularly. 'Microsporophyll' consisting of a slender but rigid stalk about 6 mm long and 0.5—1 mm wide, bearing at its distal end two upward pointing pollen sacs, and continuing beyond them 1—2 mm to an acute point. Microsporangia oval, up to 1 mm long, with a pointed apex, dehiscing into two diverging valves.

*Discussion.* As I am unable to read RACIBORSKI's account of *Ixostrobus*, I have to rely on his figures, which are excellent. The main



differences between my account and his figures are that I have been able to show that the sporophylls arise on all sides of the axis, not merely on two sides, and that each microsporophyll has two sporangia. The recognition of the first of these differences would have been impossible but for the transfer method, while the recognition of the existence of two sporangia is greatly assisted by the transfer method, which demonstrates their existence in all specimens, the great majority of which only show one upward pointing sporangium as in RACIBORSKI's figures. There is every reason to believe that similar technique would demonstrate both these features in his specimens.

The only evidence for attributing *Ixostrobus* to a species of leaf is provided by its association, which in Greenland is not at all striking. In both its localities in Greenland it is associated with *Ginkgoites hermelini* and narrow-leaved species of *Podozamites*; in one it is accompanied by a few specimens of *Czekanowskia rigida*. In Poland it is associated again with species of *Podozamites* and with a good deal of *Czekanowskia* (to which I think it unlikely to belong, see p. 136); there are no typical *Ginkgoites* or *Baiera* leaves (RACIBORSKI's *Ginkgo* aff. *whitbiensis* seems to me more like a fern leaf). On the available evidence it would seem more likely to belong to the group *Podozamites*, with which it is associated, than to the Ginkgoales, though in its general construction it agrees fairly well with *G. biloba*.

*Ixostrobus* somewhat resembles certain fossils referred to the form-genus *Stenorachis*, though it differs from all in its much smaller size. It is impossible to compare it very closely because our knowledge of *Stenorachis* is too indefinite, in all probability most species are *Beania*-like fruits and thus differ fundamentally from *Ixostrobus*.

***Ixostrobus groenlandicus* sp. nov.**

Pl. 27, figs. 12, 13; Pl. 28, figs. 1—4, 7—10, 12; Text-fig. 50 G.

Type-specimen, Pl. 28, figs. 8, 10, 12.

*Occurrence.*

Vardekløft, Liverwort Bed (rare).

Neill Cliff, Liverwort Bed (very common).

Both of these beds belong to the *Thaumatopteris* Zone.

*Diagnosis.* Male cone typically 7 cm long, consisting of an axis up to 2 mm broad, bearing fairly crowded, rigid sporophylls about 8 mm long, 0.5 mm thick, borne at right angles to the axis in the lower part of the cone but at a decreasing angle towards the apex. Sporophylls curving upwards near their distal ends and terminating in an upwardly directed point 0.8—1.0 mm long; bearing at the base of the upward curved portion two sporangia which also point more or less upwards, sporangia about 1.0 mm long, 0.6 mm broad, dehiscing to form two diverging valves.

Cuticle very delicate, pollen not recognised.

*Discussion.* *I. groenlandicus* is represented by abundant material from Neill Cliffs, but the preservation was indifferent and only a few satisfactory transfers were obtained. Several attempts were made to obtain pollen from the sporangia, but without success and this was not surprising as they have all dehisced.

*Comparison.* *Ixostrobus groenlandicus* is very like *I. siemiradzkii*, and it is indeed only possible to distinguish it by its rather more slender sporophyll stalks and its rather smaller sporangia; this difference being more pronounced between the Greenland specimens and RACIBORSKI's original specimen (1891 b, Pl. V, fig. 7) than the later ones (1892, Pl. II, figs. 5—8). I think it quite possible that the two sets of specimens may ultimately prove to be identical, but as their agreement is imperfect I prefer to distinguish them.

Genus **AMYDROSTROBUS** gen. nov.

Type-species *A. groenlandicus*.

*Diagnosis.* Male cone consisting of a slender axis bearing small, crowded sporophylls consisting of a horizontal stalk and a short up-turned pointed lamina. Sporangia somewhat elongated, attached by their whole upper sides to the lower side of the stalk of the sporophyll. Pollen grains oval, wingless.

This cone resembles that of *Pinus* in form, but differs in its pollen grains. The name is from ἀμυδρος obscure, and στροβος a cone.

**Amydrostrobos groenlandicus** sp. nov.

Pl. 29, figs. 7, 8; Text-fig. 50 A. B.

Type-specimen, Pl. 29, fig. 7.

*Occurrence.* Vardekløft, *Dictyophyllum* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Cylindrical male cone typically 2 cm long, 5—7 mm wide, consisting of an axis up to 1 mm wide at the base, bearing crowded sporophylls consisting of a horizontal portion 2—3 mm long, and an upward pointing triangular lamina 1 mm wide at the base, 2 mm long, terminating in a sharp upwardly directed point. Sporangia oval, 1.5 mm long, 0.5—0.8 mm broad, attached along their whole length to the under side of the horizontal stalk of the microsporophyll.

Cuticle very delicate; pollen grains oval, 30  $\mu$  long, 20—30  $\mu$  wide with very thin walls without definite markings.

*Discussion.* *A. groenlandicus* is represented by a good many specimens, mostly ill preserved, and very few of them showed the structure of the sporophylls, even in transfers.

# UNDETERMINED MALE CONES.

## 'Male Cone sp. A'.

"Male cone sp. A" HARRIS 1926b, p. 124; Pl. VII, figs. 4, 5.

*Occurrence.* Vardekløft, *P. agardhianus* Bed (HARTZ Collection).

This bed belongs to the *Thaumatopteris* Zone.

This species is only represented by one specimen which has been previously figured as fully as its preservation allows. Although the details of the microsporophylls are fairly well shown, it is impossible to make out with any certainty how they are attached.

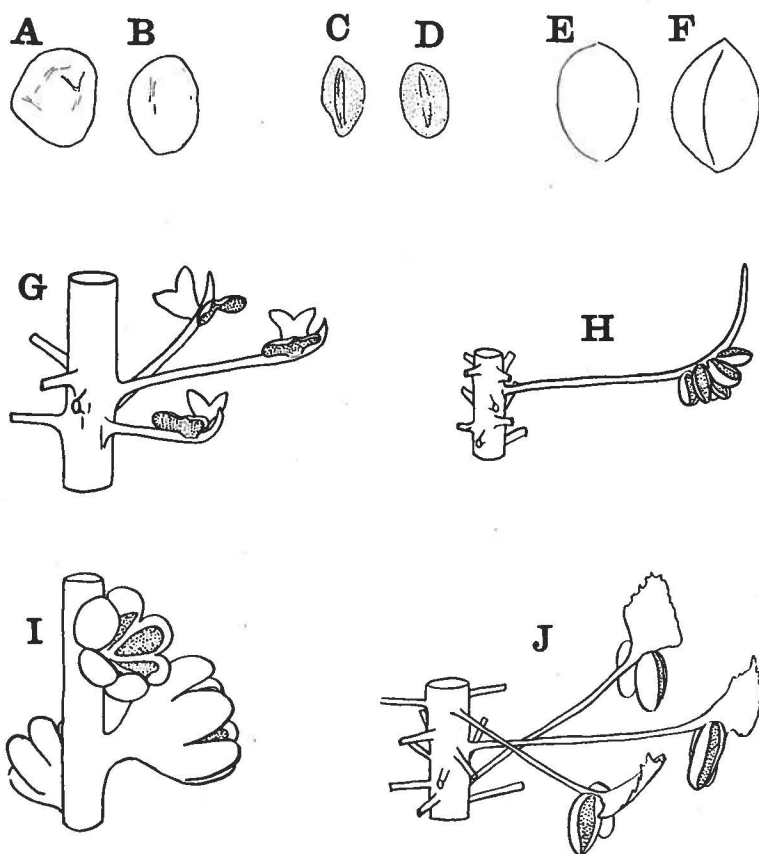


Fig. 50. Male cones.

A, B, *Amydrostrobos groenlandicus*, pollen, Slide 3663,  $\times 400$ . C, D, *Sphaerostrobos clandestinus*, pollen, Slide 3649,  $\times 400$ . E, F, *Sorosaccus gracilis*, pollen, Slide 3631,  $\times 200$ . G, restoration of *Ixostrobos groenlandicus*, showing the widely separated halves of the sporangia,  $\times$  about 3. H, restoration of *Sorosaccus gracilis*,  $\times$  about 10. I, restoration of *Leptostrobos longus*,  $\times$  about 3. J, restoration of *Stenomischus athrous*,  $\times$  about 10. In the restorations the interior of the sporangia is dotted.

## Thaumatopteris Zone.

| Male organ                                                                                                                           | Locality<br>(exact bed<br>mentioned<br>in text) | Associated Conifer<br>or<br>Ginkgoalean leaf                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Sorosaccus gracilis</i> . . . . .                                                                                                 | Dinosaur R.                                     | { <i>Ginkgoites taeniata</i><br><i>Podozamites</i> spp.<br><i>Czekanowskia rigida</i><br>(all common)                                                                                   |
| <i>Sorosaccus gracilis</i> . . . . .<br><i>Ixostrobus groenlandicus</i> . . . . .<br><i>Stenomischus athrous</i> . . . . .<br>(rare) | Neill Cliffs                                    | { <i>Ginkgoites hermelini</i> (uncommon)<br><i>Podozamites</i> sp. (abundant)                                                                                                           |
| <i>Ixostrobus groenlandicus</i> . . . . .                                                                                            | Vardekloft                                      | { <i>Ginkgoites hermelini</i> (abundant)<br><i>Podozamites</i> sp. (rare)<br><i>Czekanowskia rigida</i> (rare)                                                                          |
| Male cone sp. A (rare) . . . . .                                                                                                     | Vardekloft                                      | { <i>Podozamites</i> sp. (abundant)<br><i>Baiera spectabilis</i> (frequent)                                                                                                             |
| <i>Sorosaccus minor</i> . . . . .<br>( <i>Bernettia phialophora</i> ) . . . . .<br>( <i>Leptostrobus longus</i> ) . . . . .          | C. Stewart                                      | { <i>Ginkgoites hermelini</i><br><i>Podozamites</i> sp.<br><i>Storgaardia spectabilis</i> ( <i>Baiera spec-</i><br><i>tabilis</i> )<br>( <i>Czekanowskia hartzi</i> )<br>(all abundant) |
| ( <i>Bernettia phialophora</i> ) . . . . .                                                                                           | Vardekloft                                      | { ( <i>Baiera spectabilis</i> )<br>( <i>Czekanowskia hartzi</i> )<br>(both abundant)                                                                                                    |
| ( <i>Bernettia phialophora</i> ) . . . . .                                                                                           | Astarte R.                                      | { ( <i>Baiera spectabilis</i> ) (abundant)<br>( <i>Czekanowskia hartzi</i> ) (abundant)<br><i>Podozamites</i> sp. (abundant)<br><i>Storgaardia spectabilis</i> (rare)                   |
| ( <i>Leptostrobus longus</i> ) . . . . .                                                                                             | Storgaard R.                                    | { <i>Storgaardia spectabilis</i> (abundant)<br><i>Podozamites</i> sp. (abundant)<br><i>Ginkgoites hermelini</i> (frequent)<br>( <i>Czekanowskia hartzi</i> ) (abundant)                 |
| Male cone sp. B. . . . .                                                                                                             | Astarte R.                                      | { <i>Stachyotarus elegans</i><br><i>Podozamites mucronatus</i> P. sp.<br>indet.<br><i>Onthodendron sternbergi</i><br><i>Elatocladus patens</i> all abundant                             |

## Lepidopteris Zone.

| Male organ                             | Locality<br>(exact bed<br>mentioned<br>in text) | Associated Conifer<br>or<br>Ginkgoalean leaf                                           |
|----------------------------------------|-------------------------------------------------|----------------------------------------------------------------------------------------|
| <i>Sphaerostrobos clandestinus</i> ... | Astarte R.                                      | <i>Podozamites</i> spp.                                                                |
| <i>Amydrostrobos groenlandicus</i> ..  | Vardekloft                                      | { <i>Podozamites stewartensis</i><br><i>Ontheodendron sternbergi</i><br>(all abundant) |

The tabulated list of the various isolated male cones in this flora together with the associated *Ginkgo* and Conifer leaves is given in the hope that a similar association may be noticed in other floras and point ultimately to the plant to which they belong.

There is evidence from their structure that *Bernettia phialophora* and *Leptostrobos longus* belong to *Baiera spectabilis* and *Czekanowskia hartzi* respectively. These species are therefore inserted in brackets.

## Male Cone sp. B.

Pl. 29, figs. 5, 14.

*Occurrence.* Astarte R., Bed D.

This bed is transitional between the *Lepidopteris* and *Thaumatopteris* Zones.

*Description and Discussion.* This cone is represented by a few very similar specimens, none of which is well preserved, but the best is figured. The axis is seen to be relatively stout and crowded with the stalks of sporophylls; the stalks appear to be stiff and terminate in lanceolate expansions. Microsporangia were not definitely recognised.

This cone may possibly be similar to *Stenomischus athrous*, but it is well distinguished by the much stouter stalks of its sporophylls, but as microsporangia have not been observed it does not seem worth naming.

## Lycopodiales.

Genus **GRAMMAEPHLOIOS** gen. nov.

Type-species *G. ichtha*.

For diagnosis and discussion, see below.

The name is from γραμμαί, a chess-board, and φλοιός, bark.

***Grammaephloios ichtya* sp. nov.**

Pl. 23, fig. 4; Pl. 25, fig. 10; Pl. 27, fig. 1, 3—5, 10, 14, 15; Pl. 28, figs. 5, 13, 14.  
Type-specimen, Pl. 23, fig. 4; Pl. 28, fig. 5, 13, 14.

*Occurrence.* Neill Cliff, Liverwort Bed.

This bed belongs to the *Thaumatopteris* Zone.

*Diagnosis.* Axis varying in width from 9 mm to at least 3.5 cm, composed of a relatively slender central stele and a thick outer cortex separated from the stele by a wide space. Surface of stele showing obscure longitudinal striations, otherwise almost smooth. Inner surface of outer cortex marked out in squares corresponding to the leaves. Outer surface of cortex covered with persistent leaves. Leaves pyramidal in shape, nearly square in section at their base, about 1 mm broad  $\times$  1 mm high in the smallest and 2.5 mm broad  $\times$  2.5—3.0 mm high in the largest; leaves arranged spirally, but rows almost symmetrical so that each leaf has two others almost exactly opposite it laterally and others almost directly above and below it. Leaves projecting 1—2 mm according to the size of the stem, apex of leaf sharply pointed. No trace of a ligule or parichnos visible.

Cuticle rather ill-preserved, showing straight-walled cells.

*Discussion.* *G. ichtya* is represented by a dozen specimens, most of which were eventually made into transfers. Some of the larger specimens seem to consist of nothing but a detached portion of bark, but the smaller ones are shown by their transfers to be complete, and in two cases showed the xylem core of the stele.

The general resemblance of this stem to the Palaeozoic Lycopods, particularly *Lepidophloios*, is very striking, but is not so close in detail because it is shown by transfer preparations that the surface of this stem is covered with short persistent leaves — not merely with convex leaf cushions. Its resemblance to *Thaumasiodendron* BUREAU (1914, p. 148) is, however, very close indeed and it might not unreasonably be placed in that genus. I have refrained from doing so, however, because the leaves of *Thaumasiodendron* are, according to BUREAU, compressed in their upper part, instead of being square in cross section. How far shrinkage in preservation may be responsible for this feature of *Thaumasiodendron*, I cannot say, but the very considerable difference in age between the two fossils (*Grammaephloios* is probably basal Liassic, *Thaumasiodendron* is Carboniferous) makes me disinclined to refer them to the same genus in the absence of more perfect agreement (see also Nemejc 1934).

Comparison with other Palaeozoic genera referred to the Lycopods (*Ulodendron*, *Omphalophloios*, *Phialophloios* — see HIRMER 1927 for references) might be made but they all differ in showing more or less pyramidal leaf cushions instead of persistent leaves, though apart from this difference they look very similar.

Among Mesozoic genera, there are, of course, very few with which any comparison can be made, the two least different being perhaps *Pleuromeia* and *Caulopteristessalata*, both of which may show rhomboidal leaf cushions.

*Affinities.* I would classify *Grammaephloios* among the Lycopodiales *incertae sedis* with such genera as *Thaumasiodendron*, *Ulodendron*, etc., which it seems to resemble very closely in its essential characters. The only other group in which it could be placed is the Conifers; but it differs from them in two important respects. In the relative proportions of the xylem core, the inner cortex and the firm outer cortex, which must have been largely responsible for the rigidity of the stem, it is quite unlike any Conifer, but just like various *Lepidodendraceae*. An even more important difference is provided by a comparison of stems of *Grammaephloios* of different sizes with stems of a Conifer of corresponding sizes. In *Grammaephloios* the leaf bases are square whatever the size of the stem (though they are much larger in the large stems). Had a stem of the size of the smallest grown to the size of the largest by secondary thickening as in a Conifer, the leaf bases would either have been separated, or else they would have been stretched laterally and have become 5—10 times as broad as long (the vertical length cannot change). The fact that neither process has happened indicates that the various stems reached their full external size by primary rather than secondary growth. Nothing analogous is known in the Conifers, but in *Lepidodendron* stems of an even greater range of size, but all with leaf cushions of nearly the same sharp are familiar.

The occurrence of a large Lycopod in rocks of basal Liassic age is very interesting, since no very similar fossil stems are known outside the Palaeozoic. There is, however, the isolated cone, *Lycostrobus scotti*, which must have been borne on a rather large plant, and it would be very attractive to regard *Grammaephloios* as the stem of *L. scotti*. Unfortunately, apart from the fact that both occur in Greenland in rocks of the same age, there is no evidence in favour of this; they are not even found associated — I found no megaspores at all in the bed with *Grammaephloios*, which was not very suitable for bulk-maceration.

#### Genus **LYCOSTROBUS** NATHORST.

1908a. *Lycostrobus* NATHORST, p. 3.

Type-species *L. scotti*.

#### **Lycostrobus scotti** NATHORST.

Pl. 26, figs. 6, 7, 11, 14; Text-fig. 51 K—Q.

1908a. *Lycostrobus Scotti* NATHORST, p. 3; Pl. 1, 2.

1926b. *Lycostrobus Scotti* NATH., HARRIS, p. 50; Pl. X, fig. 1.

*Occurrence in Greenland* (Megaspores).

Vardekloft, Liverwort Bed; *P. agardhianus* Bed.

Neill Cliff, Coal Bed.

These beds belong to the *Thaumatopteris* Zone, the Neill Cliff Bed being transitional between this and the *Lepidopteris* Zone.

*Description.* About fifty specimens were obtained. The spore is rounded; the diameter varies from 500—700  $\mu$ . The wall appears to be about 15—25  $\mu$  thick and is not particularly hard; it possibly consists of two layers, but these could not be separated by teasing. The tri-radiate lamellae are extremely conspicuous; their length is about 0.85 of the radius of the spore; each lamella is 100—200  $\mu$  high and 10—15  $\mu$  thick; its margin is delicate and very irregularly toothed or incised, and sometimes perforated. 'Arcuate lamellae' are present but are rather inconspicuous. The 'facets' delimited by the arcuate and tri-radiate lamellae and are distinguished by the different character of their appendages which are irregularly branched and end very irregularly in sharp points. These processes tend to point upwards; those borne near the apex of the spore are the longest; some of them may spring from the tri-radiate lamellae themselves.

The lower part of the spore bears rather conspicuous wart-like outgrowths 20—30  $\mu$  long, 30—40  $\mu$  broad at intervals of about 50  $\mu$ . These outgrowths consist of a central core bearing a good many small, irregular pointed processes. Between these main thickenings, numerous small spines 5  $\mu$  long, 2  $\mu$  broad usually occur.

The substance of the spore wall and of the thickenings of its lower part is finely, but conspicuously granular, while the processes borne on the facets, and the tri-radiate lamellae are composed of almost homogeneous cuticle.

*Discussion.* *L. scotti* has most characteristic megaspores, and no species is known with which it could be confused. The Greenland specimens agree perfectly with the Swedish ones. It appears to be a useful zone fossil of the *Thaumatopteris* Zone (Upper Rhaetic and Basal Lias).

I believe there has been a suggestion that the original specimen of *L. scotti* might not after all have come from a Rhaetic locality, but that it might be a Carboniferous *Lepidostrobus* from another country accidentally incorporated in a Rhaetic collection. The occurrence of *L. scotti* in several localities in the basal Liassic or Rhaetic of Greenland settles any doubt which may have existed on this head.

### ? Lycopodiales — Isolated megaspores.

#### Form-genus **TRILETES** REINSCH.

1884. *Triletes* REINSCH, (I have not been able to see this paper).

1886. *Triletes* REINSCH, emended by BENNIE and KIDSTON, p. 86.

Authors dealing with Palaeozoic floras agree in referring all rounded megaspores with conspicuous tri-radiate scars to the form-genus *Triletes*,



and I consider that this name should be used for all fossil megaspores of this type, unless there is evidence of specific identity with a more completely known plant (e. g. *Lycostrobus scotti*). The use of the name *Selaginellites*, which has been recently adopted by MINER (1932) for spores of Cretaceous age, is open to criticism on various grounds, the chief being that there is no evidence that they belong to this genus (rather than to *Isoetes* or any other heterosporous Lycopod that then existed). *Selaginellites* should, if we follow HALLE (1907) be restricted to fossil shoots which show convincing evidence of closer agreement with *Selaginella* than any other genus.

I therefore propose the following new names for the species described by MINER.

*Triletes erlansonii* (MINER) N. C. for *Selaginellites erlansonii* MINER.

*Triletes papillosus* (MINER) N. C. for *Selaginellites papillosus* MINER.

*Triletes arnoldi* (MINER) N. C. for *Selaginellites arnoldi* MINER.

*Triletes greenlandicus* (MINER) N. C. for *Selaginellites greenlandicus* MINER.

*Triletes echinatus* (MINER) N. C. for *Selaginellites echinatus* MINER.

*Triletes borealis* (MINER) N. C. for *Selaginellites borealis* MINER.

*Triletes inornatus* (MINER) N. C. for *Selaginellites inornatus* MINER.

*Triletes subrotundus* (MINER) N. C. for *Selaginellites subrotundus* MINER.

*Triletes ariadnae* (MINER) N. C. for *Selaginellites ariadnae* MINER.

The chief interest of isolated megaspores lies in their possible value as zone-fossils. The value of Palaeozoic megaspores seems now to have been established; the value of the much less abundant megaspores of the Mesozoic has yet to be proved, but as far as can be judged those types of spore which bear peculiar appendages (*apiculatae*) form as well-characterized species as any type of plant fossil and are as sharply limited to certain zones, while the smooth round spores (*laevigatae*) are less distinguishable and may in consequence be without any stratigraphic value.

There is a need for a uniform and complete terminology for describing fossil megaspores, but this has not yet been worked out. As far as possible I have followed BARTLETT (1929) and ZERNDT (1930, etc.), who speak of 'tri-radiate lamellae'; 'arcuate lamellae' which may connect their free ends and an 'equatorial lamella' which perhaps corresponds to a strongly developed arcuate lamella running round the equator of the spore. I have coined the term 'facet' for the three flat areas bounded by the tri-radiate and arcuate lamellae. I assume that the spore wall in the fossil represents the cutinised exine of the original spore; occasionally an inner cutinised coat is present. The thickness of the wall is measured as an optical section at the side of the crushed spore.

The measurements given for the diameter of the spore and of the thickness of the spore wall both refer to macerated specimens in which the wall will almost certainly have swollen somewhat. To judge from a few spores which were observed before, during and after maceration, I should say that most of them may have increased their size by as much as 20 per cent.; prolonged maceration causes them to swell enormously when subsequently treated with alkali, sometimes their size being doubled, but these over-macerated specimens were easily recognised as their wall loses its structure. The dimensions given refer to spores which have been only lightly macerated.

Considering the great thickness of the exine, megaspores are surprisingly unresistant to maceration. The following modification of the ordinary technique however, gave entirely satisfactory results. The stages are as follows:—

1. Bulk maceration of the rock matrix — this involves the action of dilute mineral acid followed by alkali.
2. Gentle maceration of all the plant material in diluted  $\text{HNO}_3 + \text{KClO}_3$  followed by alkali.
3. Separation of the megaspores from most of the plant cuticles by decantation and the use of wire gauge strainers of different sized mesh.
4. Carefully controlled maceration of the isolated megaspores in more or less strong  $\text{HNO}_3$  (without  $\text{KClO}_3$ ). This maceration is not followed by alkali. The spores when sufficiently cleared in the  $\text{HNO}_3$  were washed and mounted in glycerine jelly.

*Classification.* The groups *apiculatae* and *laevigatae* are applicable to these Mesozoic spores. In the *apiculatae* I include all the spores with any definite outgrowths other than the tri-radiate and arcuate lamellae (for this purpose I regard those with pitted walls as having reticulate outgrowths), while in the *laevigatae* I include those that have smooth or nearly smooth walls. I include two species with only rather indefinite thickenings in the *laevigatae*.

#### Group 1. APICULATAE.

##### *Triletes rexargenteus* sp. nov.

Pl. 26, fig. 13; Text-fig. 51 G—J.

Selected Type-specimen HARRIS 1926b; Text-fig. 1 C.

1926b. Megaspore Type 3 HARRIS, p. 51; Text-fig. 1 C, D.

##### *Occurrence.*

Astarte R., Bed A, Bed C.

Vardekløft *Stachyotaxus* Bed; *Dictyophyllum* Bed; *A. minor* Bed.

C. Stewart *Ginkgoites minuta* Bed.

All of these beds belong to the *Lepidopteris* Zone.

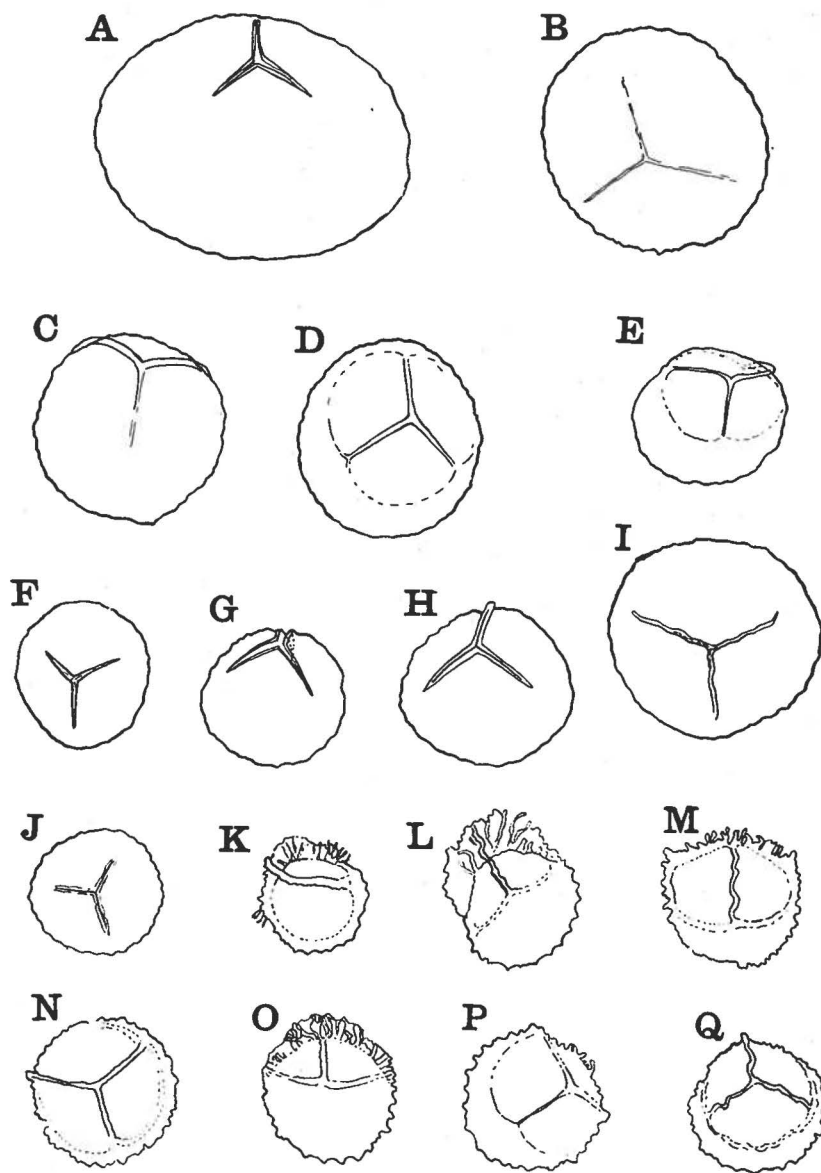


Fig. 51. Megaspores, all  $\times 28$ .

A—F, *T. areolatus*, Slides 4151, 4136, 4120, 4121, 4140, 4142. G—J, *T. rexargenteus*, Slides 4092, 4100, 4095. K—Q, *Lycostrobus scotti*, Slides 4010, 4011. The specimen shown in A was obtained from Astarte R. *T. brauniana* Bed; that in B from Vardekloft *P. agardhianus* Bed; those in C, D from Lejr R. *Czekanowskia* Bed; those in E, F from Dinosaur R. *Marattiopsis* Bed; that in G. from Astarte R. Bed C; those in H, I from Vardekloft *Dictyophyllum* Bed; those in K—Q from Neil Cliff Coal Bed.

*Diagnosis.* Almost spherical megaspore varying in diameter from  $600\ \mu$ — $1000\ \mu$ . Wall very hard; total thickness about  $40\ \mu$ — $60\ \mu$ , not separable into two layers by maceration. Tri-radiate lamellae fairly conspicuous, about  $20\ \mu$  broad, probably scarcely projecting at all in some specimens, up to  $10\ \mu$  high in others, their length being about 0.6 of the radius of the spore; arcuate lamellae absent, 'facets' entirely undistinguished. Surface of spore marked with very conspicuous round or oval pits about  $18\ \mu$  wide,  $20\ \mu$  deep and separated from adjacent pits by about  $15\ \mu$ . Substance of wall almost homogeneous, or showing an exceedingly fine granular structure.

*Discussion.* *T. rexargentus* is represented by many specimens; it is very like *T. areolatus* but quite different from the other Greenland species. From *T. areolatus* it is distinguishable by its considerably thicker wall and its smaller and deeper pits. *T. rexargenteus* is also, on the average, rather smaller. Although the pitting in both species is somewhat variable, there is never any difficulty in distinguishing them; in *T. areolatus* the pits are not very conspicuous on the wall of an unbroken spore, and their average width is at least five times the thickness of the wall separating the pits. In *T. rexargenteus*, the average diameter of a pit is not more than twice the thickness of the separating wall, in many specimens it is about equal. In *T. rexargenteus* more than half the area of the wall is thick and is most naturally described as pitted; in *T. areolatus* more than half of it is thin and the wall is most naturally described as bearing a network of lamellae. In both species the pits are occasionally confluent or joined in small groups.

From *T. erlansonii* (MINER), *T. rexargenteus* is distinguished by its more conspicuous tri-radiate lamellae and wider-spaced pits.

The name *rexargenteus* was suggested by the resemblance of this megaspore to a certain brand of golf ball.

***Triletes areolatus* sp. nov.**

Pl. 26, figs. 3, 10; Text-fig. 51 A—F.

Type-specimen, Pl. 26, fig. 3.

*Occurrence.*

Lejr R., *Czekanowskia* Bed.

Astarte R., *T. brauniana* Bed.

Vardekløft, *P. agardhianus* Bed.

Dinosaur R., *Marattiopsis* Bed.

Neill Cliff, Coal Bed; *Nilssonina undulata* Bed.

C. Stewart, *Todites* Bed.

C. Hope, Coal Bed.

All of these beds belong to the *Thaumatopteris* Zone, Neill Cliff Coal Bed being transitional between this and the *Lepidopteris* Zone.

*Diagnosis.* Almost spherical megaspore varying in diameter from 600—1400  $\mu$ . Wall not particularly hard, 15—30  $\mu$ , not separable into two layers by maceration. Tri-radiate lamellae fairly conspicuous, up to 30  $\mu$  wide, projecting about 15  $\mu$ ; their length being 0.5—0.7 of the radius of the spore. Arcuate lamellae absent, but occasionally the pits in the wall are so arranged as to give a slight suggestion of a lower border to the 'facets', but in most cases 'facets' entirely undistinguished. Surface of spore marked with more or less conspicuous round or polygonal pits about 30  $\mu$  wide and up to 7  $\mu$  deep and separated from adjacent pits by about 5  $\mu$ . Substance of wall showing a fine granular structure.

*Discussion.* *T. areolatus* is compared with *T. rexargenteus* on p. 158. It is rather like *T. erlansoni* (MINER), but appears to differ in possessing much more conspicuous tri-radiate lamellae, and smaller and shallower areolae.

*T. areolatus* is represented by an abundance of specimens. It is unusually variable in size (Text-fig. 51), but it should be realized that the extreme specimens were selected out of several hundreds of more normal ones. The majority vary between the sizes of 800  $\mu$  and 1000  $\mu$ .

A good many small, thin-walled specimens of *T. areolatus* were obtained, which I think may be immature. In one particular maceration I obtained a group of seven of these 'immature' spores cohering in a mass, and one separate spore of similar appearance. This suggests that there were more than four, perhaps eight, spores in each sporangium.

The name refers to the areolae on the wall.

### ***Triletes litchi* sp. nov.**

Pl. 25, figs. 1, 7; Text-fig. 53 K—N.

#### *Occurrence.*

Astarte R., Bed C.

Vardekløft *Stachyotaxus* Bed.

Both of these beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Spore 600  $\mu$ —850  $\mu$  in diameter; shape almost perfectly spherical; tri-radiate mark rather conspicuous, about 0.4—0.5 of the length of the radius of the spore, about 30  $\mu$  broad and projecting 20  $\mu$ . Arcuate lamellae absent, 'facets' unrecognizable. Exine covered with blunt-ended processes about 20  $\mu$  long, 15  $\mu$  wide; processes usually separate from one another, but occasionally united at their bases in small groups. Spore wall 15  $\mu$  thick (measured between the processes); not separating into two definite layers. Substance of wall very finely granular; granules in the processes usually scattered evenly, but occasionally showing a tendency to become arranged in obscure transverse rows.

*Discussion.* I obtained about a dozen of these spores but destroyed some of them in maceration; the spore wall being particularly unresistant to maceration. The various specimens agreed very well with one another.

*Comparison.* *T. litchi* most resembles *T. myrmecodes*, from which it is well distinguished by its blunt appendages and *T. mensura*, from which it is distinguished by its shorter, almost if not quite unstriated appendages and by its smaller size. From both it is distinguished by the absence of any definite 'facets'. It very closely resembles *T. papillosus* (MINER) and may in fact be indistinguishable from it, but to judge from MINER's figure it has rather more prominent papillae and shorter tri-radiate lamellae; it differs from *T. greenlandicus* (MINER) in its much shorter and more crowded papillae.

***Triletes myrmecodes* sp. nov.**

Pl. 26, fig. 4; Text-fig. 52 M—Q.

1926b. Megaspore 2, HARRIS. p. 50; Text-fig. 1 B (Type-specimen).

*Occurrence.*

Astarte R., Bed C.

Vardekloft *Neocalamites* Bed, *Dictyophyllum* Bed; *Stachyotaxus* Bed.

C. Hope, *A. minor* Bed.

All of these beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Shape rounded, but apex considerably flattened. Diameter  $500\mu$ — $600\mu$ . Wall of spore rather soft, about  $20\mu$  thick (excluding the spines), not resolvable by maceration into two layers. Tri-radiate lamellae conspicuous  $20\mu$  broad,  $40\mu$  high, their length being 0.7—0.9 of the radius of the spore. Arcuate lamellae conspicuous, up to  $40\mu$  high but usually rather less. Spore wall both in ventral part of spore and on facets bearing small spines at intervals of  $50\mu$ ; spines typically  $15\mu$  long, but occasionally longer,  $15\mu$  broad, not as a rule very sharp, their free end usually very delicate and rather irregular.

*Comparison.* *T. myrmecodes* is like *T. echinatus* (MINER) in size and in its appendages, but is probably distinguishable by its much more strongly developed arcuate lamellae and less prominent spiny appendages.

It is represented by a great many specimens of very similar size and structure. Its name is from  $\mu\sigma\rho\mu\eta\kappa\acute{\omega}\delta\eta\varsigma$ , warty.

***Triletes mensura* sp. nov.**

Pl. 26, figs. 2, 9 (Type-specimen); Text-fig. 53 J.

*Occurrence.* Astarte R., *Lepidopteris* Bed; Bed A; Bed C.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Almost spherical megaspore about  $400\mu$  in diameter. Tri-radiate lamellae scarcely developed, but tri-radiate cracks present,

their length being about 0.6 of the radius of the spore. Arcuate lamellae slightly developed, but facets fairly well distinguished from the rest of the spore by the different character of their appendages. Exine 15—

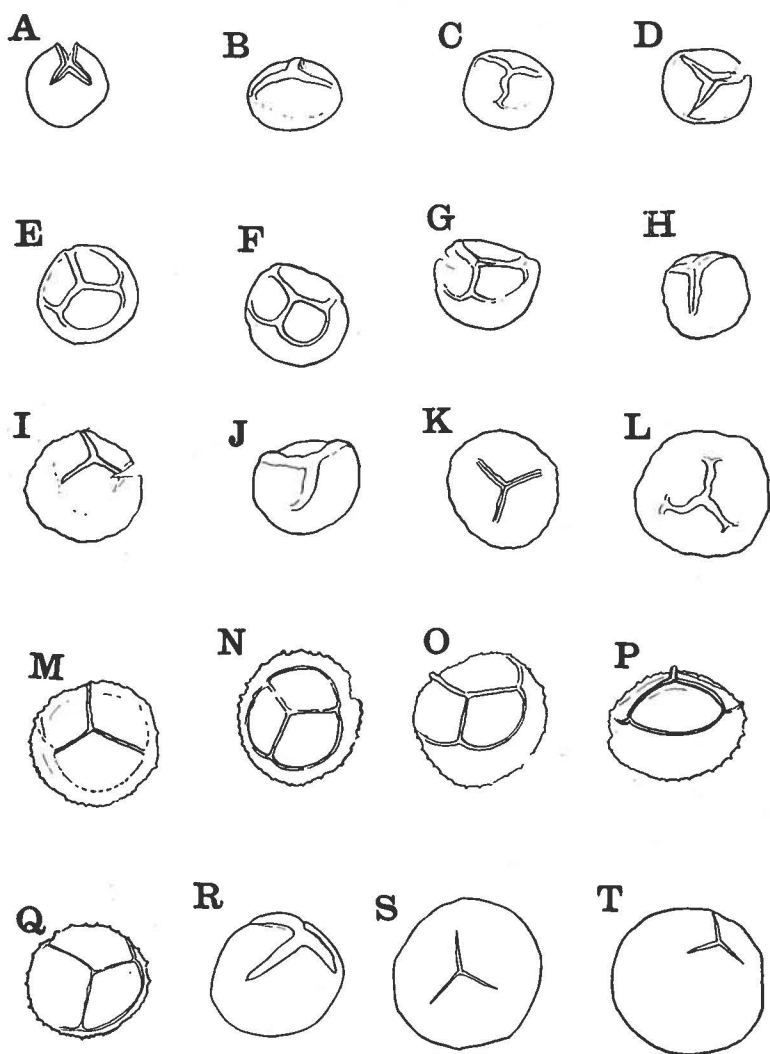


Fig. 52. Megaspores, all  $\times 28$ .

A—D, *Triletes pinguis*, Slide 4172; E—G, *T. ionthus*, Slides 4200, 4201. H—L, *T. aurantium*, Slides 4215, 4216, 4230. M—Q, *T. myrmecodes*, Slides 4021, 4025, 4030. R, *T. persimilis*, Slide 4181. S, T, *T. pedinacron*, Slides 4191, 4200. — The specimens shown in A—D were obtained from Ryders R. *Baiera* Bed; those in E, G—I, N from Astarte R. Bed C; those in F, L, S, T from Astarte R. Bed A; those in J, K, R from Astarte R., *Lepidopteris* Bed; that in M from C. Hope *A. minor* Bed; those in O, P from Vardekloft *Dictyophyllum* Bed; that in Q from Vardekloft *Stachyotaxus* Bed.

25  $\mu$  thick, composed of a single layer, substance finely granular. Appendages on region of facets consisting of numerous unbranched outgrowths about 60  $\mu$  long, 6  $\mu$  wide, which are either parallel-sided or taper slightly to a blunt apex. Appendages showing well marked transverse striations at intervals of about 2  $\mu$ .

Appendages in lower region of spore typically conical, about 5  $\mu$  long, 5  $\mu$  broad, sometimes showing traces of rather irregular transverse striation, sometimes evenly granular. Appendages in region of facets sometimes crowded, sometimes separated by about 20  $\mu$  of smooth wall.

*Comparison.* *T. mensura* is very similar to *T. tylotus*. It is, however, distinguishable by its much less developed tri-radiate lamellae, but definite facets, and by its appendages which are longer and more conspicuously striated in the apical region of the spore, but much less developed at the base of the spore. In *T. mensura* they have a much less tendency to be united in irregular groups.

*T. mensura* is distinguished from *T. litchi* by its smaller size and its fewer and longer appendages which show more definite transverse striations. It appears to be rather like *Triletes greenlandicus* (MINER), but *T. tylotus* *q. v.* is even more similar.

*T. mensura* is only represented by three specimens which are very similar to one another.

### **Triletes tylotus** sp. nov.

Pl. 26, figs. 1, 12; Text-fig. 53 F—I.

Type-specimen, Pl. 26, fig. 12; Text-fig. 53 F.

*Occurrence.* Astarte R., *Lepidopteris* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Almost spherical megaspore about 400  $\mu$  in diameter. Tri-radiate lamellae fairly strongly developed, their length being 0.4—0.5 of the radius of the spore, tri-radiate lamellae about 20  $\mu$  wide and 10  $\mu$  high. Arcuate lamellae and 'facets' entirely undistinguished. Exine about 15  $\mu$  thick composed of a single layer; substance of wall finely granular. Appendages similar in all parts of spore but sometimes more numerous towards the apex; consisting of cylindrical outgrowths typically 20—30  $\mu$  long  $\times$  10—15  $\mu$  wide with transversely truncate ends. Appendages unbranched and usually straight, but often arising in groups of two or three when they may be fused nearly to their apices. Substance of appendages sometimes finely granular, but more usually showing fine transverse striations at intervals of about 1  $\mu$ . Distance between adjacent appendages or groups of appendages typically about 35  $\mu$ .

*Discussion and Comparison.* *T. tylotus* is represented by about a dozen very similar specimens. It is compared with *T. mensura* above.



It seems rather like certain specimens of *T. greenlandicus* (MINER) but would appear to be distinguished by its shorter tri-radiate lamellae and the somewhat smaller size of the whole spore.

From *T. litchi* it is distinguished by its much smaller size and its less numerous, relatively longer appendages.

The specific name is from *τυλωτός*, knobbed.

### ***Triletes ales* sp. nov.**

Pl. 25, figs. 2, 8, 9, 11; Text-fig. 53 A—E.

Type-specimen, Pl. 25, fig. 11.

*Occurrence.* Ammonite Mtn. Coal Bed.

This bed appears to be transitional between the *Lepidopteris* and *Thaumatopteris* Zones.

*Diagnosis.* Body of spore rounded; diameter varying between 250—350  $\mu$ . Spore wall probably about 5  $\mu$  thick. Tri-radiate lamellae extremely conspicuous, forming rather delicate plates about 100  $\mu$  high; their length being about 1.5 times the radius of the spore. Arcuate lamellae present but very delicate, about 5—10  $\mu$  high, similar in structure to the tri-radiate lamellae. Margins of tri-radiate lamellae jagged, but not as a rule deeply incised, outer part of lamellae pierced by great numbers of small holes and forming a delicate lace-work. 'Facets' bearing (especially near the spore-apex) simple or forked processes up to 80  $\mu$  long and 5  $\mu$  wide. Lower part of spore bearing at intervals of 15  $\mu$  simple sharp-pointed spines about 2  $\mu$  wide and up to 5  $\mu$  long. Substance of the exine and of the spines finely and evenly granular, not resolvable into two layers. Cuticular processes of facets showing no fine structure; lamellae structureless apart from their perforations.

*Comparison.* *T. ales* is well distinguished from all the other species described in this paper. It is rather like *T. borealis* (MINER) but is distinguished by its much more pronounced tri-radiate ridges and by the presence of small spines, instead of a reticulum on the spore wall.

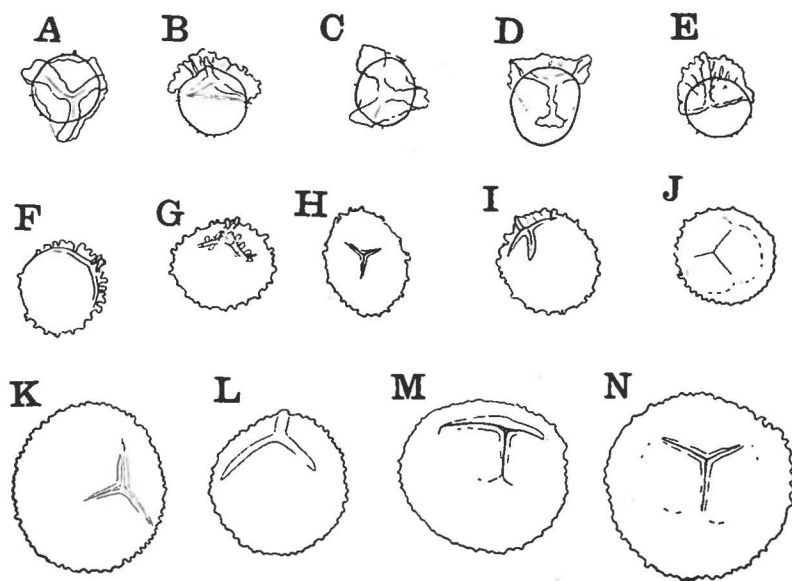
### ***Triletes* sp. A.**

Pl. 25, fig. 12.

*Occurrence.* C. Hope, A. minor Bed.

This bed belongs to the *Lepidopteris* Zone.

*Description.* A single incomplete specimen of this spore was obtained. It appears to be at least 1 mm in diameter; its shape is uncertain. Its wall appears to be about 25  $\mu$  thick; its substance is coarsely granular. Scattered over the surface at varying intervals in different parts are thickened portions 15  $\mu$  wide and about 5  $\mu$  thick. In certain parts of the spore these bear one or more processes, which are up to 40  $\mu$  long  $\times$

Fig. 53. Megaspores, all  $\times 28$ .

A—E, *Triletes ales*, Slides 4070, 4071. F—I, *T. tylotus*, Slide 4051. J, *T. mensura*, Slide 4060. K—N, *T. litchi*, Slides 4045, 4046. — The specimens of *T. ales* were obtained from Ammonite Mountain; those of *T. tylotus* from Astarte R. *Lepidopteris* Bed; those of *T. mensura* and *T. litchi* from Astarte R. Bed C.

$4\mu$  wide, unbranched and with a blunt end; in other parts of the spore they are much smaller or absent.

*Triletes* sp. A is undoubtedly different from any known species. It somewhat resembles *T. arnoldi* (MINER) but is readily distinguished by the arrangement of its appendages in groups, and by their very uneven development in different parts of the spore. It is not, however, completely enough known to be described as a new species.

## Group 2. LAEVIGATAE.

### *Triletes aurantium* sp. nov.

Pl. 25, fig. 5; Pl. 26, fig. 5; Text-fig. 52 H—L.

Type-specimen, Pl. 25, fig. 5.

#### Occurrence.

Astarte R., Bed A, *Lepidopteris* Bed, Bed C.

Vardekløft *Stachyotaxus* Bed.

C. Stewart A. *minor* Bed.

These beds belong to the *Lepidopteris* Zone.

**Diagnosis.** Rounded megaspore with a slightly flattened apex, varying in diameter from  $390\mu$  to  $600\mu$ . Thickness of wall about  $25\text{--}30\mu$ . Tri-radiate scars conspicuous,  $30\text{--}50\mu$  broad near the apex, not

projecting upwards more than about  $20\mu$ , their length usually between 0.6 and 0.8 of the radius of the spore. Arcuate lamellae undeveloped, 'facets' usually quite undistinguished from the rest of the spore, but in a few specimens there is a slight indication of a boundary. Spore wall (including 'facets') typically covered with ill-defined irregular thickenings  $30\mu$  wide,  $5\mu$  thick. Extent to which the thickenings are developed varying considerably; occasionally thickenings almost absent.

*Comparison.* *T. aurantium* differs from *T. subrotundus* (MINER) in its slightly tuberculate surface. It appears to be very like *T. inornatus* (MINER), but according to the description it should be distinguishable by its smooth exine and shorter tri-radiate lamellae. The extent to which the surface tubercles of *T. aurantium* are developed does, however, vary to some extent, and the figures of *T. inornatus* appear to show the existence of slight tuberculation so that a distinction between these two, and even *T. subrotundus*, may be hard to draw.

***Triletes persimilis* sp. nov.**

Pl. 25, fig. 4 (Type-specimen); Text-fig. 52 R.

*Occurrence.* Astarte R., *Lepidopteris* Bed.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Spore about  $600\mu$  in diameter; shape rounded but with a slightly flattened apex. Thickness of wall  $15-20\mu$ , wall not separable into two layers. Tri-radiate lamellae very conspicuous, about  $20\mu$  broad and projecting upwards  $20-30\mu$ ; their length being 0.6—0.7 of the radius of the spore. Arcuate lamellae absent; 'facets' quite indistinguishable from the rest of the spore. Spore wall perfectly smooth, showing a finely granular structure.

*Discussion.* *T. persimilis* is only represented by a few specimens.

It is very close to *T. subrotundus* (or *rotundus*) (MINER) and only differs in the thickness of the wall, which is much thinner and outside the range of variation given by MINER. From *T. aurantium*, it is distinguished by its perfectly smooth wall; from *T. pinguis* by its larger size, from *T. stenoxysmatodes* by its shorter and more prominent tri-radiate lamellae, from *T. inornatus* (MINER) by its longer tri-radiate lamellae and from *T. pedinacron* by its smaller size, thinner wall and more prominent tri-radiate lamellae.

The name *persimilis* refers to its being very like several other species.

***Triletes pedinacron* sp. nov.**

Pl. 27, fig. 6 and Text-fig. 52 S (Type-specimen); Text-fig. 52 T.

*Occurrence.* Astarte R., Bed A.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Almost spherical megaspore  $700-800\mu$  in diameter.

Thickness of wall about  $35\mu$  not separating into two layers on maceration. Tri-radiate lamellae not developed, but tri-radiate cracks bordered by a clear portion of the wall  $5\mu$  wide, but which does not project at all; length of crack about 0.4—0.5 of the radius of the spore. Arcuate lamellae absent, 'facets' unrecognizable. Spore wall quite smooth, substance finely but fairly conspicuously granular.

*Discussion.* *T. pedinacron* is only represented by two specimens which are figured. It is rather like *T. inornatus* (MINER) and other smooth species described here, but appears to differ from all of them in its quite undeveloped tri-radiate lamellae; from *T. stenoxysmatodes* it differs in its much shorter tri-radiate scar.

The name is from  $\pi\epsilon\delta\iota\nu\omicron\varsigma$ , flat, and  $\acute{\alpha}\chi\rho\omicron\nu$ , top, and refers to the absence of tri-radiate lamellae.

### ***Triletes pinguis* sp. nov.**

Pl. 25, fig. 3 (Type-specimen): Text-fig. 52 A—D.

*Occurrence.* Ryder R., Baiera Bed.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Spore of a rounded shape, but with a flattened apex. Diameter  $350\text{--}450\mu$ . Tri-radiate lamellae very conspicuous,  $30\text{--}60\mu$  high and about  $20\mu$  broad near the apex; their length 0.7—0.8 of the radius of the spore. Arcuate lamellae absent; 'facets' flattened, but quite indefinite below. Exine perfectly smooth in all parts of the spore; wall of spore very hard,  $20\mu$  thick; separating on prolonged maceration into two layers each  $10\mu$  thick; inner layer structureless, outer layer exceedingly finely granular, appearing almost homogeneous.

*Discussion and Comparison.* I obtained a dozen very similar specimens of *T. pinguis*. It is distinguished from other smooth spores by its small size and relatively thick, two-layered wall. Its name is from *pinguis* = plump.

### ***Triletes ionthus* n. sp.**

Pl. 26, fig. 8; Text-fig. 52 E (Type-specimen); Text-fig. 52 F, G.

*Occurrence.* Astarte R., Bed A; Bed C.

These beds belong to the *Lepidopteris* Zone.

*Diagnosis.* Spore  $500\text{--}600\mu$  in diameter; shape rounded, but with a rather flattened apex. Spore-wall about  $15\mu$  thick, apparently composed of only one layer. Tri-radiate lamellae very conspicuous, 0.5—0.6 of the length of the radius of the spore, bearing a lamella  $30\text{--}40\mu$  broad and up to  $50\mu$  high at the apex of the spore. Lower margin of 'facets' distinguished by a small but distinct ridge; 'facets' also well distinguished by their sculpture. Exine quite smooth in the

lower part of the spore but on the 'facets' forming a number of large rounded projections of irregular form separated by thin areas or pits.

Exosporium showing in all parts a granular structure which is so exceedingly fine as to appear homogeneous.

*Comparison.* *T. ionthus* is well distinguished from the other smooth-walled species by the very conspicuous pits and ridges which occur on the facets. Its name is from *ιονθοϛ*, a pimple on the face, refers to the surface of the facets.

### ***Triletes stenoxysmatodes* sp. nov.**

Pl. 25, fig. 6 (Type-specimen).

*Occurrence.* Astarte R., Bed C.

This bed belongs to the *Lepidopteris* Zone.

*Diagnosis.* Spore  $500\ \mu$  in diameter, spore-wall probably about  $10\ \mu$  thick. Tri-radiate lamellae feebly developed; about  $3\ \mu$  thick and possibly  $3\ \mu$  high but almost as long as the radius of the spore; arcuate lamellae absent; 'facets' undistinguished. Exine quite smooth apart from numbers of irregular pits about  $1\ \mu$  in diameter; its substance appearing homogeneous.

*Discussion and Comparison.* *T. stenoxysmatodes* is only represented by one specimen, but this is so well distinguished from all the other Greenland species by its smooth wall and remarkably long tri-radiate lamellae.

## **General Summary.**

The following species are described:—

### *Ginkgoales.*

#### Leaves.

- |                                       |                                        |
|---------------------------------------|----------------------------------------|
| 1. <i>Ginkgoites obovata</i> (NATH.). | 8. <i>B. boeggildiana</i> sp. nov.     |
| 2. <i>G. fimbriata</i> sp. nov.       | 9. <i>B. leptophylla</i> sp. nov.      |
| 3. <i>G. acosmia</i> sp. nov.         | 10. <i>B. amalloidea</i> sp. nov.      |
| 4. <i>G. minuta</i> (NATH.).          | 11. <i>Czekanowskia hartzi</i> HARRIS. |
| 5. <i>G. hermelini</i> (HARTZ).       | 12. <i>C. nathorsti</i> sp. nov.       |
| 6. <i>G. taeniata</i> (BRAUN).        | 13. <i>Hartzia tenuis</i> (HARRIS).    |
| 7. <i>Baiera spectabilis</i> NATH.    | 14. <i>Torellia ephela</i> sp. nov.    |

The genus *Hartzia* is new.

Reproductive organs ascribed to the Ginkgoales are mentioned below.

## Coniferales.

## Foliage.

- |                                            |                                             |
|--------------------------------------------|---------------------------------------------|
| 1. <i>Stachyotaxus elegans</i> NATH.       | 16. <i>E. molopicus</i> sp. nov.            |
| 2. <i>S. septentrionalis</i> (? AGARDH).   | 17. <i>E. polystictus</i> sp. nov.          |
| 3. <i>Storgaardia spectabilis</i> sp. nov. | 18. <i>E. physetus</i> sp. nov.             |
| 4. <i>Elatocladus patens</i> sp. nov.      | 19. <i>E. eurystomus</i> sp. nov.           |
| 5. <i>E. pachyteichus</i> sp. nov.         | 20. <i>E. spp. indet.</i>                   |
| 6. <i>E. perforatus</i> sp. nov.           | 21. <i>Ontheodendron sternbergi</i>         |
| 7. <i>E. stenostomus</i> sp. nov.          | (NILSSON).                                  |
| 8. <i>E. lacunosus</i> sp. nov.            | 22. <i>Podozamites stewartensis</i> HARRIS. |
| 9. <i>E. punctatus</i> sp. nov.            | 23. <i>P. astartensis</i> sp. nov.          |
| 10. <i>E. nitidus</i> sp. nov.             | 24. <i>P. punctatus</i> sp. nov.            |
| 11. <i>E. oligostomus</i> sp. nov.         | 25. <i>P. cf. schenki</i> HEER.             |
| 12. <i>E. tuberculatus</i> sp. nov.        | 26. <i>P. mucronatus</i> sp. nov.           |
| 13. <i>E. amblus</i> sp. nov.              | 27. <i>P. cf. distans</i> (PRESL).          |
| 14. <i>E. stenocytus</i> sp. nov.          | 28. <i>Desmiophyllum spp. indet.</i>        |
| 15. <i>E. polystomus</i> sp. nov.          |                                             |

The genus *Storgaardia* is new.

## Cones.

*Stachyotaxus elegans.*  
*S. septentrionalis.*

*Ontheodendron sternbergi.*

## Isolated Female Cones and Seeds.

- |                                                 |                                                               |
|-------------------------------------------------|---------------------------------------------------------------|
| 1. <i>Cycadocarpidium erdmanni</i><br>NATH.     | 13. <i>Allicospermum xystum</i> sp. nov.                      |
| 2. <i>C. swabi</i> NATH.                        | 14. <i>A. striatum</i> sp. nov.                               |
| 3. <i>Swedenborgia cryptomerioides</i><br>NATH. | 15. <i>A. hartzii</i> sp. nov.                                |
| 4. <i>S. major</i> sp. nov.                     | 16. <i>A. obscurum</i> sp. nov.                               |
| 5. <i>S. minor</i> sp. nov.                     | 17. <i>A. fragilis</i> sp. nov.                               |
| 6. <i>Callipitys leptoderma</i> sp. nov.        | 18. <i>A. ooides</i> sp. nov.                                 |
| 7. <i>Araucarites charcoti</i> sp. nov.         | 19. <i>Samaropsis nathorstiana</i> sp.<br>nov.                |
| 8. <i>Staphidiophora secunda</i> sp. nov.       | 20. <i>S. scirrhodes</i> sp. nov.                             |
| 9. <i>S. exile</i> sp. nov.                     | 21. <i>S. chalcos</i> sp. nov.                                |
| 10. <i>Ourostrobos nathorsti</i> sp. nov.       | 22. <i>Bysmatospermum macrotrache-</i><br><i>lum</i> sp. nov. |
| 11. <i>Microcheiris enigma</i> sp. nov.         | 23. <i>Chitospermum stereococcus</i> sp.<br>nov.              |
| 12. <i>Tmematostrobos eremus</i> sp. nov.       |                                                               |

The following genera are new:— *Callipitys*, *Staphidiophora*, *Ourostrobos*, *Microcheiris*, *Tmematostrobos*, *Allicospermum*, *Bysmatospermum*, *Chitospermum*.

New information is adduced about the morphology of *Swedenborgia*, *Cycadocarpidium*, *Leptostrobos*, *Bernettia* and *Ixostrobos*.

*Isolated Male Cones.*

- |                                          |                                                |
|------------------------------------------|------------------------------------------------|
| 1. <i>Leptostrobus longus</i> sp. nov.   | 6. <i>Sphaerostrobus clandestinus</i> sp. nov. |
| 2. <i>Bernettia phialophora</i> sp. nov. |                                                |
| 3. <i>Stenomischus athrous</i> sp. nov.  | 7. <i>Amydrostrobus groenlandicus</i> sp. nov. |
| 4. <i>Sorosaccus gracilis</i> sp. nov.   |                                                |
| 5. <i>S. minor</i> sp. nov.              | 8. <i>Ixostrobus groenlandicus</i> sp. nov.    |

The following genera are new:— *Stenomischus*, *Sorosaccus*, *Sphaerostrobus*, *Amydrostrobus*.

*Lycopodiales.*

## Stem.

1. *Grammaephloios icthya* gen. et sp. nov.

*Isolated spores.*

- |                                          |                                        |
|------------------------------------------|----------------------------------------|
| 1. <i>Lycostrobus scotti</i> NATH.       | 8. <i>Triletes ales</i> sp. nov.       |
| 2. <i>Triletes rexargenteus</i> sp. nov. | 9. <i>T. aurantium</i> sp. nov.        |
| 3. <i>T. areolatus</i> sp. nov.          | 10. <i>T. persimilis</i> sp. nov.      |
| 4. <i>T. litchi</i> sp. nov.             | 11. <i>T. pedinacron</i> sp. nov.      |
| 5. <i>T. myrmecodes</i> sp. nov.         | 12. <i>T. pinguis</i> sp. nov.         |
| 6. <i>T. mensura</i> sp. nov.            | 13. <i>T. ionthus</i> sp. nov.         |
| 7. <i>T. tylotus</i> sp. nov.            | 14. <i>T. stenoxysmatodes</i> sp. nov. |

In addition, the spores described by MINER under the name *Selaginellites* are referred to *Triletes*.

The delimitation of the various Ginkgoalean leaf-genera, in particular *Ginkgoites* and *Baiera*, is discussed.

The seed described as *Allicospermum xystum* is held to belong to *Ginkgoites taeniata*; the fruit *Staphidiophora secunda* to *Hartzia tenuis*; the male cone *Bernettia phialophora* to *Baiera spectabilis* and the (?) male cone *Leptostrobus longus* to *Czekanowskia hartzi*.

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### Errata.

P. 70, l. 13, p. 78, l. 3, p. 80, l. 30, p. 81, l. 16, p. 107, ls. 36, 39: *Storgaadia*, should be: *Storgaardia*.

P. 92, ls. 18, 26, p. 94, l. 27, p. 98, l. 25, p. 109, l. 8: *Storgaad River*, should be: *Storgaard River*.

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## EXPLANATION OF PLATES

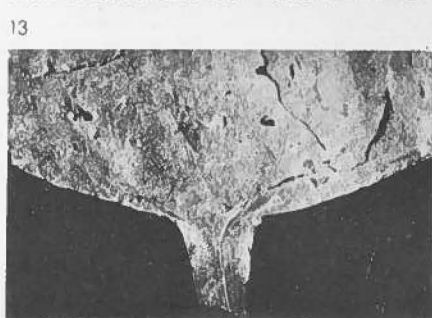
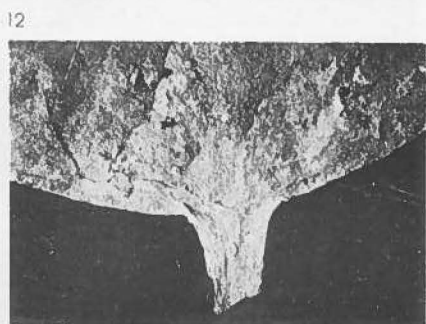
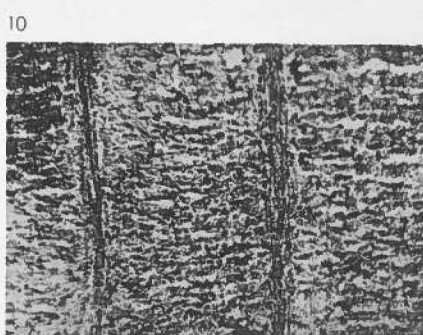
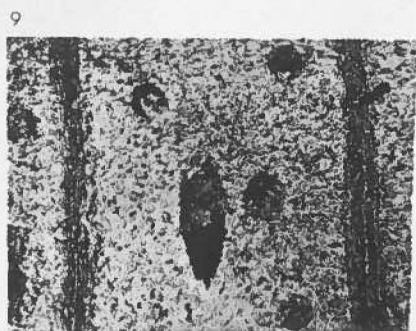
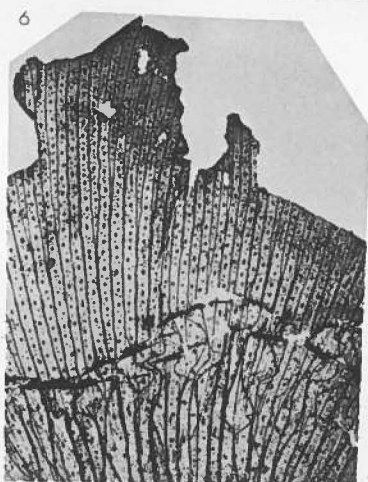
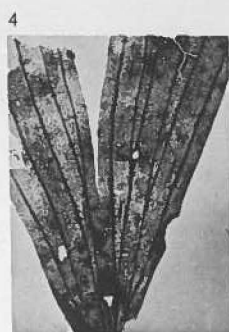
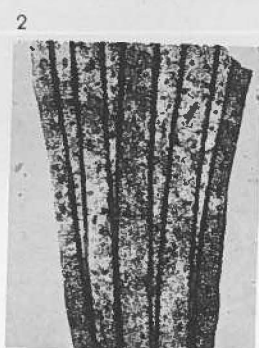
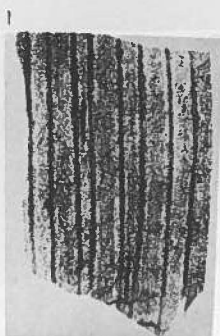
## Plate 1.

### *Ginkgoites* species.

- Fig. 1. *Ginkgoites taeniata*, leaf with very few resin bodies, Slide 2361,  $\times 4$ .  
Fig. 2. *Ginkgoites taeniata*, leaf with numerous small resin bodies, Slide 2352,  $\times 4$ .  
Figs. 3—5. *Ginkgoites acosmia*, parts of three leaves showing how the appearance varies with the preservation, Slides 1953, 1960, 1957, fig. 3  $\times 4$ , fig. 4 and 5  $\times 2$ .  
Fig. 6. *Ginkgoites obovata*, part of leaf shown in Text-fig. 2 A; the veins have shifted inside the leaf, No. 2420,  $\times 1$ .  
Fig. 7. *Ginkgoites minuta*, Slide 1985,  $\times 4$ .  
Fig. 8. *Ginkgoites hermelini*, Slide 1998,  $\times 4$ .  
Fig. 9. *Ginkgoites taeniata*, structure of leaf, Slide 2357,  $\times 25$ .  
Fig. 10. *Ginkgoites hermelini*, structure of leaf showing transverse bars of mesophyll, Slide 1998,  $\times 25$ .  
Fig. 11. *Ginkgoites fimbriata*, part of leaf showing resin bodies, Slide 1921,  $\times 4$ .  
Figs. 12, 13. *Ginkgoites obovata*, base of the same leaf showing the lower and the upper sides. Fig. 13 shows the thickening of the base of the lamina extending on to the petiole. Slide 1909,  $\times 2$ .  
Fig. 14. *Ginkgoites obovata*, lower part of leaf and petiole, No. 2412,  $\times 1$ .

The specimen shown in Fig. 1 was obtained from Dinosaur R., those in Figs. 2, 9 from C. Stewart, *A. hartzii* Bed; those in Figs. 3—5 from Astarte R., Bed A; those in Figs. 11—14 from Astarte R., *Lepidopteris* Bed; that in 7 from Astarte R., Bed B; those in Figs. 8, 10 from C. Stewart, *Todites* Bed; that in Fig. 6 from Zamites R. All the figures are untouched photographs; Figs. 1—11 are taken by transmitted light.





## Plate 2.

Cuticles of *Ginkgoites* species, all  $\times 100$ . The figures on the left represent the upper, those on the right the lower surface.

Figs. 1, 2. *Ginkgoites acosmia*, Slides 1972, 1971.

Figs. 3, 4. *Ginkgoites taeniata*, Slide 2358.

Figs. 5, 6. *Ginkgoites hermelini*, Slide 2321.

Figs. 7, 8. *Ginkgoites fimbriata*, Slide 1920.

The specimen of *G. acosmia* was obtained from Astarte R., Bed C; that of *G. taeniata* from C. Stewart, *A. hartzi* Bed; that of *G. hermelini* from Vardekløft, Liverwort Bed; that of *G. fimbriata* from Astarte R., *Lepidopteris* Bed. The figures are untouched photographs.



### Plate 3.

Cuticles of *Ginkgoites* and *Baiera* spp. All the figures are untouched photographs,  $\times 100$ . The figures on the left represent the upper, on the right the lower cuticle.

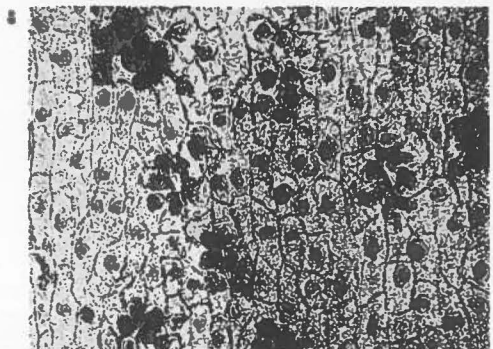
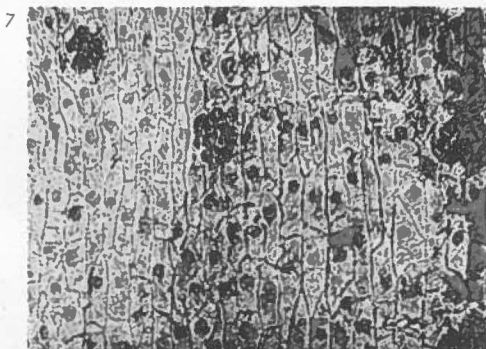
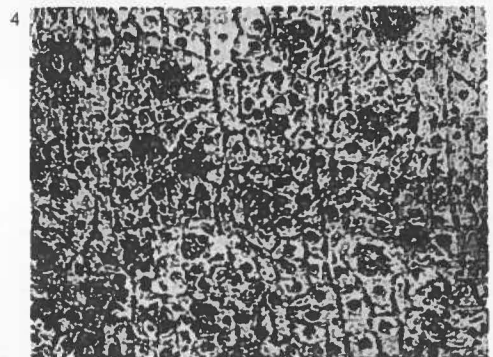
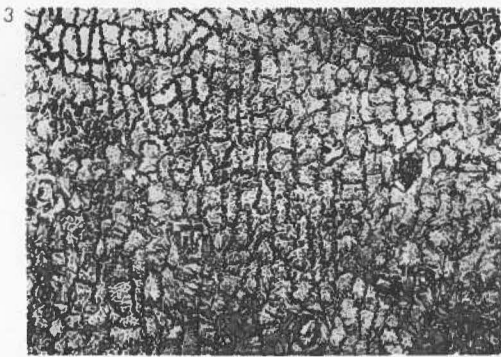
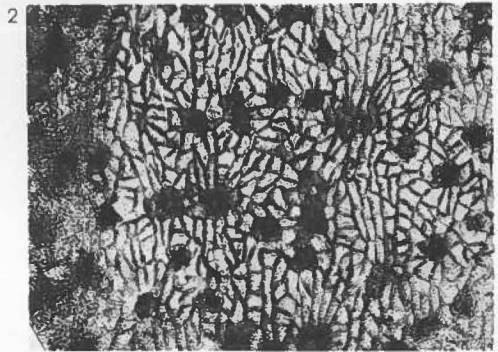
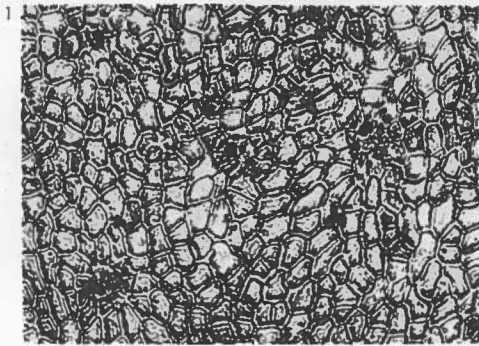
Figs. 1, 2. *Ginkgoites obovata*, Slides 1903, 1901.

Figs. 3, 4. *Baiera boeggildiana*, Slides 2382, 2383.

Figs. 5, 6. *Baiera amalloidea*, Slide 2581.

Figs. 7, 8. *Baiera spectabilis*, Slide 472 (HARTZ Collection).

The specimens of *G. obovata* and *B. boeggildiana* were obtained from Astarte R., *Lepidopteris* Bed; that of *B. amalloidea* from Astarte R., Bed C; that of *B. spectabilis* from Vardekloft, *P. agardhianus* Bed.

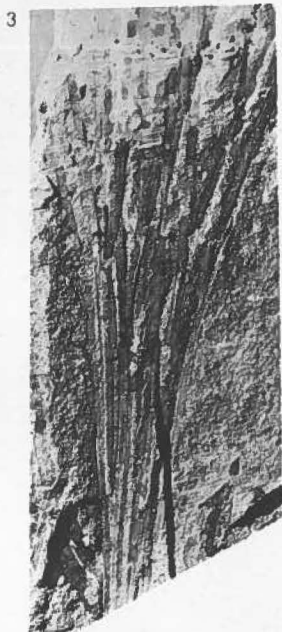
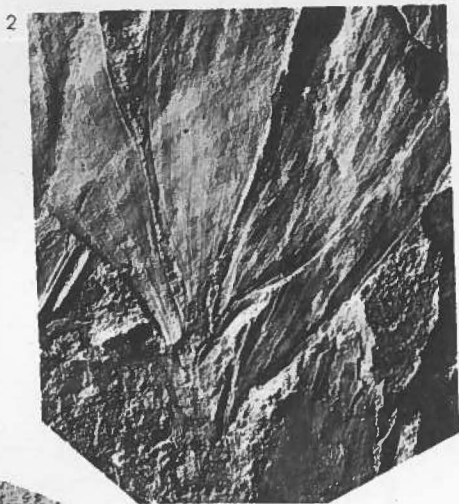
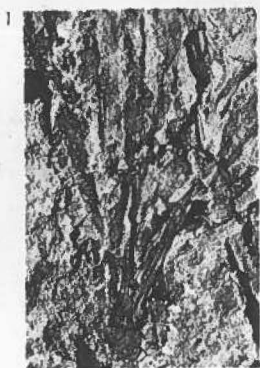


#### Plate 4.

- Fig. 1. *Baiera amalloidea*, base of leaves and short shoot, No. 2752,  $\times 1$ .  
Fig. 2. *Baiera boeggildiana*, part of specimen shown in Fig. 8,  $\times 2$ .  
Fig. 3. *Czekanowskia nathorsti*, group of leaves, No. 2951,  $\times 1$ .  
Fig. 4. *Czekanowskia hartzi*, group of leaves, No. 2816,  $\times 1$ .  
Fig. 5. *Czekanowskia hartzi*, groups of leaves still attached to main stem, No. 2821,  $\times 1$ .  
Fig. 6. *Baiera boeggildiana*, narrow leaf showing the marginal thickenings crossing on to the surface in the lower part, Slide 2384,  $\times 2$ .  
Fig. 7. *Czekanowskia nathorsti*, base of group of leaves, No. 2952,  $\times 1$ .  
Fig. 8. *Baiera boeggildiana*, Type-specimen, No. 2701,  $\times 1$ .  
Fig. 9. *Czekanowskia nathorsti*, base of group of leaves, No. 2933,  $\times 1$ .

All the figures are untouched photographs. The specimen shown in Fig. 1 was obtained from Astarte R., Bed C; those in Figs. 2, 6, 8 from Astarte R., *Lepidopteris* Bed; those in Figs. 3, 7 from Astarte R., *T. brauniana* Bed; that in Fig. 4 from Astarte R., *B. spectabilis* Bed; that in Fig. 5 from Storgaard R.; that in Fig. 9 from C. Stewart, *A. hartzi* Bed. All the figures are untouched photographs.





### Plate 5.

- Fig. 1. *Czekanowskia nathorsti*, stoma. The epidermal cells are conspicuously striated, Slide 2761,  $\times 200$ .
- Figs. 2, 3. *C. nathorsti*, stomata. The epidermal cells are only faintly striated, Slide 2762,  $\times 200$ .
- Figs. 4, 5. *C. nathorsti*, two surfaces of the same leaf. In Fig. 5 the inner layer of the cuticle has peeled off from certain cells. The epidermal cells are not striated. Slide 2721,  $\times 100$ .
- Fig. 6. *Baiera leptophylla*, upper cuticle, Slide 2401,  $\times 100$ .
- Fig. 7. *Baiera leptophylla*, lower cuticle of same leaf, a vein is situated on the left, Slide 2401,  $\times 100$ .
- Fig. 8. *Stenopteris dinosaurensis*, surface without epidermal papillae (?upper), Slide 2564,  $\times 100$ .
- Fig. 9. *Stenopteris dinosaurensis*, surface with faint epidermal papillae (?lower), Slide 2564,  $\times 100$ .

The figures are all untouched photographs. The specimens shown in Figs. 1—3 were obtained from Dinosaur R., *Marattiopsis* Bed; that shown in Figs. 4, 5 from Astarte R., *T. brauniana* Bed; that in Figs. 6, 7 from Zamites R.; that in Figs. 8, 9 from Astarte R., *T. princeps* Bed.

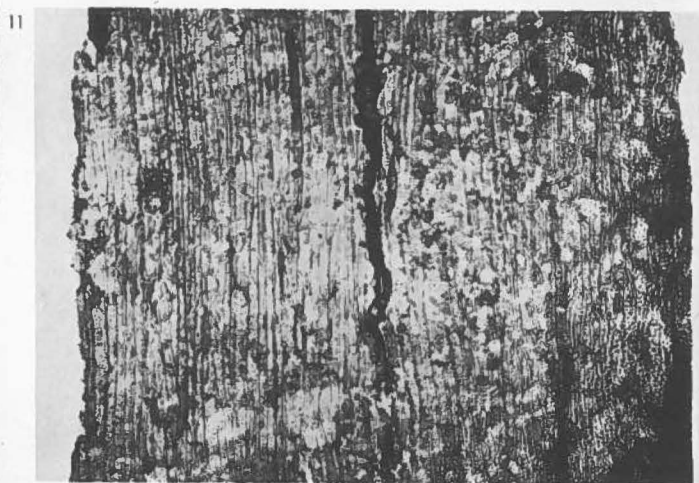
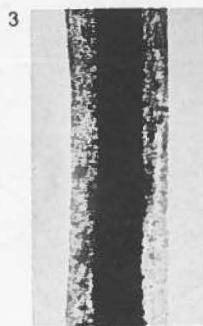
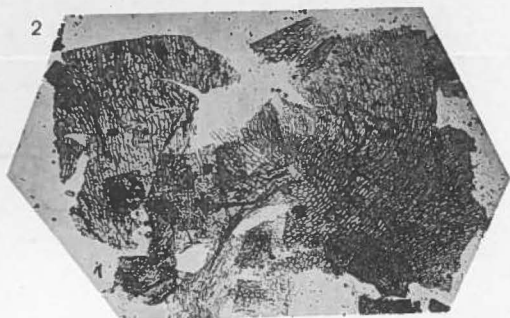




### Plate 6.

- Fig. 1. *Czekanowskia hartzi*, cuticle of scale leaf, Slide 2671,  $\times 15$ .  
Fig. 2. *Czekanowskia nathorsti*, cuticle of scale leaves, Slide 2765,  $\times 15$ .  
Fig. 3. *Czekanowskia nathorsti*, portion of leaf by transmitted light, Slide 2722,  $\times 10$ .  
Fig. 4. *Czekanowskia nathorsti*, upper part of group of leaves, No. 2962,  $\times 1$ .  
Fig. 5. *Baiera amalloidea*, base of group of leaves, No. 2758,  $\times 1$ .  
Fig. 6. *Czekanowskia nathorsti*, base of short shoot showing scale leaves, No. 2953,  $\times 2$ .  
Fig. 7. *Czekanowskia nathorsti*, lower part of group of leaves, No. 2963,  $\times 1$ .  
Fig. 8. *Czekanowskia nathorsti*, lower part of group of leaves, No. 2967,  $\times 1$ .  
Fig. 9. *Czekanowskia hartzi*, cuticle of leaf, Slide 2601,  $\times 200$ .  
Fig. 10. *Czekanowskia hartzi*, cuticle of leaf, Slide 464 HARTZ Collection,  $\times 200$ .  
Fig. 11. *Czekanowskia hartzi*, cuticle of both sides of leaf, Slide 629 HARTZ' Collection,  $\times 100$ .

All the figures are untouched photographs. The specimen shown in Fig. 1 was obtained from C. Hope, those in Figs. 2, 4, 7, 8 from Dinosaur R., *Marattiopsis* Bed; those in Figs. 3, 6 from Astarte R., *T. brauniana* Bed; that in Fig. 5 from Astarte R., Bed C; that in Fig. 9 from Astarte R., *B. spectabilis* Bed; that in Fig. 10 from C. Stewart, *Todites* Bed; that in Fig. 11 from one of HARTZ's original specimens (No. 1659 in Copenhagen Museum) from Storgaard R.

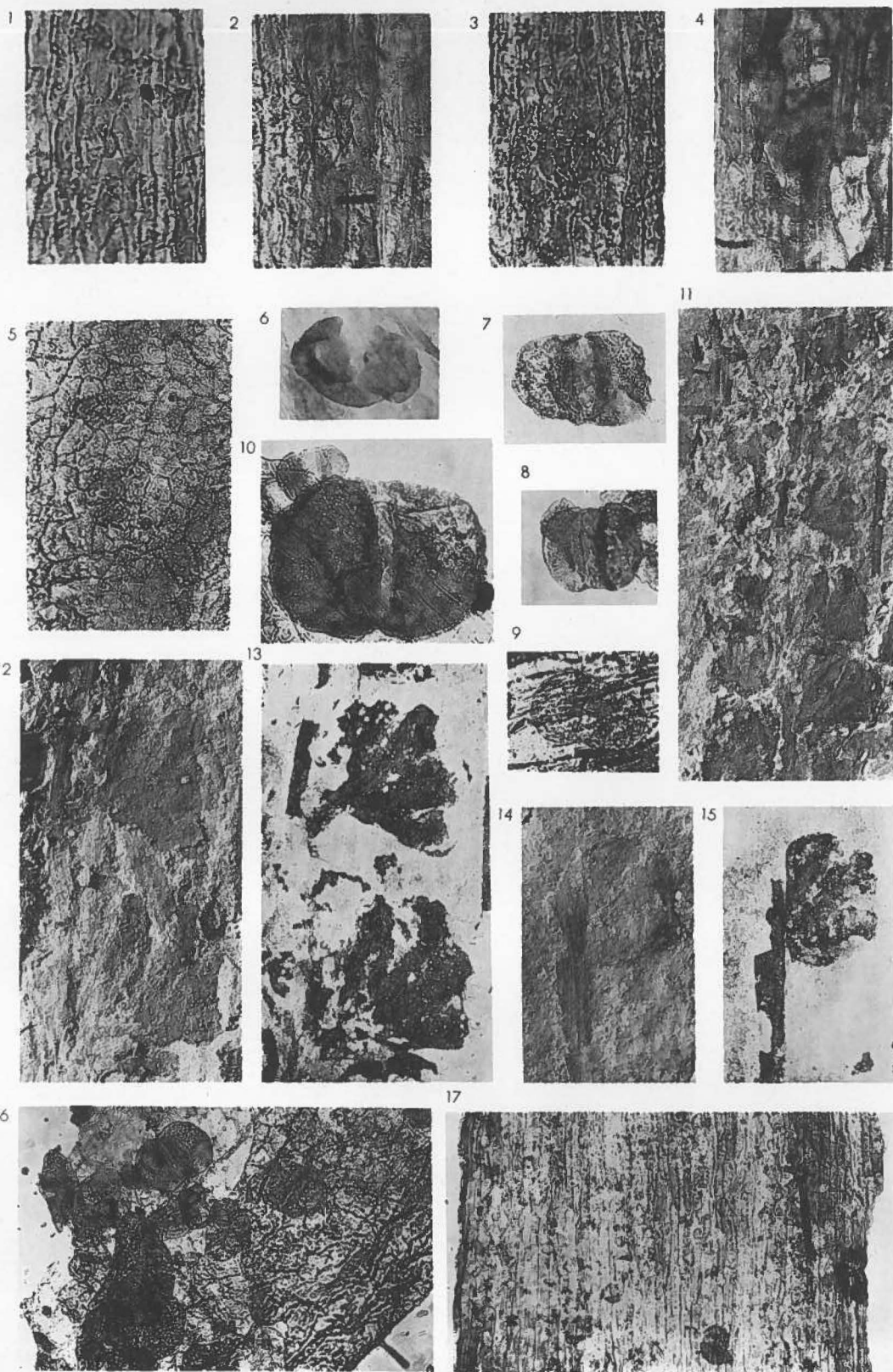


## Plate 7.

### *Leptostrobus longus*.

- Figs. 1—3. Cuticle of axis showing stomata, Slide 2803,  $\times 200$ .  
Fig. 4. Cuticle of axis less fully macerated than in Figs. 1—3, Slide 2805,  $\times 200$ .  
Fig. 5. Cuticle of wall of cup showing two stomata, Slide 2802,  $\times 100$ .  
Figs. 6, 7. Spores like those from cup sticking to cuticle of scale-leaf of *C. hartzi*. Slide 2671,  $\times 200$ .  
Fig. 8. Spore sticking to cuticle of cup of *L. longus*, Slide 2807,  $\times 200$ .  
Fig. 9. Spore sticking to cuticle of main axis of *L. longus*, Slide 2802,  $\times 200$ .  
Fig. 10. Two spores differing in size from those shown above, also sticking to cuticle of scale-leaf of *C. hartzi*, Slide 2671,  $\times 200$ .  
Fig. 11. Part of Type-specimen, No. 2981,  $\times 2$ .  
Figs. 12, 13, 14, 15. Cups photographed dry in 12 and 14, immersed in xylol in 13 and 15.  
Fig. 16. Cuticle of cup wall with microspores, Slide 2800,  $\times 100$ .  
Fig. 17. Cuticle of main axis, Slide 2805,  $\times 100$ .

All the figures are untouched photographs. All the specimens were obtained from Storgaard R., except that figured in 6, 7, 10, which was obtained from C. Hope.

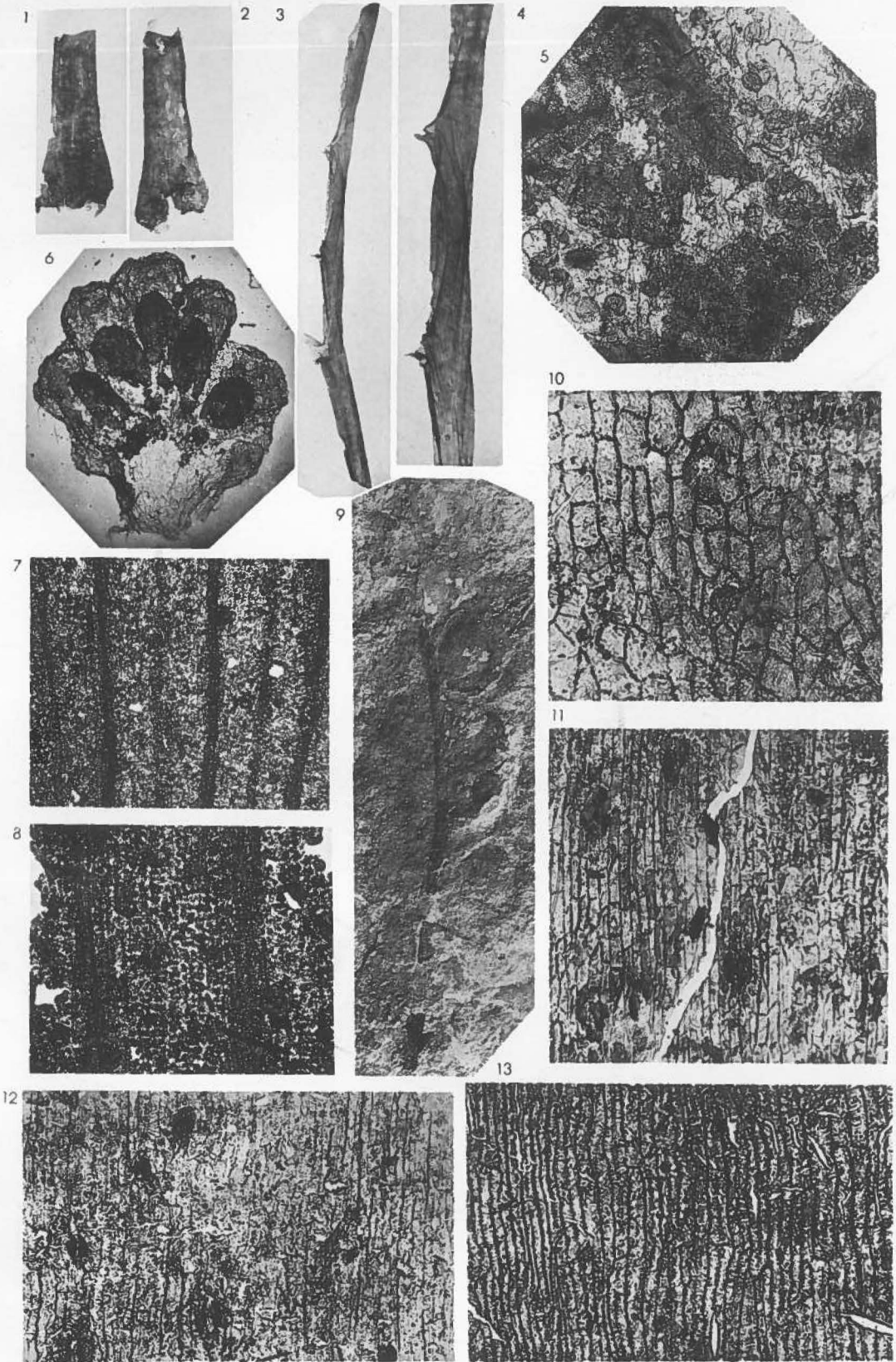




### Plate 8.

- Figs. 1, 2. *Czekanowskia nathorsti*, leaf bases, Slide 2766,  $\times 4$ .  
Fig. 3. *Staphidiophora secunda*, cuticle of axis, Slide 2866,  $\times 4$ .  
Fig. 4. *Staphidiophora secunda*, part of specimen shown in Fig. 3; note the twisting of the cuticle.  $\times 8$ .  
Fig. 5. *Microcheiris enigma*, the base of the embryo sac on the left of Fig. 6, showing numerous microspores,  $\times 50$ .  
Fig. 6. *Microcheiris enigma*. Note the small, dark mass of microspores below each embryo sac, Slide 2881,  $\times 8$ .  
Fig. 7. *Torellia ephela*, leaf by transmitted light. The interstitial ducts are unusually clear, but the mesophyll granules are scarcely seen, Slide 2843,  $\times 30$ .  
Fig. 8. *Torellia ephela*, typical leaf by transmitted light showing the mesophyll granules, Slide 2842,  $\times 30$ .  
Fig. 9. *Staphidiophora secunda*, Type-specimen photographed after most of the carbonaceous substance of the seeds has been picked off. No. 3011,  $\times 2$ .  
Fig. 10. *Staphidiophora secunda*, cuticle of integument of seed showing a stoma, Slide 2864,  $\times 100$ .  
Fig. 11. *Staphidiophora secunda*, cuticle of axis showing several stomata, Slide 2864,  $\times 100$ .  
Fig. 12. *Torellia ephela*, cuticle of underside of leaf; a vein is situated on the right; Slide 2847,  $\times 100$ .  
Fig. 13. *Torellia ephela*, cuticle of upper side of leaf showing ridges in cells, Slide 2848,  $\times 100$ .

All the figures are untouched photographs. The specimens shown in Figs. 1, 2, 7, 8, 12, 13 were obtained from Dinosaur R., *Marattiopsis* Bed, that in Figs. 3, 4, 9—11 from Vardekloft *Neocalamites* Bed; that in Figs. 5, 6 from Vardekloft *Czekanowskia* Bed.

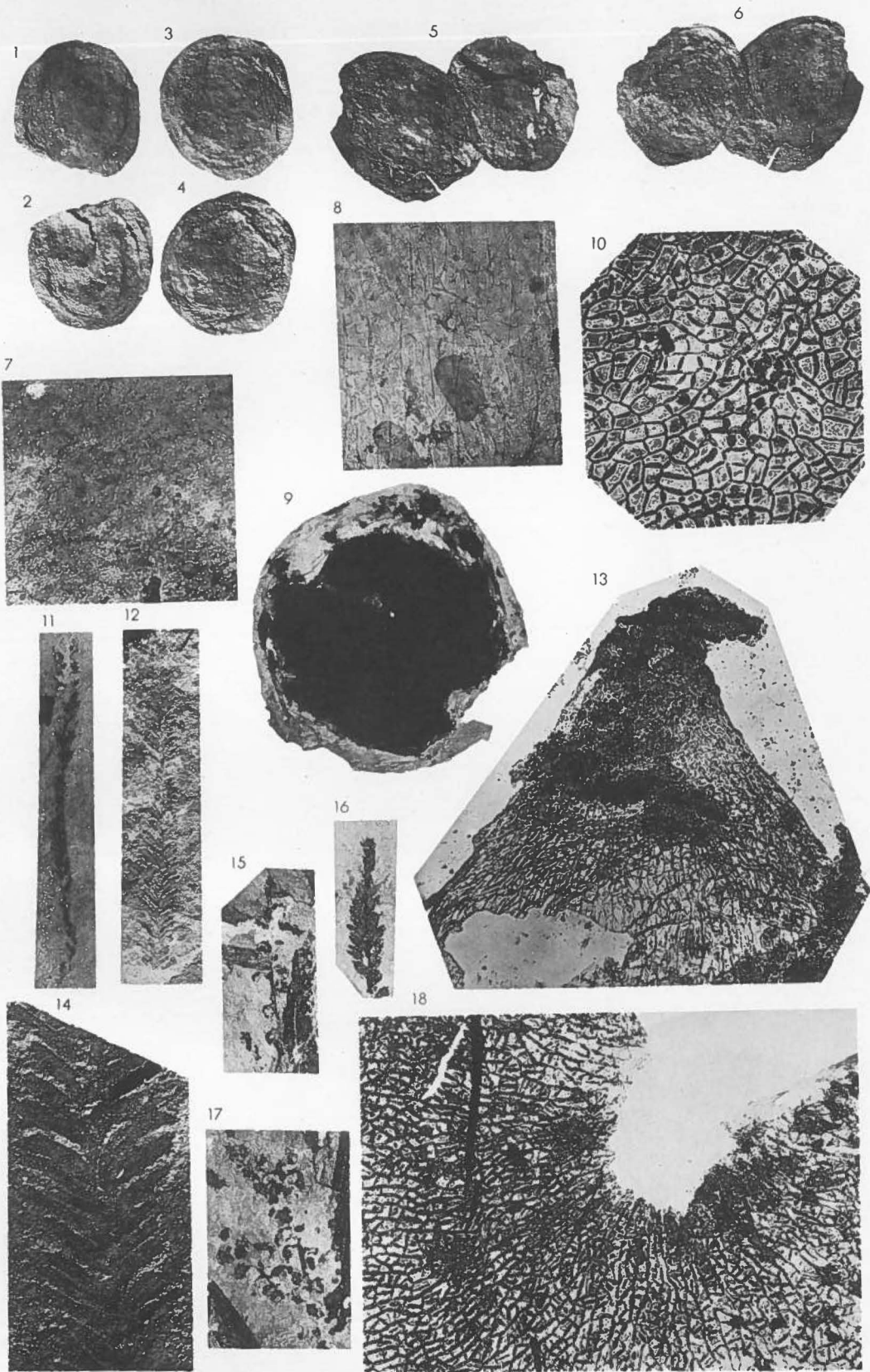


### Plate 9.

- Figs. 1, 2, 3, 4, 5, 6. *Allicospermum xystum* two pairs of seeds photographed from both sides. The pair of seeds shown in Figs. 5 and 6. may possibly be in organic connection with one another. No. 3040,  $\times 2$ .
- Fig. 7. *Allicospermum xystum*, megaspore membrane, Slide 2912,  $\times 100$ .
- Fig. 8. *Allicospermum xystum*, fused cuticles of inside of integument and outside of nucellus, Slide 2892,  $\times 100$ .
- Fig. 9. *Allicospermum xystum*, partly macerated seed by transmitted light showing the dark stone and some of the deeply situated resin bodies, Slide 2914,  $\times 4$ .
- Fig. 10. *Allicospermum xystum*, cuticle of outside of integument showing a stoma, Slide 2901,  $\times 100$ .
- Fig. 11. *Stachyotaxus septentrionalis*, shoot with small leaves, No. 3212,  $\times 1$ .
- Fig. 12. *Stachyotaxus septentrionalis*, shoot with larger leaves, No. 3212,  $\times 1$ .
- Fig. 13. *Allicospermum xystum*, cuticle of the micropylar canal (formed by inner cuticle of integument), Slide 2912,  $\times 40$ . (Type-specimen).
- Fig. 14. *Stachyotaxus septentrionalis*, shoot, No. 3205,  $\times 4$ .
- Fig. 15. *Stachyotaxus septentrionalis*, cone, No. 3213,  $\times 1$ .
- Fig. 16. *Stachyotaxus septentrionalis*, shoot, No. 3202,  $\times 1$ .
- Fig. 17. *Stachyotaxus septentrionalis*, group of cones, No. 3213,  $\times 1$ .
- Fig. 18. *Allicospermum xystum*, cuticle of integument showing the opening of micropyle, Slide 2913 (Type-specimen),  $\times 40$ .

All the figures are untouched photographs. The specimens shown in Figs. 1—7, 9, 13, 18 were obtained from Astarte R., *Thaumatopteris* Bed, that in Fig. 8 from Dinosaur R., that in Fig. 10 from C. Stewart; those in Figs. 11, 12, 15, 17 from Zamites R.; those in Figs. 14, 16 from Astarte R., *Lepidopteris* Bed.



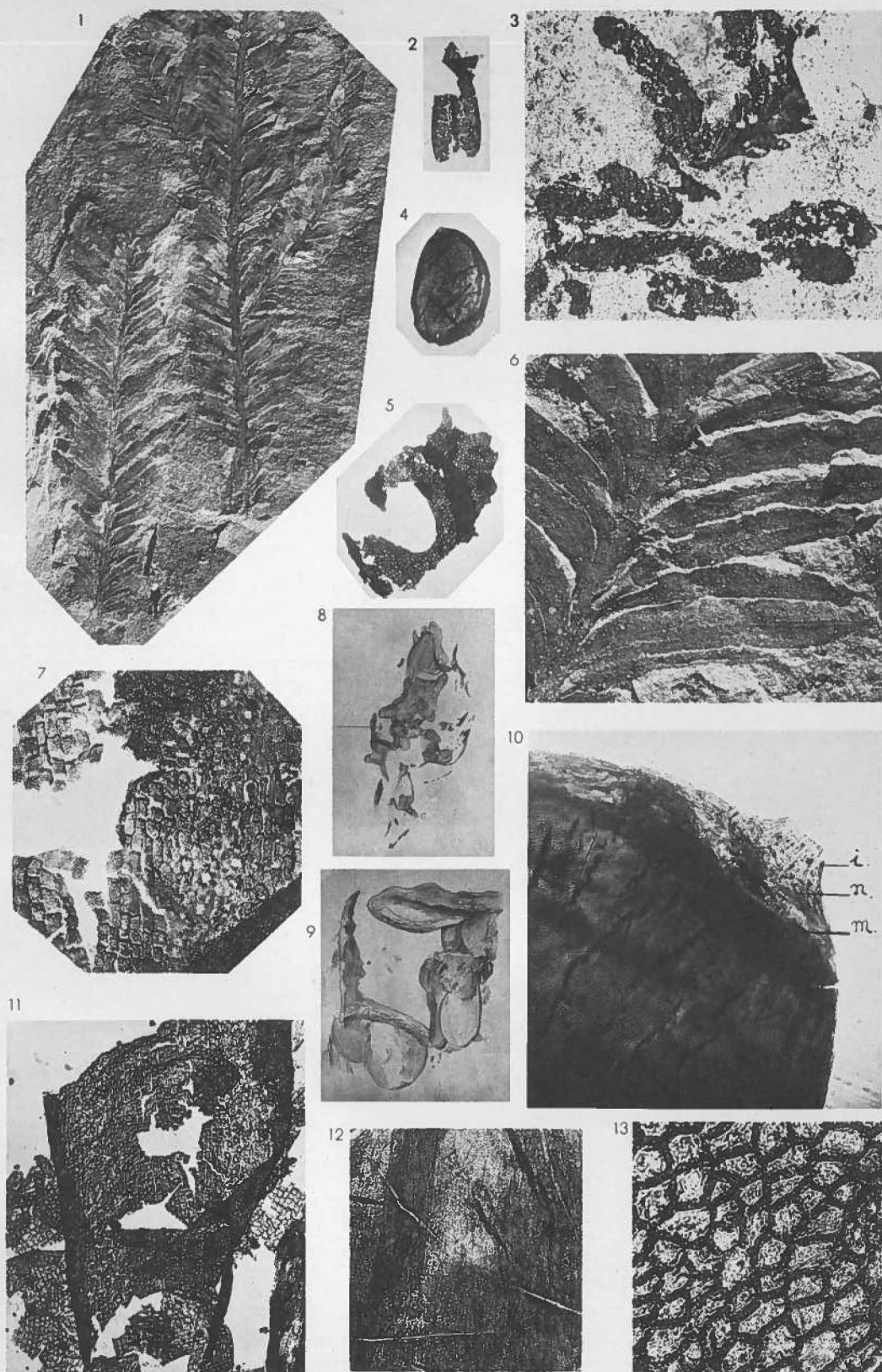


## Plate 10.

### *Stachyotaxus elegans* and *Stachyotaxus septentrionalis*.

- Fig. 1. *Stachyotaxus elegans*, typical shoots and an isolated seed, No. 3231,  $\times 1$ .  
Fig. 2. *Stachyotaxus elegans*, cuticle of small leaf, Slide 3002,  $\times 10$ .  
Fig. 3. *Stachyotaxus elegans*, male cones in transfer, Slide 3025,  $\times 2$ .  
Fig. 4. *Stachyotaxus septentrionalis*, nucellus, and megaspore of seed, Slide 2983,  $\times 10$ .  
Fig. 5. *Stachyotaxus septentrionalis*, integument of same seed, Slide 2983,  $\times 10$ .  
Fig. 6. *Stachyotaxus elegans*, typical foliage, Slide 3020,  $\times 4$ .  
Fig. 7. *Stachyotaxus elegans*, part of lower cuticle of leaf with a stomatal band, Slide 3004,  $\times 100$ .  
Fig. 8. *Stachyotaxus elegans*, drawing of part of a transfer of a male cone, the arrow marks the part shown in Fig. 9, Slide 3026,  $\times 5$ .  
Fig. 9. *Stachyotaxus elegans*, drawing of some of the sporophylls shown in Fig. 8.  $\times 20$ .  
Fig. 10. *Stachyotaxus septentrionalis*, upper part of specimen shown in Fig. 4, showing the cuticle of the inside of the integument lining the micropylar canal (i), the apex of the nucelus (n) and the dark megaspore membrane (m), Slide 2983,  $\times 100$ .  
Fig. 11. *Stachyotaxus elegans*, cuticle of leaf (shown also in Fig. 7), Slide 3004,  $\times 50$ .  
Fig. 12. *Stachyotaxus septentrionalis*, cuticles of inside of integument and of nucellus (cellular) enclosing the granular megaspore, Slide 2982,  $\times 100$ .  
Fig. 13. *Stachyotaxus septentrionalis*, outer cuticle of integument, Slide 2983,  $\times 100$ .

All the photographs are untouched. The specimens shown in Figs. 1, 2, 6, 7, 11 were obtained from Astarte R., Bed D, those in Figs. 3, 8, 9 from Vardekloft *Stachyotaxus* Bed, those in Figs. 4, 5, 10, 12, 13 from Astarte R., *Lepidopteris* Bed.



### Plate 11.

- Fig. 1. *Samaropsis scirrhodes*, seed, No. 3141,  $\times 2$ .
- Fig. 2. *Samaropsis scirrhodes*, inner cutinised membranes of seed, Slide 2975,  $\times 4$ .
- Fig. 3. *Samaropsis scirrhodes*, outer cutinised membrane of seed ('cupule'), Slide 2975,  $\times 4$ .
- Fig. 4. *Elatocladus patens*, No. 3341,  $\times 1$ .
- Fig. 5. *Ontheodendron sternbergi*, cone, No. 3375,  $\times 1$ .
- Fig. 6. *Allicospermum striatum* (seed referred to *Ginkgoites acosmia*), No. 3061,  $\times 2$ .
- Figs. 7. 8. *Allicospermum xystum* (seed referred to *Ginkgoites taeniata*); isolated stones of seeds. No. 3055,  $\times 2$ .
- Fig. 9. ?*Allicospermum* sp. A (seed associated with *Ginkgoites hermelini*) isolated stone of seed, No. 2553,  $\times 2$ .
- Fig. 10. *Elatocladus patens*, part of specimen shown in Fig. 4,  $\times 4$ .
- Fig. 11. *Elatocladus patens*, No. 3344,  $\times 1$ .
- Fig. 12. *Ontheodendron sternbergi*, Cone, No. 3374,  $\times 1$ .
- Fig. 13. *Ontheodendron sternbergi*, cone, afterwards made into transfer,  $\times 1$ .
- Fig. 14. *Ontheodendron sternbergi*, shoot, No. 3392,  $\times 4$ .
- Fig. 15. *Ontheodendron sternbergi*, cone, afterwards made into transfer,  $\times 1$ .
- Fig. 16. *Elatocladus patens*, No. 3343,  $\times 1$ .
- Fig. 17. *Storgaardia spectabilis*, part of a rather thick stem, No. 3306,  $\times 1$ .
- Fig. 18. *Ontheodendron sternbergi*, apex of a small shoot, No. 3391,  $\times 4$ .
- Fig. 19. *Elatocladus patens*, shoot shown in Fig. 16,  $\times 4$ .

All the figures are untouched photographs except Figs. 1 and 6, which are drawings on photographs. The specimen shown in Figs. 1—3 was obtained from Neill Cliff Liverwort Bed; those in Figs. 4, 10, 11, 13, 15, 16, 19 from Astarte R., Bed D; those in Figs. 5, 12 from Vardekloft *Dictyophyllum* Bed; that in Fig. 6 from Astarte R., Bed A; those in Figs. 7, 8 from Astarte R., *Thaumatopteris brauniana* Bed; that in Fig. 9 from Vardekloft Liverwort Bed; those in Figs. 14, 18 from Ryder R., *Clathropteris* Bed; that in Fig. 17 from Storgaard R.



## Plate 12.

### Conifer cuticles.

Figs. 1, 2. *Elatocladus nitidus*, Type-specimen, Slide 3131.

Figs. 3, 4. *Elatocladus tuberculatus*, Type-specimen, Slide 3151.

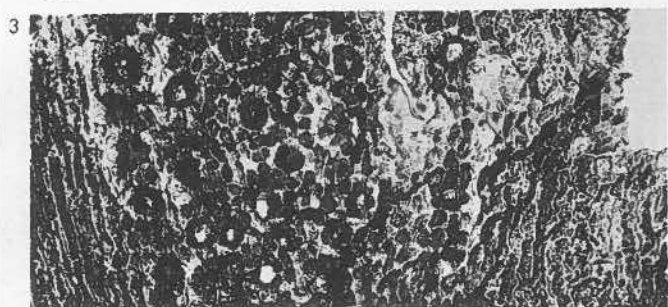
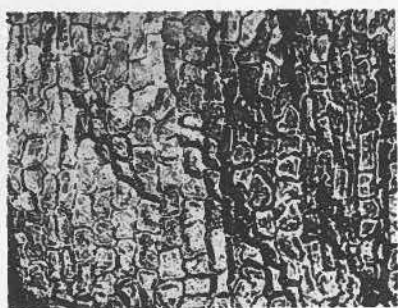
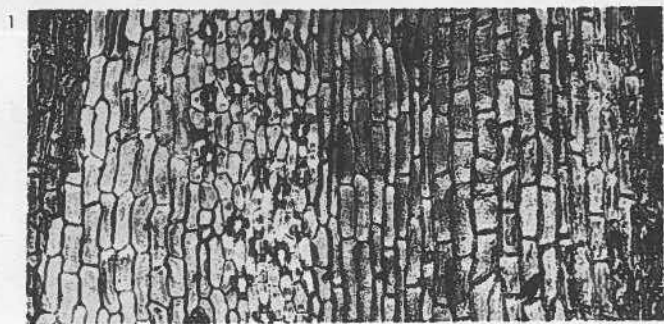
Figs. 5, 6. *Elatocladus punctatus*, Type-specimen, Slide 3121. Astarte R., Bed C.

Figs. 7, 8. *Storgaardia spectabilis*, Slide 3061.

Figs. 9, 10. *Elatocladus oligostomus*, Type-specimen Slide 3141.

The lower cuticle is to the left, the upper to the right. The specimen of *Storgaardia* was obtained from C. Stewart, that of *E. punctatus* from Astarte R. All the figures are untouched photographs at a magnification of 100.





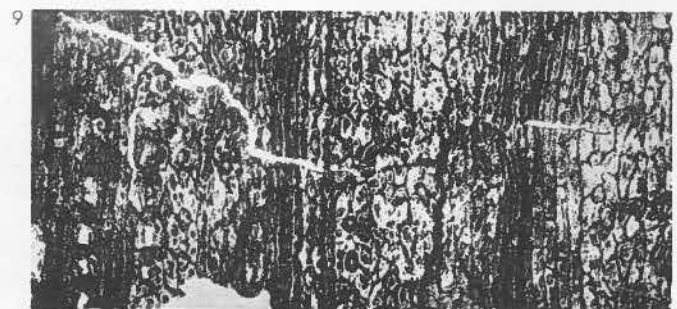
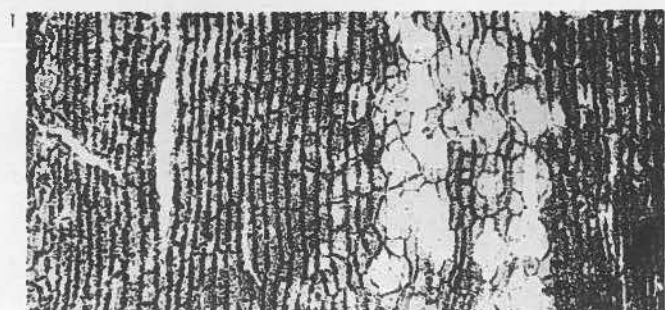
### Plate 13.

#### Conifer cuticles.

- Figs. 1, 2. *Elatocladus perforatus*, Type-specimen, Slide 3161.  
Figs. 3, 4. *Elatocladus stenostomus*, Type-specimen, Slide 3171.  
Figs. 5, 6. *Podozamites stewartensis*, Slide 3355.  
Figs. 7, 8. *Elatocladus stenocytus*, Type-specimen, Slide 3191.  
Figs. 9, 10. *Elatocladus polystomus*, Type-specimen, Slide 3201.

The specimen of *P. stewartensis* was obtained from Vardekløft *Anomozamites* Bed; that of *E. stenocytus* from C. Stewart *A. minor* Bed. All the figures are untouched photographs at a magnification of 100. The lower cuticle is to the left; the upper to the right.



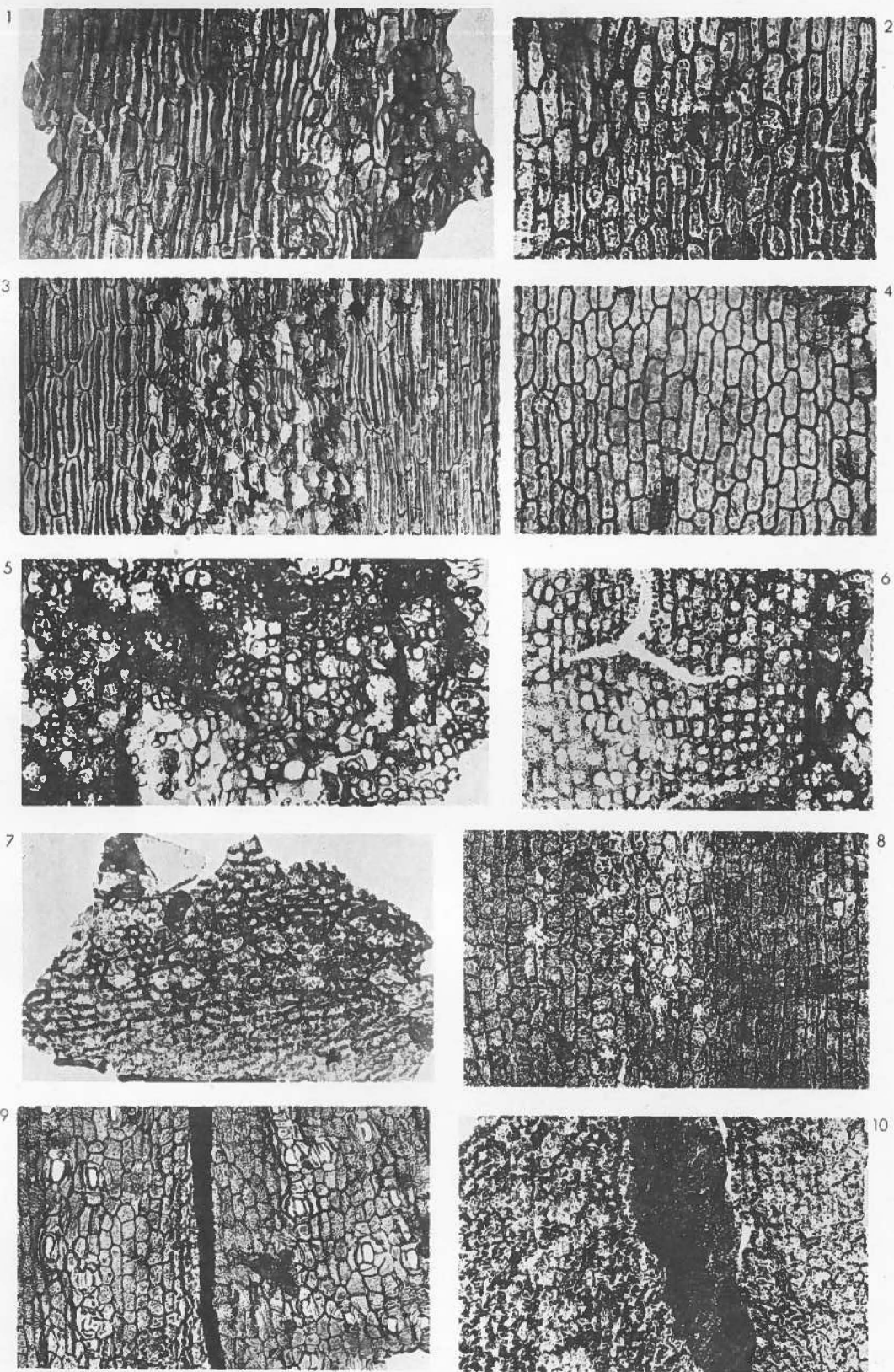


## Plate 14.

### Conifer cuticles.

- Figs. 1, 2. *Elatocladus molopicus*, Slide 3251 (Type-specimen). Lower cuticle in Fig. 1 (margin to the left); upper cuticle in Fig. 2.
- Figs. 3, 4. *Elatocladus lacunosus*, Slides 480, 481 (HARTZ collection), (Type-specimen). Lower cuticle in Fig. 3, upper in Fig. 4.
- Figs. 5, 6. *Elatocladus physetus*, Slide 3230, lower cuticle in Fig. 5, upper in Fig. 6.
- Fig. 7. *Elatocladus pachyteichus*, lower cuticle (orientated horizontally), Slide 3242.
- Fig. 8. *Elatocladus polystictus*, Slide 3210.
- Fig. 9. *Elatocladus polystictus*, Type-specimen, Slide 3213.
- Fig. 10. *Elatocladus pachyteichus*, lower cuticle to the left, upper to the right, Slide 3243.

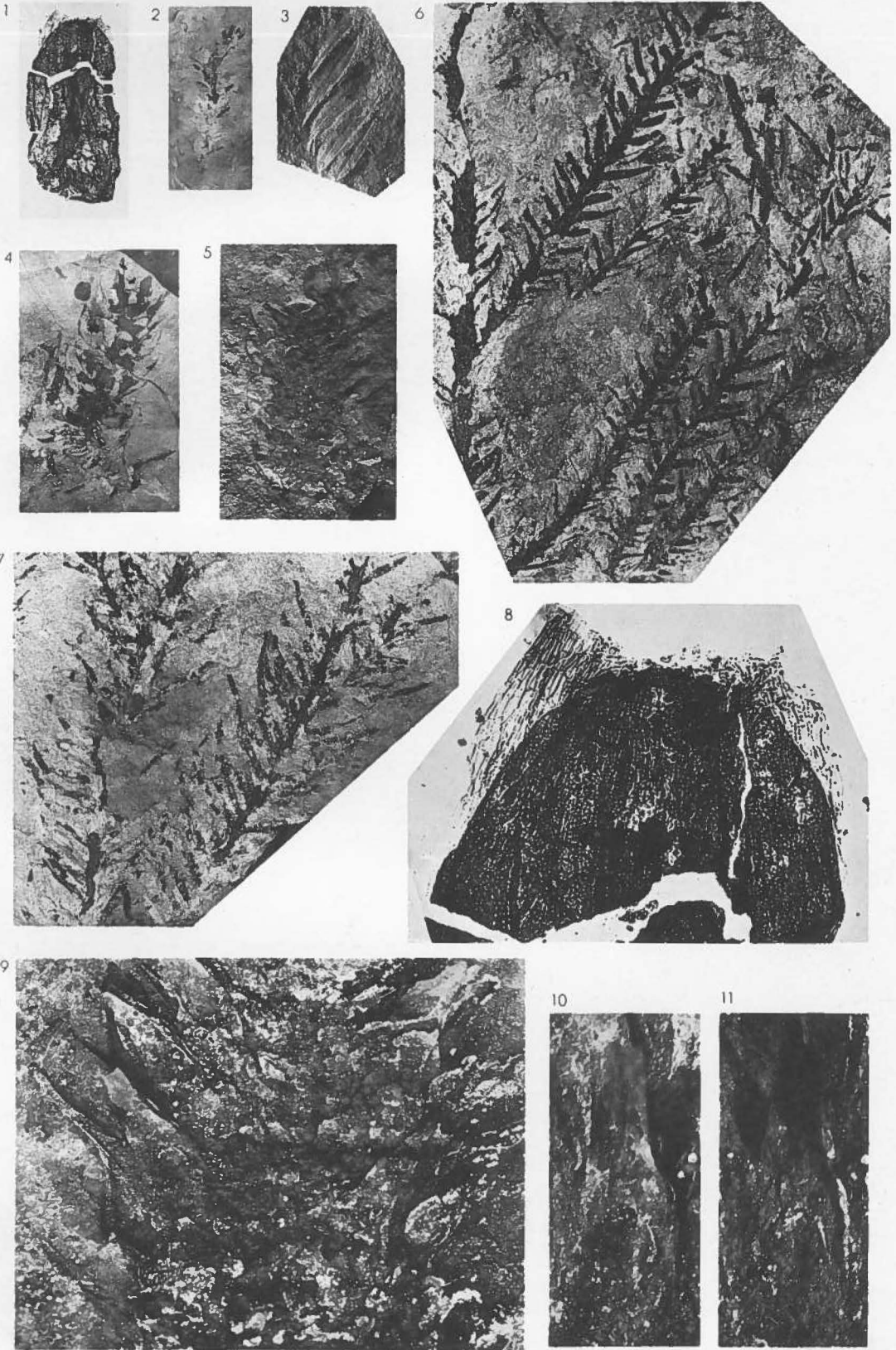
The specimen shown in Fig. 8 was obtained from Astarte R., that in Fig. 9 from C. Hope. All the figures are untouched photographs at a magnification of 100.



### Plate 15.

- Fig. 1. *Ontheodendron sternbergi* megaspore of seed (also shown in Fig. 8), Slide 3091,  $\times 20$ .  
Fig. 2. *Elatocladus pachyteichus*, Type-specimen, No. 3431,  $\times 1$ .  
Fig. 3. *Elatocladus patens*, Type-specimen, No. 3351,  $\times 2$ .  
Fig. 4. *Ontheodendron sternbergi*, shoot in organic connection with a cone, No. 3362,  $\times 1$ .  
Fig. 5. *Ontheodendron sternbergi*, cone (shown in transfer in Figs. 9—11, later macerated),  $\times 1$ .  
Fig. 6. *Ontheodendron sternbergi*, shoot, No. 3381,  $\times 1$ .  
Fig. 7. *Ontheodendron sternbergi*, shoot, No. 3371,  $\times 1$ .  
Fig. 8. *Ontheodendron sternbergi*, apex of seed invested in a delicate cellular membrane (? nucellus), Slide 3091,  $\times 100$ .  
Fig. 9. *Ontheodendron sternbergi*, transfer preparation of a cone,  $\times 4$ .  
Figs. 10, 11. *Ontheodendron sternbergi*, two views of a cone scale bearing a single seed; also shown on the left of Fig. 9,  $\times 8$ .

All the figures are untouched photographs. The specimens shown in Figs. 1, 7, 8 were obtained from Vardekloft *Dictyophyllum* Bed, that in Fig. 2 from Astarte R., *Gutbiera* Bed; that in Fig. 3 from Dinosaur R., *Marattiopsis* Bed; those in Figs. 4, 5, 9—11 from Astarte R., Bed D; that in Fig. 6 from Lepidopteris R., *Lepidopteris* Bed.

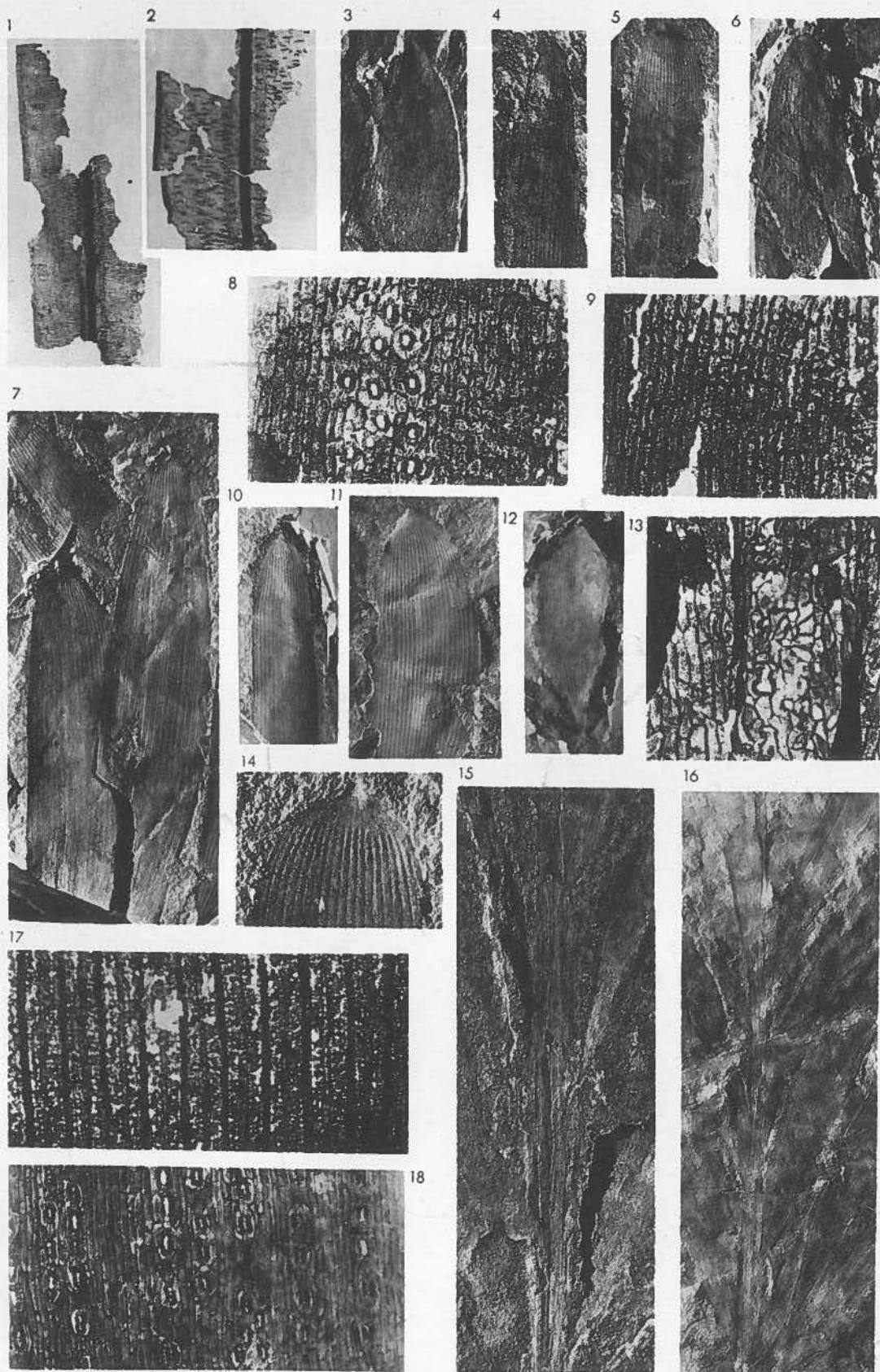




## Plate 16.

- Figs. 1, 2. *Storgaardia spectabilis*, leaves by transmitted light, showing the stomatal bands (near the midrib) and the "mesophyll", Slide 3063,  $\times 4$ .
- Fig. 3. *Podozamites distans*, apex of abnormal leaf appearing mucronate owing to inrolling of margins, No. 3628,  $\times 2$ .
- Fig. 4. *Podozamites mucronatus*, apex of abnormal leaf without a mucro (or *P. distans*?), No. 3710,  $\times 2$ .
- Fig. 5. *Podozamites mucronatus*, apex of typical leaf (also shown in Fig. 14), No. 3709,  $\times 2$ .
- Fig. 6. *Podozamites distans*, apex of typical leaf, No. 3622,  $\times 2$ .
- Fig. 7. *Podozamites mucronatus*, abnormal leaves with scarcely mucronate tips, No. 3707,  $\times 2$ .
- Figs. 8, 9. *Elatocladus amblus*, lower and upper cuticles of Type-specimen, Slide 3261,  $\times 100$ .
- Figs. 10, 11, 12. *Podozamites mucronatus*, leaves, Nos. 3706, 3705, 3707,  $\times 2$ .
- Fig. 13. *Elatocladus eurystomus*, Type-specimen, Slide 3221,  $\times 100$ .
- Fig. 14. *Podozamites mucronatus*, apex of typical leaf (counterpart of specimen shown in Fig. 5), No. 3709,  $\times 4$ .
- Fig. 15. *Podozamites stewartensis*, axis of large specimen showing decurrent leaf bases. The specimen is a fragment 22 cm long. No. 3523,  $\times 2$ .
- Fig. 16. *Podozamites stewartensis*, axis of small specimen showing decurrent bases of leaves. One leaf is springing from the upper surface of the axis. No. 3524,  $\times 2$ .
- Fig. 17. *Podozamites astartensis*, substance of the leaf by transmitted light showing the interstitial ducts, Slide 3371,  $\times 10$ .
- Fig. 18. *Elatocladus* sp. B, cuticle, Slide 3271,  $\times 100$ .

The specimens shown in Figs. 1, 2 were obtained from C. Stewart *Todites* Bed; those in Figs. 3, 6 from Vardekloft *Stachyotaxus* Bed; those in Figs. 4, 5, 7, 10—12, 14 from Astarte R., Bed D; those in Figs. 8, 9 from C. Hope, Coal Bed; that in Fig. 13 from Astarte R., Bed C; those in Figs. 15, 16 from Vardekloft *Dictyophyllum* Bed.



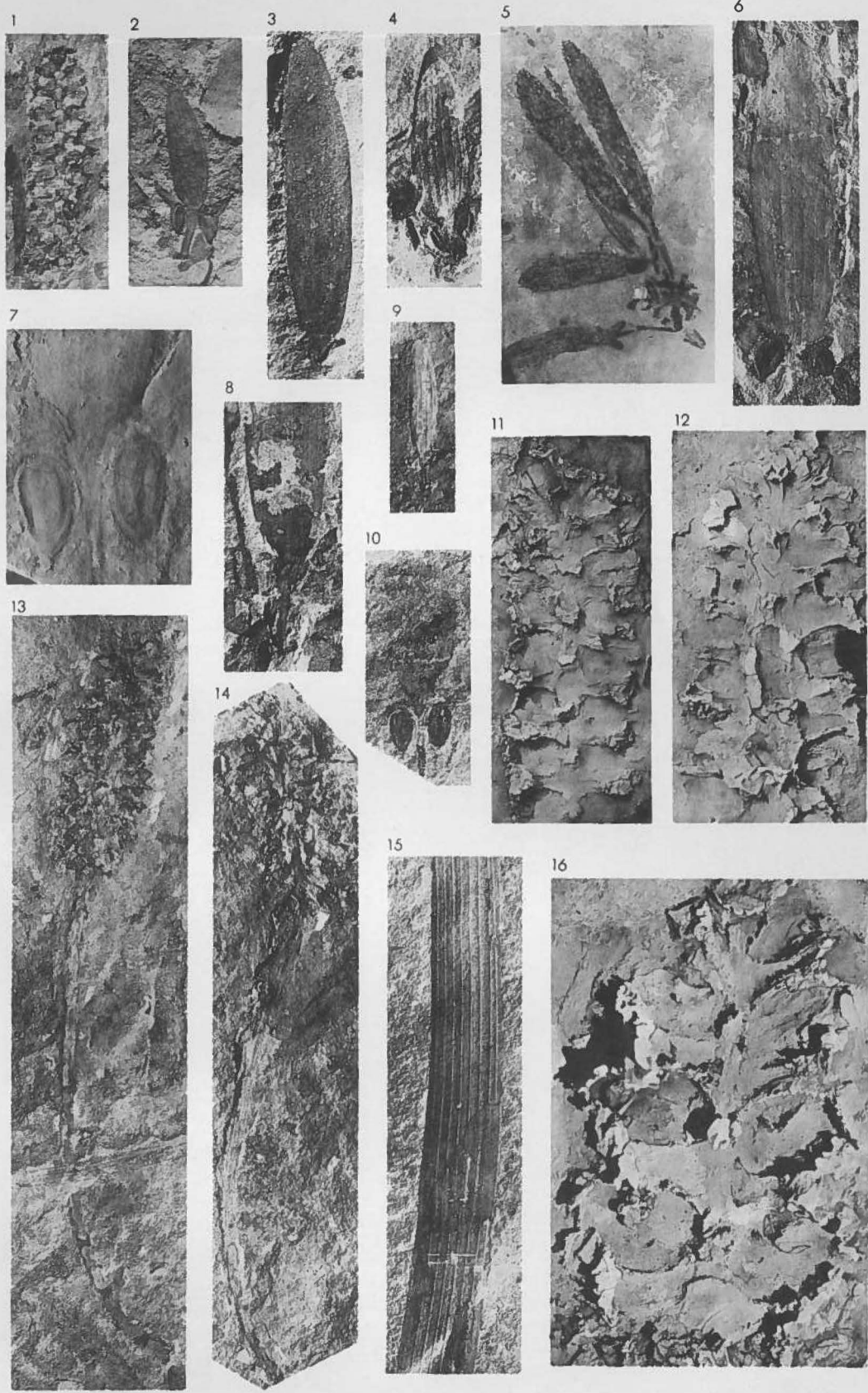
## Plate 17.

### *Cycadocarpidium*.

- Fig. 1. Cone axis B, No. 4202,  $\times 1$ .  
Fig. 2. *Cycadocarpidium erdmanni*, drawing of sporophyll, No. 4321,  $\times 2$ .  
Fig. 3. *Cycadocarpidium swabi*, specimen showing ovuliferous outgrowth without a seed, No. 4206,  $\times 2$ .  
Fig. 4. *Cycadocarpidium erdmanni*, No. 4302,  $\times 2$ .  
Fig. 5. *Cycadocarpidium swabi*, four or five specimens still attached to the remains of the cone axis (drawing on a photograph), No. 4262,  $\times 1$ .  
Fig. 6. *Cycadocarpidium swabi*, specimen showing ovuliferous outgrowths with seeds, No. 4201,  $\times 2$ .  
Fig. 7. *Cycadocarpidium erdmanni*, part of specimen shown in Fig. 10, coated with  $\text{NH}_4\text{Cl}$ ,  $\times 4$ .  
Fig. 8. *Cycadocarpidium swabi*, lower part of specimen from which seeds have disappeared, No. 4205,  $\times 2$ .  
Fig. 9. *Cycadocarpidium erdmanni*, No. 3706,  $\times 2$ .  
Fig. 10. *Cycadocarpidium erdmanni*, No. 4334,  $\times 2$ .  
Fig. 11. Cone axis B; transfer coated with  $\text{NH}_4\text{Cl}$ , Slide 3431,  $\times 2$ .  
Fig. 12. Cone axis A; transfer coated with  $\text{NH}_4\text{Cl}$ , Slide 3421,  $\times 2$ .  
Fig. 13. Cone axis A, No. 4271,  $\times 1$ .  
Fig. 14. Cone axis A, No. 4261,  $\times 1$ .  
Fig. 15. *Desmiophyllum* sp. No. 4101,  $\times 1$ .  
Fig. 16. Cone axis B, transfer coated with  $\text{NH}_4\text{Cl}$ , Slide 3432,  $\times 4$ .

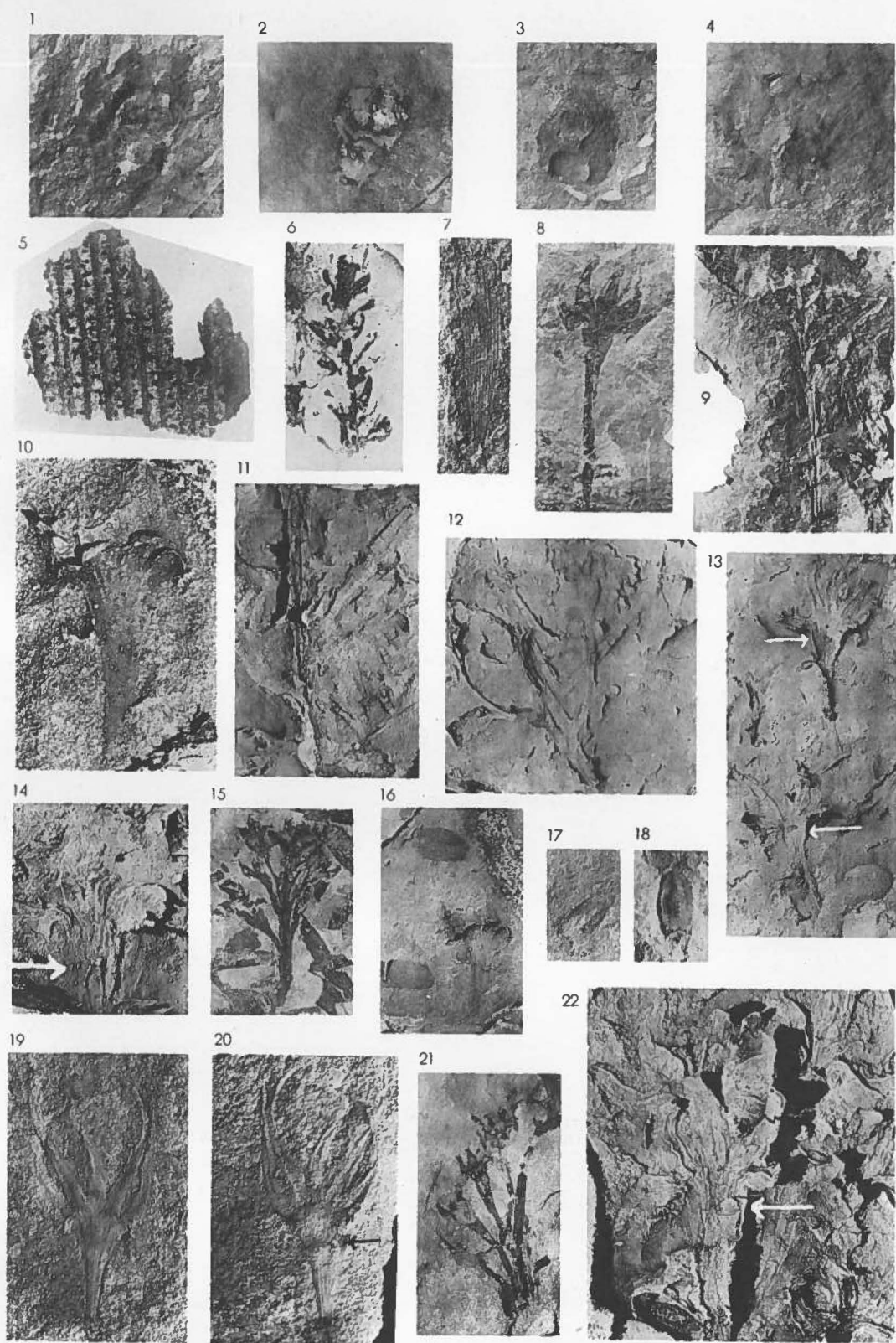
All the figures except No. 2, 5 are untouched photographs. The specimens shown in Figs. 1, 3, 4, 6, 8, 11, 16 were obtained from Astarte R., Bed A; that in Fig. 2 from Astarte R., *Lepidopteris* Bed; that in Fig. 9 from Astarte R., Bed D; those in Figs. 5, 12—14 from Vardekloft *Stachyotaxus* Bed; that in Figs. 7, 10 from Vardekloft *Neocalamites* Bed; that in Fig. 15 from Astarte R., *B. spectabilis* Bed.





## Plate 18.

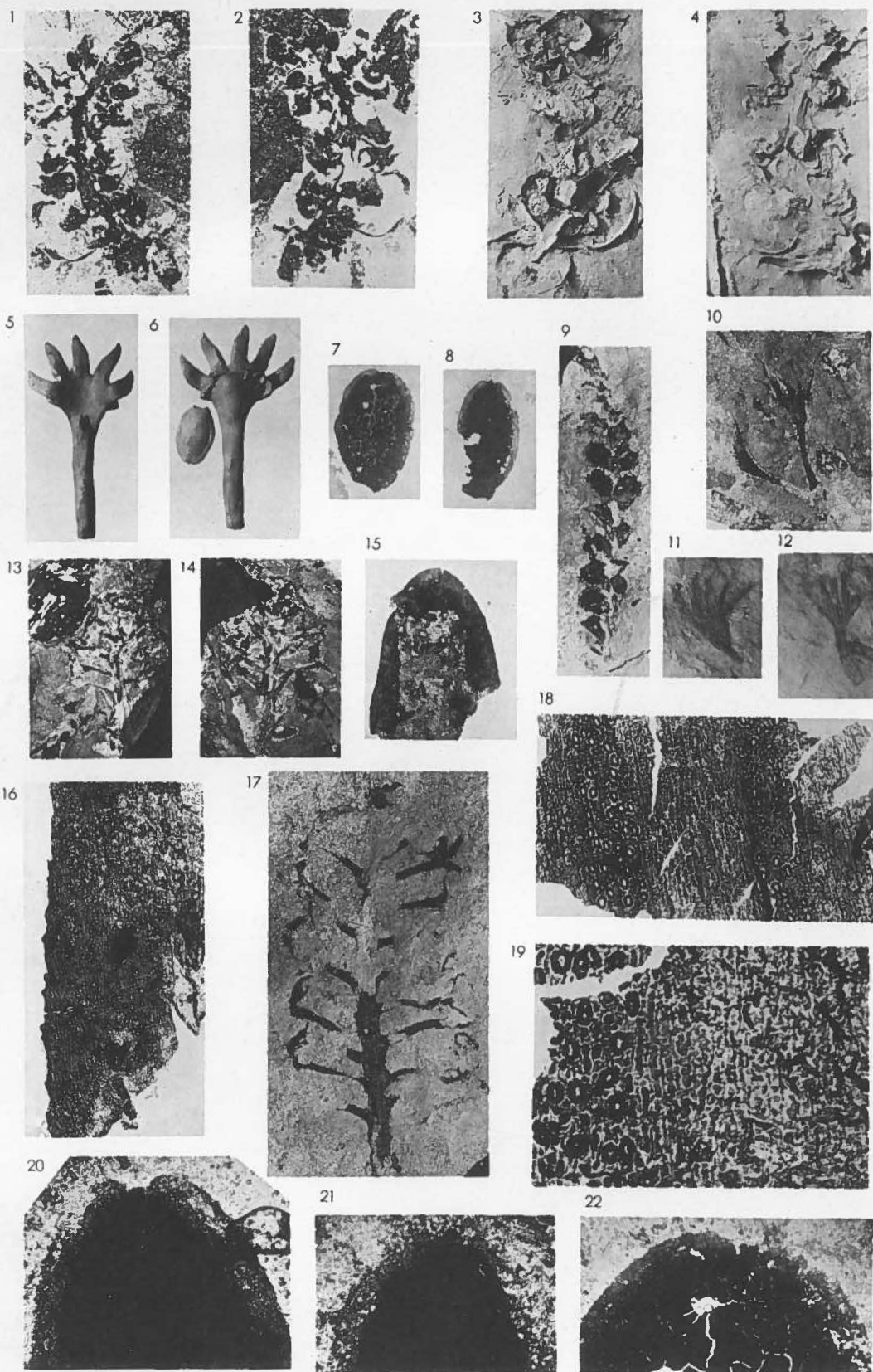
- Fig. 1. *Samaropsis nathorstiana*, Type-specimen, No. 3151,  $\times 1$ .
- Fig. 2. *Samaropsis nathorstiana*, same specimen as in Fig. 1, immersed in xylol.
- Fig. 3. *Samaropsis nathorstiana*, No. 3153,  $\times 1$ .
- Fig. 4. *Samaropsis nathorstiana*, No. 3152,  $\times 1$ .
- Fig. 5. *Podozamites punctatus*, fragment of leaf by transmitted light, Slide 3362,  $\times 8$ .
- Fig. 6. *Elatocladus pachyteichus*, leafy twig, No. 3432,  $\times 2$ .
- Fig. 7. *Podozamites* sp. Type 2, lower part of leaf, No. 3801,  $\times 2$ .
- Fig. 8. *Swedenborgia cryptomerioides*, unusually large sporophyll, showing the injury to the down-curved margins of the outer lobes causal by the rock cleavage, No. 4382,  $\times 2$ .
- Fig. 9. *Elatocladus oligostomus*, leafy twig, No. 3412,  $\times 2$ .
- Fig. 10. *Swedenborgia cryptomerioides*, upper surface of sporophyll, showing the upward projections. Transfer preparation, illuminated from bottom right-hand corner. Slide 3452,  $\times 4$ .
- Fig. 11. *Swedenborgia cryptomerioides*, cone axis, in transfer, No. 3453,  $\times 2$ .
- Fig. 12. *Swedenborgia cryptomerioides*, cone axis in transfer, No. 3451,  $\times 2$ .
- Fig. 13. *Swedenborgia cryptomerioides*, two cone scales seen from lower side, showing the recurved margins of the outer lobes. The bract-scales are pressed against the sporophyll and thus are inconspicuous; their tips are opposite the arrows. Slide 3456 (transfer preparation),  $\times 2$ .
- Fig. 14. *Swedenborgia cryptomerioides*, lower side of a cone scale, showing the bract-scale (indicated by the arrow). Transfer preparation, Slide 3454,  $\times 2$ .
- Fig. 15. *Swedenborgia cryptomerioides*, typical cone, No. 4390,  $\times 1$ .
- Fig. 16. *Swedenborgia cryptomerioides*, cone scale and seed, shown in Fig. 10 under different illumination, Slide 3452,  $\times 2$ .
- Fig. 17. *Swedenborgia cryptomerioides*, seed, No. 4389,  $\times 2$ .
- Fig. 18. *Swedenborgia cryptomerioides*, seed, No. 4389,  $\times 2$ .
- Fig. 19. *Swedenborgia major*, Type-specimen. Upper surface seen as hollow cast in sandstone showing the points of attachment of the seeds, No. 4350,  $\times 2$ .
- Fig. 20. *Swedenborgia major*, same specimen as Fig. 19, lower surface seen as hollow cast showing the bract-scale (indicated by the arrow). No. 4351,  $\times 2$ .
- Fig. 21. *Swedenborgia cryptomerioides*, cone, No. 4387,  $\times 1$ .
- Fig. 22. *Swedenborgia cryptomerioides*, transfer of a cone; one of the sporophylls shows the bract-scale (indicated by the arrow). Transfer preparation. Slide No. 3455,  $\times 4$ .



### Plate 19.

- Figs. 1, 2. *Callipitys leptoderma*, part and counterpart of Type-specimen,  $\times 2$ .  
Figs. 3, 4. *Callipitys leptoderma*, specimens shown in Figs. 1, 2 in transfer. Slide 3480,  $\times 2$ .  
Figs. 5, 6. *Swedenborgia cryptomerioides*, restoration of cone-scale and seed, from below in Fig. 5, from above in Fig. 6,  $\times$  about 2.5  
Figs. 7, 8. *Swedenborgia cryptomerioides*, seeds by transmitted light, also shown in Figs. 21, 22. Slides 3459, 3460,  $\times 4$ .  
Fig. 9. *Staphidiophora exile*, Type-specimen immersed in xylol, Slide 2870,  $\times 2$ .  
Fig. 10. *Swedenborgia major*, No. 4361,  $\times 1$ .  
Fig. 11. *Swedenborgia major*, No. 4366,  $\times 1$ .  
Fig. 12. *Swedenborgia major*, No. 4365,  $\times 1$ .  
Figs. 13, 14. *Swedenborgia minor*, cone, No. 4412, 4413,  $\times 1$ .  
Fig. 15. *Elatocladus amblus*, apex of leaf, Slide 3264,  $\times 15$ .  
Fig. 16. *Elatocladus amblus*, margin of leaf, Slide 3266,  $\times 25$ .  
Fig. 17. *Swedenborgia minor*, Type-specimen (immersed in xylol), No. 4410,  $\times 2$ .  
Fig. 18. *Elatocladus amblus*, lower cuticle of a leaf with two stomatal groves, Slide 3263,  $\times 50$ .  
Fig. 19. *Elatocladus amblus*, lower cuticle of a leaf in which the cell papillae are unusually well marked, Slide 3269,  $\times 100$ .  
Figs. 20—22. *Swedenborgia cryptomerioides*, apices of seeds by transmitted light, showing the transparent marginal wing and the slightly projecting micro-pyle, Slides 3459, 3460,  $\times 15$ .

All the figures are untouched photographs except Figs. 7, 8, 11, 12, which are drawings on photographs; Figs. 5 and 6 represent a plasticine model. The specimens shown in Figs. 1—4, 7, 8, 20—22 were obtained from Neill Cliffs, Liverwort Bed; that in Fig. 9 from C. Stewart *A. minor* Bed; those in Figs. 10—12 from Storgaard R.; those in Figs. 13, 14, 17 from C. Stewart *A. hartzi* Bed; those in Figs. 16, 18, 19 from Dinosaur R., Coal Bed.





### Plate 20.

- Figs. 1—4. *Araucarites charcoti*, Type-specimen No. 4450,  $\times 1$ . Figs. 1 and 3 show the surface coated with ammonium chloride; Figs. 3 and 4 show the cone with the upper layer of rock removed.
- Fig. 5. *Araucarites charcoti*, isolated cone-scale, No. 4450,  $\times 2$ .
- Figs. 6, 7. *Elatocladus* sp. A, upper and lower cuticles, Slide 3281,  $\times 100$ .
- Fig. 8. *Podozamites* sp. indet. Type 3, No. 4582,  $\times 1$ .
- Fig. 9. *Araucarites charcoti*, isolated cone-scale, No. 4470,  $\times 2$ .
- Fig. 10. *Araucarites charcoti*, isolated cone-scale, No. 4451,  $\times 2$ .
- Fig. 11. *Araucarites charcoti*, transfer of a small cone scale, showing the broad ridge in the basal region, Slide 3511,  $\times 2$ .
- Fig. 12. *Araucarites charcoti*, transfer of a small cone scale viewed by transmitted light, showing longitudinally running dark strands in the upper portion, Slide 3503,  $\times 4$ .
- Fig. 13. *Araucarites charcoti*, isolated cone-scale, No. 4471,  $\times 2$ .

The specimens shown in Fig. 9, 13 were obtained from Astarte R., *Lepidopteris* Bed; all the rest were obtained from Astarte R., Bed A. All the figures are untouched photographs.

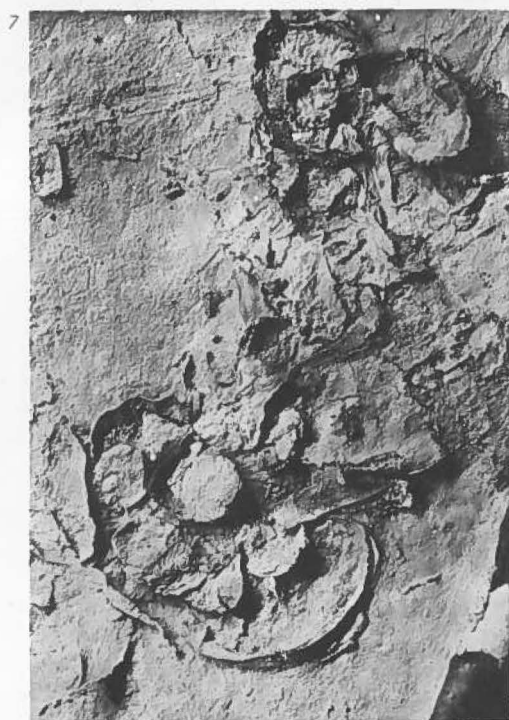
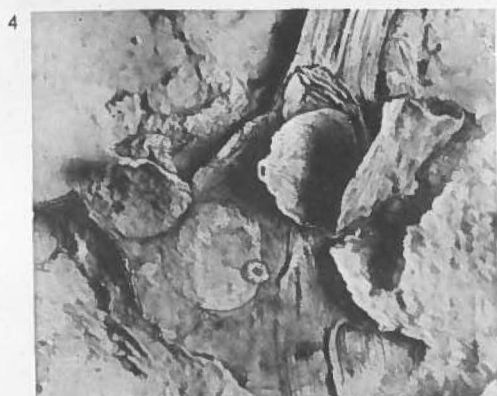


### Plate 21.

- Fig. 1. *Stachyotaxus elegans*, shoot with rather short, broad leaves, No. 3234,  $\times 1$ .  
Fig. 2. *Stachyotaxus elegans*, shoot with small leaves, rather like *S. septentrionalis*, No. 3241,  $\times 1$ .  
Fig. 3. *Stachyotaxus elegans*, shoot with unusually large leaves, No. 4270,  $\times 1$ .  
Figs. 4, 5. *Callipitys leptoderma*, two drawings (under different directions of illumination of two sporophylls, shown (opposite the arrow) at a lower magnification in Fig. 6), Slide 3840,  $\times 8$ .  
Figs. 6, 7. *Callipitys leptoderma*, transfer of part and counterpart of the Type-specimen, Slide 3840,  $\times 4$ .

All the figures except Figs. 4 and 5, which are drawings on photographs, are untouched photographs. The specimens shown in Figs. 1—3 were obtained from Vardekloft *Stachyotaxus* Bed.



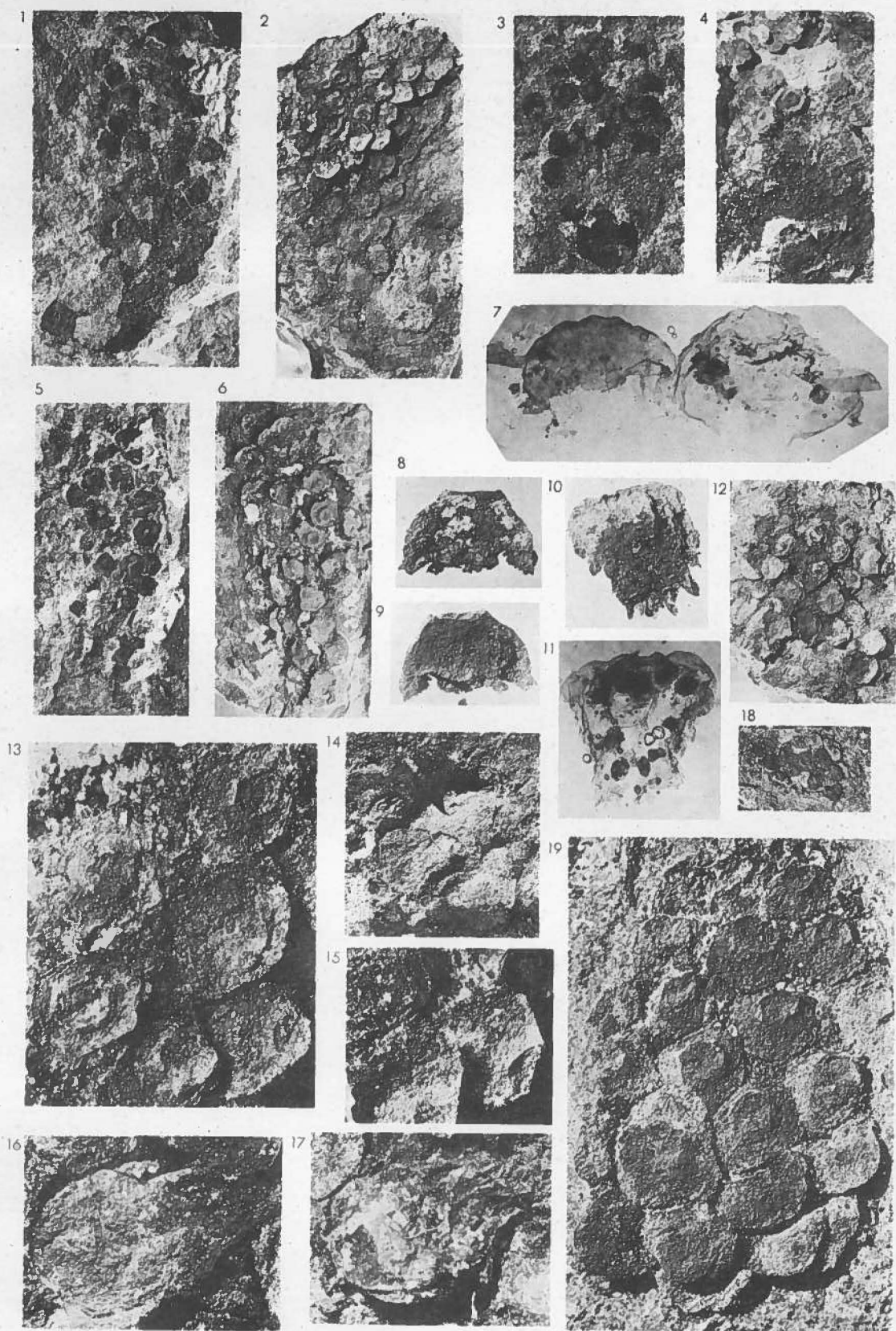


## Plate 22.

### *Bernettia phialophora.*

- Fig. 1. Type-specimen.  $\times 1$  (see also Figs. 13, 15).  
Fig. 2. Transfer of Type-specimen, Slide 3611,  $\times 1$ .  
Fig. 3. Specimen with bracts at base,  $\times 1$ .  
Fig. 4. Transfer of specimen shown in Fig. 3 (also shown in Fig. 14), Slide 3612,  $\times 1$ .  
Fig. 5. Another specimen.  $\times 1$ .  
Fig. 6. Transfer of specimen shown in Fig. 5, Slide 3613,  $\times 1$ .  
Fig. 7. Cuticle of head of scale. Slide 3603,  $\times 5$ .  
Figs. 8, 9. Front and back view of head of scale compressed laterally,  $\times 4$ .  
Fig. 10. Another laterally compressed scale,  $\times 4$ .  
Fig. 11. Macerated scale containing resin, Slide 3605,  $\times 5$ .  
Fig. 12. Transfer of another specimen (shown in Figs. 16, 17), Slide 3610,  $\times 1$ .  
Fig. 13. Part of Type specimen,  $\times 5$ .  
Fig. 14. Bracts at base of specimen shown in Fig. 4 (illuminated from bottom right-hand corner),  $\times 5$ .  
Fig. 15. Part of Type-specimen,  $\times 5$ .  
Figs. 16, 17. Two laterally compressed scales from specimen shown in Fig. 12. The ridges on the stalk may represent sporangia,  $\times 5$ .  
Fig. 18. Transfer preparation of an unusually small specimen,  $\times 1$ .  
Fig. 19. Same specimen as in Fig. 18,  $\times 4$ .

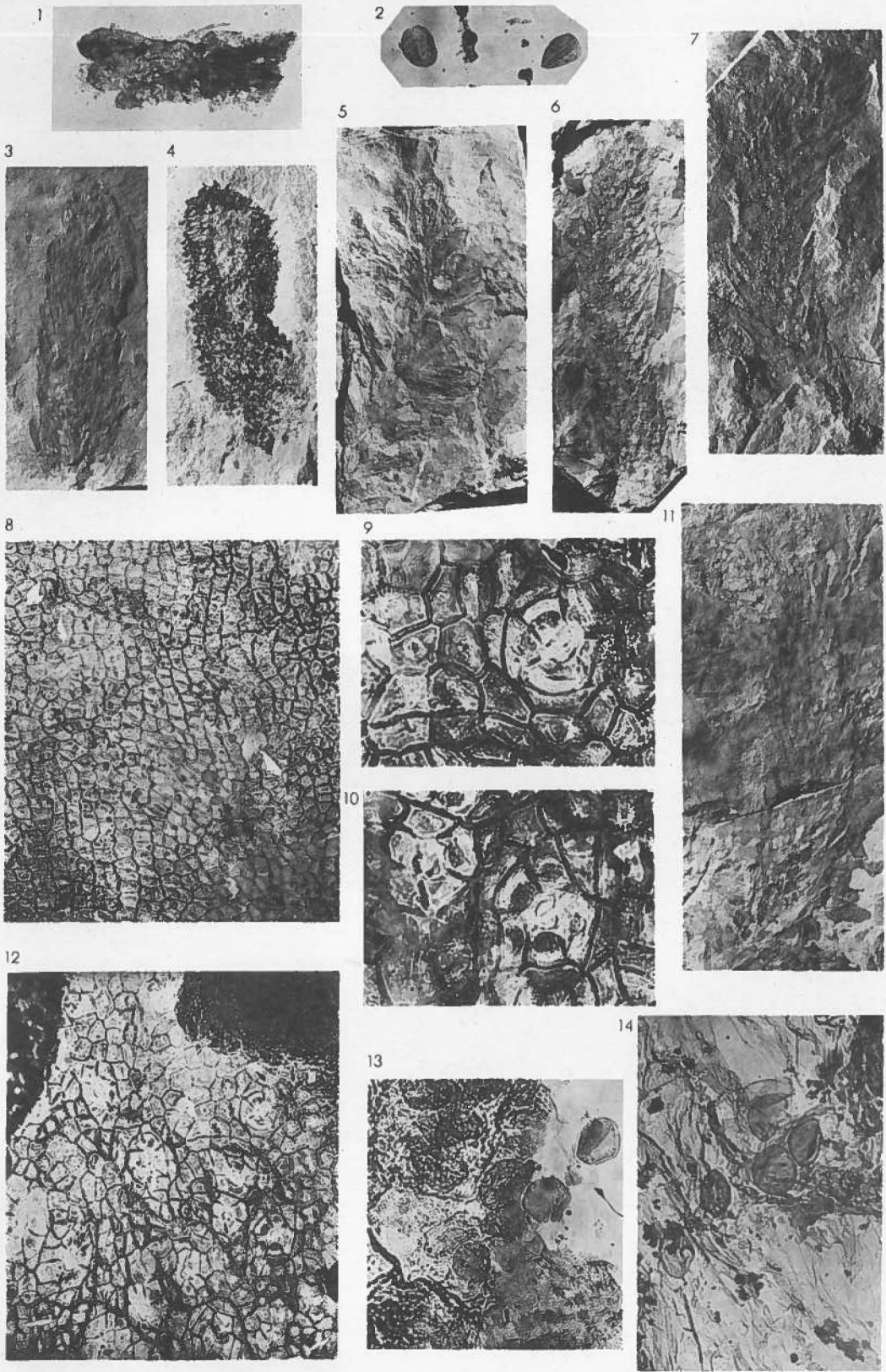
All the specimens were obtained from Vardekloft. All the figures are untouched photographs.



### Plate 23.

- Fig. 1. *Bernettia phialophora*, cuticles of sporangia, Slide 3608,  $\times 15$ .  
Fig. 2. *Bernettia phialophora*, isolated spores, Slide 3607,  $\times 200$ .  
Fig. 3. *Ourostrobos nathorsti*, cone, No. 4511,  $\times 1$ .  
Fig. 4. *Grammaephloios ichtia*, Type-specimen, No. 4801,  $\times 1$ .  
Fig. 5. *Tmematostrobos eremus*, Type-specimen, No. 4420,  $\times 1$ .  
Fig. 6. *Ourostrobos nathorsti*, cone, No. 4501,  $\times 1$ .  
Fig. 7. *Ourostrobos nathorsti*, cone, No. 4521,  $\times 1$ .  
Fig. 8. *Bernettia phialophora*, cuticle of bract (thicker side), a stoma is seen near the bottom right corner, Slide 3601,  $\times 80$ .  
Figs. 9, 10. *Bernettia phialophora*, stomata from head of sporophyll, Slide 3602  $\times 200$ .  
Fig. 11. *Ourostrobos nathorsti*, cone, No. 4491,  $\times 1$ .  
Fig. 12. *Bernettia phialophora*, cuticle of head of sporophyll, Slide 3602,  $\times 80$ .  
Fig. 13. *Bernettia phialophora*, cuticle of microsporangia with adherent microspores, Slide 3603,  $\times 200$ .  
Fig. 14. *Bernettia phialophora*, cuticle of lower part of microsporophyll with adherent microspores, Slide 3604,  $\times 200$ .

The specimens shown in Figs. 1, 2, 8—10, 12—14 were obtained from Vardekloft *Czekanowskia* Bed; that in Fig. 3 from Dinosaur R., *Marattiopsis* Bed, that in Fig. 4 from Neill Cl., Liverwort Bed; that in Fig. 5 from Tancredia R., *Lepidopteris* Bed; that in Fig. 6 from Vardekloft, *P. agardhianus* Bed; that in Fig. 7 from C. Stewart, *Todites* Bed; that shown in Fig. 11 from Storgaard R. All the figures are untouched photographs.

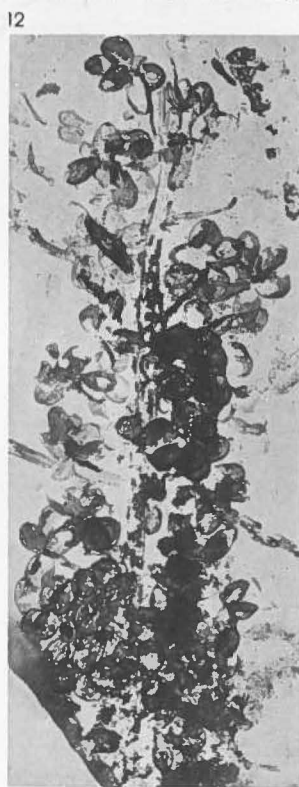
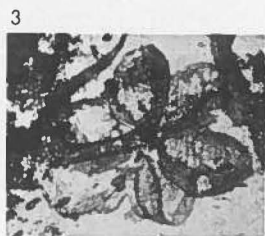




### Plate 24.

- Fig. 1. *Stenomischus athrous*, distal region of two microsporophylls, and group of sporangia, Slide 3622,  $\times 10$ .
- Fig. 2. *Stenomischus athrous*, distal region of microsporophyll bearing sporangia, Slide 3622,  $\times 10$ .
- Fig. 3. *Sorosaccus gracilis*, group of sporangia, Slide 3633,  $\times 10$ .
- Fig. 4. *Sorosaccus gracilis*, group of sporangia, Slide 3634,  $\times 10$ .
- Fig. 5. *Sorosaccus gracilis*, Type-specimen, Slide 3635,  $\times 4$ .
- Fig. 6. *Sorosaccus gracilis*, part of Type-specimen, showing the axis of a microsporophyll projecting beyond the sporangia, Slide 3635,  $\times 10$ .
- Fig. 7. *Sorosaccus gracilis*, Slide 3633,  $\times 1.5$ .
- Fig. 8. *Leptostrobis longus*, spores from C. Stewart specimen, Slide 2824,  $\times 200$ .
- Fig. 9. *Stenomischus athrous*, microspores, Slide 3623,  $\times 200$ .
- Fig. 10. *Stenomischus athrous*, Type-specimen; parts of this specimen are figured in 1, 2. Slide 3622,  $\times 4$ .
- Fig. 11. *Sorosaccus gracilis*, the free ends of many microsporophylls are still present, Slide 3636,  $\times 4$ .
- Fig. 12. *Sorosaccus gracilis*, Slide 3632,  $\times 4$ .

The specimens of *Sorosaccus gracilis* were obtained from Neill Cl., Liverwort Bed; that of *Leptostrobis longus* from C. Stewart *Todites* Bed. The figures (except Figs. 7—9) are drawings on photographs.

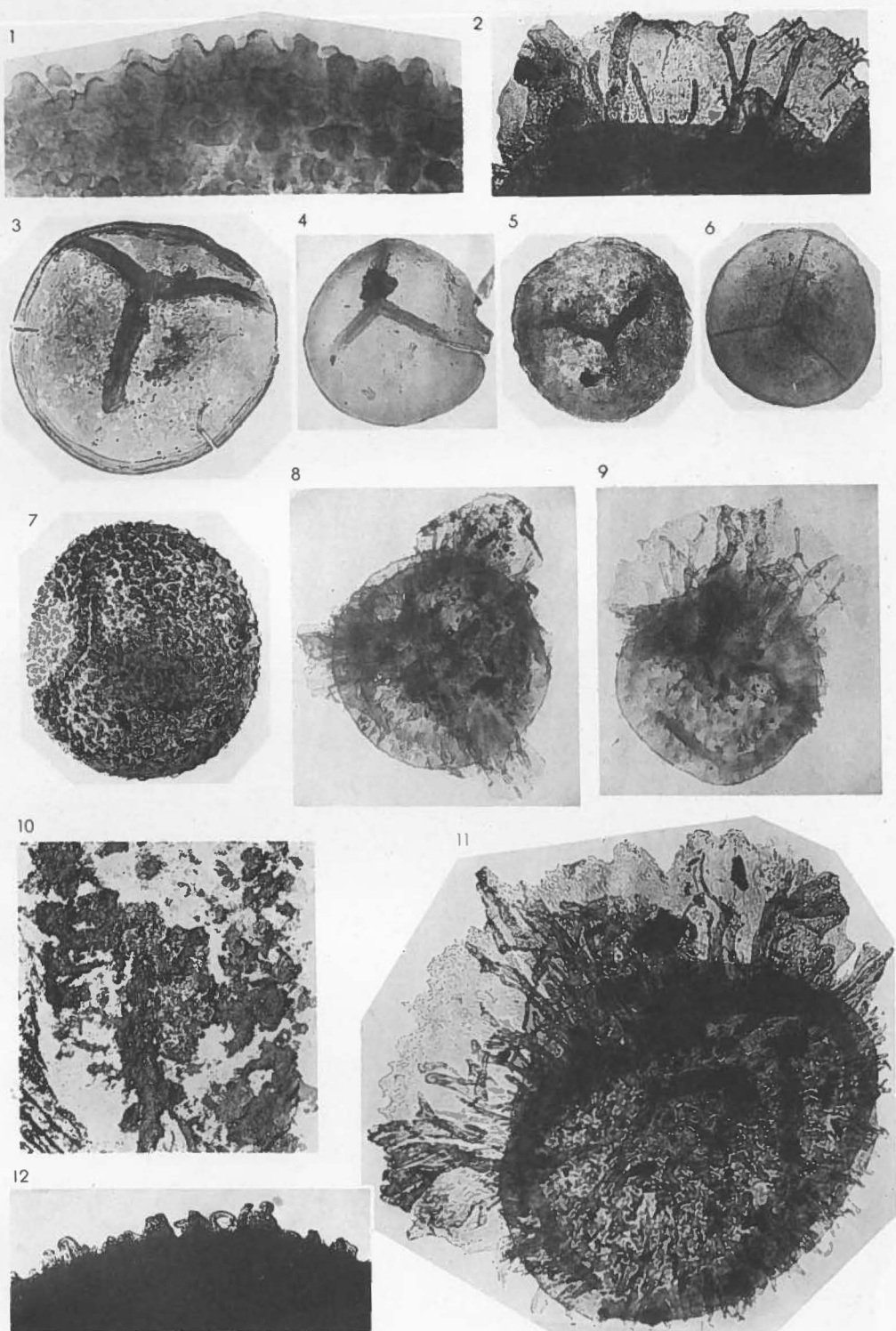


### Plate 25.

- Fig. 1. *Triletes litchi*, margin of spore, Slide 4046,  $\times 200$ .  
Fig. 2. *Triletes ales*, triradiate lamella, Slide 4070,  $\times 200$ .  
Fig. 3. *Triletes pinguis*, apical view of Type-specimen, Slide 4171,  $\times 100$ .  
Fig. 4. *Triletes persimilis*, apical view of Type-specimen, Slide 4181,  $\times 50$ .  
Fig. 5. *Triletes aurantium*, apical view of Type-specimen, Slide 4230,  $\times 50$ .  
Fig. 6. *Triletes stenoxysmatodes*, apical view of Type-specimen, Slide 4240,  $\times 50$ .  
Fig. 7. *Triletes litchi*, apical view of Type-specimen, Slide 4046,  $\times 50$ .  
Fig. 8. *Triletes ales*, apical view, Slide 4070,  $\times 100$ .  
Fig. 9. *Triletes ales*, lateral view, Slide 4070,  $\times 100$ .  
Fig. 10. *Grammaephloios ichtya*, transfer of specimen shown in Pl. 27, fig. 5, showing the xylem core, Slide 3902,  $\times 4$ .  
Fig. 11. *Triletes ales*, Type-specimen, Slide 4070,  $\times 200$ .  
Fig. 12. *Triletes* sp. A, margin of spore showing outgrowths, Slide 4081,  $\times 100$ .

The figures are untouched photographs. The specimens shown in Figs. 1, 5, 7 were obtained from Astarte R., Bed A; the others from the localities mentioned in the text.



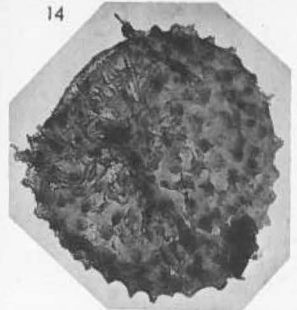
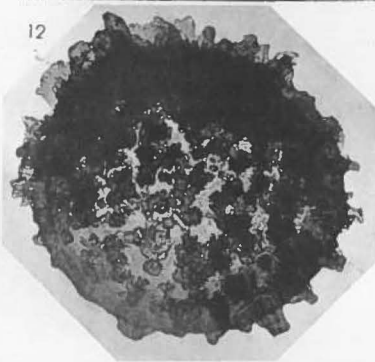
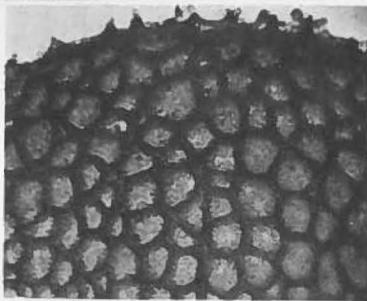
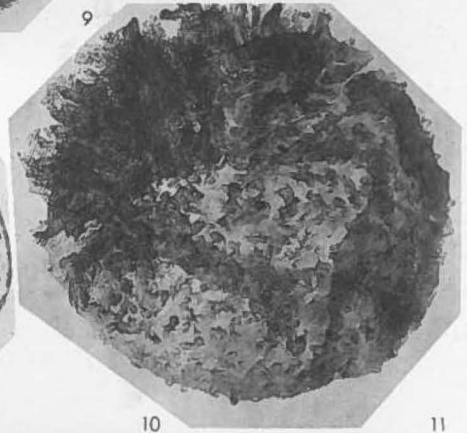
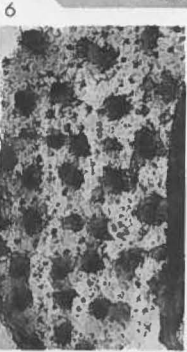
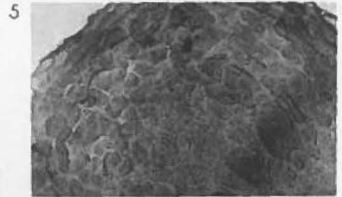
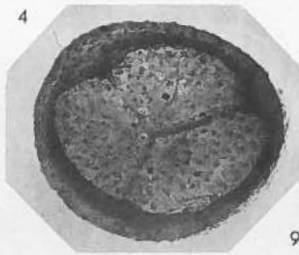
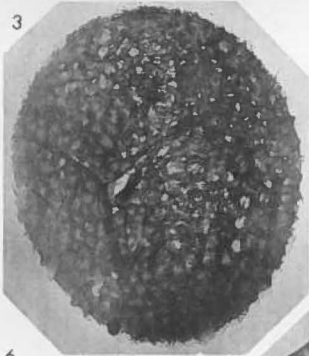
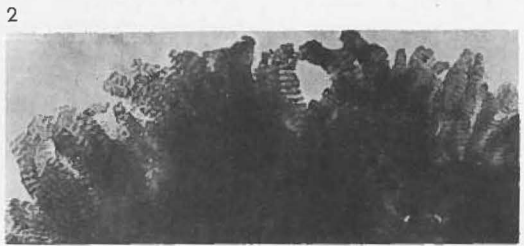
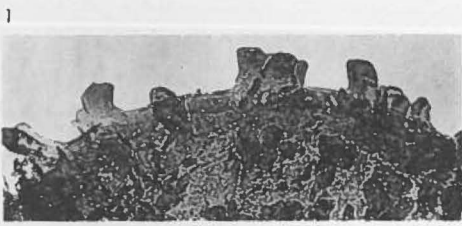


## Plate 26.

*Triletes* spp. and *Lycostrobus*.

- Fig. 1. *Triletes tylotus*, margin of spore (ventral part), Slide 4051,  $\times 200$ .
- Fig. 2. *Triletes mensura*, part of spore shown in Fig. 9,  $\times 200$ .
- Fig. 3. *Triletes areolatus*, apical view, Type-specimen, Slide 4120,  $\times 50$ .
- Fig. 4. *Triletes myrmecodes*, apical view, Slide 4035,  $\times 50$ .
- Fig. 5. *Triletes aurantium*, surface of spore, Slide 4222,  $\times 100$ .
- Fig. 6. *Lycostrobus scotti*, surface of spore (ventral part), Slide 4011,  $\times 100$ .
- Fig. 7. *Lycostrobus scotti*, margin of spore (apical part), Slide 4011,  $\times 100$ .
- Fig. 8. *Triletes ionthus*, apical view of spore, Type-specimen, Slide 4200,  $\times 100$ .
- Fig. 9. *Triletes mensura*, lateral view of spore, Type-specimen, Slide 4061,  $\times 100$ .
- Fig. 10. *Triletes areolatus*, surface and margin of spore, Slide 4120,  $\times 100$ .
- Fig. 11. *Lycostrobus scotti*, lateral view of spore, Slide 4011,  $\times 50$ .
- Fig. 12. *Triletes tylotus*, lateral view, Type-specimen, Slide 4051,  $\times 100$ .
- Fig. 13. *Triletes rexargenteus*, surface of spore, Slide 4091,  $\times 100$ .
- Fig. 14. *Lycostrobus scotti*, apical view of spore. Slide 4000,  $\times 50$ .

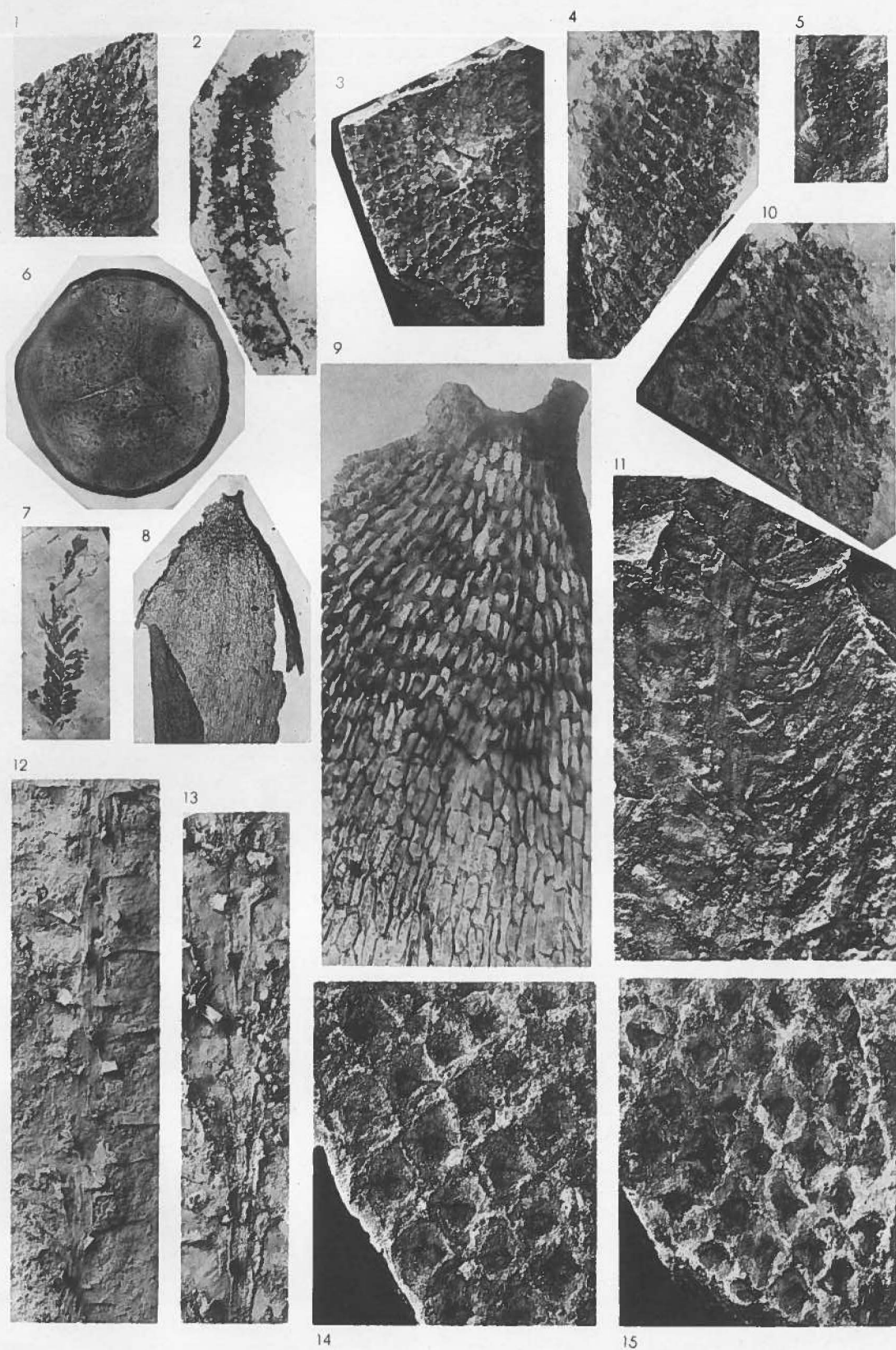
The figures are photographs which are untouched except that in some cases the background has been removed. The specimens shown in Figs. 3, 10 were obtained from Lejr R., *Czekanowskia* Bed; that in Fig. 4 from C. Hope, *A. minor* Bed; that in Fig. 5 from Vardekloft *Stachyotaxus* Bed; those in Figs. 6, 7, 11 from Neill Cl., Coal Bed; those in Figs. 2, 8, 9, 13 from Astarte R., Bed C; that in Fig. 14 from Vardekloft *Podozamites agardhianus* Bed.



## Plate 27.

- Fig. 1. *Grammaephloios ichtya*, specimen made into Transfer, Slide 3907,  $\times 1$ .  
Fig. 2. *Sorosaccus minor*, Transfer of Type-specimen, Slide 3651,  $\times 1.5$ .  
Fig. 3. *Grammaephloios ichtya*, No. 4803,  $\times 1$ .  
Fig. 4. *Grammaephloios ichtya*, No. 4802,  $\times 1$ .  
Fig. 5. *Grammaephloios ichtya*, smallest specimen found. Made into transfer, Slide No. 3902, also shown on Pl. 25, fig. 10.  
Fig. 6. *Triletes pedinacron*, Type-specimen, Slide 4191,  $\times 50$ .  
Fig. 7. *Stachytaxus elegans*, small shoot (approaching *S. septentrionalis*), No. 3234,  $\times 1$ .  
Fig. 8. *Allicospermum hartzi*, integument, No. 2941,  $\times 15$ .  
Fig. 9. *Allicospermum hartzi*, upper part of specimen shown in Fig. 8 to show the thickened cells at the base of the micropyle,  $\times 100$ .  
Fig. 10. *Grammaephloios ichtya*, largest specimen, No. 4804,  $\times 1$ .  
Fig. 11. *Ourostrobos nathorsti*, cone showing seeds at the bases of some of the scales, No. 4531,  $\times 4$ .  
Fig. 12. *Ixostrobus groenlandicus*, axis of cone in transfer, Slide 3671,  $\times 4$ .  
Fig. 13. *Ixostrobus groenlandicus*, axis of a cone in transfer, Slide 3674,  $\times 4$ .  
Fig. 14. *Grammaephloios ichtya*, part of specimen shown in Fig. 3,  $\times 4$ .  
Fig. 15. *Grammaephloios ichtya*, specimen No. 4806, counterpart of the one shown in Fig. 1,  $\times 4$ .

The specimens shown in Figs. 1, 3—5, 10, 12—15 were obtained from Neill Cliff Liverwort Bed; that in Fig. 2 from C. Stewart *Todites* Bed; that in Fig. 6 from Astarte R., Bed A; that in Fig. 7 from Astarte R. Bed D; that in Figs. 8, 9 from Neill Cliff *Neocalamites* Bed; that in Fig. 11 from Lejr R. *Czekanowskia* Bed. All the figures are untouched photographs.

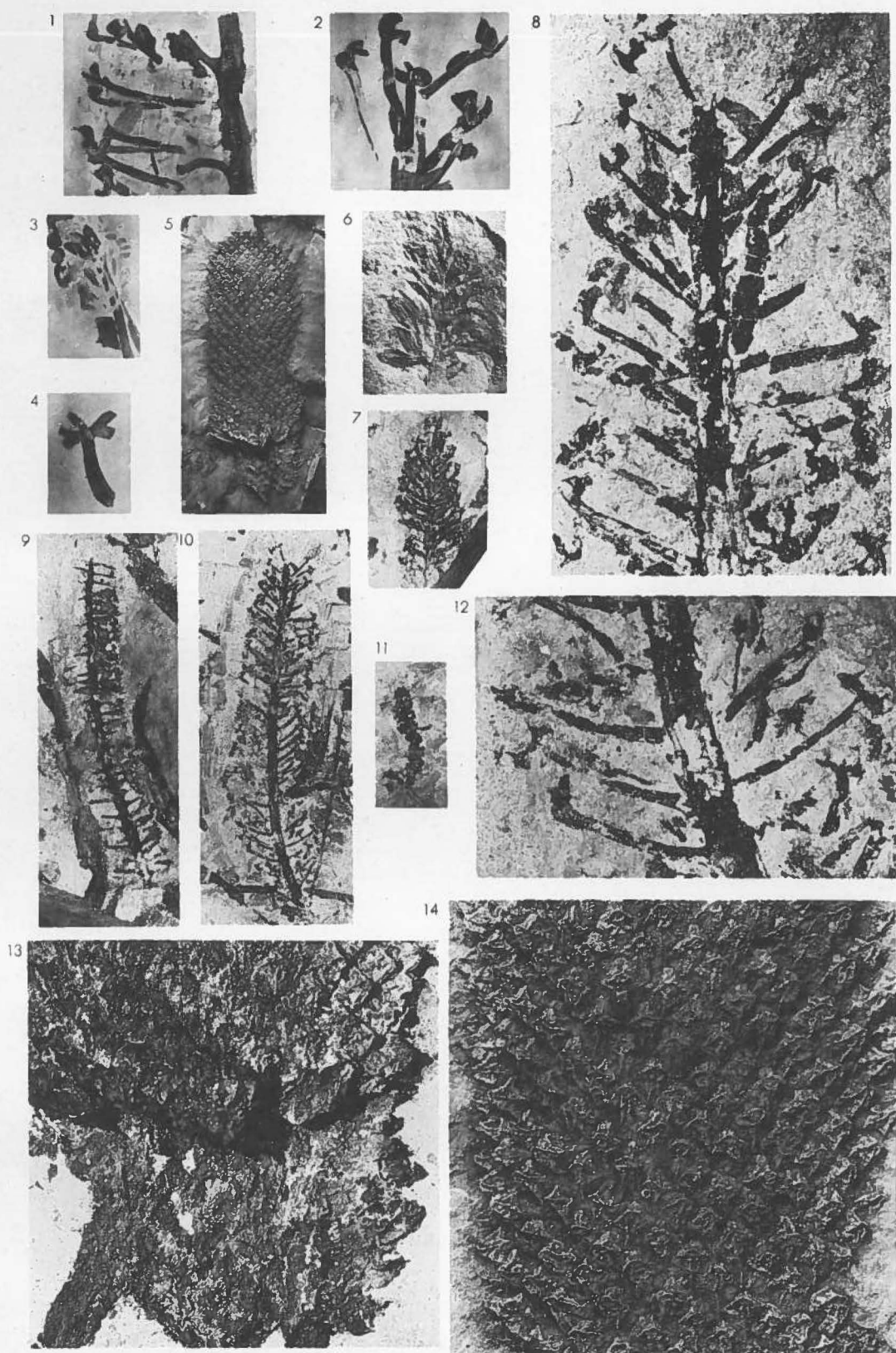


## Plate 28.

- Figs. 1—4. *Ixostrobus groenlandicus*, drawings of transfers of cones, Slides 3674, 3677, 3672, 3673,  $\times 4$ .
- Fig. 5. *Grammaephloios ictya*, transfer of counterpart of Type-specimen, Slide 3903,  $\times 1$ . Also shown in Figs. 13, 14.
- Fig. 6. *Tmematostrobos eremus*, small cone, No. 4430,  $\times 1$ .
- Fig. 7. *Ixostrobus groenlandicus*, upper part of cone,  $\times 1$ .
- Fig. 8. *Ixostrobus groenlandicus*, lower part of Type-specimen, No. 4821,  $\times 4$ .
- Fig. 9. *Ixostrobus groenlandicus*, cone, No. 4823,  $\times 1$ .
- Fig. 10. *Ixostrobus groenlandicus*, Type-specimen, No. 4821,  $\times 1$ .
- Fig. 11. *Sorosaccus gracilis*, small specimen,  $\times 1$ .
- Fig. 12. *Ixostrobus groenlandicus*, part of Type-specimen, No. 4821,  $\times 4$ .
- Fig. 13. *Grammaephloios ictya*, base of the transfer shown in Fig. 5, showing the stele,  $\times 4$ .
- Fig. 14. *Grammaephloios ictya*, upper part of the specimen shown in Fig. 5,  $\times 4$ .

All the photographs are untouched. The specimen shown in Fig. 6 was obtained from Astarte R., Bed A; all the rest from Neill Cl., Liverwort Bed.





## Plate 29.

- Figs. 1, 2. *Sphaerostrobos clandestinus*, Type-specimen, No. 4584,  $\times 1$ . The specimen is in xylol in Fig. 1, dry in Fig. 2.
- Fig. 3. *Sphaerostrobos clandestinus*, the top right-hand cone of the previous specimen,  $\times 4$ .
- Fig. 4. *Sphaerostrobos clandestinus*, specimen in which the male cones are hidden by the bracts, No. 4583,  $\times 1$ .
- Fig. 5. 'Male cone B', in transfer, Slide 3680,  $\times 5$ .
- Fig. 6. *Sphaerostrobos clandestinus*, specimen in which the bracts are deranged. No. 4585,  $\times 1$ .
- Fig. 7. *Amydrostrobos groenlandicus*, part of Type-specimen, Slide 3664,  $\times 5$ .
- Fig. 8. *Amydrostrobos groenlandicus*, specimen No. 4590, photographed under xylol,  $\times 2$ .
- Fig. 9. *Samaropsis chalcos*, Type-specimen, No. 3181,  $\times 5$ .
- Fig. 10. *Samaropsis chalcos*, specimen 3171,  $\times 5$ .
- Fig. 11. *Sphaerostrobos clandestinus*, male cone in transfer,  $\times 4$ .
- Fig. 12. *Bysmatospermum macrotrachelum*, part of micropyle and upper part of nucellus, etc., Slide 2852,  $\times 100$ .
- Fig. 13. *Chitospermum stereococcus*, apex of seed, Slide 2972,  $\times 100$ .
- Fig. 14. 'Male cone B', drawing of part of specimen shown in Fig. 5.

All the figures are untouched photographs, except Figs. 7 and 14, which are drawings on photographs. The specimen shown in Fig. 9 was obtained from C. Stewart *E. muensteri* Bed; that in Fig. 10 from C. Stewart *E. laevis* Bed; that in Fig. 12 from C. Hope; that in Fig. 13 from Vardekloft *A. minor* Bed.



