

SVERIGES GEOLOGISKA UNDERSÖKNING

SER. C.

Avhandlingar och uppsatser.

N:o 506.

ÅRSBOK 43 (1949) N:o 4.

DE GEOLOGISKA RESULTATEN
FRÅN BORRNINGARNA
VID HÖLLVIKEN

DEL 3: MICROBOTANICAL STUDIES OF CORES
FROM HÖLLVIKEN, SCANIA

BY

BRITTA LUNDBLAD

With 2 Plates

Pris 1 kr.

STOCKHOLM 1949

KUNGL. BOKTRYCKERIET. P. A. NORSTEDT & SÖNER

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In November 1946 Dr. F. Brotzen submitted some pieces of cores from the Government borings for salt and oil at Höllviken (Höllviksnäs) in SW Scania for examination by the Palaeobotanical Department of the Swedish Museum of Natural History, Stockholm. According to Dr. Brotzen, these had been obtained from layers corresponding to the »Kohlenkeuper» or »Lettenkohle» group, i. e. the lowermost division of the German Keuper, which in many respects is transitional between this and the underlying Muschelkalk series.¹ No fossils had been observed in adjacent parts of the core, but two seeds with partly preserved carbonaceous coats could be seen in one of these core fragments (labelled 1824.69 m), and a stem fragment showing well-preserved secondary wood (to be described elsewhere) had been found in another (labelled 1802.28 m). As other plant remains might also be expected in the rock, I suggested to Dr. Brotzen that I should make a search for microfossils, especially minute fragments of cuticles. A tentative examination of this kind seemed all the more indicated in view of Dr. Brotzen's own studies of the foraminiferal fauna of the Höllviken profiles, which have supplied the main palaeontological evidence for the correlation of the Cretaceous strata of the Danish-Scanian Geosyncline (Brotzen 1945). The interest in plant microfossils as a means of correlating coal seams has greatly increased in recent years, although those of Mesozoic rocks have been neglected in this respect owing to the minor economic importance of the coals of that age. So far, chiefly spores and pollen have been studied (for a summary of the present state of progress on this subject see Wilson 1944²), but in connection with the investigation of the angiospermous flora of the Tertiary »Braunkohle» in Central Europe cuticles have also attracted attention as micropalaeontological objects. (For information on cuticular analysis see Hofmann 1934, pp. 209—231, and Jurasky 1934—1935.)

The work of Harris, Florin, Thomas, and others, has in the last decades considerably changed our conceptions of the Mesozoic floras. The descriptive methods used in modern studies of carbonaceous plant remains — »compressions» — are characterized by their development towards greater exactitude,

¹ For particulars of the boring profiles see Brotzen, F. »De geologiska resultatena från borrhningarna vid Höllviken», Del 2, Sveriges Geologiska Undersökning, Ser. C, No. 505.

² From Wilson's paper the following statement may be of interest in this connection (l. c., p. 500): »Animal microfossils, such as the Foraminifera, sponge spicules and ostracods, occur widely through the limestones, shales, fine sandstones and their clastic equivalents. They do not occur very frequently in coals and peats. On the other hand, plant microfossils occur most abundantly in coals and peats, less frequently in limestones, shales and fine sandstones. Therefore, it would seem that together the two would complement each other in a thorough study of sedimentary rocks.»

expressed in the careful analysis of the microscopic details of the fossils concerned. So far, the progress made has primarily promoted a better understanding of many plant fossils from the botanical point of view, but our rapidly accumulating knowledge of this kind may be expected to result also in the extended use of plant fossils for stratigraphical purposes.¹

In connection with his studies of the fossil floras of Scoresby Sound, Harris (1926 a) made extensive use of a method of macerating rock in bulk, which gave most valuable additional knowledge not only of the vertical distribution of many species, but also of the nature and position of detached plant remains. I have for some years been studying the fossil floras of NW Scania, and with due permission from the management of the mines I had, in order to obtain additional information on the floral sequence, planned to apply Harris's method to cores drilled in this district; an attempt to use maceration in bulk for a study of the contents of the Höllviken cores was then obviously indicated. The method was originally used by Harris for shales very rich in cutinized plant remains, while these rocks are sandstones relatively poor in this respect. The fossils were as usual mounted in glycerine jelly; in some cases the objects were stained with safranin.

The plant remains obtained from the Höllviken cores include a number of remarkably well-preserved cuticles — which in the cases described below probably represent fragments of leaves —, some seeds and small pieces of wood, and some clusters of pollen-grains. — The seed-remains were not considered sufficiently well-defined to merit description; the wood fragments will be examined in conjunction with the study of the stem mentioned on p. 3.

The Material and its Stratigraphical Indications.

The following material is described and discussed:

Gymnospermous cuticles.

	Horizon	Systematic position suggested.
Cuticle A. Pl. 1, figs. 1—2	1824.69 m	»Mesozoic pteridosperm» (or pre-bennettitalean)
» B. » » » 3—5	» »	» »
» C. » » » 6—7	» »	» »
» D. » » » 8—9	1805 m	» »
» E. Pl. 2, figs. 3—4	» »	possibly cycadealan
» F. » » » 1—2	1769.29 m	conifer, cf. <i>Voltzia</i>
» G. » », fig. 5	1805 m	
» H. » » » 6	1824.69 m	
» I. Pl. 1, » 10	» »	

¹ *Addendum, July 1948.* After this manuscript was written, my attention was drawn to recent work on this line made by Indian palaeobotanists; see progress reports »Palaeobotany in India» (quoted at the end of the bibliography), containing annual reviews of palaeobotanical work made in India from the year 1939 (first report printed in 1940). According to information from Prof. Sahni, stratigraphical correlations of cores including cuticle material have been made in India since 1942. Among papers on this subject cf. especially Sahni B. 1946: Microfossils and the Salt Range Thrust. — Proc. Nat. Acad. Sci. India Vol. 16, Parts 2—4. Lucknow.

Pollen-grains.

<i>Sporomorpha a.</i>	Pl. 2, figs. 7—8	1769.29 m
»	b. » » fig. 9	1824.69 m
»	c » » figs. 10—11	» »

In summarizing the age indications provided by the composition of the flora, the following statements appear justified:

- 1) The absence of *typical Bennettitales* suggests a pre-Rhaetic age of the flora; on the other hand, the presence of floral elements *to some extent* comparable with bennettitalean remains and with so-called Mesozoic pteridosperms indicates a Mesozoic age of the flora (cf. p. 9), as does also the presence of a possibly cycadalean element (p. 10).
- 2) The presence of a coniferous form recalling »*Voltzias*» adds to the probability of a *pre-Rhaetic* age of the flora (p. 11).
- 3) The facts that the Bunter flora of Germany generally contains no carbonized plant remains, and that the »*Muschelkalk*» series mostly lacks plant-remains altogether, favour the assumption of a Lower or Middle Keuper age of the Höllviken material.
- 4) The Lettenkohle flora of Germany is known to contain elements comparable with the present forms, although a closer comparison is prevented by the lack of a modern description of this flora. The only slightly younger flora of Lunz in Austria (Alpine Trias) is, on the other hand, in several respects comparable with Rhaetic floras.

Descriptions.**Gymnospermous cuticles.**

According to earlier authors there appear to be two main types of cuticles: one withstanding oxidative maceration, found in gymnosperms, angiosperms, and several other groups, and another destroyed by such treatment, which is characteristic of ferns. Harris suggests that the presence of the former type of cuticle should be used as a criterion for differentiating a leaf from ferns; according to him, the chemical composition of the cuticle may be of some phylogenetic significance (Harris 1926, p. 67; 1932, pp. 4, 103). — All the descriptions of cuticles given below refer to fragments only a few sq. mm in size. The external shape of the leaf is not indicated in any of the cases.

Cuticle A.

Pl. 1, figs. 1—2.

Occurrence.: boring Höllviken II, preserved in a light grey, finegrained sandstone; 1824.69 m.

Description. — Cuticle showing straight-walled cells of varying shapes, mostly isodiametric and polygonal, with about 20 stomata per sq. mm. Leaf substance thick, brownish, epidermal cells with strongly thickened walls. No

differences observed between stomatic areas and non-stomatiferous zones, distribution and orientation of stomata quite irregular (Pl. I, fig. 1).

The stomatal slits are mostly surrounded by two lateral and two polar subsidiary cells. The lateral cells may have divided to form a pair of subsidiary cells proximally to the guard-cells and a pair of distal encircling cells. Even a radial wall sometimes appears in the subsidiary cells, increasing the number of subsidiary cells to 5—6. Both types of division may occur in the same stomatal apparatus. The shape of the guard-cells is not known in detail; they are sunken, but the poles are always near the surface (Pl. I, fig. 2). The total length of the guard-cells is 43μ (5 measurements).

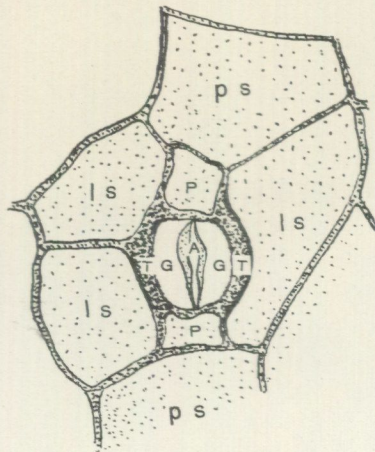
Cuticle B.

Pl. I, figs. 3—5; text-fig. 1.

Occurrence. Höllviken II; 1824.69 m.

Description. — Stomata-bearing cuticle thick, its cells mostly isodiametric, straight-walled, often polygonal, provided with strongly thickened walls and often with superficial median thickenings. No difference between stomatic and non-stomatiferous zones, irregular distribution and orientation of the stomata. The number of stomata per sq. mm. is about 40—50 (Pl. I, fig. 3).

Subsidiary cells 4—6, generally 4 or 5, the lateral arranged in pairs bordering on unspecialized epidermal cells (Pl. I, fig. 4), or on a pair of encircling cells of similar shape; the subsidiary cells are sometimes more or less irregularly arranged around the guard-cells. — The surface of the guard-cells is exposed,



Textfig. 1. *Cuticle B.* Höllviken II; 1824.69 m.
Stomatal apparatus, surface view. — 750/1.

ls = lateral subsidiary cells
ps = polar » »
G = guard-cells
P = polar ends of guard-cells
A = aperture

T = curved distal thickenings of guard-cells
and walls between guard-cells and lateral
subsidiary cells.

but at a slightly lower level than the neighbouring epidermal cells. The central portion of the guard-cells is thin, as at the poles, but the aperture itself is provided with a faintly cutinized lining, and the guard-cells have well-defined, curved distal thickenings, interconnected at the ends of the aperture by transverse bars (Pl. 1, figs. 4—5; textfig. 1). The total length of the guard-cells is about 35μ (average of 5 measurements), the aperture being about half as long.

Cuticle C.

Pl. 1, figs. 6—7.

Occurrence. Höllviken II; 1824.69 m.

Description. — This cuticle differs but little in detail from that shown in fig. 3, Pl. 1, although the general aspect is dissimilar (Pl. 1, fig. 6). The epidermal cells are sometimes more elongated, and arranged in short longitudinal rows; further, the distal thickenings of the guard-cells are broader than in the preceding case (Pl. 1, fig. 7). The length of the guard-cells is about the same. There were no papillae, but in one case a structure interpreted as a trichome base was observed. The stomata often have only two lateral subsidiary cells, but vary somewhat in this respect.

Cuticle D.

Pl. 1, figs. 8—9.

Occurrence. Höllviken II, preserved in a grey argillaceous sandstone with calcareous pebbles, which contains pieces of fossil wood; 1805 m.

Description. — This cuticle represents a type similar to those previously described. It shows epidermal cells of varying shape, with strongly cutinized straight walls, the cell surfaces having short papillae or bulging thickenings in some parts and lacking extrusions in others. The stomata are irregularly distributed and orientated, their concentration being about 50 per sq.mm. (Pl. 1, fig. 8).

The stomata are surrounded by 4—7 variously arranged subsidiary cells (Pl. 1, fig. 9). Stomata with a single pair of lateral subsidiary cells have been observed. The subsidiary cells may occasionally be provided with papillae arching over the stomatal pit. In most cases only the polar ends of the sunken guard-cells were found close to the surface of the epidermis, as in the stomata seen in *Cuticle A*, but in a few cases the whole of the guard-cells was visible, suggesting a type similar to that of *Cuticle B* shown in figs. 4—5, Pl. 1 and textfig. 1. The total length of the guard-cells is 40μ (5 measurements).

Cuticles A—D; discussion.

As regards the individual and specific variations in epidermal structure, and the value of these characters in systematic botany, I refer to Florin 1931 and Jurasky l. c. (cf. also discussion in Florin 1944, pp. 402—406). The cuticles

described above probably belong to a complex of related species. Epidermal characters of allied species may overlap, but in the present case I think descriptions under different headings justified.

The great diagnostic value of stomatal characters has long been generally recognized. In this case the interest centres in the difference between the syndetocheilic type characteristic of the fossil *Bennettitales* and the genera *Gnetum* and *Welwitschia* of recent gymnosperms, and the simpler haplocheilic type found in all other groups of gymnosperms (Florin 1933, p. 14; cf. Thomas and Bancroft 1913 and Florin 1931).

The present material seems to be of an unusual type in this respect, with stomata suggesting both Florin's haplocheilic and his syndetocheilic type occurring together in the same cuticle. As regards *Cuticle A*, a classification of the stomata as of the syndetocheilic type seems preferable. Several stomata differ, however, from those of most bennettitalean genera in that the lateral subsidiary cells are occasionally divided by a wall radiating from the guard-cells, which may make the stomatal complex reminiscent of Florin's haplocheilic type. Cell-walls more or less parallel to the guard-cells were also occasionally found in the original subsidiary cells, a condition also observed in bennettitalean leaves. — The same conditions as in *Cuticle A* are shown by the stomata of the other cuticles (B—D). However, numerous stomata of *Cuticle C* are provided with two undivided lateral subsidiary cells, while the arrangement of the cells round the guard-cells varies in *Cuticle B* and is similar in *Cuticle D*, most stomata suggesting Florin's haplocheilic type.

The interpretation of these »transitional» conditions is difficult in fossil material, where the ontogenetic development of the stomata cannot be investigated. A similar case was discussed at some length by Linnell (1932, pp. 251—254) in his description of *Sphenozamites tener* Compter of the Lettenkohle. Linnell compared the stomata of this species with those of *Nilssonia* (*Cycadales*), which are haplocheilic. Florin (1933, p. 39) mentions a similar instance in *Macrotaeniopteris simplex* Krasser from the Keuper of Lunz, interpreting the conditions observed as anomalies due to arrested growth. Atypical stomata suggesting the haplocheilic type occur among the syndetocheilic stomata of the leaf of the recent *Welwitschia mirabilis*, especially in the cotyledons, but Florin (1934), who studied their ontogenetic development, refers these deviations, too, to arrested growth. The resemblance of the epidermal structure in the cases just cited to that of the present material is restricted to the above features.

In a paper on pteridospermous plants from the South African Mesozoic rocks (from the Molteno beds of Natal, which lie at the base of the Stormberg Series, the uppermost division of the Karroo System; Lower Keuper according to v. Huene) Thomas (1933) has discussed the epidermal structures of representatives of the leaf genera »*Stenopteris*» and *Dicroidium* when comparing their leaves with the pteridospermoid reproductive structures of the family *Corynospermaceae*. The general appearance of the epidermis of these plants is about the same as in my types, although that of the said leaf genera differs in the »microsinuosity» of the cell walls. Thomas's description of the arrangement of the cells of the stomata of the leaves confirms this similarity (Thomas 1933, p. 250): »There may be a pair of lateral subsidiary cells in some, while in others one or both may be divided into two by a wall running out radially from the guard-cells; occasionally a division by a wall more or less parallel to the guard-cells separates off cells like the 'Kranz' cells of Florin . . .». The cutinization of

the stomatal guard-cells of the *Corystospermaceae* resembles that of corresponding structures in *Cuticle B*, but represents a type frequently occurring in Mesozoic »cycadophytes» and also in living cycads.

The pioneer work in the study of epidermal characters of fossil plants for systematic purposes was Bornemann's (1856) paper on the flora of the Lettenkohle formation of Thuringia. The fossil remains studied by him had been subjected to natural maceration (the word »maceration» is not adequate when applied to the oxidative chemical treatment of carbonaceous matter, cf. Florin 1931, p. 36) and could be studied microscopically without preliminary treatment. Bornemann also examined the epidermal structures of a number of recent cycads to compare them with those of the fossil material. Bornemann's paper shows the microscopical structure of some detached epidermal fragments resembling the cuticles described above (Bornemann, l. c. figs. 1—2, Pl. 8). Unfortunately, the stomata are not shown in high magnification, but it is interesting to note that the lengths of the stomata given by Bornemann (l. c., p. 77) closely agree with those obtained in *Cuticle B*, the one which most resembles Bornemann's drawings. In accordance with the views of his time, Bornemann interpreted the remains as being of dicotyledonous or monocotyledonous plants. The modern conception is that the angiosperms did not dominate until Late Mesozoic time; they can therefore be left out of the discussion. — It is of considerable interest that epidermal types matching the present material in respect of stomatal features are entirely absent from the rich floras of the Rhaetic-Liassic deposits of Scoresby Sound described by Harris (l. c.) as well from the Jurassic flora of Yorkshire, which he is now re-examining by modern methods. Nor are any types permitting close comparison known from the Keuper flora of Lunz in Austria with the exception of *Macrotaeniopteris simplex* KRASSER mentioned above; in the region of the lower epidermis of the leaf nearest to the rachis, the stomata and their subsidiary cells may be arranged in a way resembling that described from Höllviken, while the main portion of the leaf recalls the bennettitalean type (see Kräusel 1921, p. 206; pl. 10, figs. 1—2; cf. Florin 1933, p. 39).

Summarizing the discussion of *Cuticles A—D*, it may be said that

- 1) the stomatal structure does not wholly correspond to that of either the typical *Bennettitales* or the *Cycadales*; and that
- 2) plants with similar epidermal structure are not known from Rhaetic-Liassic or Jurassic floras, but are indicated in floras of slightly older geological age.

With due reservation, it may be added that the material from Höllviken is possibly derived from leaves of plants similar to the so-called Mesozoic pteridosperms or representing predecessors of the true *Bennettitales*. Nothing definite can be said of their geological age, however, as our knowledge of the earlier Mesozoic floras is still too unsatisfactory to serve as a reliable basis for more precise stratigraphical determinations with the aid of micromorphological leaf-characters alone.

Cuticle E.

Pl. 2, figs. 3—4.

Occurrence: Höllviken II; 1805 m.

Description. — The cuticle shown in fig. 3, Pl. 2, is too fragmentary to permit a full description of its epidermal characters, but seems to be fairly characteristic.

The cuticle is rather thin. The epidermis indicates a differentiation into stomatic areas, showing polygonal cells with small but distinct median papillae, and stripes of longitudinal rows of more elongated cells lacking stomata and mostly papillae.

The guard-cells are surrounded by varying numbers of subsidiary cells, suggesting Florin's haplocheilic type. The subsidiary cells may be provided with single, strongly cutinized papillae protruding over the stomatal pit. In shape and cutinization, the guard-cells are similar to those of *Cuticle B*, having curved marginal thickenings as well as transverse bars at the ends of the aperture (Pl. 2, fig. 4). The length of the aperture in the stoma figured is 16 μ .

Discussion. — This type of epidermis may belong to some representative of the *Cycadales*, but it should be pointed out that the microscopical leaf-characters of cycadalean forms may partly overlap those of incompletely known supposed pteridosperms, although very little is so far known of these conditions. The *Cycadales* of the Mesozoic have been discussed by Florin (1933), who discovered indisputable evidence of their occurrence in the Rhaetic. It is of interest that megasporophylls recalling those of recent cycads have been described from the Lettenkohle formation of Germany (*Dioonitocarpidium pennaeforme*; see Rühle von Lillienstern 1928, cf. Florin 1933, pp. 121—122). Unfortunately, the epidermal structure of these organs is not yet known.

Cuticle F.

Pl. 2, figs. 1—2.

Occurrence: Höllviken II, preserved in grey, fine-grained sandstone containing pieces of carbonaceous wood; 1769.29 m.

Description. — Cuticle moderately thick, but with more or less regular rows of stomata, the strongly cutinized subsidiary cells of which stand out distinctly from the ordinary epidermal cells. The unspecialized epidermal cells are isodiametric and polygonal in shape or slightly elongated, with well-marked walls and distinct median papillae.

The stomata are of the haplocheilic type, and monocyclic (Florin 1931); adjacent stomata may be touching. There are 5—7 perigene subsidiary cells; these are provided with strong papillae, which protrude over the stomatal pit and conceal the guard-cells.

Discussion. The finding of this form of leaf cuticle at Höllviken is very interesting. The papillose stomata are of a type characteristic of certain older gymnosperms designated »ginkgoid» by Kräusel (1923, p. 93); Kräusel regarded this type as phylogenetically important. The epidermal characters of Mesozoic ginkgophytes are well known from recent papers by Ôishi (1933), Harris (1935), Florin (1936) and Kräusel (1943). A comparison with the descriptions given by these authors seems to indicate that the cuticle described here is probably not of ginkgoalean type, notwithstanding a certain agreement in the shape of the stomata. It seems to differ from it in the arrangement of the stomata in isolated longitudinal rows.

Some of the older genera of conifers, e. g. *Ernestiodendron* from the Upper Carboniferous and Lower Permian, *Pseudovoltzia* and *Ullmannia* from the Upper Permian, and *Voltzia* from the Triassic (Florin 1944, p. 411), are characterized by the stomata's being arranged in longitudinal rows. The genus *Ernestiodendron* is well known from Florin's investigations (see Florin 1939, 1944). The epidermal characters of the type species, *E. filiciforme*, do not recall those of the Höllviken fragment, nor was any such resemblance expected, considering its geological age. The epidermis of *Ullmannia Bronnii* as figured by Gothan and Nagalhard (1922; pl. 5, fig. 2; pl. 6, fig. 1) resembles that of the present form. Of the Triassic »genus» *Voltzia*, which according to Florin (1944, p. 411) apparently comprises more than one natural genus, this author writes (Florin 1944, pp. 413—414):

»Was die triassischen 'Voltzien' betrifft, so gilt für sie dasselbe wie für die Ullmannien, dass sie nämlich einer gründlichen systematischen Durchforschung bedürfen. Die Epidermisstruktur der Laubblätter ist von Kräusel (1923, p. 87, und 1938, p. 25) und Schlüter u. Schmidt (1927, p. 15) untersucht worden. Die betreffenden Arten haben Längsreihen von anscheinend vorzugsweise monozyklischen und mit 5—7 Nebenzellen versehenen Spaltöffnungsapparaten, die denen von *Ullmannia Bronnii* weitgehend ähnlich sind. Bemerkenswert ist, dass diese 'Voltzien' in der Blattepidermisstruktur stärker an die genannte *Ullmannia*-Art als an *Pseudovoltzia* erinnert, obwohl betont sei, dass alle drei Gattungen . . . in dieser Hinsicht sich nahe aneinander schliessen.»

It may be added that the dimensions of the stomatal apparatus are in the present case similar to those of the genera discussed (cf. fig. 2, Pl. 2, of this paper, and textfigs. 26 a—c in Florin 1944). A type of cuticle, apparently with papillose epidermal cells similar to those of the Höllviken material, is illustrated by Kräusel (1938, textfig. 3 d); it is from a species of the »*Voltzia*» complex from the German Gipskeuper.

From the above discussion it seems to me probable that the cuticle described above represents a leaf-fragment of a conifer of the type characteristic of the older Triassic floras. It should be noted that no forms resembling these old conifers have been described from the richly plant-bearing Rhaetic-Liassic beds of East Greenland. They are mainly restricted to Lower and Middle Triassic rocks, and particularly frequent in Europe (»*Voltziensandstein*» of the Vosges).

Cuticle G.

Pl. 2, fig. 5.

Occurrence: Höllviken II; 1805 m.

Description. — Cuticle fairly thick, of brownish colour, showing mostly elongated cells joined in more or less distinct longitudinal rows. Stomata irregularly distributed, longitudinally orientated, and occurring with moderate frequency. The surfaces of the epidermal cells show a characteristic, finely reticulate pattern, which at low magnifications gives a granulate appearance to the cuticle.

Stomata monocyclic or incompletely amphicyclic, of Florin's haplocheilic type. The number of subsidiary cells is 4—6. Usually there are two polar cells. The number of lateral perigene cells varies, there being often only one single pair of lateral subsidiary cells. The cuticle of the stomatal guard-cells were lost in maceration.

The affinities of this form are entirely unknown.

Cuticle H.

Pl. 2, fig. 6.

Occurrence: Höllviken II; 1824.69 m.

Description. — The fragment of cuticle shown in fig. 6, Pl. 2, has isodiametric, straight-walled cells, and the stomata of the subsidiary cells are surrounded by roundish papillae. The wall of the epidermal cells are rather thick and the cells have often small median papillae on their surfaces. — This type of cuticle occurs in certain genera of pteridosperm-like plants, and in the ginkgophytes.

Cuticle I.

Pl. 1, fig. 10.

Occurrence: Höllviken II; 1824.69 m.

Description. — Cuticle fragment with unspecialized epidermal cells of rectangular shape, with numerous protuberances made up of varying numbers of epidermal cells and resembling trichome bases.

Pollen-grains.¹

Some clusters of pollen-grains were found in investigating some core samples, but the individual grains were mostly stuck together and difficult to separate. Only a few intact grains suitable for description were obtained. I have had an

¹ In the present cases it is impossible to say definitely whether the strong chemical agents used (concentrated HNO₃ and KClO₃ for several hours, followed by NH₄OH) may have influenced the dimensions of the pollen-grains to any appreciable extent. According to Harris (1944, pp. 672—673), who studied these matters in order to ascertain if spore-size can be used as a means of distinguishing allied species, a recognizable swelling effect due to overmaceration becomes evident only when the point of destruction of the cuticle is approached (in the material studied by Harris (*Dictyophyllum rugosum* L. & H.) a swelling of up to 30 per cent was observed under such conditions). The sizes of the grains described as *Sporomorpha* c (p. 13) may possibly have been affected in this way.

opportunity to discuss the interpretation of my material with Dr. Erdtman, who has recently proposed an artificial system for the classification of fossil spores (Erdtman 1947). As the present rather scanty material is hardly a proper basis for the introduction of new generic names, I have used only provisional denominations in the following.

Sporomorpha a.

Pl. 2, figs. 7—8.

Occurrence: Höllviken II; 1769.29 m.

Description (Pl. 2, fig. 7). — Large, roundish-ovoid pollen-grain, about 80 μ in length, maximum breadth 59 μ . Central body rather narrow, with smooth outer surface, exine of wings granulate to slightly reticulate.

The pollen-grain shown in fig. 8, Pl. 2, represents the same sporomorpha; it was found in the same slide as the specimen described above together with clusters of similar grains sticking together.

Discussion. — In its general habit, *Sporomorpha a* recalls the microspores of *Caytonanthus* HARRIS, although it is much larger than the *Caytonanthus* spores hitherto described. Microspores similar to those known from the *Caytoniales* (cf. the discussion of the genus *Alisporites* DAUGHERTY by Schopf, Wilson, and Bentall 1944, pp. 48—49) also occur in the »Mesozoic pteridosperms» described by Thomas (1933); the grains of similar plants and of conifers might possibly be overlapping to some extent, and confused with another in material in an unfavourable state of preservation. »*Caytonanthus*-like spores» are reported from the Lower Gondwana rocks of India by VIRKKI (1945), which suggests a large vertical distribution of similar forms.

Sporomorpha b.

Pl. 2, fig. 9.

The pollen-grain shown in fig. 9, Pl. 2, was found in a slide made from the sample labelled 1824.69 m. According to Dr. Erdtman it is reminiscent of the winged grains of recent conifers.

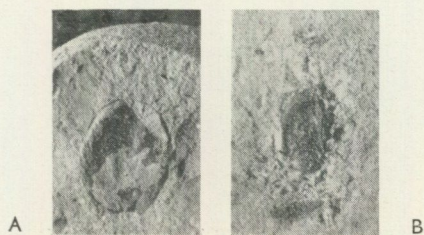
Sporomorpha c.

Pl. 2, figs. 10—11.

The sporomorpha shown in figs. 10—11, Pl. 2, does not permit a safe interpretation, but the fossils seem to be sufficiently well-defined to make future recognition possible. The grains are gigantic (dimensions of the specimen shown in fig. 11, pl. 2, 212 μ in length, 141 μ in breadth); average of 6 measurements 212 and 134 μ (extreme values 204—219 μ : 127—148 μ). The surface of the grains is granulate, in some of the specimens partly covered with numerous small granules 1—2 μ in diameter. The light roundish spots seen in the specimen shown in fig. 11, Pl. 2, are probably due to corrosion.

In my opinion, a possible interpretation would be that the pollen-grain was provided with two large air-sacs close together on the distal side of the grain, the proximal side of which might show a central circular-elliptical body flanked by the

continuations of the air-sacs (cf. Virkki 1945, p. 117: »Spore 73»); there might also be one continuous air-sac provided with a median fold, or the sporomorpha might represent two-winged grains with unexpanded wings (cf. Thomas 1933, p. 235). The actual construction of the grain, however, cannot be determined in the present material.



Textfig. 2. *Carpolithus* spp. Höllviken II, 1824.69 m. A. — 1/x. B. — 3/x.

The pollen-grains described above give no stratigraphical indications of value.

Appendix.

Carpolithus spp. — The »seeds» mentioned on p. 3 are shown in textfig. 2 A—B. (It is impossible to say whether the bodies actually represent seeds or fruits.) The larger body is roundish-ovate, its dimensions being 15×12 mm. The smaller (dimensions 4×2 mm) has a flattened base and a blunt, slightly pointed apex. Maceration left very little residue of the larger structure, and completely dissolved the carbonaceous substance of the smaller.

Seeds or fruits superficially resembling the larger type are described from the Lettenkohle formation of Apolda by Compter (1902, p. 169) as »*Fructus Sphenozamitis*». In this case, too, the material was unsuitable for microscopical investigation, being destroyed by treatment with alkali.

I wish to express my gratitude to Professor Halle for putting the facilities of the Palaeobotanical Department at my disposal, and to both him and Professor Florin for reading my MS. and improving its text stylistically. I am further indebted to Dr. Erdtman for giving me an opportunity to discuss with him the pollen-grains described in this paper.

Riksmuseets Paleobotaniska Avdelning, Stockholm, May, 1947.

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Explanation of Plates.

All the figures are unretouched photographs made from slides kept in the Palaeobotanical Department of the Swedish Museum of Natural History, Stockholm. The material was obtained from the boring Höllviken II. — The photographs are taken by Mr. K. E. Samuelsson.

Plate 1.

- | | | |
|------------|--|------------|
| Figs. 1—2. | <i>Cuticle A.</i> | 1824.69 m. |
| | Fig. 1. Portion of epidermis. — 100/I. | |
| | Fig. 2. Stomatal apparatus from the same, surface view, — 500/I. | |
| Figs. 3—5. | <i>Cuticle B.</i> | 1824.69 m. |
| | Fig. 3. Portion of epidermis. — 200/I. | |
| | Fig. 4. Stomatal apparatus. — 500/I. | |
| | Fig. 5. Stomatal apparatus under still higher magnification, showing cutinization of guard-cells. — 750/I. | |
| Figs. 6—7. | <i>Cuticle C.</i> | 1824.69 m. |
| | Fig. 6. Portion of epidermis. — 100/I. | |
| | Fig. 7. Stomatal apparatus showing cutinization of guard-cells. — 500/I. | |
| Figs. 8—9. | <i>Cuticle D.</i> | 1805 m. |
| | Fig. 8. Portion of epidermis. — 100/I. | |
| | Fig. 9. Stomatal apparatus. — 500/I. | |
| Fig. 10. | <i>Cuticle I.</i> | 1824.69 m. |
| | Portion of epidermis. — 100/I. | |

Plate 2.

- | | | |
|--------------|--|------------|
| Fig. 1—2. | <i>Cuticle F</i> (scf. <i>Voltzia</i>). | 1769.29 m. |
| | Fig. 1. Portion of epidermis. — 100/I. | |
| | Fig. 2. Stomatal apparatus. — 400/I. | |
| Figs. 3—4. | <i>Cuticle E.</i> | 1805 m. |
| | Fig. 3. Portion of epidermis. — 100/I. | |
| | Fig. 4. Stomatal apparatus showing cutinization of guard-cells. — 500/I. | |
| Fig. 5. | <i>Cuticle G.</i> | 1805 m. |
| | Portion of epidermis with stomata. — 100/I. | |
| Fig. 6. | <i>Cuticle H.</i> | 1824.69 m. |
| | Portion of epidermis showing stomata. — 200/I. | |
| Figs. 7—8. | <i>Sporomorpha a.</i> — 500/I. | 1769.29 m. |
| Fig. 9. | <i>Sporomorpha b.</i> — 500/I. | 1824.69 m. |
| Figs. 10—11. | <i>Sporomorpha c.</i> | 1824.69 m. |
| | Fig. 10. — 100/I. | |
| | Fig. 11. — 250/I. | |



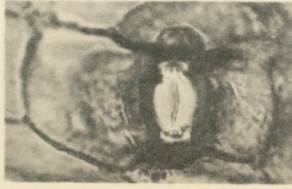
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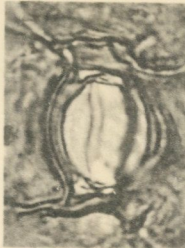
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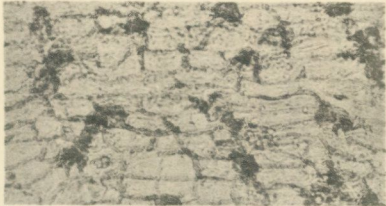
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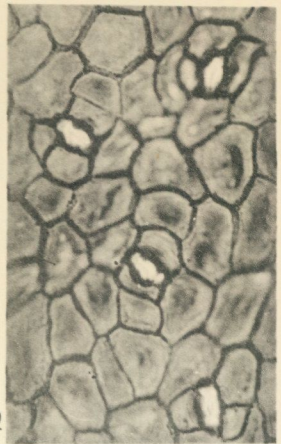
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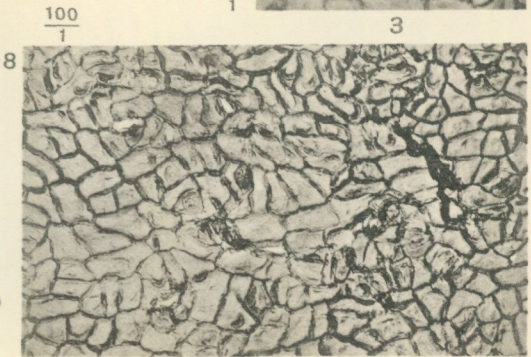
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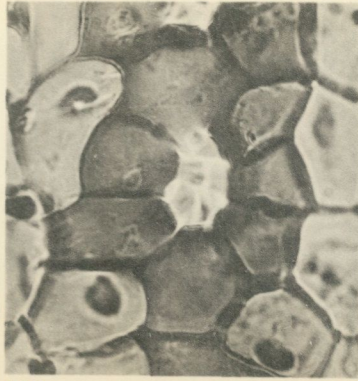


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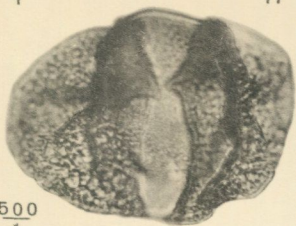
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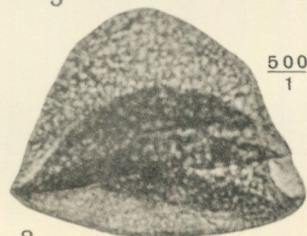


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