SVERIGES GEOLOGISKA UNDERSÖKNING

SER. C. Avhandlingar och uppsatser. N:o 507.

ÅRSBOK 43 (1949) N:o 5.

DE GEOLOGISKA RESULTATEN FRÅN BORRNINGARNA VID HÖLLVIKEN

DEL 4: ON THE PRESENCE OF LEPIDOPTERIS IN CORES FROM »HÖLLVIKEN II»

BY

BRITTA LUNDBLAD

With 1 Plate

Pris 1 kr.

STOCKHOLM 1949
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During the summer of 1947 I had the opportunity to study the large materia of cores kept at Höllviksnäs. It was my intention especially to look for plant material suitable for maceration in bulk (Harris 1926 a), and if possible to determine if strata in the »Höllviken II» boring might be proved to belong to the Rhaetic-Liassic.[1] The conditions for making specific determinations of stratigraphical value from plant-remains megascopically indeterminable, or from microfossils, seemed to me to be exceptionally favourable in material of that age, members of the Rhaetic-Liassic floras of Scania being in part very thoroughly known through previous work by Swedish investigators and the modern descriptions of the floras of Scoresby Sound, East Greenland, by Harris (1926, 1931—37).

When the previous report on plant-remains from the Höllviken cores was written, I was not aware of the publication of two volumes dealing with the age of the Saline Series of the Salt Range of the Punjab, where results obtained from similar palaeobotanical-geological work are reviewed and discussed (Proc. Nat. Acad. Sci. India 1944, Sect. B, Vol. 14, Part 6; 1946, Sect. B, Vol. 16, Parts 2—4). The Indian palaeobotanist Sahni and his co-workers try to determine the geological age of rock samples and cores by similar methods (cf. 1946 volume, p. XXXVI), through the examination of small fragments of cuticles and wood as well as other minute fossils. Their results have been the subject of considerable discussion, however, as the *in situ* nature of the fossil material investigated is not universally accepted; but the work may lead to further cooperation between palaeobotanists and geologists.

During my search for material in cores from the »Höllviken II» bore-hole, plant remains occurring at a depth of 1451.81—1454.0 m, in the clayey intercalations of a fine, light greyish sandstone, attracted my attention. The sandstone underlies a layer of black shale very similar to the dark shales associated with the coal-beds of the Mine formation of NW Scania. On the clayey surface thus exposed, a small leaflet was observed (Fig. 1, pl. 1). The state of preservation of this fragment — it was dark brownish in colour — recalled that of the leaves of *Lepidopteris Ottonis* (Goepp.) Schimper collected in NW Scania, even its shape (dentate margin) being reminiscent of leaflets of this species. It was thought that maceration of a portion of the fragment might possibly settle the question. The epidermal structure of the leaf was actually found to be identical with that of *L. Ottonis*, a matter of great interest since the species is regarded as an important zone fossil of the Rhaetic. As a result of maceration in

[1] For particulars of the »Höllviken II» profile, see Brotzen, F., »De geologiska resultaten från borrningarna vid Höllviken», Del 2. Sveriges Geologiska Undersökning, Ser. C, No. 505.

bulk of the portion of the core containing the *Lepidopteris* fragment exposed, additional material was obtained (Figs. 2—5, pl. 1), which most probably belongs to the same species. Detached cuticles of the *L. Ottonis* type were found in abundance; also a sporomorpha (Fig. 13, pl. 1) similar to the microspores of this species (*Antevsia Zeilleri* (Nath.) Harris).

Description of the material.

Pl. 1, Figs. 1—5, 7—8, 10—11, 13; textfig. 1 A—B.

The material consists of a small number of fragmentary leaflets of somewhat varying shape, with apices acute or rather obtuse, the margin entire, uneven or dentate (Figs. 1—5, pl. 1). In the only specimen exposed without previous chemical treatment of the rock (Fig. 1, pl. 1) no veins were visible, although the organic material was not completely transformed into carbonaceous matter (brownish colour).

Epidermal structure. — The cuticle of the leaflet shown in Fig. 1, pl. 1. is thick, and resistant to treatment with nitric acid and potassium chlorate, that of the upper and the lower side of the leaf having about the same thickness. The leaf is amphistomatic. The epidermal cells are polygonal, isodiametric or elongated. The outlines of the cells are thick; median papillae are often present but may be absent. The stomata are scattered over the surface of the leaf. In one fragment obviously belonging here, stripes of longitudinally orientated cells with stomata lacking or occurring at a lower frequency could be distinguished (corresponding to veins); in another, similar fragment no such differentiation could be observed, but the stomata occurred at a lower frequency on one

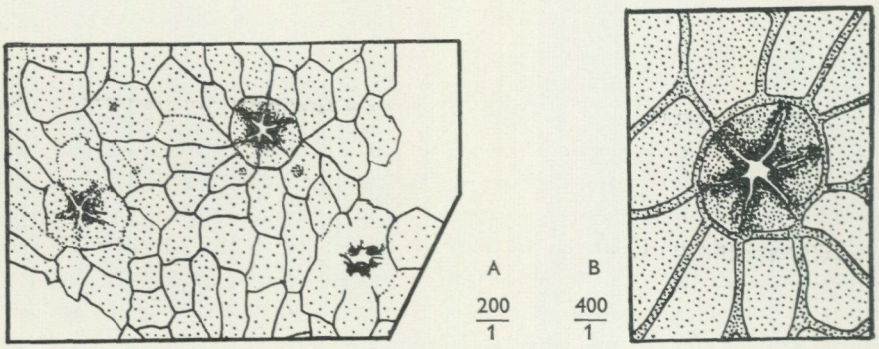

Fig. 1.

Cf. *Lepidopteris Ottonis* (Goepp.) Schimper. Höllviken II, 1451.81—1454.0 m.

A, drawing of portion of cuticle shown as fig. 7, pl. 1. — 200/1.
B, drawing based upon the stoma shown in fig. 10, pl. 1. The papilla-bearing subsidiary cells are contrasted to the unspecialized encircling cells by closer dotting. Somewhat schematical. — 400/1. — For comparison see Antevs 1914, pl. 1, fig. 6; Harris 1926, text-fig. 8 D; 1932, text-fig. 27 A—B.

side of the leaf than on the other. Fig. 7, pl. 1 and textfig. 1 A show a portion of a cuticle preparation from the leaflet shown in Fig. 1, pl. 1; in Fig. 8, pl. 1 a cuticle of another fragment is shown at somewhat lower magnification.

The haplocheilic stomata are monocyclic or incompletely amphicyclic; the subsidiary cells are provided with strong papillae, overarching the stomatal pit and concealing the guard-cells. The subsidiary cells are strongly cutinized, five to eight in number (Figs. 10—11, pl. 1; textfig. 1 B).

The spore (pollen-grain) shown in Fig. 13 was found adhering to the cuticle of the dentate fragment in Fig. 5. The oval grain is of medium size, 44 μ, monosulcate; the exine is smooth.

Comparison.

The material from Höllviken described above shows in all respects striking agreement with *Lepidopteris Ottonis* (Goepp.) Schimper, the most common plant fossil in the Rhaetic of NW Scania (see Antevs 1914, Harris 1926, 1932, 1937). To facilitate comparison a portion of a leaf from the Rhaetic of NW Scania, given as Fig. 9, pl. 2 in Antevs's paper, is reproduced (Fig. 6, pl. 1). A dentation of the margin similar to that seen in the fragments shown in Figs. 1 and 5, pl. 1 is seen in the apical portions of the »pinnae of the second order» in Antevs's specimen. The close agreement as regards microscopical characters is illustrated by Figs. 8—9, pl. 1. Fig. 8 represents a portion of the cuticle of a leaflet obtained through maceration in bulk of the Höllviken material; Fig. 9 is a photograph from one of the specimens studied by Antevs, from Bosarp (Rhaetic). The degree of cutinization, the shape of the cells, the architecture of the stomata, and the distribution of papillae are similar in the material from Höllviken and that from NW Scania. The close resemblance between the stomata of the Höllviken cuticles and those of Antevs's material is illustrated by Figs. 10 and 12, pl. 1. The stoma shown in Fig. 11, pl. 1, from a Höllviken specimen, may differ slightly from the other ones as regards the cutinization of the subsidiary cells (possibly due to incomplete maceration), but similar instances may also be observed in material from NW Scania.

The sporomorpha described above resembles in size and shape the microspores of *Lepidopteris Ottonis* [*Antevsia Zeilleri* (Nath.) Harris] — see Nathorst 1908, p. 21; Antevs 1914, p. 12; Harris 1932, p. 63; 1937, p. 35. The length of the specimen, 44 μ, is within the range of variation observed by Nathorst (l. c.) for the Swedish specimens (36—48 μ); Harris (1932) gives a somewhat lower figure (30 μ) for material from Scoresby Sound. — An isolated sporomorpha without special characteristics cannot be appropriately assigned to a species of fossil plants when so little is known of the components of the spore and pollen flora of deposits of this age, but its association with the leaf material described above is of interest as confirming to some extent the correctness of its identification with *Lepidopteris Ottonis*.

Discussion; the genus Lepidopteris.[1]

The genus *Lepidopteris* was instituted by Schimper in 1869 for fern-like leaves from the Keuper characterized by the scaly appearance of the rachis (in reality not caused by scales but tubercles). These were regarded by Schimper and other contemporary palaeobotanists as true fern fronds, and swellings occasionally found on the leaflets were interpreted as sori. Since the reproductive organs corresponding to the *Lepidopteris* leaves have been detected (Antevs 1914; Harris 1932; Thomas 1933), the plant is regarded as belonging to the so-called Mesozoic Pteridosperms. In this connection it may be recalled that the resistance to chemical agencies found in these »Pteridosperms», as well as in other Gymnosperms, is not matched by the leaves of the true ferns, wherefore this group can be omitted from the discussion. I prefer not to elaborate this with a review of the epidermal characters of the older (Palaeozoic) Pteridosperms, since it would add nothing to the determination;[2] as for the other genera assigned to »Mesozoic Pteridosperms» (*Ptilozamites, Stenopteris, Thinnfeldia* etc.) none is comparable with the present material. Harris (1926, pp. 67—69) and Sze (1933, pp. 8—9) assigned rather small leaf-fragments to *Lepidopteris Ottonis*, even though these did not show the megascopic features regarded as the main characters of the genus; a study of the epidermal structure was deemed sufficient compensation for the incompleteness of the material.

The best known species of *Lepidopteris*, except for *L. Ottonis*, are *L. stuttgardiensis* (Jaeger) Schimper from the Middle Keuper (Schilfsandstein) of Stuttgart, and *L. natalensis* Thomas, from the Molteno beds of South Africa. Only in the latter species have microscopical structures too been described; unfortunately, no modern description is available of the former. The description of *L. stuttgardiensis* given by Gothan in Potonié (1909, No. 111) does, however, indicate a closer resemblance of the Höllviken material with *L. Ottonis* than with the Schilfsandstein species. The pinnules shown in Fig. 1 A, B in Gothan's description are entire, with rather obtuse apices, whereas the corresponding segments of *L. Ottonis* (pinnules; pinnae of second order) are mostly acute, often dentate or even pinnulate (tripinnate leaves, cf. Antevs 1914, pp. 6—7).[3] Moreover, the leaf of *L. stuttgardiensis* is often characterized

[1] *Postscript.* A review of the genus was recently given by Frenguelli (1943, pp. 263—271, Spanish); it does not contain any new descriptions of species but an emended diagnosis is given for the genus, in accordance with additional knowledge obtained after Schimper.

[2] Harris (1932, p. 58) mentions the resemblance between certain species of the genus *Callipteris* (characteristic of the Permian), and *Lepidopteris* as regards the general appearance of the leaf. Gothan and Nagalhard (1922, pp. 451—453; pl. 6, Figs. 5—6, pl. 7, Figs. 1—3) pointed out the agreement in epidermal structure between material of *Callipteris Martinsi* (Germar) Zeiller from the Rotliegendes of Germany described by them and *L. Ottonis*. Their comparison with the Palaeozoic species is of interest as illustrating the difficulties associated with determinations from epidermal characters alone.

[3] In the original description by Jaeger (1827, p. 33) the shape of the pinnules in *L. stuttgardiensis* is not quite clear: the drawing reproduced (l. c., Tab. VIII), does not show the details of the leaf. Jaeger makes the following statements, however: »Sie (the pinnules) sind zungenförmig und ganzrandig. An den Rändern bemerkt man ziemlich tiefe Kerben oder einen erhabenen Saum mit kleinen

by a very rough surface structure (Gothan 1909, fig. 1; Jaeger 1827, p. 33) matching that of the rachis of *L. Ottonis*. The roughness of the rachis in *Lepidopteris* was believed by Gothan (1909, Nos. 109—111) to be due to shrinking during fossilization, but was found by Zeiller (1911, pp. 3—4) and Antevs (1914, pp. 4—5) to be caused by the presence of roundish swellings; the nature of the similar structure of the pinnules of *L. stuttgardiensis* is unknown. — The South African *L. natalensis* (Lower Keuper according to v. Huene) is well known through the investigations of Thomas (1933, p. 251). As regards megascopic characters it closely resembles *L. Ottonis*, but by microscopical examination leaves of the two species are easily distinguishable, the South African species possessing epidermal cells with sinuous anticlinal walls and thus differing from the material described here.

Some more or less incomplete or inadequately described material from deposits older than the Rhaetic has been assigned to the genus *Lepidopteris*. Specimens from the Uppermost Beaufort beds (South Africa) ascribed by Du Toit (1927, p. 400) to *L. stuttgardiensis* according to Thomas (1933, p. 250), cannot with certainty be included in the genus. Material from Madagascar, ascribed to the same species by Zeiller (1911, p. 3), was never described and figured. Specimens from the same formation (Sakamena Group) were later studied by Carpentier (1935, p. 14; 1936, p. 9); they were designated *Lepidopteris* (?) *madagascariensis* n. sp. Carpentier regards the generic belongings of the poor material as doubtful, but the findings are of interest as possibly indicating that the genus is slightly older in the Southern Hemisphere than in Europe (Lower Triassic; cf. Carpentier 1935, pp. 27—28). — Two inadequately described species from the Keuper of Germany (*L. rigida* and *L. Kurri*, see Schimper 1869, p. 573) were regarded by Frentzen (1922, p. 6) and Harris (1932, p. 70) as identical with *L. stuttgardiensis;* the material ascribed to these species was also found in the Keuper of Stuttgart. Harris suggests that *L. Ottonis* and *L. stuttgardiensis* might even turn out to be specifically indistinguishable, but is more inclined to regard them as distinct.

After studying slides from NW Scania and Scoresby Sound and specimens kept at the Swedish Museum of Natural History I feel convinced of the identity between the present material and *L. Ottonis*, though I should prefer to designate the Höllviken material cf. *Lepidopteris Ottonis* (Goepp.) Schimper.

The age of the Höllviken material.

Lepidopteris Ottonis (Goepp.) Schimper is regarded as the guide fossil *par préférence* of the plant-bearing deposits of the European Rhaetic. It belongs to the older flora of the »Grenzschichten» in Germany (Gothan 1914) and is present in the beds assigned to the *Lepidopteris* Zone at Scoresby Sound, East Greenland, and in the Mine formation of Sweden (cf. Harris 1937, Troedsson 1938 and 1943). It has also been found in the Province of Kueichow in Southern China (Sze 1933).

Vertiefungen auf der Fläche, die man vielleicht für Fructificationen ansehen könnte.» (cf. p. 6), The drawings in Schimper (1874, pl. XXXIV, Fig. 1) and in Quenstedt's Petrefactenkunde (1885, pl. 92, Fig. 2), which are rather schematical, show leaflets with roundish apices and entire margins.

Beside the material described above and ascribed to *L. Ottonis*, a great number of cuticles, and occasionally spores and pollen-grains too, have been obtained by bulk-maceration of core material from the horizon concerned. This material has not yet been studied in detail, but it may be mentioned here that cuticles showing epidermal structures identical with those of *Pterophyllum ptilum* Harris, of the *Lepidopteris* Zone of Greenland, have been observed in the preparations.[1]

Judging from the occurrence of leaflets, classified as *Lepidopteris Ottonis* (Goepp.) Schimper by the aid of cuticular preparations, accompanied by a sporomorpha similar to the microspores of *Antevsia Zeilleri* (Nath.) Harris (the male reproductive organs of *L. Ottonis*), and cuticles identical with those of *Pterophyllum ptilum* Harris, the age of the strata (Höllviken II; 1451.81—1454.00 m) appears to be Rhaetic.[2]

Sveriges Geologiska Undersökning, Stockholm, January, 1948.

Addendum.

Samples from a depth of 1480.78—1485.44 m of the »Höllviken II» boring, consisting of a light sandstone with clayey intercalations, have been subjected to the same treatment as the material from 1450 m. No determinable megascopic remains were exposed on the surface of the cores, but the rock apparently contained carbonized plant remains; fragments of cuticles, spores and pollen-grains were obtained by maceration. Cuticles identical with those of *Lepidopteris Ottonis*, as seen in other material from Scania, occurred in abundance but in this case the minute fragments provided no indication of the shape of the leaves. Fragments of cuticles identical with those of *Pterophyllum aequale* (Brongniart) Nathorst (= *Pterophyllum Schenki* in Harris 1932 a, 1937), were obtained (textfig. 2). The observations point in the direction of a Rhaetic age of the strata concerned.

On the basis of cuticular preparations of small leaflets or microfossils, it may be stated preliminarily that the strata at a depth of between 1450 and 1485 m in the Höllviken profile belong to the Rhaetic, but the total range of the fossili-

[1] No material of this species from Scania has yet been published, but some from the Rhaetic beds of Hyllinge is described by the author (unpublished manuscript); the Swedish material from Hyllinge differs from that from Greenland through a high frequency of papillae, but is similar to it in other respects. The Höllviken cuticles were identical with those seen in a preparation of the Greenland material of the species made by Harris and kept in the collections of the Swedish Museum of Natural History (specimen labelled 1933: 7; Astarte R., *Lepidopteris* Bed.)

[2] *Postscript.* — During a visit to Reading in September, 1948, I had opportunity to show some slides of the Höllviken material assigned to *Lepidopteris Ottonis* and *Pterophyllum ptilum* to Professor Harris, in comparing them with material of the same species from Scoresby Sound. Prof. Harris accepted my determinations: »in so far as any fragments are determinable they are identical», and regarded my conclusions as to a Rhaetic age of the material as justified.

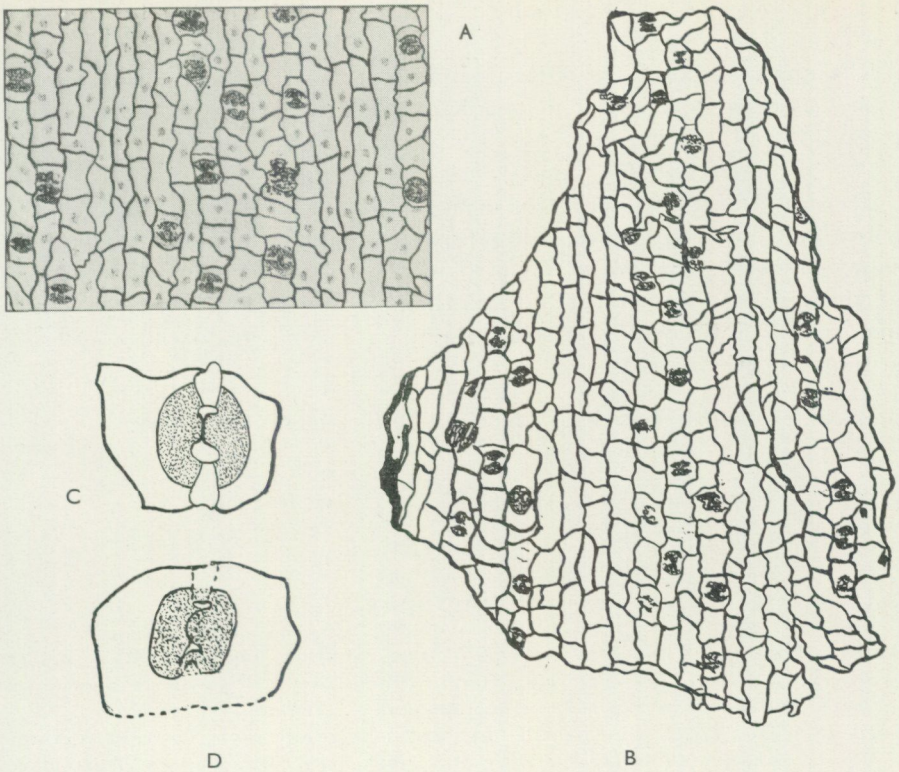

Fig. 2.

A, *Pterophyllum aqeuale* (BRONGNIART) NATHORST (= *P. Schenki* ZEILLER in Harris 1926, p. 88, 1932 a, p. 49, 1937, p. 51).
Lower cuticle of specimen from »Ljungsgård», Billesholm (Rhaetic of NW Scania), showing venation (non-stomatiferous areas with elongated cells corresponding to veins). — 100/1.

B, cf. *Pterophyllum aequale* (BRONGN.) NATH.
Lower cuticle of leaf, specimen obtained through maceration in bulk of »Höllviken II» core, 1480.78—1485.44 m. — 100/1.

C, *P. aequale*. Specimen from the lower coal bed of Hyllinge (Rhaetic). Stoma, showing confluent thickenings of subsidiary cells and guard-cells; polar ends of guard-cells exposed. — 500/1.

D, cf. *P. aequale*. Stoma from the fragment shown in B, further enlarged. — 500/1.

Outlines of cells partly indistinct in the Höllviken material; drawings of stomata (C, D) very schematical.

A revision of material assigned to *P. aequale* (and *P. Schenki*) is in preparation. Brongniart's type specimen of *P. aequale* is an impression, with no cutinized remains left, whereas the epidermal features of Zeiller's type specimen of *P. Schenki* are still unstudied; the material belonging to the »*P. aequale* complex» is thus in need of complete revision, with especial regard to microscopical characters. Specimens described by Nathorst from the Rhaetic of NW Scania under *P. aequale*, and material from the Rhaetic of Scoresby Sound assigned by Harris to *P. Schenki* are identical, however, both as regards megascopic and microscopic characters (cf. synonymy by Harris 1937, p. 51). The presence of median thickenings or papillae in the lower epidermis of the leaf (cf. text-fig. 2 A, B) is subject to variation in the material from NW Scania and Greenland; papillae may be quite absent (cf. Harris 1932 a, p. 49).

ferous strata referable to the Rhaetic is as yet unstudied.

The upper range of the Triassic strata of the »Höllviken II» boring was earlier assumed to be 1495 m (see Kungl. Maj:ts proposition nr 150, 1947, p. 3).

I wish to thank Dr. F. Brotzen of Sveriges Geologiska Undersökning for his readiness to place the cores at my disposal, and for the kind interest he has shown my work. This paper was prepared at the Palaeobotanical Department of the Swedish Museum of Natural History, Stockholm; I wish to express my sincere gratitude to Professor Halle for putting the facilities of his institution at my disposal.

Riksmuseets Paleobotaniska Avdelning, Stockholm, June 1948.

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Explanation of Plate.

All the figures are untouched photographs (except that in one case the background was changed) made from slides kept in the Palaeobotanical Department of the Swedish Museum of Natural History, Stockholm. They were taken by Mr. K. E. Samuelsson.

Figs. 1—5. Cf. *Lepidopteris Ottonis* (GOEPP.) SCHIMPER Höllviken II, 1451.81—1454.0 m.

Fig. 1. Dentate leaflet (no previous chemical treatment). — 3/1.

Figs. 2—4. Leaflets obtained through maceration in bulk of sample containing the fragment shown in Fig. 1, probably belonging to the same species (no control of determination by microscopical examination obtainable). — 3/1.

Fig. 5. Fragment showing dentate margin of leaf, by examination of cuticle shown to be identical with the leaflet shown in Fig. 1. — 3/1.

Fig. 6. *Lepidopteris Ottonis* (GOEPP.) SCHIMPER. NW Scania, Rhaetic. Specimen reproduced by Antevs 1914 (Fig. 9, pl. 2. »Portion of a pinna of first order.»). — 1/1.

Figs. 7—8, 10—11. Cf. *L. Ottonis* (GOEPP.) SCHIMPER. Cuticular preparations. Höllviken II, 1451,81—1454,0 m.

Fig. 7. Portion of epidermis with stomata, preparation made from leaflet shown in Fig. 1 (refigured as a drawing in textfig. 1 A, to facilitate interpretation). — 200/1.

Fig. 8. Portion of epidermis, from a leaflet obtained through maceration in bulk. — 100/1.

Fig. 10. Stomatal apparatus, surface view, from cuticular preparation of the leaflet shown in Fig. 1 (cf. textfig. 1 B). — 400/1.

Fig. 11. Stomatal apparatus from the cuticle shown in Fig. 8 (number of subsidiary cells unusually high). — 400/1.

Figs. 9, 12. *L. Ottonis* (GOEPP.) SCHIMPER. Bosarp, Rhaetic. The labelling indicates the slide photographed to be the original of Antevs 1914 (not identified).

Fig. 9. Portion of epidermis, at the same magnification as the photograph shown in Fig. 8. — 100/1.

Fig. 12. Stomatal apparatus, shown at the same magnification as those in Figs. 10 and 11. — 400/1.

Fig. 13. *Sporomorpha*, similar to the microspores of *Antevsia Zeilleri* (NATH.) HARRIS (adhering to the cuticle of the fragment shown in Fig. 5). — 500/1.


3/1
1


3/1
2


3/1
3


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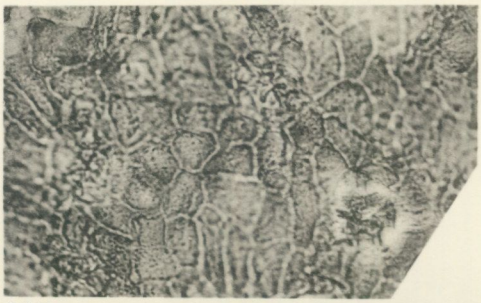
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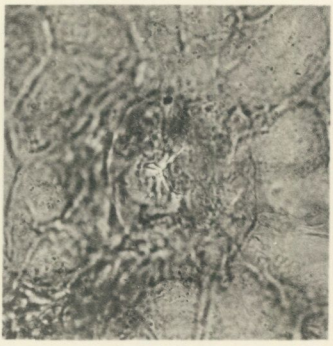
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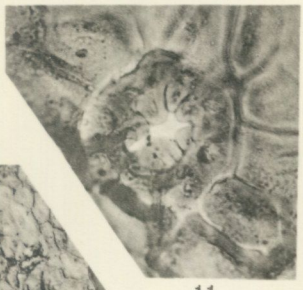
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