A Selaginelloid Strobilus from East Greenland (Triassic).

By

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Abstract.

Description of plant remains from the Eotriassic of Hold with Hope collected during the G. G. U.[1]) expedition in 1946. A strobilus containing megaspores — *Selaginellites polaris* sp. n. — is associated with microspores and dichotomizing vegetative organs. The remains are interpreted as belonging to a Selaginella-like plant, possibly to a heterosporous Lycopsid of a size between the living Selaginellas and the arborescent forms of the Palaeozoic, a type known from the Triassic in particular. The morphology of the megaspores is discussed at some length, with especial reference to the studies in recent Selaginellas by FITTING.

Introduction.

The Greenland plant remains described below were submitted to me for investigation by Professor T. G. HALLE, Stockholm, who in November 1947 obtained some material of this kind from the Palaeozoological Department of the Swedish Museum of Natural History. Through Dr. E. JARVIK of this Department, the rock specimens were later on sent to Copenhagen for labelling by their collector, Dr. EIGIL NIELSEN, who provided the data given below. The material belongs to the collections of the G. G. U. expedition made in the summer of 1946, under the leadership of Dr. NIELSEN. The plant remains to be described here were collected — in a single hand-specimen — in the Hold with Hope area, East Greenland, on the northern slope of Mt. Steensby, at a horizon ca. 10 m below the Zone with *Myalina kochi* of NIELSEN 1935 (altitude 445 m above sea level). The material belongs to a succession of strata, which from the evidence provided by the fossil faunas is regarded as of Eotriassic age (see NIELSEN 1935).

[1]) G. G. U. = Grønlands Geologiske Undersøgelse, Geological Survey of Greenland.

Description of the Material.

On a slab of very fine-grained yellowish grey sandstone was exposed the impression of a small strobilus shown in text-fig. 1 and figs. 1–2. At first sight it might be mistaken for a Coniferous cone, but microscopical investigation of some carbonaceous remains attached to the impression showed after maceration (HNO_3 + $KClO_3$ + ammonia) Lycopsid affinities of the fossil, which was also confirmed by a closer study of the scale-like carbonaceous structures still attached to the surface of the strobilus (fig. 3), which in fact represented compressed megasporangia.

In order to obtain microfossils that might be of some stratigraphic value, the slab containing the strobilus was subjected to bulk maceration according to HARRIS (1926), a method used by the SAHNI school of India in searching for micro-fossils for stratigraphical purposes (see review in SAHNI 1946). Attempts were also made to separate microfossils from the rock by a method given by KNOX (1942), previously used by the present author on cores from Höllviken in SW Scandia. No well-defined plant remains were obtained, however, except for clusters of microspores of a type known to occur among the heterosporous Lycopsida (figs. 8–11), and a few megaspores identical with those found in the strobilus. The association of a strobilus containing megaspores with microspores as well as with impressions of dichotomizing stems or leaves is of great interest, although the different remains cannot be definitely referred to the same plant on the evidence now available.

Selaginellites polaris sp. nov.

Text-fig. 1, Plate VI figs. 1–11.

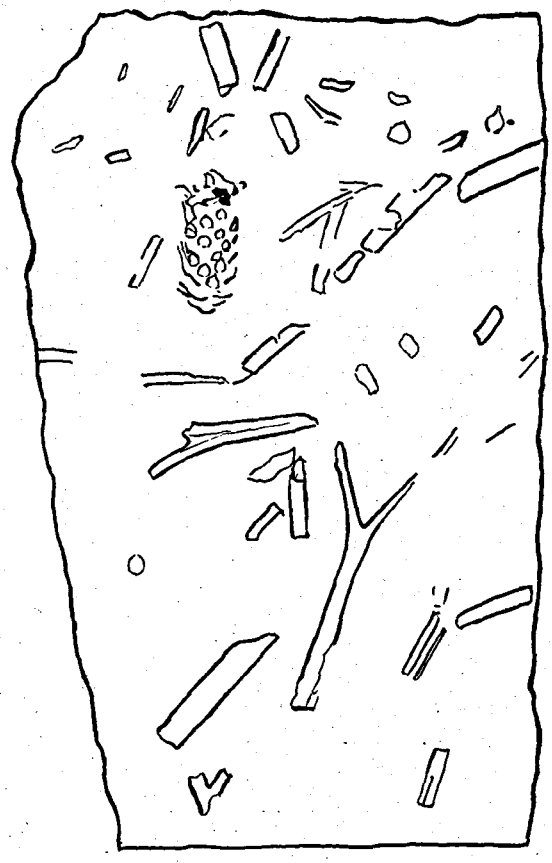
Coll. — EIGIL NIELSEN 9/8 1946.

Occurrence. — East Greenland, Hold with Hope; northern slope of Mt. Steensby, 445 m. Ca. 10 m below the *Myalina kochi* Zone.

Age. — Eotriassic.

Diagnosis. Description of type specimen. — Strobilus about 7 mm wide, at least 18 mm long. Surface of strobilus showing roundish scars, up to 2 mm in diameter, spirally arranged on the axis; sporophylls visible mainly in perifery of strobilus, especially in its basal portion. Spatial arrangement of sporangia and sporophylls not quite clear, original lenght of strobilus unknown. Number of megaspores in megasporangium large. Figs. 1–3.

Megaspore.[1]) — Megaspore spheroidal, equatorial diameter 412 μ (5 measurements, range 392–431 μ). P:E = 0.91 (only one measurement, referring to a specimen with an equatorial diameter



Text-fig. 1. Schematic drawing of rock-specimen showing strobilus (*Selaginellites polaris* sp. nov.), and dichotomizing stem or leaf fragments. — $^1/_1$.

of 431 μ, a polar diameter of 392 μ). Diameter of mesospore considerably smaller than that of exospore, 284 μ (5 measurements, range 274 μ–294 μ)[2]). Exospore finely granulate, with a thickness of

[1]) Terminology of spore coats in accordance with FITTING 1900; cf. p. 356.

[2]) Unfortunately, the figures given in the diagnosis may possibly refer to ± overmacerated specimens; in a specimen subjected to very gentle chemical treatment the diameter of the outer spore coat was 314 μ, the inner coat 225 μ (p. 354). Some overmaceration is difficult to avoid, however, as the individual grains of the original

about 10 μ; triradiate markings attaining a length of up to about half the diameter of the spore, height of triradiate ridges about 40 μ (as seen in the specimen shown in fig. 6). Mesospore thin, quite smooth or with position of triradiate markings represented by three-rowed scars, converging towards apex of spore. Figs. 4–7.

Microspore (*Selaginellites polaris*?)—Microspore of medium size, trilete, roundish triangular in polar view, consisting of a spore body with an equatorial diameter of about 40 μ, and a marginal flange, 5 μ broad. Exospore smooth, tetrad scars rather faint, apex of spore showing three spots in the angles between the tetrad markings. Figs. 8–11.

Remarks. — The strobilus named *Selaginellites polaris* was probably composed in the manner of recent Selaginellas, i. e. with sporangia placed adaxially in spirally arranged sporophylls. Owing to the relatively large size of the megaspores, their presence was indicated in the sporangia even when these were still attached to the strobilus. The aspect of the macerated megaspores is rather peculiar, because of a characteristic separation of the spore wall into two coats (fig. 4–6). This condition may in part be due to a tendency to shrinking on the part of the inner coat of the spores, the mesospore, combined with some swelling of the outer coat, the exospore, but probably reflects the original anatomical structure of the spores (p. 356). The spores shown in figs. 4–6 may probably to some degree have suffered from overmaceration (cf. HARRIS 1944, pp. 672–673), but the distance between the two spore coats was at any rate large, even in specimens subjected to gentle chemical treatment. To the description may be added that the finely granulate exospore contains large granulae resembling oil-drops. In strongly overmacerated grains the inner coat was seen to leave its envelope, entering the maceration fluid in the form of detached grains of smaller size (fig. 7).

As the state of preservation of the microspores was not particularly favourable, most of the specimens being still in tetrads or clusters (figs. 10–11), only a few isolated spores of this type could be studied (figs. 8–9). There is no reason, however, to suppose that the material was not homogeneous, i. e. did not belong to the same plant.

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clusters of spores do not separate, and thus cannot be properly studied until the oxidative processes are already relatively far advanced.

Discussion.

Strobilus.

The strobilus described on p. 352 must—at least provisionally—be assigned to the genus *Selaginellites* instituted by ZEILLER (1906) for heterosporous fossil species of Lycopods resembling recent Selaginellas. I do not intend to survey the genus here, but refer the reader for information to HALLE 1907, p. 8; SEWARD 1910, p. 85, HARRIS 1935, p. 155; cf. also DARRAH 1938. Although fossil Selaginellas are known from the Carboniferous, remains of these delicate plants are very rare. Only one species of *Selaginellites* has as yet been described from the Mesozoic (SEWARD 1913), but the rather extensive presence of the group is indicated by finds of megaspores (cf. BLACK 1929, p. 418; HARRIS 1935, p. 154; 1947, p. 21; WICHER 1942, pl. 27).

The type species of the genus *Selaginellites*, *S. Suissei* ZEILLER, of the Carboniferous of Blanzy, was stated by its author to differ from recent Selaginellas in having more than four megaspores in each megasporangium, a feature shared by the Greenland strobilus described here and also known to occur in *S. elongatus* (GOLDENBERG) HALLE. ZEILLER considered this feature a distinction between *Selaginellites* and the living genus. Later research has shown, however, that the number of megaspores in the megasporangium may be occasionally large even in now living forms, up to 42 spores being recorded from one megasporangium in *Selaginella Willdenowii* (DUERDEN 1929).

When compared with living and fossil Selaginellas, it is quite evident that the present material does not very well agree with the general aspect of *Selaginella* cones. These are generally very slender, at times *(Homoeophyllum)* almost indistinguishable from sterile shoots, whereas the present strobilus is remarkable on account of its relative stoutness. On the other hand, its dimensions do not match those of the Early Mesozoic successors of the *Lepidodendrales*, e. g. the well-known *Pleuromeia* of the Bunter or *Lycostrobus* of the Upper Triassic. The type of strobilus represented by the Bunter genus *Poecilitostachys* FLICHE (1910, p. 261) is nothing like the present material, although its strobili are larger than those of the Selaginellas. The rather large *Lepidostrobus paläotriasicus* FRENTZEN (1915, pp. 92–93; pl. 14, figs. 3–5), of the Bunter of Baden, may resemble the Greenland material somewhat, but is too incompletely known—its Lycopsid affinities are doubtful—to permit adequate comparison.

Rare forms, of sizes comparable with the present type, occur among the fructifications of the Palaeozoic members of the Lycopsida. The *Lepidostrobus* cones differ in shape from those of recent Lycopods in the radial extension of their megasporangia and the overlapping laminae of their sporophylls. As far as can be seen from the present specimen, the Greenland material is more reminiscent of the strobili of the living Selaginellas than of those of the arborescent Lycopods of the Palaeozoic, although its axis might possibly have been more fleshy.

Megaspore. — The size of the megaspores of *S. polaris* is within the range of sizes occurring in the genus *Selaginella*, according to HIERONYMUS between 0.14 and 1.5 mm.

The ready separation of the megaspore coats is characteristic of the present material (pp. 353–354). FITTING (1900) examined material of some species of *Selaginella* and found that during the development of the spore the exospore and the mesospore — which in the mature spores are lying close together — generally separate to a considerable extent (l. c. p. 43; pl. II, figs. 23, 26–27; in these figures the exospore and the mesospore are still joined at the apex of the spore, cf. fig. 6 of the present paper). FITTING mentions earlier observations in this direction; cf. also HIERONYMUS 1900, p. 661; LYON 1901, p. 129. SEWARD (1913, p. 87) observed a thin inner membrane in the interior of a megaspore of *Selaginellites Dawsoni*, which apparently is comparable with the conditions seen in the megaspores of *S. polaris*. HARRIS (1935) mentions a separation of the spore wall into two layers in one of the species of *Triletes* described by him from the Rhaetic-Liassic deposits of Scoresby Sound (*T. pinguis*). Even if the influence of a possible over-maceration of many specimens is considered, the differences in the sizes of the two coats seem rather extreme in *S. polaris*; in HARRIS'S material they were at any rate slight.

The interpretation of similar observations made in studying megaspores from the Carboniferous may be recalled in this connection (cf. review in DIJKSTRA 1946, pp. 22–23: "Bau der Sporenwand"). A thin inner coat noticed in some spores has been described by some authors (WICHER, ZERNDT) as the mesospore. In other cases, apparently when a sculpture is clearly visible on the inner coat, this has been interpreted as representing an inner layer of the exospore. A comparison with the endospore of living forms is out of the question, cf. WICHER 1934, p. 168. In the case illustrated

here (fig. 7) the triradiate markings on the inner membrane are faint, and could not be distinguished at all in many similar specimens. For these reasons I am inclined to believe that this inner sculpture might have been produced during fossilization by the pressure of the overlying proximal portion of the exospore on an originally smooth mesospore (cf. spore cast figured by SITHOLEY 1943: pl. 5, phot. 30 A). A comparison with FITTING'S illustrations makes the interpretation of the inner spore coat of *S. polaris* as the mesospore seem very attractive.

No fossil Lycopsid megaspore from the Mesozoic described in literature shows specific identity with *S. polaris*, (cf. FITTING 1907, NATHORST 1908, SEWARD 1913, MÄGDEFRAU 1931, MINER 1932, HARRIS 1926 a, 1935, 1946, MURRAY 1939, KENDALL 1942, SITHOLEY 1943). The megaspore of *S. polaris* belongs to the *Triangulati* section of SCHOPF (1938) and to the "*Triletes laevigati*" of KIDSTON, who compared the forms included in this group with the megaspores of the recent *Selaginella Martensii* (BENNIE and KIDSTON 1886, p. 106).

Microspore. — The microspores probably referable to *S. polaris* are within the range of sizes of the microspores of *Selaginella* (0.03 –0.085 mm, HIERONYMUS 1900, p. 664; 15 μ to 50 μ according to KNOX 1938, p. 442). They also agree in shape with the microspores of this genus, some species of which have wing-like equatorial extensions of the spore wall (see for instance HIERONYMUS 1900, fig. 402; J. KNOX, l. c. p. 442, fig. 23).

A counterpart to the peculiar pitted sculpture of the microspore apices may be seen in the megaspores illustrated in HALLE 1907 (pl. 3, figs. 3–4: *Selaginellites elongatus*) and KIDSTON 1886 (pl. II, fig. 2 c); HALLE interprets the pitting as pores in the exospore (l. c. p. 12).

The Reference of the various Plant-remains to the same Plant.

The evidence in favour of a connection between the megaspore-bearing strobilus and the microspores is strong; no other spores were found (besides a few megaspores of the type seen in the strobilus itself), although repeated attempts were made to obtain microfossils from the rock. This was obviously sufficiently fine-grained to preserve cutinized material, but no carbonaceous substance was left on the impressions, nor were any determinable cuticles obtained when the rock was disintegrated. For these reasons I am inclined to

think that the dichotomizing leaf or stem fragments seen in text-fig. 1 may possibly belong to the Lycopsid reproductive organs (the leaf cuticle of the lower vascular plants is generally delicate and destroyed by oxidative maceration), but the question cannot be definitely settled by these indications. Additional information from new material would at any rate be of great botanical interest, as the plant belongs to a group which is rarely found in the fossil state.

The plant-remains from the Hold with Hope area of East Greenland, described as *Selaginellites polaris* sp. nov., belong to a heterosporous Selaginelloid plant probably larger than the living Selaginellas. Occurences of heterosporous Lycopsida of sizes between those of the small forms now living and the arborescent types of the Palaeozoic are known from the Triassic in particular, but the vertical range of the genus *Selaginella sensu latu* extends from the Palaeozoic to the present time, and the material is thus of little stratigraphic value. Owing to the exceptional rarity of fossil preservations of similar plants, however, the finds are of considerable interest from a botanical-morphological point of view.

Postscript. Samples of some additional rock specimens from East Greenland, sent to Stockholm by Dr. NIELSEN, were prepared according to KNOX 1942. In a slab of yellowish or greenish grey, very fine-grained sandstone, collected by NIELSEN (16/8 1948)

Explanation of plate.

Figs. 1–7. *Selaginellites polaris* sp. nov.

Fig. 1. Strobilus (type specimen) with dichotomizing stem or leaf fragments. — 1/1.

Fig. 2a, b. The same, enlarged. — 3/1.

Fig. 3. Megasporangia, from uppermost portion of strobilus. — 6/1.

Fig. 4. Megaspore, probably ± overmacerated. Polar view. — 100/1.

Fig. 5. Megaspore, overmacerated. Oblique-polar view. — 100/1.

Fig. 6. Megaspore, probably overmacerated. Lateral view. — 100/1.

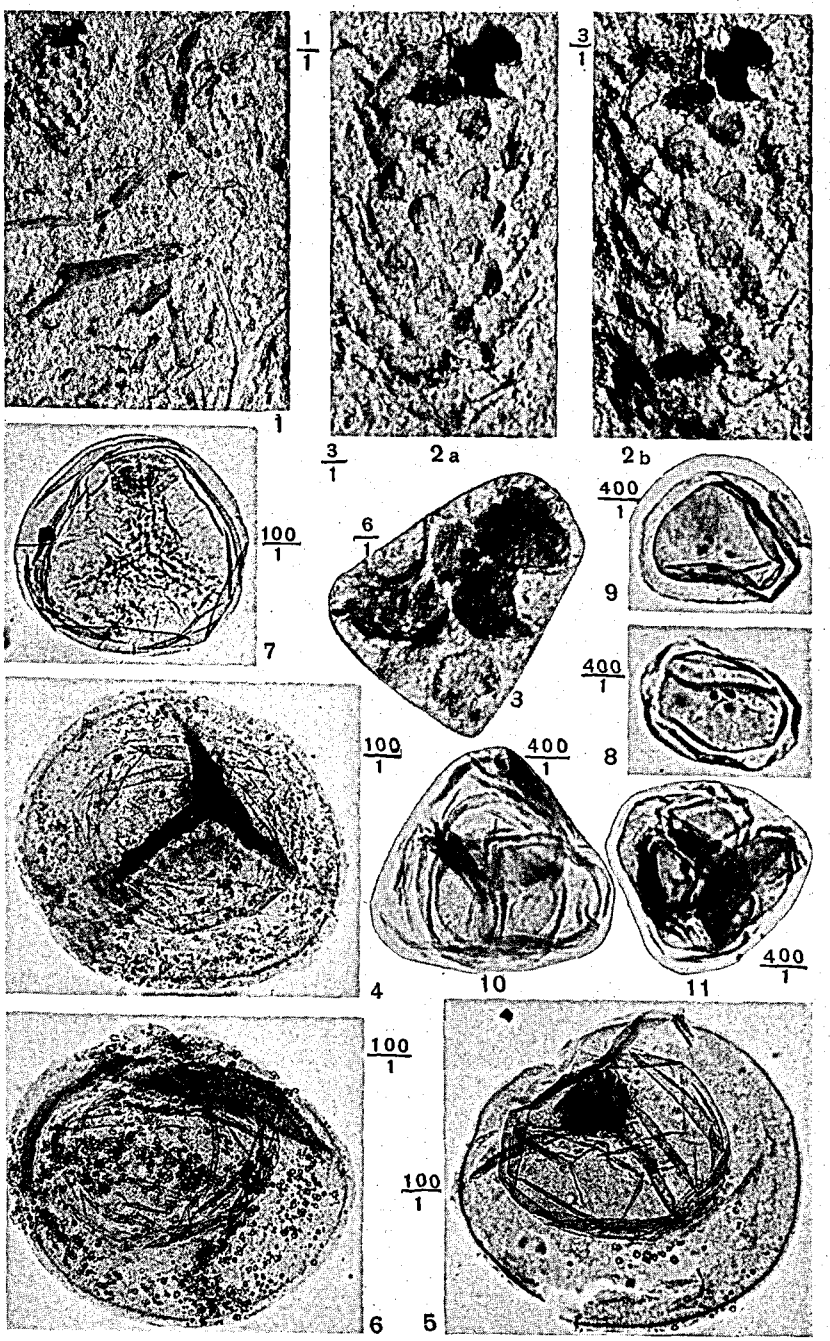
Fig. 7. Inner coat of megaspore (mesospore) obtained from overmacerated, crushed specimen. Polar view. — 100/1.

Figs. 8–11, *Selaginellites polaris* sp. nov. (?)

Figs. 8–9. Microspores. Fig. 8 oblique view, fig. 9 polar view. — 400/1.

Figs. 11–11. Microspores in tetrads. — 400/1.

Type specimen kept at Geol. Min. Museum, University of Copenhagen, spore preparations in Paleobotaniska avdelningen, Riksmuséet, Stockholm. — All the photographs are untouched.



(K. E. Samuelsson, phot.).

and labelled Traill Island, central portion of Mt. Svinhuvud, 830–840 m, megaspores obviously conspecific with *Selaginellites polaris* from Hold with Hope were obtained. The rock seemed to be identical with that of the Hold with Hope locality, and contained a fragmentary stem cast (indeterminable), 4–7 mm broad. — The macerated material shows the morphological characteristics of the megaspores obtained from the strobilus; the variation in size of the diameter of the spores measured (E) was 324–437 μ (5 measurements, average 353 μ), whereas the diameter of the inner coat was found to be about 262 μ (3 measurements, range 259–267 μ). It is difficult to ascertain if variations refer to the material itself, the state of preservation or the chemical treatment; shrinkage was observed, however, in some of the spores measured.

I wish to express my sincere gratitude to Professor HALLE for entrusting to me the investigation of this material, and for putting the facilities of the Palaeobotanical Department at my disposal. I am further indebted to Dr. E. JARVIK for his courtesy in forwarding to me the geological information about the material.—The photographs were taken by Mr. K. E. SAMUELSSON, Stockholm.

Riksmuséets paleobotaniska avdelning, Stockholm, October 1948.

BIBLIOGRAPHY

BENNIE, J., and KIDSTON, R.: 1886. On the occurrence of spores in the Carboniferous formation of Scotland. — Proc. Roy. Phys. Soc. Edinb., Vol. IX. Edinburgh.

BLACK, M.: 1929. Drifted plant-beds of the Upper Estuarine Series of Yorkshire. — Quart. Journ. Geol. Soc., Vol. LXXXV, Pt. 4. London.

DARRAH, W. C.: 1938. A remarkable fossil *Selaginella* with preserved female gametophytes. — Bot. Mus. Leafl. Harvard Univ., Vol. 6, No. 6. Cambridge, Mass.

DIJKSTRA, S. J.: 1946. Eine monographische Bearbeitung der karbonischen Megasporen mit besonderer Berüksichtigung von Südlimburg (Niederlande). — Uitk. n. geol.-pal. Onderz. Ondergr. Nederl. In Meded. Geol. Sticht., Ser. C, III, 1, No. 1. Maastricht.

DUERDEN, H.: 1929. Variations in megapore number in Selaginella. — Ann. Bot. 43. London.

FITTING, H.: 1900. Bau und Entwickelungsgeschichte der Makrosporen von *Isoëtes* und *Selaginella* und ihre Bedeutung für die Kenntniss des Wachstums pflanzlicher Zellmembranen. — Bot. Zeitung, Heft VII/IX. Leipzig.

— 1907. Sporen im Buntsandstein — die Makrosporen von *Pleuromeia?* — Ber. Deutsch. Bot. Ges., Bd. XXV, H. 8. Berlin.

FLICHE, P. and ZEILLER, M. R.: 1910. Flore Fossile du Trias en Lorraine et Franche-Comté. — Bull. Soc. Sci. Nancy, Sér. 3, 11. Paris & Nancy.

FRENTZEN, K.: 1915. Die Flora des Buntsandsteins Badens. — Mitt. Grossh. Bad. Geol. Landesanst., Bd. VIII, H. 1. Heidelberg.

HALLE, T. G.: 1907. Einige krautartige Lycopodiaceen paläozoischen und mesozoischen Alters. — Ark. f. Bot., Bd. 7, No. 5. Uppsala & Stockholm.

HARRIS, T. M.: 1926. Note on a new method for the investigation of fossil plants. — New Phytol., Vol. XXV, No. 1. London.

— 1926 a. The Rhaetic flora of Scoresby Sound, East Greenland. — Medd. om Grønland, Bd. 68. København.

— 1935. The fossil flora of Scoresby Sound East Greenland. Part 4: *Gingkoales, Coniferales, Lycopodiales* and isolated fructifications. — Ibidem, Bd. 112, No. 1.

— 1944. Notes on the Jurassic Flora of Yorkshire, 13—15. — Ann. Mag. Nat. Hist., Ser. 11, Vol. XI. London.

— 1946. Liassic and Rhaetic plants collected in 1936–38 from East Greenland. — Medd. om Grønland, Bd. 114, No. 9. København.

— 1947. The problems of Jurassic paleobotany. — Bol. Soc. Geol. Portugal, Vol. VI, Fasc. III. Porto.

HIERONYMUS, G.: 1900. *Selaginellaceae.* — In ENGLER, A. & PRANTL, K. 1902. Die natürl. Pflanzenfam., I. Teil, 4 Abt. Leipzig.

KENDALL, M.: 1942. Jurassic Lycopod megaspores from the Gristhorpe plant bed. — Ann. Mag. Nat. Hist., Ser. 11, Vol. IX. London.

KNOX, A. S.: 1942. The use of bromoform in the separation of non-calcareous microfossils. — Science, N. S., 95. Lancaster, Pa.

KNOX, E. M.: 1938. The spores of *Pteridophyta*, with observations on microspores in coals of Carboniferous age. — Trans. Bot. Soc. Edinb., Vol., 32, pt. 3. Edinburgh.

LYON, F. M.: 1901. A study of the sporangia and gametophytes of *Selaginella apus* and *Selaginella rupestris.* — Bot. Gaz., Bd. XXXII. Chicago Ill.

MINER, E. L.: 1932. Megaspores ascribed to *Selaginellites*, from the Upper Cretaceous coals of Western Greenland. — Journ. Wash. Acad. Sci. Vol. 22, No. 18, 19. Baltimore, Md.

MURRAY, N.: 1939. The microflora of the Upper and Lower Estuarine Series of the East Midlands. — Geol. Mag., Vol. LXXVI. London.

MÄGDEFRAU, K.: 1931. Zur Morphologie und phylogenetischen Bedeutung der fossilen Pflanzengattung *Pleuromeia.* — Beih. Bot. Centralbl., Bd. XLVIII, Abt. II, Heft 1. Dresden.

NATHORST, A. G.: 1908. Paläobotanische Mitteilungen 3. *Lycostrobus Scotti,* eine grosse Sporophyllähre aus den rätischen Ablagerungen Schonens. — Kungl. Sv. Vet. akad. Handl., Bd. 43, No. 3. Uppsala & Stockholm.

NIELSEN, E.: 1935. The Permian and Eotriassic Vertebrate-bearing Beds at Godthaab Gulf (East Greenland). — Medd. om Grønland, Bd. 98. København.

SAHNI, B.: 1946. Microfossils and the Salt Range thrust. — Proc. Nat. Acad. Sci., Vol. 16. Lucknow.

SCHOPF, J. M.: 1938. Spores from the Herrin (No. 6) coal bed in Illinois. — Illinois State Geol. Survey, Rep., No. 50. Urbana, Ill.

SEWARD, A. C.: 1910. Fossil plants. Vol. II. — Cambridge.

— 1913. A British fossil *Selaginella.* — New Phyt., Vol. 12, No. 3. London.

Sitholey, R. V.: 1943. Plant Remains from the Triassic of the Salt Range in the Punjab. — Proc. Nat. Acad. Sci., Ind., Vol. 13. Lucknow.

Wicher, C. A.: 1934. Zur Mikrobotanik der Kohlen und ihrer Verwandten. Sporenformen der Flammkohle des Ruhrgebietes. — Arb. Inst. Paläobot. u. Petr. d. Brennsteine, Bd. 4. Berlin.

— 1942. Praktikum der angewandten Mikropaläontologie. Berlin.

Zeiller, R.: 1906. Études sur la flore fossil du bassin houiller et permien de Blanzy et du Creuzot. — In Études des gîtes minéraux de la France. Paris.

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