71-28

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DEPARTMENT OF ENERGY,
MINES AND RESOURCES

PAPER 71-28

EARLY DEVONIAN LAND PLANTS FROM BATHURST ISLAND, DISTRICT OF FRANKLIN

(Report and 3 plates)

F. M. Hueber

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ABSTRACT

Two collections of Early Devonian land plants belonging to the Zosterophyllophytina and Lycophytina, from Bathurst Island, District of Franklin, are described and figured. The assemblage from GSC plant locality 8370 contains *Bathurstia denticulata* n. gen. et n. sp., *Rebuchia capitanea* n. sp., *Sawdonia ornata* (Dawson) Hueber, *Drepanophycus spinaeformis* Göppert, cf. *Bathurstia* sp., and an unnamed zosterophylloid axis. A specimen of *Sawdonia ornata* is described from GSC plant locality 8376. The plants are of Siegenian and Emsian age respectively on the bases of the invertebrate fossils and dispersed plant spores with which they are associated. The Siegenian plants represent the earliest record thus far of land plants in Canada and the first report of Early Devonian plants from the Canadian Arctic.

The presence of a cuticle was demonstrated for all but one of the plants. Evidence of a vascular strand composed of tracheids was obtained only from the specimen of *Drepanophycus*. Those fossils with a cuticle but lacking a xylem strand should be described as those of land plants and not as those of land vascular plants. The probable sequence in the origin of cuticle, cutinized spores, vascular strand composed of tracheids, and stomata, is briefly discussed.

RÉSUMÉ

L'auteur donne une description, avec illustrations, de deux collections de plantes terrestres du début du Dévonien des genres Zosterophyllophytina et Lycophytina de l'île Bathurst, dans le district de Franklin. L'assemblage provenant du site paléobotanique 8370 de la Commission géologique du Canada comprend *Bathurstia denticulata* n. gen. et n. sp., *Rebuchia capitanea* n. sp., *Sawdonia ornata* (Dawson) Hueber, *Drepanophycus spinaeformis* Göppert, cf. *Bathurstia* sp. et un axe zosterophylloïde, non dénommé. L'auteur décrit un spécimen de *Sawdonia ornata* trouvé au site paléobotanique 8376 de la CGC. L'association de ces plantes avec certains fossiles d'invertébrés et spores de plantes indique qu'elles appartiennent au Siegenien et à l'Emsien respectivement. Les plantes du Siegenien sont jusqu'ici les plus anciennes plantes terrestres découvertes au Canada ainsi que les premières plantes du début du Dévonien mises à jour dans l'Arctique canadien.

Toutes les plantes, à l'exception d'une, présentent une cuticule. Seul le spécimen de *Drepanophycus* présentait une évidence d'une fibre vasculaire composée de trachéides. Les fossiles avec une cuticule mais sans liber sont ceux des plantes terrestres et non pas des plantes terrestres à fibre vasculaire. L'auteur traite brièvement de la séquence probable de l'apparition de la cuticule, des spores cutinisées, de la fibre vasculaire à trachéides et des stomates.

EARLY DEVONIAN LAND PLANTS FROM BATHURST ISLAND, DISTRICT OF FRANKLIN

INTRODUCTION

Among the richly productive collecting sites of the world for fossils of early land plants, the Devonian sediments in Canada are particularly noteworthy. The region of Gaspé Bay, Québec, for example, is an historical site that continues to yield new collections of importance in elucidating early stages of evolution of plants. The great value of the Gaspesian fossil flora is lessened only slightly by the fact that it does not represent the oldest land flora in the geological record. The oldest documented occurrences of fossil land plants are those of the genus *Cooksonia* in the Upper Silurian of Wales (Downtonian; Lang, 1937), Podolia (Skala; Ischenko, 1969), and Czechoslovakia (Pridoli; Obrhel, 1962). Banks (in press) indicates the first occurrence of land plants in the Western Hemisphere, i.e., *Cooksonia* in the Upper Silurian (Cayugan Series, Bertie Limestone) of New York State. Churkin, *et al.* (1969) presented the first evidence for the oldest Devonian land vascular plant remains in this hemisphere. These remains were from southeastern Alaska, and are associated with the graptolite *Monograptus* aff. *M. thomasi* Jaeger. On the basis of graptolites, the Alaskan plants are considered to be the same age as the *Baragwanathia* flora of Australia, the age of which is Siegenian (Jaeger, 1967).

An attempt is made in this report to describe Early Devonian land plants found associated with graptolites, conodonts and cutinized, dispersed, plant spores in collections obtained from Bathurst Island, District of Franklin, by D.C. McGregor and T.T. Uyeno. One locality, GSC plant locality 8370, is in a section 4 miles east of the head of Young Inlet, northeastern Bathurst Island. Plant remains are found in hard, fine-grained sandstone 30 feet below the top of the Bathurst Island Formation and below a thin chert-pebble conglomerate that marks the base of the overlying Stuart Bay Formation. Based on invertebrate and palynological fossils, the age of the plant-bearing horizon is Siegenian (McGregor and Uyeno, in press). This constitutes the earliest record of vascular plants in Canada and the first report of Early Devonian plants from the Canadian Arctic.

From a second locality, GSC plant locality 8376, a single specimen is described in this report. The horizon is in the Stuart Bay Formation, 525 feet higher in the same stratigraphic section as that in which GSC plant locality 8370 occurs. This horizon is Emsian (McGregor and Uyeno, in press).

The writer wishes to thank the Geological Survey of Canada for permission to study and describe these plant remains. Photographic illustrations of the specimens by the photographic section of the Geological Survey of Canada and James P. Ferrigno of the Division of Paleobotany, Smithsonian Institution, are gratefully acknowledged.

PRESERVATION

The plants are preserved as lustrous black films on grey to dull, brownish black, fine-grained sandstone. The grey colour of the matrix is due to prolonged weathering of the naturally broken bedding-plane surfaces. On

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Plate I (GSC No. 201781-A)

Figure 1. Fragment of poorly preserved xylem of *Drepanophycus spinaeformis* Göppert 1852 showing portions of eight tracheids. Secondary wall thickenings are pointed out at the arrow and others may be seen at various points along neighbouring tracheids, x 75. Hypotype, GSC No. 29905. GSC plant loc. 8370. (Page 14)

Figure 2. Mass of poorly preserved spores isolated from sporangia at the apex of the spike of *Rebuchia capitanea* n. sp., x 100. Holotype, GSC No. 29899. GSC plant loc. 8370. (Page 5)

Figure 3. *Drepanophycus spinaeformis* Göppert 1852. Hypotype, GSC No. 29905, x 1. GSC plant loc. 8370. (Page 14)

Figure 4. *Sawdonia ornata* (Dawson) Hueber 1971. Spinous axis with branch at arrow, x 1. Hypotype, GSC No. 29897. (Page 4)
Specimen intertangled with *Bathurstia denticulata* n. gen. et n. sp., x 1. Paratype, GSC No. 30022. GSC plant loc. 8370. (Page 9)

Figure 5. *Rebuchia capitanea* n. sp., x 1. Holotype, GSC No. 29899. GSC plant loc. 8370. (Page 5)

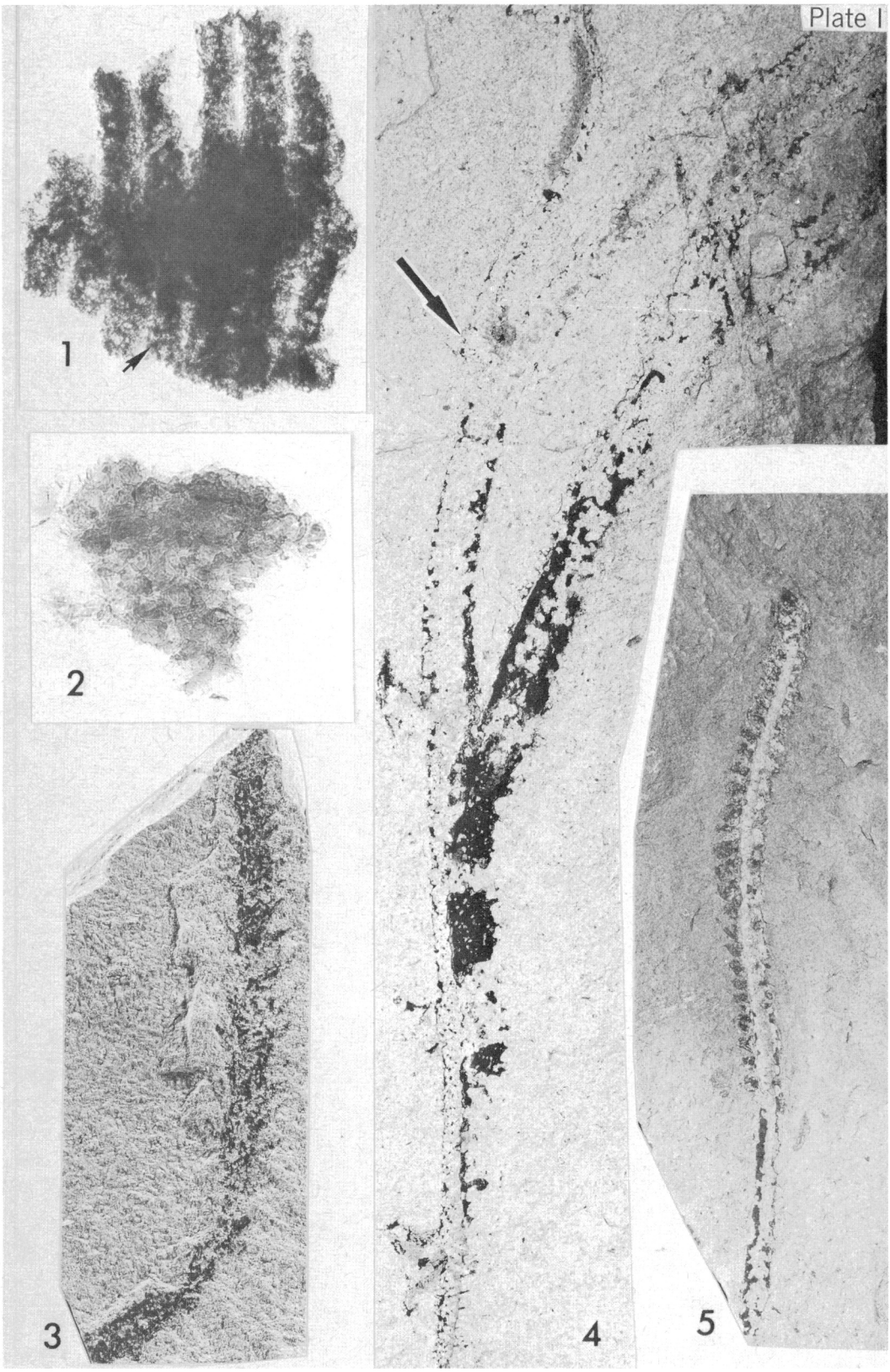


Plate I
1
2
3
4
5

freshly broken surfaces the matrix is very dark and the plants are discernible only under oblique lighting. Although fragmentary and not very well preserved, the plant remains are more abundant and generally represent plants of more robust size than those described from Alaska (Churkin, *et al.*, 1969).

Evidence that the plants went through an extended period of decay and softening of tissues prior to burial and compression is clearly shown. Featureless cuticular material, poorly preserved spore masses (Pl. I, fig. 2), and small groups of poorly preserved tracheids (Pl. I, fig. 1) were isolated from some of the fragments of carbon removed from the stems and sporangia. Repeated attempts to obtain more anatomical details failed, and, as a result, the descriptions of the genera represented in these collections stress the morphology of the axes and fertile parts as observed on the matrix.

Treatment of fragments of carbon from the various plant axes and sporangia consisted of oxidation with Schulze's solution followed by washing with water and treatment with dilute ammonium hydroxide (*ca.* 5 per cent solution). The fragments of cuticle, vascular tissue and spore masses were mounted in glycerine jelly on slides. None of the cuticle exhibits epidermal patterns. The tracheids are nearly disorganized. The spores in the spore masses isolated from sporangia are not identifiable with known genera of *sporae dispersae*, and, accordingly, are of no stratigraphical value (D.C. McGregor, pers. comm.).

DESCRIPTION OF SPECIES

Genus *Sawdonia* Hueber 1971

Sawdonia ornata (Dawson) Hueber 1971

Plate I, figure 4

Psilophyton princeps var. *ornatum* Dawson 1871, p. 38, fig. 101.

Description.

Two fragments of this species are identifiable from the collections. Only the better is illustrated here. It is from GSC plant locality 8370 (Siegenian) and is closely associated with a large fragment of *Bathurstia*, a new genus described herein. The two specimens seem to have become entangled while drifting to the site where they sank and were buried. The stem fragment of *Sawdonia* is 22 cm long and 2.5 to 3 mm wide. One branch is poorly visible along the left side of the specimen (arrow). The spinous character of the stem is best observed on the lower portion of the specimen where a lateral view is obtained of the spines and the irregularly punctate pattern of spinae bases is preserved on the stem surface. The spines are gradually tapered to fine points and are from 1.5 to 2.3 mm in length. The second stem (GSC plant locality 8376; Emsian) is 11.5 cm long and 4 to 4.5 mm wide. Spines are visible in lateral view along the margins of the specimen, but most of the morphological details of the stem surface have been removed by weathering. The spines are 2.5 to 3 mm long and are the same as those described for the better specimen. No sporangia are associated with either fragment of *Sawdonia*. Flakes of carbonized tissues removed from the stems were chemically treated. Featureless cuticle was obtained and no internal anatomical details were revealed.

Remarks.

Prior to this Siegenian (GSC plant locality 8370) report, the geological range of *Sawdonia* has been considered as Emsian to basal Frasnian. Fossils reported as either *Psilophyton princeps* or *Psilophyton princeps* var.

ornatum require re-examination in order to confirm their identifications. Confirmation is also required of the age of the sediments from which they were obtained. The task of dispelling the nomenclatural and distributional confusion between *Psilophyton princeps* Dawson 1859 and *Sawdonia ornata* (*Psilophyton princeps* var. *ornatum*, Dawson 1871), is difficult but near completion.

The writer prefers to place *Sawdonia* in the Family Zosterophyllaceae rather than in the Gosslingiaceae as proposed by Banks (1968, p. 77). Banks' reference to the plant as (sic) "*Psilophyton* (non-Dawson, new name required)" would have been more appropriately given as "*Psilophyton princeps* var. *ornatum* Dawson 1871" in order to maintain nomenclatural accuracy. *Sawdonia* is placed in the Zosterophyllaceae because there is insufficient knowledge of the constituent species of the Zosterophyllophytina to warrant segregation of more than the single Family Zosterophyllaceae.

Types. Hypotypes, GSC Nos. 29897 (GSC plant loc. 8370) and 29898 (GSC plant loc. 8376).

Genus *Rebuchia* Hueber 1970

Type species. *R. ovata* (Dorf) Hueber 1970.

Bucheria ovata Dorf 1933, pp. 245-248, figs. 9-17.

Rebuchia ovata (Dorf) Hueber 1970, p. 822.

Diagnosis.

"Spineless, narrow axes bearing at their distal ends clusters of small rounded appendages, which are bilaterally-symmetrically arranged on opposite sides of the axes. Appendages closely set, sessile, and opposite to subopposite." (Dorf, 1933, p. 245.)

Rebuchia capitanea n. sp.

Plate I, figures 2, 5; Plate II, figures 1, 2

Description.

Fragment of axis 12 cm long, smooth and unornamented for 4 cm of its length and bearing fifty-four sporangia in two rows that extend to the apex of the specimen. Axis tapers from 3.8 mm at the base to 2 mm near the apex. Sporangia reniform in face view, ovate in side view, minutely, broadly stalked and arranged oppositely to subopposite along two sides of the axis forming a bilaterally symmetrical spike. Dehiscence of the sporangia is marked by a dark rim that extends around the periphery of each sporangium suggesting basipetal and complete dehiscence into two equal valves. Sporangia, where complete, are 3.2 to 3.5 mm high and 3.6 to 3.9 mm wide. Spore masses isolated from sporangia at the apex of the spike contained smooth, featureless spores.

Remarks.

R. capitanea is larger than any other species of *Rebuchia*. The name is derived from the Latin *capitaneus*, large, chief in size. *R. capitanea* differs from *R. ovata* (Dorf) Hueber, the type species of the genus, in that its sporangia are larger and more numerous. The spike of *R. capitanea* contains fifty-four sporangia whereas that of *R. ovata* contains sixteen to twenty. The sporangia of *R. capitanea* are one-fourth to nearly one-third larger than those of *R. ovata*. Dorf (1933, 1934a) gave no dimensions of the sporangia in his

Plate II (GSC No. 201781-B)

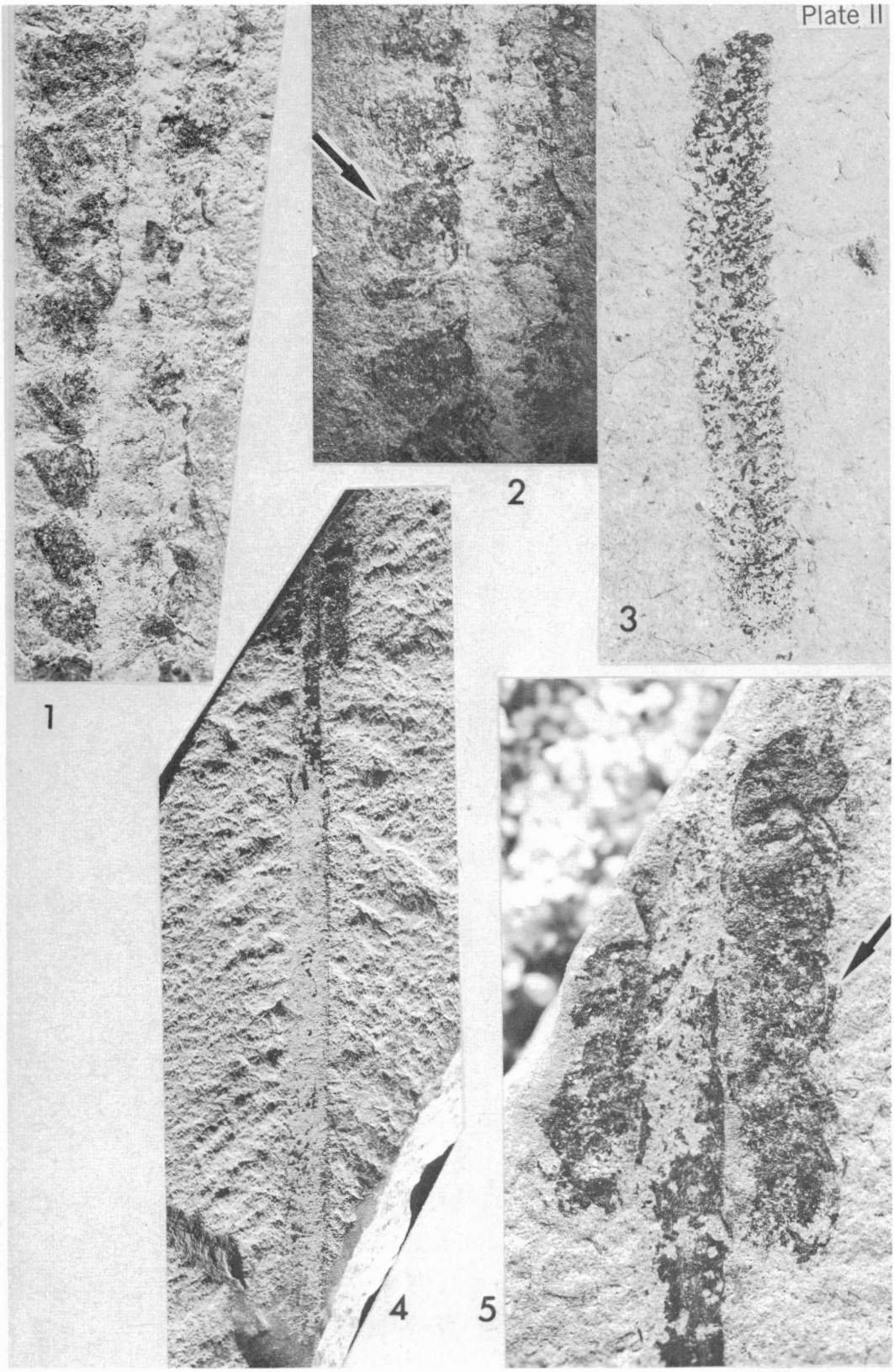
Figures 1, 2. *Rebuchia capitanea* n. sp. Views (x 4) of the sporangia illustrating outlines acquired by the sporangia as a result of compression or subsequent abrasion and weathering. A sporangium illustrating the true outline is shown at the arrow in Figure 2. Note the dark rims which mark the line of dehiscence along the margins of the valves. Holotype, GSC No. 29899. GSC plant loc. 8370. (Page 5)

Figure 3. Cf. *Bathurstia* sp. Fragment of spike composed of elongate reniform sporangia, x 1. The pointed appearance of some of the sporangia is due to their partial burial in the matrix. Hypotype, GSC No. 29903. GSC plant loc. 8370. (Page 13)

Figure 4. Zosterophylloid axis. Hypotype, GSC No. 29904, x 1. GSC plant loc. 8370. (Page 13)

Figure 5. Zosterophylloid axis, same as Figure 4, spike of sporangia, x 4. Note dark rims (arrow) which mark the line of dehiscence. Hypotype, GSC No. 29904. GSC plant loc. 8370. (Page 13)

Plate II



original description of *R. ovata* but Høeg (1967, p. 264) stated that the sporangia are 4 mm in diameter. No sporangia on specimens in the original collections made by Dorf, or any that this writer has observed in other collections, exceed 3 mm. The sporangia in *R. ovata* are definitely smaller and the size appears to be constant for that species.

The description of *R. mucronata* (Mägdefrau) Høeg (1942) was based on a single fragmentary specimen. The sporangia were described as mucronate. The validity of that characteristic could be debated because of the various shapes acquired by the sporangia of *Rebuchia* during the process of fossilization. In some specimens of *R. ovata* in which the sporangia have been flattened laterally, the sporangia appear to be mucronate (*see* Dorf, 1933, Pl. VI, fig. 13). *R. mucronata* is probably *R. ovata*; this assignment will be discussed in a later paper. The question of similarity of the sporangia of *R. mucronata* and *R. capitanea* is raised by illustrations of *R. capitanea* (Pl. I, fig. 5; Pl. II, fig. 1) which show what appear to be mucronate sporangia along the lower left margin of the spike. This appearance is due to the loss in that area of half of each of the sporangia in a plane perpendicular to the line of dehiscence when the matrix was split along the bedding plane. The similarity between *R. capitanea* and *R. mucronata* is superficial and the difference of size serves to separate them.

Bucheria? valdei Stockmans (1948) was properly treated as a questionable generic identification. The writer has examined the type specimen in Stockmans' collection and has observed that there are short, broadly based, minute hairs on the axis bearing the sporangia. The sporangia are larger and have longer and more pronounced stalks than *Rebuchia* and their mode of dehiscence is apparently by splitting only along their upper margins. The split does not seem to result in the production of two equal valves as in the dehiscence of a sporangium of *Rebuchia*. Therefore, *B.? valdei* probably should not be considered as belonging to *Rebuchia* and should be assigned to a different genus. *R. capitanea* differs from *B.? valdei* in that its axis is unornamented, its sporangia are only minutely stalked, and dehiscence is basipetal and complete along the entire distal margin of the sporangium.

Bucheria longa Høeg 1942, and *Bucheria? pendula* Stockmans 1940 have been reduced to junior synonyms (Høeg, 1967, pp. 259, 329), the former with *Zosterophyllum* Penhallow 1892, the latter with *Dawsonites* Halle 1916. The writer agrees with Høeg that both species originally were not properly assigned to *Bucheria* and that it was proper to place *B. longa* with *Zosterophyllum*; however, the assignment of *B.? pendula* to *Dawsonites* is not accepted. The morphology of the sporangia in *B.? pendula* is different from that for which *Dawsonites* was established. *Dawsonites* is a valuable genus to which isolated fragments of axes bearing terminal, fusiform, longitudinally dehiscent sporangia can be assigned. The sporangia in *B.? pendula* are not of that form.

Rebuchia is most closely related to *Zosterophyllum*, subgenus *Platyzosterophyllum*, Family Zosterophyllaceae, Order Zosterophyllales in the Subdivision Zosterophyllophytina.

The geological range of *Rebuchia* is not certain because of the doubtful identification of the genus in the described Devonian floras of the Northern Hemisphere. The type locality, in the Beartooth Butte Formation at Beartooth Butte, Wyoming, U.S.A., was designated by Dorf (1934b) simply as Lower Devonian. The age is probably Siegenian-Emsian on the basis of the composition of the flora described by Dorf.

Type. Holotype, GSC No. 29899.

Horizon. 30 feet below the top of the Bathurst Island Formation; Siegenian.

Genus *Bathurstia* n. gen.

Type species. *Bathurstia denticulata* n. sp.

Diagnosis.

Plant consisting of robust, cuticularized axes with small emergences that produce a denticulation along the margins of the compressed axes. Apices of axes circinnate. Sporangia large, elongately reniform, borne singly and alternately in two rows on opposite sides of the axis, the arrangement forming a bilaterally symmetrical, dense spike.

Bathurstia denticulata n. sp.

Plate I, figure 4; Plate III, figures 1-5

Description.

Plant with gently arching stems up to 8.0 mm in diameter and tapering very gradually at 0.012 mm per cm, apices circinnate. Stem surfaces cuticularized. Emergences on the stem are 1 to 1.8 mm high and 0.8 to 0.85 mm broad at their bases. Arrangement of the emergences produces a denticulate margin as the result of compression of the axes. Sporangia large, elongately reniform, 6.0 to 6.3 mm wide and 2.5 to 2.8 mm high, borne singly and alternately in two rows along opposite sides of the axis producing a spike 1.85 cm wide at the base.

The generic name *Bathurstia* is derived from the name of Bathurst Island, Parry Island Group, District of Franklin. The specific epithet is derived from the Latin *denticulatus*, with small teeth.

Remarks.

The pattern of branching, arrangement of the emergences over the surface of the stem, length of the spike, and anatomy of the stem and sporangia remain unknown for this plant. However, the details available from the type specimens are sufficient to indicate that they represent a new taxon.

The morphology of *Bathurstia*, as it is now known, suggests that it be classed in the Family Zosterophyllaceae. Tentatively it is most closely allied to *Zosterophyllum* subgenus *Platy-zosterophyllum* on the basis of the arrangement and morphology of its sporangia. However, this interpretation may change when better specimens showing more detail of sporangial anatomy and arrangement are obtained.

Bathurstia is distinguished from other genera of the Zosterophyllaceae by the denticulation along the margins of its compressed axis, the elongate reniform shape of its sporangia, and its robust size. Other genera of the Zosterophyllaceae that have ornamented stem surfaces are *Crenaticaulis* Edwards *ex* Banks and Davis 1969 and *Sawdonia*. In *Crenaticaulis* the teeth or emergences are arranged in one or two rows and are smaller than those in *Bathurstia*. The sporangia in *Crenaticaulis* are smaller than those in *Bathurstia* and are of a different morphology, exhibiting dehiscence into two unequal valves. The sporangia in *Crenaticaulis* are arranged in a loose spike whereas those in *Bathurstia* are closely arranged in a compact spike. *Bathurstia* can be distinguished readily from *Sawdonia;* the stems of the latter genus are ornamented with long, multicellular, narrowly pointed spines rather than small tooth-like emergences.

Plate III (GSC No. 201781-C)

Bathurstia denticulata n. gen. et n. sp. GSC plant loc. 8370. (Page 9)

Figure 1. Note portion of spike of sporangia and the denticulate margin of the axis, x 1. Holotype, GSC No. 29900.

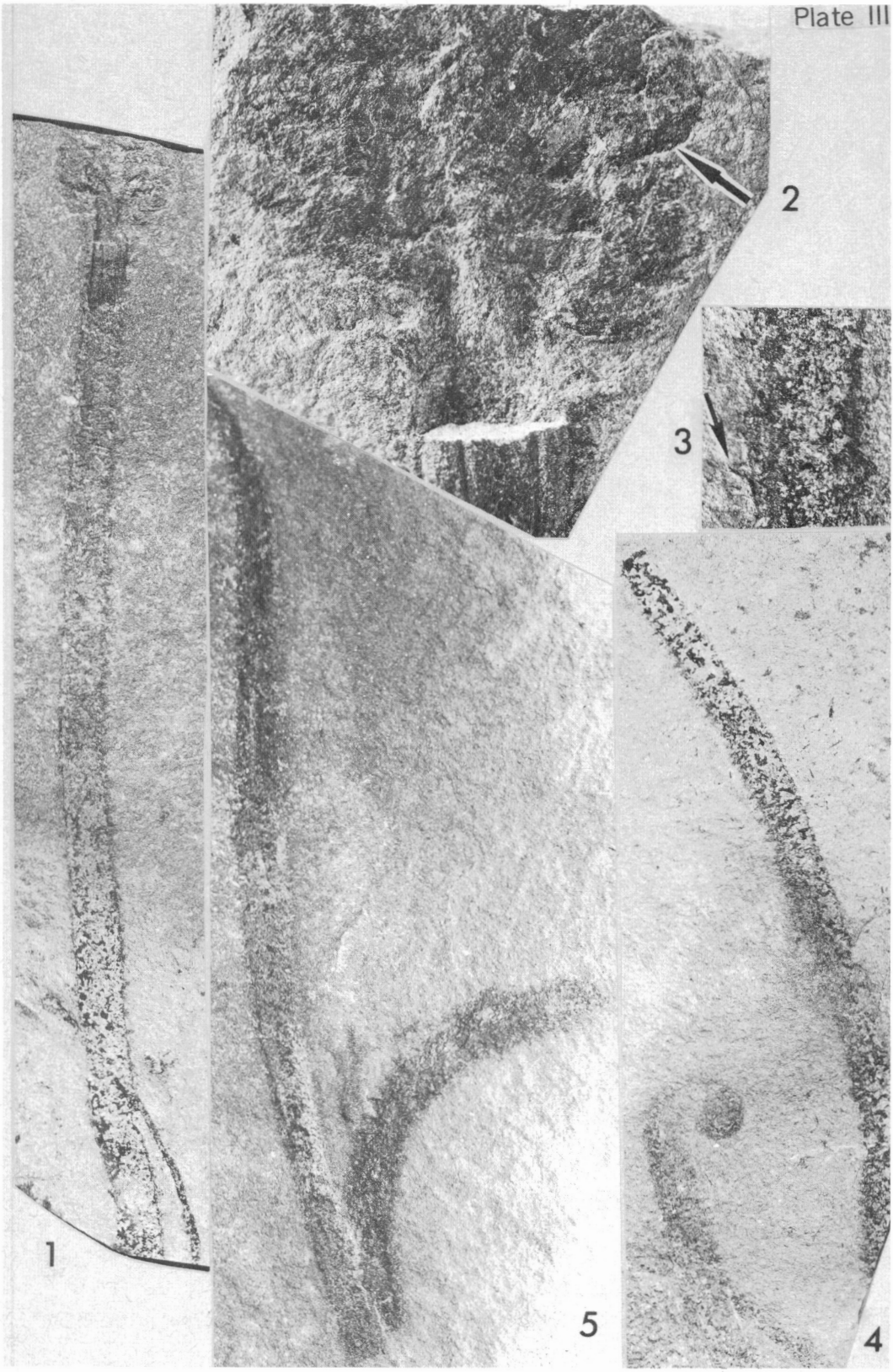
Figure 2. Basal fragment of spike of sporangia, x 4. Arrow points out radially elongate, reniform sporangium. Holotype, GSC No. 29900.

Figure 3. Arrow points out a single typical tooth-like emergence from those that produce the denticulate margin of the compressed axes, x 4. Holotype, GSC No. 29900.

Figure 4. Circinnate apex of axis and an axis with well-defined marginal denticulation, x 1. Paratype, GSC No. 29901.

Figure 5. Two axes with variable preservation of the denticulate margins of the axes, x 1. Paratype, GSC No. 29902.

Plate III



The elongate reniform shape of the sporangia and their aggregation into a compact spike suggest similarity between *Bathurstia* and members of the Family Barinophytaceae. *Bathurstia* is distinguished from some members of that family by the apparent absence of a bract-like appendage subtending each sporangium. Such a structure is characteristic, for example, of *Krithodeophyton croftii* Edwards (1968) and *Barinophyton sibiricum* Petrosyan (*in* Lepekhina, *et al.*, 1962). The apparent infrequent branching of the axes in *Bathurstia* distinguishes it from other genera in the Barinophytaceae, all of which have regular dichotomous branches separated by rather short internodes. None of the members of the Barinophytaceae is described as having stems that are ornamented with spines or other emergences.

Bathurstia has limited chronological value. The Family Zosterophyllaceae, to which it is assigned, ranges in age from Gedinnian to Frasnian with an apparent acme in Emsian-Eifelian time.

Discussion.

At the beginning of a study of early plant fossils such as *Bathurstia*, search is made for a cuticle, a vascular strand, cuticularized spores, and stomata. If any or all of these structural entities can be demonstrated, it is with some confidence that the remains can be described as those of land plants. Each structure represents a modification of the plant body during the processes of adaptation to the rigors of growth on land. The structural changes probably evolved at different rates rather than appearing at the same time, and the question arises as to the most likely sequence in which these modifications arose. Megafossils of early terrestrial semiaquatic plants yield only slight evidence of the relative times of appearance of each characteristic. The stem cuticle was probably the first modification and initially consisted of a very thin protective layer. Preservation of such delicate cuticles would depend on short distance transport or burial *in situ*. The enclosing sediments had to be fine-grained and subsequent metamorphism of the sediments had to be minimal. Such prerequisites for preservation are obvious obstacles to discovery of the earliest evidence for the appearance of the cuticle.

Spores with cutinized walls probably developed along with, or shortly after, the stem cuticle. Those adaptations very likely were closely followed by the development of the vascular strand composed of tracheids. Stomata appear to have been the last of the adaptations for growth of plants on land. Some of the early evidence for their development shows the stomata to have been not much more than simple pores, as for example in *Sawdonia ornata* and *Drepanophycus*. A stomatal apparatus with functional guard cells probably evolved quite rapidly. Evidence for this is found in some Emsian plants included by Banks (1968) in the Trimerophytina. Morphologically clearly defined guard cells are present in the epidermal layers of those genera. A primitive plant of the *Rhynia gwynne-vaughani* type (Kidston and Lang, 1917) seems precocious in its possession of a well-defined stomatal apparatus but all of the other adaptations for successful growth on land were also well developed in the plant. The primitive nature of *Rhynia* by comparison with its contemporaries is reflected primarily in its morphology and in the fact that the sporangia apparently were not supplied with a dehiscence mechanism.

Fragments of cuticle were obtained by oxidative maceration of particles of the carbonized stems of *Bathurstia* but no cellular detail could be observed. The presence of a cuticle does indicate that the genus, to a degree, was capable of withstanding the drying effects of exposure to air. Thus, in a description of the habitat of the plant, the adjective "land" may be applicable in meaning estuarine or coastal marsh land. In those situations the plant was adapted for periodic exposure to air as tidal waters flowed and ebbed. The plant may have been either aquatic or semiterrestrial.

Although it is thought that *Bathurstia* was a vascular plant, no remnants of tracheids were isolated that could prove the presence of a vascular

strand. Accordingly, the genus is described objectively as a land plant and not as a land vascular plant. The difference between a land plant, for example, on the evolutionary level of the mosses and liverworts, and a land vascular plant, a tracheophyte, is important in the objective evaluation of early plant fossils. Too often the term vascular is used in the description of Devonian or older plant fossils whereas no evidence is given to demonstrate the presence of tracheids. Probably there were many experiments in the evolution and development of the advanced tracheophyte vascular system. The fossil remains of early plants should be examined objectively to ensure that the advanced characteristic of such a system is not attributed to an intermediate or primitively experimental genus.

This does not mean that *Bathurstia* was allied to the mosses and liverworts just because a vascular strand composed of tracheids was not found in its axis. Instead, it should be emphasized that *Bathurstia* cannot objectively be called a land vascular plant because it could be in the early stages of adaptation to growth on land and its vascular system, whatever form it may have taken, may have been poorly developed and thus not preserved.

Types. Holotype, GSC No. 29900; paratypes, GSC Nos. 29901, 29902, 30022.

Horizon. 30 feet below the top of the Bathurst Island Formation; Siegenian.

Cf. *Bathurstia* sp.

Plate II, figure 3

Description.

The specimen is a poorly preserved fragment of a detached spike of sporangia 9.5 cm long and from 1.2 to 1.3 cm wide. No vegetative portions of the plant are preserved, and the apex and the base of the spike are missing. The sporangia are elongately reniform, 5.5 to 6.0 mm wide and 2.2 to 2.9 mm high. They are arranged alternately and in two opposite rows along the margins of the axis. Although the sporangia have smoothly rounded margins, some appear to taper laterally to points. This is clearly illustrated along the upper right margin of the spike in Plate II, figure 3. The pointed appearance is due to the partial burial of the sporangia in the matrix. No spores could be obtained from the sporangia and no cellular detail of any form could be observed in the preparations made from fragments of carbonized tissue from the axis.

Remarks.

The specimen is compared to *Bathurstia* on the basis of the morphology of the spike and the sporangia. As no vegetative portions of the axis were preserved in this specimen, comparison to *B. denticulata* is impossible. Comparison of the specimen to *Bathurstia* is probable but it is preferred at this time to treat it as a separate entity.

Type. Hypotype, GSC No. 29903.

Zosterophylloid axis

Plate II, figures 4, 5

Description.

The specimen is a fragment of an unbranched axis 12.8 cm long, tapering from a width of 5 mm at the base to 3 mm in the region of the spike

of sporangia at the apex. The spike is incomplete. Only 1.3 cm is preserved. Nine reniform sporangia comprise the fragment and they are borne alternately, in two rows, on opposite sides of the axis. The sporangia are 4.8 to 5.3 mm wide and 3.0 to 3.3 mm high. A pronounced dark rim is preserved along the distal margins of the sporangia (Pl. II, fig. 5) giving evidence of a line of dehiscence which apparently resulted in the division of the sporangia into equal valves. Spores were not obtained from oxidative macerations of fragments of the sporangia. The surface of the axis, where carbonized tissue is retained, shows no evidence of ornamentation. The impression of the axis on the surface of the matrix also is featureless.

Remarks.

The morphology of the sporangia and the manner in which they were borne on the axis are evidence suggesting that this plant was allied to the Family Zosterophyllaceae. Details are inadequately preserved that could serve for description of the specimen on a species level. However, it can be compared to the subgenus *Platy-zosterophyllum* on the basis of the morphology of its spike. I prefer to leave the specimen described and referred to as a zosterophylloid axis rather than expand the family with an additional genus based on limited and poorly preserved material.

Type. Hypotype, GSC No. 29904.

Horizon. 30 feet below the top of the Bathurst Island Formation; Siegenian.

Genus *Drepanophycus* Göppert 1852

Drepanophycus spinaeformis Göppert 1852

Plate I, figures 1, 3

Description.

In the collections is a single fragment of a stem 11 cm long, varying from 6 to 6.5 mm in diameter, and covered for three-fourths of its length with thornlike leaves which are 4 to 5.5 mm long. The leaves are falcate and gradually taper to a point from an enlarged base. The leaves appear to be irregularly arranged and are distributed four to eight per cm along the exposed surface of the stem. No surface patterns on the axis are preserved. Poorly preserved fragments of xylem (Pl. I, fig. 1) were obtained from the carbonaceous remains. The specimen represents the terminal portion of a branch or of a young plant.

Remarks.

Drepanophycus can be considered the most primitive genus of early lycopods, and *D. spinaeformis*, from all evidence at hand, is the least advanced of the five species that comprise the genus. The seemingly irregular arrangement of the leaves is perhaps the most outstanding characteristic that sets the species apart from other early lycopods. Often there is no clear indication of a spiral arrangement of the leaves, apparently because there was no structural modification of tissues in the outer cortical regions between the leaf bases. Such modifications, generally consisting of a few to several layers of cells with thickened walls, are typical in the later or evolutionarily advanced lycopods. The morphology of the layers of thick-walled cells between the leaf bases in advanced lycopods is revealed on fossilization as patterns on the stem surfaces. The differential resistance of the secondarily thickened tissues to compression and decay played a significant part in the formation of the leaf base patterns which are utilized in characterizing fossil lycopod genera. The patterns emphasize the spirality or

orderly arrangement of the leaves. In *D. spinaeformis*, the apparent absence of secondarily thickened cortical tissues between the leaf bases increases the tendency for the spiral arrangement of the leaves to be less clearly indicated.

The xylem strand in *D. spinaeformis* is known only from compressed specimens and accordingly, the configuration of the xylem strand in transverse section is not known. The strand is quite small in relation to the diameter of the axis. The stem apparently was composed in large proportion of soft parenchymatous tissue and would have relied to a great degree on turgor pressure to keep the plant in an upright position. The xylem strand would have offered only a small part of the support for so large an axis. It is suspected, although without proof, that the xylem strand in *D. spinaeformis* was terrete in transverse section and not stellate as was the case in *D. gaspianus* (Dawson) Kräusel and Weyland 1948 (*see* Grierson and Hueber, 1967). As more anatomical details of the internal structure of *D. spinaeformis* are obtained, it will be necessary to separate the other species into different genera, excepting, perhaps, *D. spinosus* (Krejci) Kräusel and Weyland 1933. This probability of change has been alluded to by Grierson and Banks (1963, p. 234).

Drepanophycus spinaeformis occurred in the Devonian from Siegenian to Frasnian time. It was formerly considered an excellent index to sediments of Siegenian-Emsian age (Kräusel and Weyland, 1930, 1935). However, Banks and Grierson (1968) have reported the species from Frasnian sediments in Greene County, New York, U.S.A. The specimen described here is dated as Siegenian based on its occurrence with invertebrate fossils and *sporae dispersae*.

Type. Hypotype, GSC No. 29905.

Horizon. 30 feet below the top of the Bathurst Island Formation; Siegenian.

REFERENCES

Banks, H.P.
1968: The early history of land plants; *in* Evolution and environment: a symposium presented on the occasion of the 100th anniversary of the foundation of Peabody Museum of Natural History at Yale University, Yale Univ. Press, New Haven, pp. 73-107.

In press: Occurrence of *Cooksonia*, the oldest vascular land plant macrofossil, in the Upper Silurian of New York State; *Indian J. Bot.*

Banks, H.P. and Davis, M.R.
1969: *Crenaticaulis*, a new genus of Devonian plants allied to *Zosterophyllum*, and its bearing on the classification of early land plants; *Am. J. Bot.*, vol. 56, No. 4, pp. 436-449.

Banks, H.P. and Grierson, J.D.
1968: *Drepanophycus spinaeformis* Göppert in the early Upper Devonian of New York State; *Palaeontographica (B)*, vol. 123, pp. 113-120.

Churkin, M., Jr., Eberlin, G.D., Hueber, F.M. and Mamay, S.H.
1969: Lower Devonian land plants from graptolitic shale in southeastern Alaska; *Palaeontology*, vol. 12, Pt. 4, pp. 559-573.

Dawson, J.W.
1859: On fossil plants from the Devonian rocks of Canada; *Quart. J. Geol. Soc. London*, vol. 15, pp. 477-488.

Dawson, J.W. (cont.)
1871: The fossil plants from the Devonian and Silurian formations of Canada; *Geol. Surv. Can.*, Publ. 428.

Dorf, E.
1933: A new occurrence of the oldest known terrestrial vegetation, from Beartooth Butte, Wyoming; *Bot. Gaz.*, vol. 95, No. 2, pp. 240-257.

1934a: Lower Devonian flora from Beartooth Butte, Wyoming; *Bull. Geol. Soc. Am.*, vol. 45, pp. 425-440.

1934b: Stratigraphy and paleontology of a new Devonian Formation at Beartooth Butte, Wyoming; *J. Geol.*, vol. 42, pp. 720-737.

Edwards, D.
1968: A new plant from the Lower Old Red sandstone of South Wales; *Palaeontology*, vol. 11, Pt. 5, pp. 683-690.

1969: Further observations on *Zosterophyllum llanoveranum* from the Lower Devonian of South Wales; *Am. J. Bot.*, vol. 56, No. 2, pp. 201-210.

Göppert, H.R.
1852: Fossile Flora des Ubergangsgebirges; *Verhandl. Kaiserl. Leopoldinisch-Carolinischen Akad. Naturforsch.*, Suppl. Band 14.

Grierson, J.D. and Banks, H.P.
1963: Lycopods of the Devonian of New York State; *Palaeontographica Americana*, vol. IV, No. 31, pp. 220-295.

Grierson, J.D. and Hueber, F.M.
1967: Devonian lycopods from northern New Brunswick; Intern. Symp. on Devonian System; *Alberta Soc. Petrol. Geol.*, vol. 2, pp. 823-836.

Halle, T.G.
1916: Lower Devonian plants from Röragen in Norway; *Kgl. Svenska Vet. Ak. Handl.*, vol. 57, No. 1, p. 24.

Høeg, O.A.
1942: The Downtonian and Devonian flora of Spitzbergen; *Svalbard Ishavsunders Skr.*, No. 82.

1967: Psilophyta; *in Traité de Paléobotanique*, Tome II, pp. 191-433.

Hueber, F.M.
1970: *Rebuchia:* a new name for *Bucheria* Dorf; *Taxon*, vol. 19, No. 5, p. 822.

1971: *Saxdonia ornata:* a new name for *Psilophyton princeps* var. *ornatum; Taxon*, vol. 20.

Ischenko, T.A.
1969: The Cooksonian paleoflora in the Skala horizon of Podolia and its stratigraphical significance; *Geol. J.*, vol. 29, pp. 101-109 (in Russian).

Jaeger, H.
1967: Preliminary stratigraphical results from graptolite studies in the Upper Silurian and Lower Devonian of southeastern Australia; *J. Geol. Soc. Australia*, vol. 14, Pt. 2, pp. 281-286.

Kidston, R. and Lang, W.
1917: On Old Red sandstone plants showing structure, from the Rhynie chert bed, Aberdeenshire. I. *Rhynia gwynne-vaughani*, Kidston and Lang; *Trans. Roy. Soc. Edinburgh*, vol. 51, pp. 761-784.

Kräusel, R. and Weyland, H.
1930: Die Flora des deutschen Unterdevona; *Abh. Preuss. Geol. Landesanst.*, N.F. 131, pp. 1-92.

1933: Die Flora des böhmischen Mitteldevons; *Palaeontographica(B)*, vol. 78, pp. 1-46.

1935: Neue Pflanzenfunde im rheinischen Unterdevon; *Palaeontographica(B)*, vol. 80, pp. 171-190.

1948: Pflanzenreste aus dem Devon. XIII. Die Devon-Floren Belgiens und des Rheinlandes, nebst Bemerkungen zu einigen ihrer Arten; *Senckenbergiana*, vol. 29, pp. 77-99.

Lang, W.H.
1937: On the plant-remains from the Downtonian of England and Wales; *Phil. Trans. Roy. Soc. London*, vol. 227B, pp. 245-291.

Lepekhina, V.G., Petrosyan, N.M. and Radchenko, G.P.
1962: Main Devonian plants of the Altay-Sayan Mountain region (Vazhneishie devonskie rasteniya Altae-Sayanskoi gornoi oblasti); *Trudy Vses. Nauchno-issled. Geol. in-ta*, vol. 70, pp. 61-189. [Trans.: RTS4357, National Lending Library for Science and Technology, Walton, Boston Spa, Yorkshire, England].

McGregor, D.C. and Uyeno, T.T.
In press: Stratigraphic ranges of spores and conodonts in Devonian rocks of Melville and Bathurst Islands, Northwest Territories; *Geol. Surv. Can.*, Paper.

Obrhel, J.
1962: Die Flora der Pridoli-Schichten (Budnany-Stufe) des mittel-böhmischen Silurs; *Geologie*, vol. 11, pp. 83-97.

Penhallow, D.P.
1892: Additional notes on Devonian plants from Scotland; *Can. Record Sci.*, vol. 5, pp. 1-13.

Stockmans, F.
1940: Végétaux éodévonien de la Belgique; *Mus. Roy. Hist. Nat. Belgique*, Mém. 93, pp. 1-90.

1948: Végétaux du dévonien supérieur de la Belgique; *Mus. Roy. Hist. Nat. Belgique*, Mém. 110.