OCCURRENCE OF *PSEUDOBORNIA* NATHORST IN ALASKA*

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ABSTRACT

A small collection of fossil plants from north-eastern Alaska contains *Pseudobornia ursina* Nathorst, which aids in the differentiation of age of rocks in a difficult stratigraphic section. This is not only the first occurrence of *Pseudobornia* in the western hemisphere, but also the first verifiable occurrence since the original discovery of *Pseudobornia* on Bear Island.

IN 1894 A. G. Nathorst described a series of fossil floras from the Arctic regions, including an assemblage from the Upper Devonian rocks of Bear Island, south of Spitzbergen. This flora was predominantly a fern-lycopod association, such as commonly characterizes Upper Devonian floras in other parts of the world. However, it was of unusual interest inasmuch as it contained a peculiar arthrophyte unknown until then; Nathorst named this plant *Pseudobornia ursina*. Several years later (1902) Nathorst described supplemental material of *Pseudobornia*, also from Bear Island, so that there is now available a fairly detailed description and several excellent illustrations of both fertile and sterile parts of this plant.

Subsequent to Nathorst's publications, the genus was not discovered elsewhere until 1960, when it was found in Alaska. Two earlier occurrences are recorded, but in each case the identification of *Pseudobornia* is accompanied by doubt. Mägdefrau (1936) described several small articulate stem fragments from the Upper Devonian "Braunwacken" of Lerchenberg and Weinberg in Thuringia, Germany. Mägdefrau identified this material as *P. ursina*, and although the stem fragments correspond reasonably well with some of those described by Nathorst, Mägdefrau's collection contained none of the unique foliage that characterizes *Pseudobornia*. Even more suspect is White's identification (*in* Kindle, 1912, p. 209) of *Pseudobornia* in the Upper Devonian Huron Member of the Ohio Shale, of northern Ohio, and the Genesee Formation and other Devonian units in New York State. White examined specimens reputedly identical with Sir William Dawson's *Calamites inornatus* and informally renamed it *Pseudobornia inornata*. However, the material described by Dawson exhibits none of the features peculiar to *Pseudobornia*; instead, it almost certainly represents stem fragments of *Asterocalamites* Schimper, which is characterized by direct superposition of all the ribs at the nodes. Since the material studied by White is no longer available for examination, and particularly in view of the apparent absence of diagnostic leaves, I concur with Read (1953, p. 16) in viewing White's identification of *Pseudobornia* as unsubstantiated.

Zimmerman (1959, p. 224) mentions occurrences of *Pseudobornia* in Ireland and eastern Siberia, but he has informed me (written communication, 1961) that these reported occurrences are erroneous.

Source of Material — The Alaskan *Pseudobornia* was identified in one of three small collections that were referred to me for fossil identification and age determination by W. P. Brosgé and H. N. Reiser of the U.S. Geological Survey. The fossils were found while the collectors were conducting a geological mapping project in the Christian and Arctic quadrangles, north-eastern Alaska, and were submitted with the specific intent of utilizing them, if possible, in determining the enclosing sediments as either Devonian or Cretaceous. The collection numbers and geographic locations are:

Be 672. 68°20′ N, 146°19′ W (Shale interbedded with micaceous quartzites)
Be 661. 67°51′ N, 145°24′ W (Black shale interbedded with graywacke)
Rr 635. 68°15′30″ N, 144°08′ W (Black shale immediately below Kanayut conglomerate and above thrust fault)

According to the collectors (BROSGÉ and REISER, written communications, 1961) the beds indicated above were originally determined as Devonian on the basis of invertebrate fossils, and are contained in a sequence of slates, shales, sandstones, quartzites, and graywackes. This sequence is conformably overlain by the Kanayut Conglomerate, of known Late Devonian age. The stratigraphy is complicated by faulting, and lithologic

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similarities to rocks of known Cretaceous age in the Chandalar quadrangle, as well as the general scarcity of diagnostic fossils, create difficulties in distinguishing the Devonian rocks from the Cretaceous. The field problem is summarized by Brosgé and Reiser (written communication, 1961) as follows: " The Devonian age identification of collection 60 ABe 661 was particularly important as the rocks in which they occur are less metamorphosed than the rocks of known Devonian age in the immediately adjoining areas. Although the sequence of lithologic units indicates the rocks at 60 ABe 661 to be of Devonian age, the fact that they lie more or less on strike with a belt of very similar sedimentary rocks of known Cretaceous age coupled with the complex structure of the area prohibits positive Devonian age assignment without the fossil control."

Description of the Material — Collection Be 672 consists of only a few small slabs of black, micaceous shale in which there are no identifiable plant megafossils. It contains a number of small, coalified remnants of slender woody plant axes, but these show no diagnostic features.

Collection Be 661 consists of several slabs of dark grey to black shale with abundant plant debris on the irregular bedding surfaces. The plant fragments are mostly small, coalified films of undeterminable origin. No leaves are recognizeable, but there are a number of longitudinally ridged axial fragments, the largest of these measuring about 4 cm. in width. A few of these have swollen nodes and evidence of large nodal branch scars, which together with the coarse surface ribbing, suggest that these are secondary or smaller axes of *Pseudobornia*.

The most important specimen in this small collection is illustrated in Fig. 1. It is a short fragment of a rather stout, partly decorticated lycopod axis, measuring 4 cm. in width. Its surface is ornamented with closely set, spirally arranged, axially elongated leaf cushions that compare closely with some of the specimens illustrated by Nathorst (1902, cf. Pl. 10, Fig. 4) as *Bothrodendron* (*Cyclostigma*) *kiltorkense* Haughton. Although a positive identification of the Alaskan specimen is not possible because of faulty preservation, the specimen is at least recognizable as a representative of the Paleozoic arborescent lycopod complex, and as such is sufficient to identify the enclosing sediment as Devonian rather than Cretaceous.

Plant material in the most significant of the three collections, Rr 635, is contained in a hard, thin-bedded black shale, rich in detached foliar material of *Pseudobornia* and axial fragments that probably represent the stems and branches of the same plant. The stem fragments are preserved as coalified compressions or as mere impressions on the bedding surfaces. The longest is 16 cm. long and 2 cm. wide, but the entire width is not represented since the specimen is split longitudinally. Stem fragments are as much as 4 cm. in width, but most specimens are only 6-7 mm. wide. Some of the broader specimens are ornamented with longitudinal ribs, which may be as much as 4 mm. in width. These show only slight relief, and probably vary according to the degree of pre-preservational decortication of the stems. The smaller stems show faint longitudinal striations, very closely set. Except for a few nodal compressions with evidence of branch scars, the stem fragments are otherwise lacking in distinctive features. A few of the fragments show swollen nodes, some of which exhibit faint depressions that are probably branch scars (Fig. 3); in this feature they agree well with *Pseudobornia* stems figured by Nathorst. The specimen shown in Fig. 3 has a distinct node, to either side of which is attached the basal part of a lateral appendage. Whether these were leaves or branchlets, however, cannot be determined. This is the only specimen showing nodal attachment.

Foliar material is abundant in the collection, although most of the specimens are small fragments. Almost every slab contains one to several leaf specimens. These are preserved as high rank coalifications in which cuticular material and cell structure have been destroyed, so that only the outlines are preserved. There is little contrast between the black compressions and black matrix, and it is difficult to examine the specimens under direct light. However, the fossils have a graphitic lustre that is lacking in the containing matrix, and oblique lighting causes the plants to stand out sufficiently well that their outlines are easily observed and the leaves may be photographed with reasonable success.

Repeated division of the leaf blade in an essentially dichotomous manner to produce two to several, long, narrow, wedge-shaped lobes is one of the distinguishing features of *Pseudobornia*, and some of the larger

specimens in the Alaska collection show this feature fairly well. The specimen shown in Fig. 7, an apparently complete leaf 5 cm. long, shows a deep basic division into two main lobes, each of which is again deeply dissected. The resultant lobes are in turn marginally incised in an irregular manner, producing relatively narrow lobes, all directed apically at a very narrow angle of decurrence.

Marginal laciniation or fimbriation of the lamina, which constitutes the most diagnostic vegetative feature, is plainly shown by all the Alaska specimens. The whole margin of every foliar fragment is deeply dissected into numerous narrow unbranched lobes, which are 0·15-0·30 mm. wide and 3-10 mm. long. The ultimate lobes are closely spaced and so numerous that they impart to the laminae a plumose appearance. As in the case of the penultimate lobes, the ultimate lobes are directed apically at a very narrow and graceful angle of decurrence. Their consistently well-ordered alignment and completeness discourage interpretation of these specimens as distantly transported plant material. Rather, the specimens likely grew at, or very near to, the present site of preservation.

There is no evidence of the original venation, although it seems reasonably safe to presume a basic dichotomous vascular system. Whether or not each of the many narrow marginal lobes received a veinlet is not known, but to judge from their extremely narrow proportions, it seems likely that they were largely unvascularized, with the veinlets ending short of the ultimate lobes.

The cuticles are not preserved, nor is attachment of leaves clearly demonstrated in this material.

In spite of the absence of larger, more complete specimens that would demonstrate the fruiting habit and other morphological features of the Alaska plants, the leaf fragments compare so closely with leaves of Nathorst's original material of *Pseudobornia* that the identification of the Alaska material may be made without hesitation. The peculiar form of the leaves is unique to *Pseudobornia*, and this is clearly duplicated in the Alaska specimens (compare FIGS, 2, 4, 5, 6 and 7 with the leaves shown on NATHORST'S PLS. 7, 8). Furthermore, the association with articulate stem fragments, again duplicative of some of Nathorst's specimens (compare FIG. 3 with NATHORST'S PL. 8, FIGS. 10, 11), strengthens the leaf identification.

On the specific level there is no evident basis for separating the Alaska specimens from the type material from Bear Island. Quantitative features of the Alaska specimens fall well within the range of variation shown by the type species, so that pending the discovery of material that would controvert this decision, the Alaska material is identified here as *Pseudobornia ursina* Nathorst.

The collection is deposited in the Paleozoic plant collections of the U.S. National Museum, Washington, D.C.

Discussion — The identification of *Pseudobornia ursina* in the Devonian of Alaska represents the first positive evidence of the presence of the order Pseudoborniales on the North American continent or, indeed, in the western hemisphere. In this regard mention should be made of *Prosseria grandis* Read (1953), described from the Upper Devonian Genesee Group of New York State. *Prosseria* was an articulate plant with much enlarged nodes and long, grass-like leaves. Read recognized similarities between this plant and other articulates and considered the possibility that it was pseudobornialean; however, it was only with question that he referred it to that group. Since Read's publication, no additional information has been uncovered in regard to the morphology or systematic position of *Prosseria*, so that the Alaska occurrence of *Pseudobornia* remains the only unquestionable discovery of pseudobornialean plants in the western hemisphere. Although the Alaska material provides no new information on the morphology or phylogenetic relationships of *Pseudobornia*, its occurrence entails several points of signifinance.

As the second known occurrence of *Pseudobornia*, this establishes for the genus a considerable geographic range, for even though both the Alaska and Bear Island localities lie within the Arctic Circle, they occur on nearly opposite longitudinal meridians and are separated from each other by a distance of more than two thousand miles. The significance of this fact, of course — coupled with the apparently conspecific identity of the Alaska and Bear Island plants — is that *Pseudobornia*, one of the 'strange' elements in the Upper Devonian land flora, was not an endemic, but a plant with a considerable geographic range indicative of some means of communication between Bear Island and Alaska. Thus another of the primitive plant groups falls into the

general pattern of widespread geographic distribution of Devonian floras in the northern hemisphere. It now seems possible that Alaska will eventually produce Devonian plant assemblages of diversity comparable to those of the better known Devonian plant localities in Europe and eastern North America. Furthermore, positive demonstration of the fact that *Pseudobornia* was not limited in geographic distribution to the immediate environs of Bear Island permits anticipation of future, additional discoveries of *Pseudobornia* in association with the Upper Devonian *Archaeopteris* flora, which may provide valuable information on the botanical nature and relationships of the genus and order, and perhaps on the early history of the articulate plants in general.

From the paleogeographic point of view, the Alaska occurrence of *Pseudobornia* constitutes an additional item in evidence of a Devonian land mass that occupied part of the position of present-day Alaska. The physical evidence of this was summarized in 1951 by Payne and others, who illustrated (1951, FIG. 23) the geologic conditions that hypothetically obtained from the Middle Devonian through the Permian. Their map includes a large northern land mass, the Barrow Platform, which extends southward to overlap the northern edge of Alaska and northwest Canada. The platform is delimited on the south by a broad amagmatic geosynclinal belt, trending east-west across northern Alaska and north-western Canada and presumably receiving sediments from the Barrow platform to the north; to the south of the geosynclinal belt is shown an extensive magmatic geosynclinal belt, which covers more than the southern half of Alaska. Inasmuch as the *Pseudobornia* locality lies well within the hypothetical limits of the amagmatic geosynclinal belt, it becomes obvious that (1) this geosynclinal belt contained emergent land areas, sufficiently persistent to permit population by a land flora, at least during Late Devonian time, or (2) a more southern extension of the Barrow Platform, which would encompass the position of the plant deposit, is indicated.

Whichever of the foregoing interpretations proves to be correct, it is virtually certain that the land on which the Alaska *Pseudobornia* grew occupied the same geographic position as that of the present-day fossil site. The fossil deposit evidently represents the remains of an essentially pure stand of *Pseudobornia*, preserved at or at least very near the original habitat. Extensive transportation before burial is doubtful, to judge from the undamaged appearance of the fine marginal fimbriations of the leaves. Moreover, if the deposit represents a basin of deposition that received plant material from distant areas containing a variety of habitats, it is probable that the sediments would now contain a greater variety of plant remains than just one recognizable species.

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EXPLANATION OF PLATE 1

1. Partly decorticated lycopod stem fragment from locality Be 661. U.S.N.M. 41849. × 1. (All other figured specimens from locality Rr 635.)

2. Fragment of axis at right, with two leaves of *Pseudobornia ursina* converging toward axis from left. U.S.N.M. 41850. × 1.

3. Part of axis showing enlarged node with faint branch scars and basal parts of two appendages attached at node. U.S.N.M. 41851. × 2.

4. Foliar fragments of *Pseudobornia ursina*, showing typical dichotomous division and marginal fimbriations. U.S.N.M. 41852. × 2.

5. Part of slab showing two large leaf fragments and several smaller ones. Specimen at right shown enlarged as Fig. 4. U.S.N.M. 41852. × 1.

6. Large leaf fragment, showing repeated dichotomous division and marginal fimbriations. U.S.N.M. 41853. × 1.

7. Same specimen as Fig. 6. × 2.

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