

ON THE STRUCTURE AND RELATIONSHIP OF *PHOROXYLON SCALARIFORME* SZE

H. C. SZE (斯行健)

(Institute of Palaeontology, Academia Sinica)

One of the interesting points brought out during the investigation of many sections cut from a petrified wood from the Jehol province in Northern China is that the species *Phoroxylon scalariforme* Sze found from the Cretaceous of Northern Manchuria described in 1951 by the writer might probably be more nearly allied to the two species of *Bucklandia*: *B. sahnii* Bose and *B. indica* Seward. The anatomical feature of the secondary wood exhibited by *P. scalariforme* that appears to distinguish the species *B. sahnii* is the structure of the uniseriate rays throughout the secondary wood as seen in the tangential section. The majority of the medullary rays of *B. sahnii*, as described by Bose, are uniseriate, but biseriate ones occur frequently and a few triseriate ones are also found. It is interesting that the tracheids of the secondary wood of *B. sahnii* have also mainly scalariform pitting, but the early wood of this species shows various types of pitting varying from scalariform to multiseriate rounded bordered pits. In regard to the uniseriate structure of the medullary rays of the secondary wood, the Chinese species approaches nearest to *B. indica*, but the tracheids of the latter species have multiseriate bordered pits on their radial walls, instead of the scalariform pitting in the majority of Cycadeoidea stems. According to Bose, there are no scalariform pitting observed in *B. indica*. The writer has reexamined all the slides originally cut from the material found from Northern Manchuria and has found that all the tracheids of *P. scalariforme* as has been described before, are characterized only by the scalariform pittings throughout the secondary wood. There are no round or circular bordered pits to be seen. Only very rarely the scalariform pittings are anastomosed and reticulated, forming very small multiseriate pits that are contiguous and appear to be flattened into alternate polygons recalling those of Araucarineae. Many new sections of the same stem have been cut and the result is always the same as before. The writer has then examined the numerous sections cut from the

*First published in Chinese in *Acta Palaeontologica Sinica*, Vol. II, No. 4, pp. 347-354, 1954.

new material found from the Cretaceous beds of the Jehol province and has found also only the overwhelming scalariform pittings on the radial walls of the tracheids. There are thoroughly no circular bordered pits to be observed. As far as the features of the secondary wood are concerned, the Chinese species recalls *B. indica* in regarding to the uniseriate medullary rays as seen in the tangential sections and recalls *B. sahnii* in regarding to the scalariform pitting on the radial walls of the tracheids, though the pronounced uniseriate and multiseriate rounded bordered pits of the latter species are still not to be observed. Judging from the material at hand, the present writer is disposed to believe that so far as the features of secondary wood only are concerned, the species *P. scalariforme* might occupy an intermediate position between *B. indica* Seward and *B. sahnii* Bose. *Bucklandia* is one of the important stem genera of the Bennettiales. Most of the species of *Bucklandia* are known from casts and are characteristic from the Rhaetic to the Lower Cretaceous strata. The surface of the stem is covered with leaf-bases preserved as imbricate broad, and obtuse or truncate scales or as slightly convex polygonal areas in some cases showing a tendency towards an irregular zonal arrangement of larger and smaller leaf-bases. Some of the specimens reach a length of several feet and afford evidence of occasional branching. The central portion of the *Bucklandia*-stems is characterized by a very large pith^[1, 2]. The structure of the primary wood is also known in several species. In *B. sahnii*, as remarked by Bose, the primary xylem is endarch, they occur either in groups or scattered. Walls of the primary cells are rather thin compared with the secondary xylem. Longitudinal section shows that the innermost part of the xylem ring is composed of 4 to 8 layers of slender tracheids with the spiral thickenings on their walls. The next elements further out are the bordered scalariform tracheids, forming part of the secondary xylem. The pith of *B. sahnii* resembling that of *B. indica* is also very wide. It consists mainly of parenchymatous cells with hundreds of irregularly scattered thick-walled cells exactly like those found in the cortex. The parenchymatous cells are isodiametric with well-developed intercellular spaces. In longitudinal sections, the pith cells are rectangular, and the elongated thick-walled cells are of various calibres. Sometimes they are forked and become γ -shaped. Since only the secondary wood is available, many of the anatomical features of *P. scalariforme* is unknown. When one is dealing with species, it is customary to emphasize differences rather than similarities. It is also true that with but a limited amount of material at hand for study, certain differences will be noted. The secondary wood of *P. scalariforme* is also very massive with sharply marked growth-rings. The stem found from Jehol is measured more than 15 cm in diameter and is composed nearly entirely of the secondary xylem. A closer examination leads inevitably to the conclusion that the pith of *P. scalariforme*, if preserved, must be very small. This difference does appear to be of sufficient importance for at least generic separation. It seems to the present writer that the evidence of relationships of *P. scalariforme* as remarked above, hardly amounts to proof that our plant belongs also to the Bennettiales.

The conjecture that this species might probably belong to one of those extinct Mesozoic conifers could however probably be ruled out. Dr. J. Hsü is of the opinion that the species *Phoroxylon scalariforme* Sze as well as *Homoxylon rajmahalense* Sahni are both the secondary woods of the Bennettitalean stems. *P. scalariforme* is indeed one of many plants of which we know enough to make us long for more information. All that can be said now is that under the present circumstance, it would be premature to hazard the opinion that the very massive and compact secondary wood of the *Phoroxylon* type belongs also to the Bennettitales group and bears also the *Ptilophyllum*, *Otozamites* and *Zamites* leaves as well as the *Williamsonia* flowers.

In this connection, it is of interest to note that a recent coniferous genus *Agathis* of the Araucarineae has occasional tendency towards a scalariform type of pitting as remarked by Seward (Foss. Pl. Vol. IV, p. 143 and Fig. 691D). Thomson has also called attention to the occasional occurrence, especially in the regions of rays, of transversely elongated or scalariform pits in the tracheids of *Araucaria* (Seward: l.c. p. 133). In regard to the presence of the uniseriate rays throughout the secondary wood and the abietinean pitting on the tangential walls of rays as seen in the tangential sections, the presence of the small, oval or circular pits in the medullary ray cells as seen in the radial sections, and the occasional occurrence of the araucarioid pitting on the radial walls of the tracheids, the present wood bears indeed strong relationships with the Coniferales. It is interesting that the Chinese Mesozoic *Phoroxylon* consists of a combination of anatomical characters of both Abietineae and Araucarineae as well as of Bennettitales.

The species *P. scalariforme* may be redescribed in the present paper:

Transverse section.

As figure 1 pl. I, figure 1 pl. II and figure 1 pl. III show, an examination of the transverse section conveys the impression of a gymnospermous wood with sharply marked growth-rings. There are no vessels, the bulk of the wood is composed of tracheids, mostly quadrangular in section and compactly arranged in radial rows. Growth-rings distinct, 0.5-1.5 mm, rarely more than 2 mm wide, growth-ring boundaries prominent. The spring wood zones are preserved as white bands, while the autumn wood zones are rustly brown. The autumn wood shows a more or less equal development compared to the spring wood, autumn wood rather dense, relatively thick-walled, intercellular space distinct. Spring wood distinct, occasionally strongly crushed, tracheids relatively larger, thick-walled, mostly rectangular in section. Owing to the lateral pressure, the tangential walls of the tracheids look narrower than they are, but even after allowing for this, the spring tracheids are actually wider in the radial direction than in the tangential. The medullary rays are prominent, ray interval about 2-8, average 4 cells. The structure of the rays and other details are not clearly made out in the cross-section.

Radial section. The radial sections are the most instructive, for the pitting of the tracheids and of the medullary ray cells, as well as some of the other characteristic of this peculiar wood are here clearly seen. The most striking feature of the wood is the presence of the scalariform type of pitting, covering the whole of the radial walls of the tracheids. The scalariform pittings are particularly distinct in the tracheids of the spring-wood. There are no round or circular bordered pits to be seen. Only very rarely the scalariform pittings are anastomosed and reticulated forming very small multiseriate pits that are contiguous and appear to be flattened into alternate polygons recalling those of Araucarineae.

The structure of the medullary rays is best preserved in the autumn wood. All the cells are thick-walled and heavily pitted, the pits being clearly seen. In many places, the preservation is deceptive and gives the impression that some of the cells are thin-walled. This is due to a partial decay of the walls before petrification. The ray cells as seen in the radial section are usually two to four times as long as they are high but rarely isodiametric. Their end-walls are vertical and oblique. The pits in the "field" are small, oval or circular and are simple or half-bordered. In number, they vary from two to six in the spring wood as well as in the autumn wood.

Tangential section.

The medullary rays are conspicuous by their number and crowded occurrence, as seen in the tangential section of the wood. As a rule, the rays are separated from each other by only two to four tracheids. They are all uniseriate. In height, they vary from two to about 25 cells, usually 10-15 cells high. The ray cells appear to be all alike, all the cells are much higher than they are broad, intercellular space distinct. Ray cells with pitted tangential walls, pits very small, numerous, circular or oval, 10-15 per cell. There are also scalariform pittings presented on the tangential walls of the tracheids, especially of the spring wood.

The original diagnosis of *P. scalariforme* is reprinted here with some slight additions due to the study of the new material discovered from the Jehol province, N. China.

Arborescent; trunk large, fifteen centimetres in diameter. Secondary wood gymnospermous, very massive, consisting of tracheids and rays; growth-rings numerous, boundaries conspicuous, irregularly spaced. Spring tracheids large, thick-walled, rectangular; autumn tracheids dense, small, thick-walled, squarish, somewhat rounded in diameter. Boundary pitting usually of scalariform type. Very rarely the scalariform pittings anastomosed and reticulated forming very small multiseriate, contiguous, flattened, alternate polygons recalling those of Araucarineae. Resin canals absent. Xylem-parenchyma indistinct. Medullary rays 2-25 cells high, generally 10-15 in height, all uniseriate. Ray cells all alike, parenchymatous, horizontal walls

irregularly thickened, tangential walls with numerous small pits, lateral walls with 2-6 small, circular or oval, simple or half-bordered pits in the "field".

The new studies of *Phoroxylon* have served to emphasize two points, which, it is believed, are significant. The first is the wide distribution of the genus in the probable Cretaceous horizons of Northern China. The second point is that the features of the secondary wood alone of this genus might probably be more nearly related to the Bennettitales. The problems of recognizing species from secondary wood characters are frequently stressed in the anatomical literature and it is obvious that only with the secondary wood at our disposal, a decided expression of opinion as to the affinities of the plant is out of question. The result of the new investigation of numerous sections of *Phoroxylon scalariforme* shows also that the development of the autumn wood may not exceed that of the spring wood. When the spring wood is in normal condition, i.e. not in the crushed condition, it shows a development as wide as that of the autumn wood.

A close comparison of the anatomical features of the petrified woods found from Jehol and Northern Manchuria reveals certain minor differences which may be of specific rank, but, apart from these minor differences, these two forms may be classed under one anatomical type. The occasional presence of the reticulated, more or less Araucarioid pittings on the radial walls of the tracheids in the Jehol wood is not well defined than in the woods found from Northern Manchuria, and the pittings on the tangential walls of the ray cells of the Manchuria material are also not well distinguished on the slides cut from the Jehol specimen. These minor differences may well be due to the state of the preservation. The small oval or circular, simple or half-bordered pits in the "field" as seen in the radial sections of the Manchurian woods can also be observed in the Jehol material. Besides several specimens of the petrified woods, a few very fragmentary specimens of *Cladophlebis*-impressions are also found from the same bed of the Jehol province. In regarding to the shape and size of the pinnules and the pattern of the venation, the present fragments are closely related to the important species of the Lower Cretaceous age such as *Cl. browniana* (Dunker), *Cl. dunkeri* (Schimper) etc.

REFERENCES

- [1] Seward, A. C., 1917. Fossil Plants, **III**, 488, Fig. 579B. Cambridge Biological Series.
- [2] Bose, M. N., 1953. *Bucklandia Sahnii* sp. nov. from the Jurassic of the Rajmahal Hills, Bihar.—*The Palaeobotanist*, Vol. 2, pl. 2, Fig. 14, Birbal Sahni Institute of Palaeobotany, Lucknow.
- [3] Sze, H. C., 1951. Petrified Woods from Northern Manchuria.—*Science Record*, Vol. 4, No. 4, Academia Sinica, Peking.
- [4] Seward, A. C., 1919. Fossil Plants, Vol. IV, p. 133, p. 143; p. 132, Fig. 691D. Cambridge Biological Series.