SOME ELEMENTS OF THE GONDWANALAND FLORA IN NORTH AMERICA

CHESTER A. ARNOLD

University of Michigan, Ann Arbor, Mich., U.S.A.

ABSTRACT

According to recent refinements of the Pangaea concept, it would not be necessary to construct long land bridges to account for the occurrence of constituents of the *Glossopteris* in the Late Paleozoic and Mesozoic rocks of North America. The *Dicroidium*-like *Supaia* in the Lower Permian Hermit Shale flora of the Grand Canyon, the *Rhexoxylon*-like *Hermanophyton* in the Late Jurassic of Southern Utah, and *Glossopteris* in the Middle Jurassic of Mexico are all constituents of the *Glossopteris* flora of Gondwanaland that moved into their present sites over relatively short overland migration routes.

Because of the great distance between North America and any of the land areas that once composed Gondwanaland, similarities between the fossil floras of the two regions are matters of interest. This is especially true of the *Glossopteris* flora which is a distinctive one that is assumed to have originated and developed in an isolated environment.

Any reference to Gondwanaland and its floras invariably leads to discussion of the hypothesis of continental drift and its bearing on distribution of ancient floras. This theory is built upon the assumption that the present major land areas of the earth moved to their present positions after the breakup of Pangaea, the original super-continent. According to some recent refinements of the drift concept, Pangaea was a more or less continuous land mass throughout the Paleozoic Era (DIETZ and HOLDEN, 1970). Presumably it was quite irregular in shape, with the Tethys Sea making a large deep indentation in its eastern side. The land areas that later became North and South America fitted snugly against Africa and Eurasia. The rest of the world consisting of Peninsular India which was not then attached to Asia, Australia, and Antarctica, was a more or less contiguous mass that jutted eastward and southward from the present southeastern coast of Africa.

By the end of Triassic time the Tethys Sea had pushed westward so that it had almost completely separated Pangaea into two parts, Laurasia and Gondwanaland. Further fragmentation took place during the Jurassic Period, and by the end of Cretaceous time the Atlantic was a major ocean. Antarctica, though still attached to Australia, had parted company with South America and Africa, and Peninsular India was a large island east of Africa.

If the breakup of Pangaea actually took place in the sequence outlined above, the *Glossopteris* flora had developed in a part of the super-continent while it was still more or less intact, and the unique features of the flora cannot be explained on the assumption that it developed in an area without land connections with other areas. Also it seems unlikely that the flora ever occupied all of Gondwanaland either before or after the Tethys Sea had forced it apart from Laurasia. The reason for these assumptions is that the *Glossopteris* flora is found

White identified some twigs bearing short needlelike leaves from the Hermit Shale as *Ullmannia frumentaria*, but because some of the leaves showed what appeared to be terminal bifurcations, he mentioned a resemblance to the Indian Gondwanaland conifer *Buriadia*. This resemblance should, of course, receive serious consideration if and when better material of the Hermit Shale plant is ever found, but identity is no more than vaguely suggested by White's figures. Whether the bifurcations are natural, or the result of tearing during transport before fossilization, is not clear. Forked leaves occur in some other Paleozoic conifers, for instance in *Carpentieria*, and on the penultimate branches of *Lecrosia* and *Walchia*.

The single species of *Sphenophyllum*, *S. gilmorei*, in the Hermit Shale is of interest. Although it does not closely resemble *S. speciosum*, the Gondwanaland species, it is different from the other North American Permian members of that genus. Its closest relatives seem to be some of the Permian sphenophylls from eastern Asia. White compared it with *S. thonii* and *S. stuckenbergi*, and ASAMA (1970) transfers it to his new genus *Parasphenophyllum* which is characterized by the slight outward curvature of the veins next to the leaf margins.

An even closer resemblance to the Gondwanaland species of *Sphenophyllum* seems to be shown by some of the sphenophylls from the Lower Permian of the Appalachian coal basin (FONTAINE and WHITE, 1880). A few of these, which have been variously identified as *S. oblongifolium* and *S. filiculmis*, seem close to *S. speciosum* in having leaf whorls of the *Trizygia* type where the whorl consists of three leaf pairs of different lengths. This feature is strongly expressed in the Gondwanaland species that Royle used when he founded the genus *Trizygia* in 1833.

DELEVORYAS (1966, 1969) has recently announced the discovery of leaves in the Middle Jurassic of the State of Oaxaca in Mexico that are indistinguishable from *Glossopteris* leaves found in the Southern Hemisphere. This discovery came as a surprise because we had always assumed that by Middle Jurassic time *Glossopteris* had become extinct several million years before. Unfortunately no fertile parts were found and no cuticles were preserved on the leaves, so the identification as *Glossopteris* rests entirely on the external resemblances to leaves found elsewhere. Even if the Mexican plant is ultimately shown to be generically identical with the Gondwanaland *Glossopteris*, this discovery does not necessarily indicate a spread of the *Glossopteris* flora into Mexico because no other members of this flora were found associated with it. The associated plants are mostly species of *Thinnfeldia* and *Ptilophyllum* which are common genera in Middle Mesozoic floras in Europe and North America. Of special interest in Oaxaca are the foliage and "flowers" of *Williamsonia* that were first published by G. R. Wieland many years ago.

The above is by no means the first report of *Glossopteris* outside the confines of Gondwanaland. Many years ago the Russian geologist Amalitzky claimed to have found it in the Permain of Siberia. To account for this seeming anomaly in the well established distributional pattern of *Glossopteris*, land bridges were built (figuratively speaking) across the Tethys Sea connecting India and Siberia. These bridges permitted *Glossopteris* to escape from confinement and to extend its range (SEWARD, 1931, p. 167). More than half of a century later EDWARDS (1955) examined the material of the supposed Siberian *Glossopteris* and he reported it to be absolutely worthless as a record of that genus.

HARRIS (1932) found leaf fragments showing anastomosing veins like those of *Glossopteris* in the Rhaetic at Scoresby Sound in eastern Greenland, but he says the identity of the leaves is not established beyond all doubt.

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Fully as unexpected as the discovery of *Glossopteris* in southern Mexico was the unearthing a few years earlier of the trunk of a small tree that resembled *Rhexoxylon* in the Upper Jurassic Morrison Formation in Garfield County, in southern Utah (ARNOLD, 1962). *Rhexoxylon* is a Middle Triassic genus, having previously been recognized only in Argentina and South Africa. Its perfectly straight unbranched trunk was 11 feet long and about four inches thick at the base. It was silicified but only the secondary wood cylinder was preserved. The surface was marked by perfectly straight longitudinal ribs, 13 in number, with crests 1.5 to 3.0 cm. apart. The tissues that were preserved corresponded in every detail with those of *Rhexoxylon*. However, none of the primary tissues were preserved, so whether in its original state it possessed the peculiar type of anomalous tissue arrangement that characterizes *Rhexoxylon* is unknown. For this reason, and coupled with the fact that it came from a Late Jurassic rather than a Mid-Triassic horizon, the plant from Utah was made the type of a new genus, *Hermanophyton*. It was freely admitted, however, when this new genus was proposed that it could not be distinguished on any morphological basis from *Rhexoxylon*. This was merely a precautionary measure imposed by the lack of preserved diagnostic characters.

CONCLUSION

Under the hypothesis that Pangaea was a universal continent that broke up during the Mesozoic Era, it is not necessary to construct long transoceanic land bridges to account for the occasional occurrences of components of the Gondwanaland flora in North America. If Gondwanaland was a part of Pangaea at the time the *Glossopteris* flora developed, the isolation under which that flora evolved must have been imposed by climate rather than by separation from Laurasia by wide seaways. At various times a few plants were able to cross the climatic barrier that "fenced in" the *Glossopteris* flora. As a result we find that a few of its components reached Arizona during the Early Permian. *Glossopteris* itself, or some form with identical foliage, migrated into southern Mexico where it established itself along with the flora already there in niches favourable for its survival into Jurassic time. *Rhexoxylon* reached Utah where it was also able to survive after becoming extinct in the Southern Hemisphere.

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