Glossopterids: Suzerains of Geologically Past Indian Forests

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The group Glossopteridales has been an enigma to palaeontologists for more than hundred years, although enormous amount of fossil evidences have been recovered from Indian Lower Gondwana basins and other parts of the world. As the sovereignty of the geologically past Indian forests was maintained by Glossopterids for about fifty million years, these fossil remains are one of the most important tools to trace the evolution of plants on mother earth.

Forest is a collection of naturally occurring plants of diverse forms and obviously forms an integral part of the biosphere. Depending on the environmental conditions of a place, forests may be tropical or temperate; evergreen or deciduous; or may be rain forests desert-arid forests or alpine forests. Today the forests throughout the world are dominated mostly by the less-primitive angiosperms; though certain temperate and subarctic habitats throughout the world are still dominated by gymnosperms. But in the geologic past particularly during Early Cretaceous period (i.e. more than 150 million years ago) the whole scenario was different. Then the forests were dominated by the naked-seeded gymnosperms – a group with wide reproductive, morphological and anatomical diversities. The gymnosperms of the geologic past were restricted to different geographical areas corresponding to the environmental conditions. During Permo-Carboniferous periods (345–280 million years ago) the distribution pattern of the oldest forest of the world was divided into four distinct floristic provinces, namely, (1) Euramerian floral province (2) Angara floral province (3) Cathaysian floral province (4) Gondwana floral province, in both the 'Laurasia' and 'Gondwana' supercontinents of ancient 'Pangaea' landmass of primitive earth. These forests of the geologic past have been converted into today's coal beds. Vari-

ous types of fossils are the only evidences which support the occurrence of such primitive forests.

The Euramerian floral province was composed of tropical, subtropical and coastal swamps of Lycopsids especially *Lepidodendron* flora, Sphenopsids, Pteridosperms, Cordaitales, etc. during Carboniferous followed by the Conifers in the Permian period. The Angara and Cathaysian flora had more or less the same floral elements comprising subtropical to arid to equatorial swamp habitats. On the other hand the Gondwana floral province (popularly known as the *Glossopteris* floral province) is considered as a temperate province because there is evidence of widespread glaciation during Late Carboniferous to Early Permian in the whole Gondwana landmass. As a result the floral elements of Gondwana province were different from other provinces. Almost the entire Indian subcontinent was an integral part of Gondwana floral province.

After a thorough study of the fossil evidences of Indian Gondwana it is evident that during Permo-Carboniferous periods the environment was moist temperate where forest type vegetation was dominated by gymnospermous plants probably belonging to Glossopterids along with the undergrowths of some pteridophytes.

The earliest forest of the Indian Peninsula was occupied by gymnospermous plants (Pant, 1992), especially Glossopterids though certain members of Lycopsids, Sphenopsids, Filicopsids, Cycads, Ginkgophytes, Conifers, etc, were also present. The *Glossopteris* flora flourished during Permo-Carboniferous and continued upto the Early Triassic, i.e. spanned for fifty million years. According to the bipartite division of the Indian Gondwana system, the Lower Gondwana sedimentary rocks were deposited mainly between Late Carboniferous to Permian and continued upto Early Triassic. During the Permian, cyclic deposition of sandstones, shales and coal seams occur while in the Triassic only the sandstones and shales are reported. Within these sediments the Glossopterids occur predominantly in the Permo-

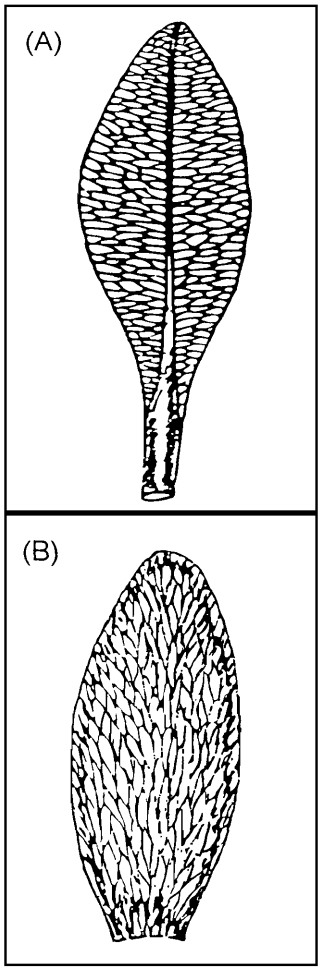


Figure 1. The two main leaf types of Glossopteris flora (A). Glossopteris (B). Gangamopteris

Carboniferous rocks with few remains in the Early Triassic.

Glossopterids initially include several leaf genera, viz, *Euryphyllum, Gangamopteris, Glossopteris, Maheshwariphyllum, Palaeovittaria, Rhabdotaenia* and *Rubidgea*. These leaf genera are accompanied by a root system, a coniferous trunk system and large number of fertile organs generally associated with leaves. Among the leaf genera the *Glossopteris* (*Glosso* = tongue; *pteris* = leaf) is the most common and dominant genus with about 160 species. From Indian Lower Gondwana more than hundred species have been reported (Maheshwari, 1992). The *Glossopteris* leaf (*Figure* 1A) is provided with a prominent midrib from base to apex. The reticulate venation pattern differs from species to species. It may be either dichotomously forked secondary veins or anastomosing veins or both the types may be present in a single leaf. *Rhabdotaenia* has distinct midrib which is parallel to rarely forked secondary veins at right angle. The midrib of Palaeovittaria continues about 3/4th distance from base; then divides into forked veins. *Gangamopteris* (*Figure* 1B) has reticulate venation like *Glossopteris*, but it lacks midvein. In *Euryphyllum* and *Rubidgea* the midrib is also lacking and the genera are with parallel, straight or slightly arched secondary veins. *Maheshwariphyllum* is more or less similar to *Euryphyllum* and *Rubidgea* with much closer midveins simulating midrib.

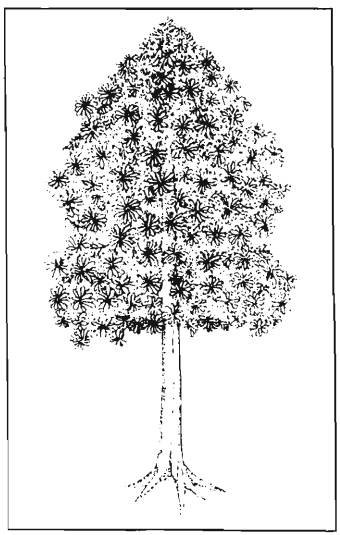
The root system of Glossopterids is represented by the organ-genus *Vertebraria*. It is a taproot system and occurs at the base of the upright axis. The main axis of *Vertebraria* root gives out branches in all directions which again branch into several rootlets. The root anatomy of *Vertebraria* is very interesting. It comprises five or more distinct exarch primary vascular bundles. Primary xylem strands are alternately arranged with the secondary xylem strands. Secondary xylem forms wedge-shaped strand. For this reason compression-impression fossils of *Vertebraria* show characteristic wedge-like sectors (*Figure* 2). *Vertebraria* possesses gymnospermous pycnoxylic woods (i.e. with abundant wood elements and hard in texture) and aerenchymatous tissues.

The glossopteroid stem popularly known as *Araucarioxylon*, is a columnar structure with branching in all directions. Again each of the branches gives rise to several thinner branches. Wood is gymnospermous, massive and resembles the extant araucariaceae of today. The reconstructed *Glossopteris* tree (Gould and Delevoryas, 1977) has a tall trunk with leaves arranged in close spirals or apparently in whorls in the extremities of branches (*Figure* 3).

Figure 2. Vertebraria, the root system of Glossopterids.

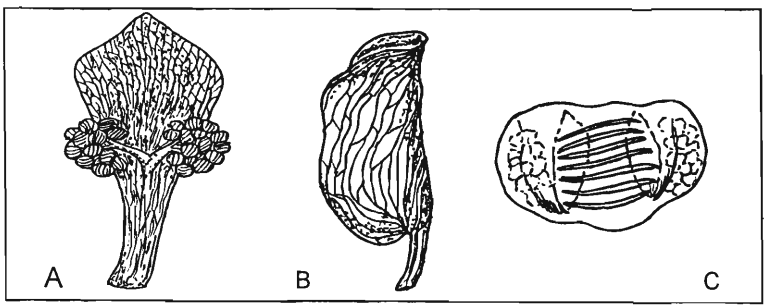
About 40 genera of glossopteridean fertile organs have been described so far (McLoughlin, 1990). These fossil evidences include mostly unisexual (both microsporangiate and ovulate structures) and occasionally bisexual fertile organs. One microsporangiate strobilus, *Eretmonia* (*Figure* 4A), consists of an expanded, more or less triangular bract within which is a stalk originating from the midrib of the bract or in the axil of the bract on the adaxial surface. The branch is divided equally on the two sides of the midrib. Each branch bears whorls of *Arberiella*-type sporangia (*Figure* 4B). Another microsporangiate fertile organ, *Glossotheca* is more or less same as *Eretmonia* except for little differences in midrib branching and is provided with clusters of *Arberiella* sporangia, also frequently known from Indian Lower Gondwana coal-beds.

Figure 3. The Glossopteris tree (Redrawn from reconstruction made by Gould and Delevoryas, 1977).



Indian Lower Gondwana sedimentary rocks also contain abundant microfossils in forms of dispersed spores and pollen grains

Figure 4. (A). Eretmonia – the male fructification (after Surange and Maheshwari, 1970). (B). Arberiella stalked sporangium (after Pant, 1977). (C). Faunipollenites – disaccate striate pollen-grain (after Pant 1977).



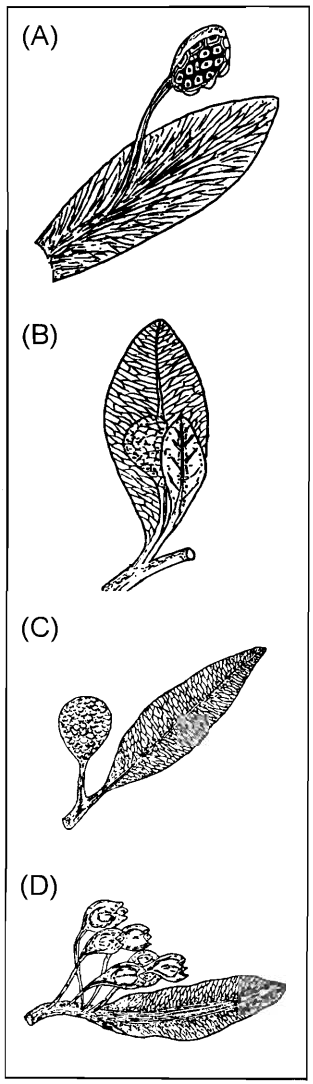


Figure 5. (A). Ottokaria – with ovule bearing capitulum. (B) Dictyopteridium – a well known ovulate frucitfication. (C) Scutum – with ovule bearing receptacle. (D) Denkania – with cupules.
(Redrawn from Surange and Chandra, 1971).

referable to cryptogams and gymnosperms. The gymnospermous pollen grains may be monosaccate or disaccate. D C Bharadwaj (1955-1977) investigated thoroughly these dispersed spore forms and came to the conclusion that many of these disaccate striate forms are the pollen grains of Glossopterids. Later investigations by Gould and Delevoryas (1977), K B Pigg (1988) and others established that the dispersed pollen grain genus *Faunipollenites* (*Figure* 4C) actually belongs to the microsporangiate fertile organ *Eretmonia.*

Many genera, namely *Denkania, Dictyopteridium, Ottokaria, Partha, Scutum,* etc. represent the ovulate fructification of Indian Glossopterids. These fructifications may be with ovule bearing capitulum (*Figure* 5A) or receptacle (*Figure* 5B and 5C) or even cup-like cupulate structure containing single ovule (*Figure* 5D). Again these fructifications may be found on unmodified Glossopterid leaf, or on modified leaf or bract or sometimes as detached fructifications. *Ottokaria* bears a flesh flattened capitulum (head) with the marginal frill bearing the ovules on the undersurface, attached to the foliage of *Gangamopteris*. *Dictyopteridium* consists of a strobiloid ovule-bearing receptacle borne in the axil of a stalked fertile bract. Both the receptacle and its fertile bract are attached to the petiole of a *Glossopteris* leaf. Another fructification, *Scutum* bears a bilateral receptacle with ovules covered on one side by a protective *Glossopteris* foliage. *Denkania* is another interesting fructification. Here, some 5-6 cup-like long stalked structures, containing solitary ovule in each, are arranged on the adaxial basal portion of a glossopteroid leaf. Again, some small sized detached ovules with short stalks and bifid micropylar ends are assigned to the genus *Indocarpus*. These are considered as glossopteroid members due to their presence and abundance in *Glossopteris* dominated Indian Permian sedimentary rocks.

At the end, it is evident that India is a treasure land of glossopteroid fossil flora. Here one thing is also to be noted that, there are possibilities to discover new taxa in future which will enrich our knowledge about the palaeodiversity of Indian Lower

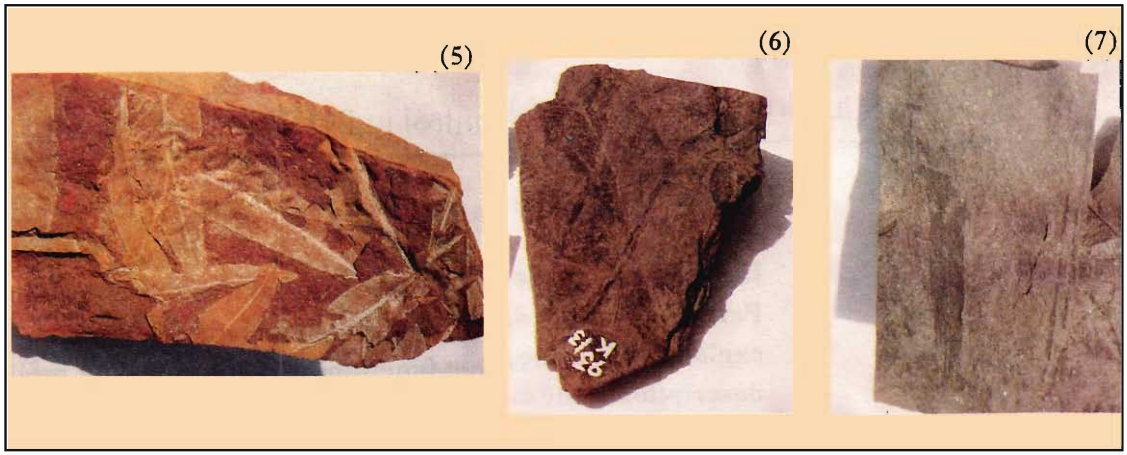


Figure 6. Glossopteris, a very common member of lower Gondwana flora of India.

Figure 7. Glossopteris, with broad tongue shaped leaf.

Figure 8. Another Glossopteris, with linear leaf.

Gondwana system. However, palaeontologists consider Glossopterids as an enigmatic group which shares characters with coniferophytes in their woods comprising distinct growth rings, leaves and disaccate striate pollen grains. Fructifications of this group are unique and not observed in any known group of Gymnospermopsida although some Pteridosperm families show similarities with glossopteridean cupulate fructifications. As a result, the group with such synthetic characteristics is yet considered as a group of uncertain affinity which however dominated for more than fifty million years in the geologically past Indian forests. And it is also very astonishing how such a group with such luxuriant vegetation became extinct from this green planet at the advent of Jurassic age.

Suggested Reading

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