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Glossopteris flora: A review

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ABSTRACT

Gondwana flora consists of three basic floral assemblages. These are *Glossopteris* flora, *Dicroidium* flora and *Ptilophyllum* flora of Permian, Triassic and Lower Cretaceous time. The present article deals with various aspects of *Glossopteris* flora. Different plant groups and genera of Glossopteris flora are briefly discussed. Habit of Permian bryophytes, pteridiphytes and gymnosperms are also summarized.

1. Introduction

India was a member of the supercontinent Gondwanaland that existed toward the southern pole during Permian-Lower Cretaceous times. A typical flora often called Gondwana flora developed within the continents of Gondwanaland during this period. Gondwana flora of India is conventionally divided into following 3 groups; viz., Lower Gondwana flora or Glossopteris flora, Middle Gondwana flora or Dicroidium flora and Upper Gondwana flora or Ptillophyllum flora.

Gondwana sediments ranging from Asselian to Albian in age, contain remnants of these three basic floral assemblages namely, *Glossopteris* Assemblage, *Dicroidium* Assemblage and *Ptilophyllum* Assemblage, which can be recognized through Permian, Triassic and Lower Cretaceous.

There was fall of Rhacopteris flora and rise of Glossopteris flora in the beginning of the Permian. The change in palynology was also observed in the transformation from *Grandispora* assemblage to *Potoneisporites-Plicatipollenites* assemblage. Some important genera like *Botrychiopsis* (=*Gondwanidium*) of Rhacopteris flora are also existed in Glossopteris flora up to Karharbari time. It meant that the Glossopteris flora probably evolved from pre-existing Carboniferous stock through saltations. The glacial episode could have acted as a catalyst for rapid genetic reorganizations in the Rhacopteris flora resulting in newer morphophysiological types. Canyonization of River Basin during Late Permian regression facilitated the drainage of lowland bogs and lakes, which helped the luxuriant growth of Glossopteris flora (McLoughlin and Drinnan, 1996). At the end of the Permian, several changes in the lithosphere occurred including changes in proportion of the atmospheric gases, rotation of plate, transgression of sea, change in the drainage system i.e. change in the dynamics of the entire fluvial systems (Veevers and Tewari, 1995; Tiwari, 2001). As a result a stress was created which distinctly brought a change of flora i.e. from *Glossopteris* to *Dicroidium* prominence. However, the alteration was slow and the climate has not changed drastically in PTB. Similarly onset of Dicroidium flora was in Early Triassic Period. It

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proliferated and diversified in the Middle Triassic period and declined in late Late Triassic (Rhetian) period. There is a big hiatus between the red bed facies (Upper Kamthi/ Panchet Fm.-Triassic) and the next overlying sequence of Upper Gondwana sediments. There was last and third phase of shift when Ptilophyllum flora arose in Late/Upper Jurassic and diversified much during Early Cretaceous time.

2. Glossopteris flora

Evidently Glossopteris flora grew as an indigenous product from the few plants that were left over at the end of Carboniferous glaciations that affected the Gondwanaland. Glossopteris flora may have accompanied the ice age or may be slightly younger than it. Occurrence of dissacate pollens and presence of poorly preserved stems with growth rings from some glacial tillites of Talchir formation may indicate that its earlier members co-existed with late carboniferous glaciations; but Glossopteris itself and most of the other members of this flora are believed to be post glacial origin (Veevers and Tewari, 1995; Tiwari, 2001). The flora soon reached its climax under a damp and wet temperature climate in marshy environment. This is evident by its association with huge number of coal seams and the general absence of growth rings in petrified stem fossils within Lower Gondwana rocks. In India, the major occurrences of Glossopteris flora are found localized within the sedimentary rocks deposited along some major river basins of peninsular India. These include, the Damodar basin (covering parts of Madhya Pradesh, Bihar and West Bengal), the Pranhita-Godavari basin (of Andhra Pradesh and Maharashtra) and the Mahanadi basin (of Orissa and Chhatishgarh). Besides, several isolated Lower Gondwana rocks, reported from some localities such as Sikkim, Kashmir, Rajasthan and Eastcoast of India also yield Glossopteris flora (Sastry *et al*., 1977; Surange and Chandra, 1978). Glossopteris floral members are found in all rock formations of Lower Gondwana sequence of the type area, such as Talchir, Karharbari, Barakar, Barren Measures and Raniganj formations and their equivalent formations in other Gondwana basins. A long standing idea about stratigraphic age of Lower Gondwana flora is that it is ranging from Earliest Lower Permian to Lower Triassic. In other words, it is beginning with initiation of Talchir and ending with Lower Panchet. In most of the field sections, the first appearance of Glossopteris flora is noted in rocks immediately overlying the glaciogene tillities occurring at the base of the Talchir formation. Again the main bulk of the flora became extinct at the base of Panchet formation. So it is essential to demarcate the age of the tillities and the base of Panchet to find out the total range of the Glossopteris flora. The climate warmed after the ice age of the Late Carboniferous and earliest Permian, and a rich flora evolved that was dominated by *Glossopteris*. Coal deposits were formed in extensive areas of cool-temperate swamps where plant communities thrived. For the first time Ginkgoes and Conifers make their appearance in the fossil record, colonising the drier hill sides, not requiring swamps for their survival (Maheshwari, 1966; Maithy, 1966). There were also many tree ferns, cycads, equisetales, sphenophyllales. Dense and low swamp vegetation composed of ferns, seed-ferns, and possibly mosses like peat, herbaceous lycopods grew in dense masses. As the continental ice sheets melted in the earliest Permian, the rising sea inundated large areas of India. The part of the continent was the first to become dry land again when the seas retreated. Then the Gondwana basins remained flooded by the shallow seas until the Middle Permian. In the swamps and adjacent areas of high water table, *Glossopteris* grew that had specially adapted aeration roots to allow them to grow in marshy conditions. Mangroves use the same type of roots to grow along the coasts at present. Each formation is represented by some index fossils (Table 1). These fossils have immense use in biostratigraphic correlation.

Table 1

The index fossils of various formations of Glossopteris flora

Sl. No.	Formation	Index Fossil
1	Upper Kamthi/Panchet	Dicroidium
2	Lower Kamthi/ Raniganj	Broad mesh form *Glossopteris species*
3	Barren Measures/ Kulti	Barren of Fossils
4	Barakar	Middle Mesh form *Glossopteris species*
5	Karharbari	*Gondwanidium, Buriadia,* G*angamopteris, Noeggerathiopsis, Euryphyllum*
6	Talchir	*Arberia*, *Ottokaria*, Narrow mesh form *Gangamopteris species*

2.1 Barren measures: devoid of plant megafossils

The report of mega-fossil remains in the Barren Measures Formation is uncommon. It is because mostly due to the change in facies rather than the paucity of floral elements during that period. As is evidenced by presence of ironstone shales and purple brown shales in this formation, the depositional environment was mostly oxidising, thus preventing good preservation of vegetative remains. The ecological conditions may also have been arid with dry hot and wet humid spells as postulated by various workers, but not to that extent that plant life couldn't leave its signature on the sediments. Besides, wherever carbonaceous / grey shale sediments were deposited, miofloral remains (spores/ pollens) are found in good amount (Tripathi and Bhattacharya, 2001). The tectonic set up was also not stable enough to form coal and the depositional regime was also not conducive for the preservation of megafloral remains during Barren Measures time (Cassyap and Tewari, 1988, Goswami *et al*, 2006a-c).

2.2. Common Glossopteris flora

2.2.1 Bryophytes

Bryophytes are devoid of true vascular tissues, lacking extensive resistant mechanical tissue with little or almost no cuticle. Thus, it is difficult to expect that such diminutive plants would lend themselves fossilization. The report of bryophytes in Indian Gondwana is outstanding (Chandra, 1995). Fossil bryophytes reported are few as compared to vascular plants, but they indicate early existence of mosses and liverworts. Bryophytes cannot be transported for great distances due to their fragile nature. Thus, the assemblage of bryophytes has been preserved at the same place where they were growing. As the bryophyte cannot tolerate salinity, so the sea must not have been in the near proximity to the bryophytic site. They were growing in and around a fresh water pool, or a stream from melting ice.

2.2.2 Pteridophytes

It includes different plant groups and a number of genera (Table 2). Majority of the pteridophytes (ferns, lycopods and arthrophytes) were growing in and around marshy system. All arthrophytes and lycopods were probably aquatic or semi-aquatic plants growing in shallow waters or marshy places around lakes, ponds or rivers. Lycopod were possibly herbaceous plants growing as ground-cover in mires. The paucity of lycopsid remains may be due to their delicate nature and their suppression by an overwhelming preponderance of gymnosperms (Maheshwari, 1974). Equisetales and sphenophyllales like *Schizoneura, Raniganjia, Bengalia, Benlightfootia* and *Trizygia* were less abundant than *glossopteridales. Schizoneura,* a herbaceous plant, had a main axis giving alternate branches and possessing opposite leaflets on finer branches. *Raniganjia* species may have had a trailing habit and were smaller than *Schizoneura. Bengalia* and *Benlightfootia* were uncommon and geographically restricted. *Bengalia* represented small delicate plants. *Benlightfootia* had a slender axis with swollen nodes bearing clusters of leaflets. *Trizygia* represented small upright plants having slender unbranched axes with whorled leaflets. According to Maithy (1978), this plant was erect, herbaceous, and more or less 20 cm tall with 16-22 whorls of leaves. These plants are preferentially preserved in argillaceous shales, suggesting growth in quiet flood-basin settings. Ferns like *Neomariopteris* and *Dichotomopteris* may have grown in temperate shady sites with high humidity, perhaps below *Glossopteris* trees. *Neomariopteris hughesii* might have been a small tree based on branched stems of considerable height and width rather than a typical prostrate fern (Singh and Chandra, 1999). *Dichotomopteris* plants were delicately built as evidenced by their slender rachises and pinnules (Goswami *et al*., 2006a; b; c).

Table 2

Important groups of pteridophytes and most common genera of Glossopteris flora

Sl. No.	Fossil group	Common genera
1	*Lycopodiales*	*Cyclodendron*
2	*Equisetales* and *Sphenophylales*	*Equisetaceous stems, Trizygia, Schizoneura, Raniganjia, Benlightfootia, Phyllotheca* and *Bengalia*
3	*Filicales*	*Neomariopteris* and *Dichotomopteris*

2.2.3 Gymnosperms

It includes several plant groups and genera of which *Glossopteris* and *Gangamopteris* were small to large arboroscent plant. The plants were deciduous in nature. While interpreting the habit of the plant; a great variation in the diameters of *Vertebraria* (root of *Glossopteris* plant), the attachment of seemingly diverse fertile organs and different organisation of ovules in the fructification demonstrate that the plant of *Glossopteris* and *Gangamopteris* had different types of habits. These plants during the deposition of Talcher Formation (early Lower Permian) were possibly very stunted forms attaining a height of a small shrub as evidenced by no report of woody stems from this period throughout the Gondwana. Subsequently, during the deposition of Karharbari formation (middle Lower Permian), some of the species attained a height of trees, while others remained as small bushy plants. In later period (during late Lower Permian and Upper Permian), most of them attained an arborescent habit. However, some of them could possibly have retained an herbaceous habit. Besides *Glossopteris* and *Gangamopteris,* rest of the genera also grew luxuriantly around the vicinity of the lake and pond. Conifer genus, *Buriadia* was small and bushy plant. *Macrotaeniopteris* was probably arborescent in habit. The *Ginkgoites* species was a small tree. *Vertebraria indica* represents the root system of *Glossopteris* plants. Most of these plants including *Palaeovittaria kurzii* and *Surangephyllum elongatum* were deciduous. These gymnosperms form terrestrial system.

Table 3

Important groups of gymnosperms and most common genera of Glossopteris flora

Sl. No.	Fossil group	Important genera
1	*Cordaitales*	*Noeggerathiopsis, Cordaites, Euryphyllum, Kawizophyllum*
2	*Cycadales*	*Macrotaeniopteris, Pseudotenis balli*
3	*Ginkgoales*	*Ginkgoites*
4	*Coniferales*	*Buriadia*
5	*Glossopteridales* (leaf form)	*Glossopteris, Surangephyllum, Gangmopteris, Palaeovittaria*
6	*Glossopteridales* (root)	*Vertebraria*
7	*Glossopteridales* (fertile forms)	*Venustostrobus, Cistella, Ottokaria, Dictyopteridium, Senotheca, Eretmonia, Glossotheca, Kendostrobusi*

Genera namely *Denkania, Dictyopteridium, Eretmonia, Glossotheca, Indocarpus, Khania, Lidgettonia, Nesowalesia, Partha, Utkalia, Ottokaria, Senotheca*, *Cistella, Scutum, Jambadostrobus, Plumsteadiostrobus, Venustostrobus, Kendostrobus, Arberia, Raniganjiostrobus, Gonophylloides, Isodictyopteridium, Lanceolatus, Plumsteadia, Bankolaea, Gondwanolepis, Ghosialepis, Mohudaea* of glossopterid fructifications are reported from the Indian Gondwana. Amongst them *Partha, Denkania, Lidgettonia, Scutum, Jambadostrobus, Plumsteadiostrobus, Venustostrobus, Cistella, Ottokaria, Dictyopteridium, Senotheca* (female reproductive organs) and *Eretmonia, Glossotheca* and *Kendostrobusi* (male reproductive organ) are generally reported attached with *Glossopteris* leaves or found detached, where a good number of *Glossopteris* leaves were recorded.

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