THE GLOSSOPTERIS FLORA OF INDIA AND THE ANGARA FLORA OF U.S.S.R.

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ABSTRACT

It is a common belief that some elements of the Glossopteris flora were present in the Angara flora. The known genera of Lepidodendrales, Calamitales and Equisetales, Sphenophyllales, Fern-like fronds, Ginkgoales and other gymnosperms from the Angara as well as the Gondwana floras have been briefly examined. It is concluded that apart from superficial resemblance in some cases, the Angara and the Gondwana plants are distinct and possibly no common elements are present in them. Although the present outliers of both floras are separated by a few hundred kilometers, India possibly lay far south in the late Palaeozoic time and the two land masses were separated by the Tethys epicontal sea. This would at least partly explain why there could be no intermixing between these two contemporaneous floras.

In the late Carboniferous and the Permian, four main fossil floras have been distinguished: (1) Euramerian flora, (2) Angara flora, (3) Gondwana flora and (4) Caythasian flora. The Euramerian and Caythasian floras flourished in an equitable climate, whereas the Gondwana and Angara floras flourished in temperate conditions. The present territories of Angara and Gondwana floras lie juxtaposed with only a few hundred kilometers separating the outliers of the two floras. The present proximity of the two floristic provinces perhaps influenced previous workers like ZALESSKY (1914), ARBER (1905) and others to identify some common elements in the Angara and the Gondwana floras.

According to the present thinking, in the late Palaeozoic time India did not lie in its present geographical position. It perhaps occupied a position in the southern hemisphere in juxtaposition with the continents of Antarctica, Australia and Africa, with Tethys epicontal sea stretching between this landmass and the continents of the northern hemisphere (SCHOPF, 1970). Whatever might have been the geographical position of India *vis a vis* the Angaraland during the Carboniferous and the Permian, it would be interesting to examine critically the Permian Gondwana and Angara floras, in order to ascertain whether any common related plants were really present in the two floras and if so, what was the route of their migration.

Being acquainted with the Glossopteris flora of India, it was interesting for me to examine the Permian plants from the U.S.S.R., with a view to see how far there is a mixture of Glossopteris plants in the Angara flora. Recently I had an opportunity to examine fossil collections from Kuznetsk basin, Petchora basin and other regions of the Angaraland. One thing that strikes at once is that the Angara flora is richer than the Glossopteris flora in genera and species and it is dominated by the cordaitean types of gymnosperms. All the major groups of plants are no doubt represented in the Angara flora, but there is a greater variety, and the preservation in many cases is excellent.

I would like to take this opportunity to express my thanks to Dr. S. V. Meyen of the Geological Institute, Moscow, with whose help I examined the Angara fossil plants from different basins. Our discussions during my visit to U.S.S.R., and later during his visit to India, have helped me a great deal in finalizing this paper.

Lepidodendrales

There is a striking paucity of lycopods in the Permain Angara flora of the U.S.S.R. and it is true for the Glossopteris flora of India also. The Angara lycopods are described in old literature under the genera *Viatscheslavia*, *Lepidodendron*, *Knorria*, *Demetria* and *Angarodendron*. They usually show somewhat different arrangements of leaf and leaf cushions than the lycopod genera of the Euramerian flora. The lycopods of the Glossopteris flora are also considered to be distinct from the northern forms. The most widespread southern genus is *Cyclodendron*, which occurs in India mostly in the Barren Measures. Although the stems of *Cyclodendron* from India lack leaf cushions, the eye-shaped leaf scars are typical of the genus. Neuburg described a genus *Tundodendron* from Petchora basin, which was regarded superficially similar to *Cyclodendron*, but recently it has been found that it is distinct from it. Thus *Cyclodendron* is not present in Angaraland.

Recently some lycopod stems with leaf cushions showing ligular scars (?) were described from Kashmir by Srivastava and Kapoor (1969) and Kapoor (1969). Although the impressions appear like lycopod stems, the generic identity is not convincing, because the specimens are poorly preserved and the scars are devoid of vascular bundle marks and parichnos. Even the presence of a ligule needs confirmation from well preserved specimens. The scars described and figured as lingules seem to correspond to the elevations which are left on cushions when leaves dried without abcission like those in *Sublepidodendron*. The identification of *Lepidostrobus* (Srivastava and Kapoor, 1969) is again doubtful. The presence of a peduncle—a stalk—coupled with the absence of any characteristic features of a *Lepidodendron* cone, makes one wonder whether it really belongs to a *Lepidodendron* or it represents some other genus. So the presence of the genus *Lepidodendron* in the Permian of Kashmir needs confirmation. Although this Kashmir flora appears to be distinct from the typical Glossopteris flora of the peninsular India, it may be presumed that the presence of Angara *Lepidodendron*-like plants have not yet been proved in the Gondwanaland. There is, therefore, no ground to suppose that this genus migrated to India from the northern floras.

Calamitales and Equisetales

The articulates in the Angara flora are represented by the following genera: *Annularia*, *Phyllopitys*, *Annulina*, *Paracalamites*, *Schizoneura* and *Phylloytheca*. In the Indian Gondwana flora the following genera are present: *Schizoneura*, *Phyllotheca*, *Stellotheca* and *Raniganjia*.

The Angara plants *Annularia*, *Paracalamites*, *Phyllopitys* and *Annulina* are totally absent in India, whereas *Stellotheca* and *Raniganjia* of Gondwanas are not present in the Angara flora at all. As regards *Schizoneura*, it is doubtful whether this genus is present in Angaraland at all. *Schizoneura sibirica* has been rightly transferred recently by Radezenko to a new genus *Paraschizoneura*.

So we are left with the only common genus *Phyllotheca*. The vegetative shoots of Angara and Gondwana phyllothecas indeed look strinkingly similar, but the known fructifications of the two are distinct. *Phyllotheca australis*, which is very similar to the Indian *Phyllotheca indica* has twice forked sporangiophores, whose terminal branches bear peltate discs with four free sporangia. The fructifications of Angara *Phyllotheca* is described under the genus *Tschernovia* Zal. It consists of an unbranched stalk with 4 – 11 sponrangia attached to a disc with flattened proximal part and they are at least partially fused. The fructifications of the southern as well as the northern Phyllothecas are thus quite distinct and, as rightly regarded by Meyen (1967), should belong to at least two separate families of articulates. The contention of Meyen (1967) that *Phyllotheca* should be regarded as a form genus is sound. The similarity between

the articulates of Angara flora and the Indian Glossopteris flora, thus, is more apparent than real.

The only possible common genus of Angara and Gondwana articulates is *Barakaria* (Meyen, 1967) which, however, is extremely rare in both floras. The genus, too, is very imperfectly known and so the similarity between the form *Barakaria* of Angara and Gondwanaland may not prove to be more than superficial.

Sphenophyllales

Sphenophyllum, which should also be regarded as a form genus, is found in all the four Palaeozoic floras of the world. Only one species, *S. speciosum*, is known from India and, according to Pant and Mehra (1963), it stands out distinct from all the northern species in number and form of the leaves and, to a lesser extent, in the details of venation and epidermal structure.

The Angara sphenophylls are referred to *Trizygia*, a generic name used by Royle in 1839 for some specimens of *S. speciosum*. Their epidermal structure is not known and, therefore, Meyen (1967) is right in assuming that there are no grounds for ascribing the Angara species to *Trizygia*. Thus, although in Angara the genus *Sphenophyllum* is represented by many species, not a single species has been conclusively shown to be identical with the Indian *S. speciosum*.

Fern-Like Fronds

Fern-like fronds which are generally described under various form genera, form an essential element in all the four Palaeozoic fossil floras of the world. None of them should be regarded as genetically related unless similar fructifications are found on them. *Sphenopteris* and *Pecopteris* are very common in the Angara flora as well as in the Glossopteris flora. These are not natural genera and so it would be misleading to presume any relationship between the *Sphenopteris* and *Pecopteris* of the Angaraland and the Gondwanaland.

Sphenopteris, *Pecopteris* and *Alethopteris* are widespread in the Indian Glossopteris flora. The Indian *Alethopteris* differs in details of venation from its typical Euramerian representatives and it is completely absent from the Angara flora. The Angara flora, in addition to *Sphenopteris* and *Pecopteris*, possess other genera also such as *Neuropteris*, *Comia*, *Comsopteris* and *Callipteris*. The last four are, however, absent in the Indian Glossopteris flora. Furthermore, there are certain fern-like fronds which are peculiar to each of them. *Angaropteridium*, and *Angaridium* occur in the Angara flora, whereas *Merianopteris* and *Belemnopteris* occur in the Indian Glossopteris flora.

The well known fern-like genus of the Indian Gondwana is *Gondwanidium* which has odontopteroid venation but no midrib. Earlier some similar looking fronds from Angaraland were identified with *Gondwanidium*. But recently Meyen has put all the Angara species of *Gondwanidium* into a separate genus *Paragondwanidium*, on the ground that *G. sibiricum* from Kuznetsk has a distinct midrib and the lateral veins are concentrated in bundles. The venation pattern as well as attachment of pinnules in both is so distinct as to justify their keeping under two separate genera. Thus the genus *Gondwanidium* is also not present in Angaraland.

Ginkgoales

Plants of ginkgoalean appearance are widespread in the Permian of U.S.S.R., but they are extremely rare in the Indian Glossopteris flora. Ginkgoales as such are poorly represented

in the southern hemisphere. Two species of *Rhipidopsis* have been reported from the Barakar and Raniganj stages but they are extremely scarce. Another genus *Psygmophyllum* is doubtfully reported from Kashmir. On the other hand, the ginkgoalean genera, *Baira*, *Ginkgophyllum*, *Dicranophyllum* and *Rhipidopsis* are represented by many species in Angaraland. It, therefore, appears that the homeland of ginkgoalean plants was the Angaraland, particularly the Western part according to Meyen, where they were present in abundance. Later in the Mesozoic they spread over the whole of Angaraland and became one of the dominant element of the flora.

Other Gymnosperms

The majority of the Permian gymnosperms from India and Angaraland are entirely distinct, the former being dominated by such genera as *Glossopteris* and *Gangamopteris* and the latter by *Zamiopteris*, *Tatarina*, *Pursongia* and other leaf genera. But there are certain genera which have been identified as common in both.

Noeggerathiopsis is one such form genus which is reported both from the Angara flora and the Indian Glossopteris flora. In India it is represented only by a few species, mostly in the Karharbari beds, but is comparatively rare in other Gondwana horizons. In Angara, however, it is represented by many species. I had the occasion to examine the epidermal structure of some Angara leaves. The epidermal structure of the Gondwana *Noeggerathiopsis* leaves (Pant and Verma, 1964; Lele and Maithy, 1964; Maithy, 1964) is distinct from those of the Angara *Noeggerathiopsis* leaves. *Rufloria* of Angara is, again totally absent in the Gondwana flora of India.

Another genus *Samaropsis* occurs in abundance and in great variety both in the Angara and the Gondwana floras and some Indian species no doubt appear very similar to those from the Angaraland. A few of the *Samaropsis* seeds have also been found on different types of fructifications. It may be that many more different types of gymnospermous plants in both the Angara and the Gondwana bore similar winged types of seeds. However, many fructifications bearing different kinds of seeds are not yet known and it is, therefore, difficult to say whether the plants bearing similar looking seeds in both the Angara and the Gondwana floras were genetically related. At least gymnospermous leaf genera are distinct in both.

Some scale leaves in the Indian Glossopteris flora look strikingly similar to the Angara scale leaf genera such as *Nephropsis*, *Crassinervia* and *Lepeophyllum*. The specimens in our collection are mere impressions and their structure is not known in detail. The resemblance between the Glossopteris and Angara scale leaves may, therefore, be superficial; nevertheless, it is very striking.

At the end of the 19th century certain leaves from the Upper Permian of North Drina river in U.S.S.R. were identified as *Glossopteris* by Amalytzky. They have no midrib and there is no anastomosing of the secondary veins. Such specimens have, therefore, been rightly transferred to a separate genus *Pursongia*. Those leaves which yielded cuticle have been placed under a new genus *Tatarina*. They are associated, according to Meyen with *Peltaspermum*–like fructifications. It must be stated that leaves looking like *Glossopteris*, although extremely rare, are present in the Angara flora, although fructifications frequently associated with *Glossopteris* have never been reported from Angaraland. I have been able to examine two such specimens from the Upper Permian of the Kuznetsk and Tunguska basins. They show a midrib and anastomosing of the secondary veins. From the shape, venation and other external characters, it is impossible to separate these specimens from the form genus *Glossopteris*. Zimina also reported *Gangamopteris* from the Far East with axial bundle of veins. I have

not seen these specimens. I amt old that hardly a do·en specimens with *Glossopteris*-like venation have so far been discovered in the Angaraland. In any case, the mere presence of *Glossopteris* in Angara flora is puzzling. Either the Angara specimens are true *Glossopteris*, or more probably they might have belonged to a different group of plants which possessed *Glossopteris*-like leaves. But if they are real *Glossopteris*, how did they reach Angara land?

Furthermore, even the plants of uncertain affinities are different in Angara and the Gondwanaland. For example, the Angara has genera such as *Glottophyllum*, *Vojnovskya*, *Niazonaria*, *Cladostrobus*, *Tychopteris* etc., whereas the Gondwana has *Euryphyllum*. *Rubidgea*, *Dolianitia*, *Palmatophyllites* etc. Similarly the petrified gymnospermous wood genera are distinct in the Angaraland and the Gondwanaland. Although this difference may not be very significant as these plants are so little known, it does serve the purpose of emphasizing the distinctness of the two floras.

CONCLUSIONS

Recently Schopf (1970) has summarised the relation of floras of the southern hemisphere to continental drift. The anomalies of plant distribution of the past can be explained if some land connections between the southern continents are accepted. Schopf (1970) summarised nonbiological evidence of "geophysical studies, particularly of the ocean basin, which has now provided an acceptable mechanism that accounts for rifting and shifting of sialic continents through geologic time". He further stated that "there is now a great deal more evidence that can be taken to suggest that Gondwanaland truely did in Permian and Triassic time occupy the latitudes and longitudes of much of the Indian ocean".

Although the present outliers of the Indian Gondwanaland (Kashmir) and the southern localities of Angaraland are separated by only a few hundred kilometers, yet the floras of the two regions, during atleast the late Carboniferous and the Permian, were quite distinct. There is indeed no evidence for the migration of Gondwana elements into the Angara or *vice versa*. On the other hand, recent investigations have clearly brought out the fact that no common elements are present in the two, and that whatever superficial resemblance there is in some cases, it may be more apparent than real. This is an evidence of plant geography which shows that there was some great barrier which did not allow intermixing of the two temperate floras and it was perhaps the great Tethys sea which separated India from the Angaraland.

Another striking fact is that the Glossopteris and the Angara floras were the two Permian floras which were flourishing in cold climate with seasonal variations and, therefore, the dominant elements in them were the gymnospermous plants. The fructifications of the Gondwana and Angara gymnosperms are meagrely known, and so we are unable to appreciate the variety of forms present in them. However, from whatever little is known, new types have been thrown up which defy classification under the traditional groups of gymnosperms. It is most likely that many more new types of gymnosperms than we know today will come to light from the two temperate floras.

Most of the living gymnosperms had almost attained their modern look by the Jurassic, but it seems that they had much wider base in the Permian. It is in the Permain that the gymnosperms were rapidly evolving in different ways, as is evident from the bizzare types discovered in the Glossopteris and the Angara floras. Before the end of the Permain, most of them became extinct, perhaps some continued into the Triassic in modified forms, but by the end of Jurassic they died out, yielding place to the most successful competitors which continue to this day.

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