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Study of Plant Fossils Recovered from Gondwana

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ABSTRACT: Lower Gondwana plant fossils from the Bhareli Formation, exposed between Pinjoli Nala and Sessa along the Bhalukpong - Bomdila Road, West Kameng district, Arunachal Pradesh, were seen. The assemblage comprises *Gangamopteris cyclopteroides, G. intermedia, Glossopteris angustifolia, G. communis, G. damudica, G. indica, G. intermittens, Scutum cf. stowanum, Vertebraria indica, Noeggerathiopsis* sp., *Cheirophyllum lacerata*, stem of *Buriadia, Cordaicarpus cordai*, *Rotundocarpus striatus* and *Walikalia cahenii*. The assemblage is comparable to that of the Karharbari Formation of Early Permian Coalfields of Peninsular India. The most important fossil flora of India is what is known as the Gondwana Flora which covers the period Upper Carboniferous to Jurassic. Indian plant fossils are known before (a few) and after (quite a large number) this period but no flora is as interesting as the Gondwana Flora. Towards the end of the Palaeozoic were the great Hercynian mountain building waves.This was followed in the Upper Carboniferous and the Permian by severe glaciation and the Permian in India is the greatest coal- forming age. The geography of the Earth at that time was quite different from what it is today .

KEYWORDS: Indian Gondwana, plant fossils, carboniferous, Jurassic, flora, coal, geography

I. INTRODUCTION

There were three continents—the Eur-American Continent (modern Europe and North America) to the North-West, Angaraland (Siberia and North China) to the North-East and a vast Gondwana land on the South which combined the land masses of India, Africa, Australia, South America and Antarctica. In between the continents was the great Sea of Tethys.The Gondwana land has been named after the Gond tribe of Madhya Pradesh ruled by the famous Rani Durgabati during the reign of Akbar. The name was coined by H. B. Medlicott in 1872 but actually published by O. Feistmantel in 1876.[1] The Gondwana land began to split in the Jurassic as shown by the intensive lava injections at that age.There was drifting apart of the continents in the Cretaceous, gradually bringing them to their present positions. Another series of great mountain building waves built the present dominant Mountains (Himalayas, Alps, etc.) on the location of the Sea if Tethys.The whole Gondwana land (now distributed over five continents) shows a uniformity of the Flora (and also the Fauna).In Indian Geology the Gondwana rocks are considered to form a Group which is almost equivalent to an Era like Palaeozoic. Feistmantel (1882) divided the Gondwana into Lowor Gondwana (Permo-Carboni- ferous with Glossopteris Flora), Middle Gondwana (Triassic with *Glossopteris*-Thiimfeldia (*Dicroidium* Flora) and Upper Gondwana (Jurassic with *Ptilophyllum* Flora).[2]

This three-fold division has been followed by many authorities like Wadia and Lele. But many other authorities prefer a two-fold division into Lower Gondwana (Upper Carboniferous to Lower Triassic) and Upper Gondwana (Lower Triassic to Jurassic, probably reaching Cretaceous).The two-fold division is supported by the two (*Glossopteris* Flora and *Thinnfeldia (Dicroidium*)—*Ptilophyllum* Flora) distinct floras (and faunas) in the two divisions.There is a sudden break between the two floras[3] as during the Upper Permian and Triassic intensive glaciation and drought killed most of the previous early Gymnosperms and arborescent Pteridophytes giving place to the more modern Gymnosperms and herbaceous Pteridophytes (mainly ferns).[4]

Places in Indian showing Gondwana rocks occur mainly in the Damodar, Sone, Narbada, Godavari and Mahanadi Valleys. There are also some exposure along the Himalayan foothills of Nepal, Bhutan and Arunachal and also in the Punjab, Himachal, Kashmir and Baluchistan. It should be noted against that the Triassic beds [5](Maleri, Mahadeva, Pachmarhi, Parsora, Panchet) spreading from Sone to Godavari Valleys are placed by some in Middle Gondwana.[6]

Upper Gondwana rocks are more detached occurring in patches along Rajmahal-Cuttack to Kanya Kumari, in Madhya Pradesh, Rewa, Saurashtra, Kutch and in Ceylon. A vivid leaf fossil dating back to Gondwana era is the latest addition

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to the private collection of Coimbatore-based fossil collector A.R.K. Arun.[7] Picked up during a recent search at Gunduperumbedu in Kancheepuram, the *Ptilophyllum* fossil must be 400 million years old, he said. Explaining the clear lines of petiole and stalk of the leaf fossil, as it looks like a feather, Mr. Arun said that Ptilophyllum could be the forefather of present day *Cycas Revoluta*, a popular garden plant."It was after hours of search I came across this clear and pictorial *Ptilophyllum* fossil. The piece of rock seemed simple but the clear fossil of the lead came to me as a surprise as I sectioned it into two pieces," said Mr. Arun who is fondly called as 'Kallu'[8] (stone) among known circles.He said that the area from where the fossil was picked up could have been a backwater or swampy land in the past. Presence of fossils is also considered as petroleum guider. Fossils of *Glossopteris* and *Taeniopteris* non-flowering plants are also found in Gunduperumbedu fossil bed. In Ariyalur, known as the land of mass mortality, fossils of marine invertebrates of Cretaceous period can be found. Thiruvakkarai[9] is another site rich with fossils of Miocene era," said Mr. Arun, whose collection primarily includes marine invertebrates fossils of Cretaceous system that started 136 million years ago and lasted 71 million years.Mr. Arun's collection of over 1,000 fossils, one of the largest among individual collectors in the country, includes rocks, minerals, gems, volcanic lava, meteorite and tectite. According to him, the youngest fossil in his collection is Dadoxylon, a tree fossil, which is 20 million years old.[10]

K. Raju, Superintendent (Geology), Geological Survey of India Training Institute at Chitradurga, Bengaluru, said that several pockets of Kancheepuram are known for fossils of *Taeniopteris* and *Ptilophyllum* plant varieties dating back to Gondwana era.[11]

At Gunduperumbedu, indeed these fossils were collected and safeguarded by the locals, who had termed them as `poo kal' (flower stones). They use to sell them to the fossil collectors and botanists who arrive at this village in search of these sedimentary shale rock with plant fossils.These rock pieces, some of them in pure white, some with pink markings could be seen strewn around in mounds all over the village, revenue department sources said.[12]

II. DISCUSSION

Gondwana succession in India range in age from late Paeozoic glaceogene Talchir Formation to the early Jurassic Kota Formation. The coal bearing Lower Gondwana formations are relatively more affected by faults, and are characterized by the presence of the *Glossopteris* flora, whereas unconformably overlying Upper Gondwana cover are relatively less deformed and often over laps prominent faults and are characterized by the presence of the *Ptilophyllum* flora. A transition zone in between contains lingering elements of *Glossopteris*, with advent of the *Dicroidium flora*, common presence of the reptilian fauna and of red beds. The Gondwana sedimentation covering from the ice-house setting to the green-house setting,the latter causing intense chemical weathering, provide another climate forced correlation tool.[13]

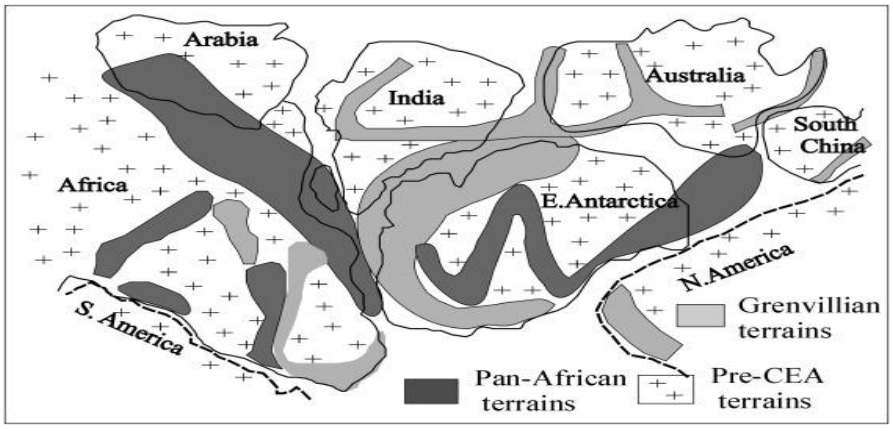

Fig.1 Pan-African and Circum-East Antarctica (Grenvillian) terrains in east Gondwana during c. 1000–500 Ma.

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The adjective "Gondwanan" is in common use in biogeography when referring to patterns of distribution of living organisms, typically when the organisms are restricted to two or more of the now-discontinuous regions that were once part of Gondwana, including the Antarctic flora. For example, the plant family Proteaceae, known from all continents in the Southern Hemisphere, has a "Gondwanan distribution" and is often described as an archaic, or relict, lineage. [14] The distributions in the Proteaceae is, nevertheless, the result of both Gondwanan rafting and later oceanic dispersal. During the Silurian, Gondwana extended from the Equator (Australia) to the South Pole (North Africa and South America) whilst Laurasia was located on the Equator opposite to Australia. A short-lived Late Ordovician glaciation was followed by a Silurian Hot House period. The End-Ordovician extinction, which resulted in 27% of marine invertebrate families and 57% of genera going extinct, occurred during this shift from Ice House to Hot House. By the end of the Ordovician, *Cooksonia*, a slender, ground-covering plant, became the first vascular plant to establish itself on land. This first colonisation occurred exclusively around the Equator on landmasses then limited to Laurasia and, in Gondwana, to Australia. In the Late Silurian,[15] two distinctive lineages, zosterophylls and rhyniophytes, had colonised the tropics. The former evolved into the lycopods that were to dominate the Gondwanan vegetation over a long period, whilst the latter evolved into horsetails and gymnosperms. Most of Gondwana was located far from the Equator during this period and remained a lifeless and barren landscape. [16]

Fig.2 Reconstructions of (left) a Late Silurian *Cooksonia*, the first land plant, and (right) a Late Devonian *Archaeopteris*, the first large tree

West Gondwana drifted north during the Devonian, bringing Gondwana and Laurasia close together. Global cooling contributed to the Late Devonian extinction (19% of marine families and 50% of genera went extinct) and glaciation occurred in South America. Before Pangaea had formed, terrestrial plants, such as pteridophytes, began to diversify rapidly resulting in the colonisation of Gondwana. [17]The Baragwanathia Flora, found only in the Yea Beds of Victoria, Australia, occurs in two strata separated by 1,700 m (5,600 ft) or 30 Ma; the upper assemblage is more diverse and includes Baragwanathia, the first primitive herbaceous lycopod to evolve from the zosterophylls. During the Devonian, giant club mosses replaced the Baragwanathia Flora, introducing the first trees, and by the Late Devonian this first forest was accompanied by the progymnosperms, including the first large trees *Archaeopteris*. The Late Devonian extinction probably also resulted in osteolepiform fishes evolving into the amphibian tetrapods, the earliest land vertebrates, in Greenland and Russia. The only traces of this evolution in Gondwana are amphibian footprints and a single jaw from Australia. [18]

The closure of the Rheic Ocean and the formation of Pangaea in the Carboniferous resulted in the rerouting of ocean currents that initiated an Ice House period. As Gondwana began to rotate clockwise, Australia shifted south to more temperate latitudes. An ice cap initially covered most of southern Africa and South America but spread to eventually cover most of the supercontinent, save for northernmost Africa-South America and eastern Australia. Giant lycopod and horsetail forests continued to evolve in tropical Laurasia[19] together with a diversified assemblage of true insects. In Gondwana, in contrast, ice and, in Australia, volcanism decimated the Devonian flora to a low-diversity seed fern flora – the pteridophytes were increasingly replaced by the gymnosperms which were to dominate until the Mid-Cretaceous. Australia, however, was still located near the Equator during the Early Carboniferous, and during this period, temnospondyl and lepospondyl amphibians and the first amniote reptilians evolved, all closely related to the Laurasian fauna, but spreading ice eventually drove these animals away from Gondwana entirely.[20]

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The Gondwana ice sheet melted, and sea levels dropped during the Permian and Triassic global warming. During this period, the extinct glossopterids colonised Gondwana and reached peak diversity in the Late Permian when coal-forming forests covered much of Gondwana. The period also saw the evolution of Voltziales, one of the few plant orders to survive the end-Permian extinction (57% of marine families and 83% of genera went extinct) and which came to dominate in the Late Permian and from whom true conifers evolved. Tall lycopods and horsetails dominated the wetlands of Gondwana in the Early Permian. Insects co-evolved with glossopterids across Gondwana and diversified with more than 200 species in 21 orders by the Late Permian, many known from South Africa and Australia[21]. Beetles and cockroaches remained minor elements in this fauna. Tetrapod fossils from the Early Permian have only been found in Laurasia but they became common in Gondwana later during the Permian. The arrival of the therapsids resulted in the first plant-vertebrate-insect ecosystem.[22]

III. RESULTS AND CONCLUSIONS

During the Mid- to Late Triassic, hot-house conditions coincided with a peak in biodiversity — the end-Permian extinction was enormous and so was the radiation that followed. Two families of conifers, Podocarpaceae and Araucariaceae, dominated Gondwana in the Early Triassic, but *Dicroidium*, an extinct genus of fork-leaved seed ferns, dominated woodlands and forests of Gondwana during most of the Triassic. Conifers evolved and radiated during the period, with six of eight extant families already present before the end of it. Bennettitales and Pentoxylales, two now extinct orders of gymnospermous plants, evolved in the Late Triassic and became important in the Jurassic and Cretaceous. It is possible that gymnosperm biodiversity surpassed later angiosperm biodiversity and that the evolution of angiosperms began during the Triassic but, if so, in Laurasia rather than in Gondwana. Two Gondwanan classes, lycophytes and sphenophytes, saw a gradual decline during the Triassic while ferns, though never dominant, managed to diversify.[23]

The brief period of icehouse conditions during the Triassic–Jurassic extinction event had a dramatic impact on dinosaurs but left plants largely unaffected. The Jurassic was mostly one of hot-house conditions and, while vertebrates managed to diversify in this environment, plants have left little evidence of such development, apart from Cheiroleidiacean conifers and Caytoniales and other groups of seed ferns. In terms of biomass, the Jurassic flora was dominated by conifer families and other gymnosperms that had evolved during the Triassic. The Pteridophytes that had dominated during the Palaeozoic were now marginalised, except for ferns. In contrast to Laurentia, very few insect fossils have been found in Gondwana, to a considerable extent because of widespread deserts and volcanism. While plants had a cosmopolitan distribution, dinosaurs evolved and diversified in a pattern that reflects the Jurassic break-up of Pangaea.[24]

The Cretaceous saw the arrival of the angiosperms, or flowering plants, a group that probably evolved in western Gondwana (South America-Africa). From there the angiosperms diversified in two stages: the monocots and magnoliids evolved in the Early Cretaceous, followed by the hammamelid dicots. By the Mid-Cretaceous, angiosperms constituted half of the flora in northeastern Australia. There is, however, no obvious connection between this spectacular angiosperm radiation and any known extinction event nor with vertebrate/insect evolution. Insect orders associated with pollination, such as beetles, flies, butterflies and moths, and wasps, bees, and ants, radiated continuously from the Permian-Triassic, long before the arrival of the angiosperms. Well-preserved insect fossils have been found in the lake deposits of the Santana Formation in Brazil, the Koonwarra Lake fauna in Australia, and the Orapa diamond mine in Botswana. [25]

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Fig.3 Still extant Triassic conifers (*Agathis*, *Wollemia*, *Araucaria*, and *Podocarpus*) that once dominated Gondwana

Dinosaurs continued to prosper but, as the angiosperm diversified, conifers, bennettitaleans and pentoxylaleans disappeared from Gondwana c. 115 Ma together with the specialised herbivorous ornithischians, whilst generalist browsers, such as several families of sauropodomorph Saurischia, prevailed. The Cretaceous–Paleogene extinction event killed off all dinosaurs except birds, but plant evolution in Gondwana was hardly affected. Gondwanatheria is an extinct group of non-therian mammals with a Gondwanan distribution (South America, Africa, Madagascar, India, Zealandia and Antarctica) during the Late Cretaceous and Palaeogene. Xenarthra and Afrotheria, two placental clades, are of Gondwanan origin and probably began to evolve separately c. 105 Ma when Africa and South America separated. The laurel forests of Australia, New Caledonia, and New Zealand have a number of species related to those of the laurissilva of Valdivia, through the connection of the Antarctic flora. These include gymnosperms and the deciduous species of *Nothofagus*, as well as the New Zealand laurel, *Corynocarpus laevigatus*, and *Laurelia novae-zelandiae*. New Caledonia and New Zealand became separated from Australia by continental drift 85 million years ago. The islands still retain plants that originated in Gondwana and spread to the Southern Hemisphere continents later.[25]

Fig.4 Fossilised *Walchia* and *Utrechtia*, two voltzialean pines from which modern conifers evolved

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REFERENCES

1. "Gondwana". Dictionary.com. Lexico Publishing Group. Retrieved 18 January 2010.
2. ^ Bradley, D.C. (2011). "Secular Trends in the Geologic Record and the Supercontinent Cycle". Earth-Science Reviews. **108** (1–2): 16–33. Bibcode:2011ESRv..108...16B. CiteSeerX 10.1.1.715.6618. doi:10.1016/j.earscirev.2011.05.003. S2CID 140601854.
3. ^ "Gondwanaland". Merriam-Webster Online Dictionary. Retrieved 18 January 2010.
4. ^ Torsvik & Cocks 2013, Abstract
5. ^ Meert & Van Der Voo 1997, Abstract
6. ^ Chakrabarti, Pratik (2019). "Gondwana and the Politics of Deep Past". Past & Present. **242** (1): 119–153. doi:10.1093/pastj/gty016.
7. ^ Suess 1885, p. 768: "Wir nennen es Gondwána-Land, nach der gemeinsamen alten Gondwána-Flora, … "(We name it Gondwána-Land, after the common ancient flora of Gondwána …)
8. ^ McLoughlin 2001, Gondwana or Gondwanaland?, pp. 272–273
9. ^ Meert 2003, Fig. 10, p. 19
10. ^ Meert & Van Der Voo 1997, Introduction, pp. 223–226
11. ^ Miashita & Yamamoto 1996
12. ^ Meert & Van Der Voo 1997, p. 229
13. ^ Defined but not named in Collins & Pisarevsky 2005: "Azania" was a Greek name for the East African coast
14. ^ Li et al. 2008, The birth of Gondwanaland (600–530 Ma), p. 201
15. ^ Meert 2003, Abstract
16. ^ Grantham, Maboko & Eglington 2003
17. ^ Cawood 2005, Definition and Tectonic Framework, pp. 4–6
18. ^ Münker & Crawford 2000, Abstract
19. ^ Torsvik & Cocks 2013, Marginal microcontinents and terranes, p. 1008
20. ^ Torsvik & Cocks 2013, Southern Europe, pp. 1008–1009
21. ^ McLoughlin 2001, Cimmerian terranes, p. 278
22. ^ Torsvik & Cocks 2013, South-central and eastern Asia
23. ^ Cawood 2005, Peri-Gondwanan continental basement assemblages, pp. 15–16
24. ^ Rapalini 2001; Rapalini 1998, pp. 105–106
25. ^ Dalla Salda et al. 1998, Abstract; Vujovich, van Staal & Davis 2004, Conclusions, p. 1053

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