Occurrence of *Dipterocarpus* in the Mar Formation of Bikaner, Rajasthan, western India

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The occurrence of fossil wood of *Dipterocarpus* Gaertn.f. in the sediments of Mar Formation (Plio-Pleistocene) of Bikaner, western desertic part of Rajasthan, is of great significance both climatically and phytogeographically in view of the present day distribution of the genus in India. Its complete absence in the western (Gujarat and Rajasthan) and north-western parts of India today indicates drastic climatic changes in the region since the time of deposition of the fossil.

Key-words—Fossil wood, *Dipterocarpus*, Phytogeography, Palaeoclimate, Mar Formation, Plio-Pleistocene, Rajasthan (India)

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सारांश

पश्चिमी भारत में राजस्थान में बीकानेर के मार शैल-समूह में डिप्टेरोकार्पस की उपस्थिति

जसवन्तसिंह गुलेरिया

राजस्थान के पश्चिमी मरुस्थली भाग में बीकानेर के मार शैल-समूह (अतिनूतन-अत्यन्तनूतन) में *डिप्टेरोकार्पस* की अश्मित काष्ठ की उपस्थिति भारत में इस प्रजाति के वर्तमान वितरण को दृष्टिगत रखते हुए जलवायवी एवं पादपभौगोलिक दृष्टि से अत्यन्त महत्वपूर्ण है। भारत के पश्चिमी (गुजरात एवं राजस्थान) और उत्तर-पश्चिमी भागों में आजकल इसकी अनुपस्थिति निक्षेपण के समय से अब तक इस क्षेत्र में हुए जलवायवी परिवर्तनों की द्योतक है।

BIKANER is situated in the northern part of the Thar Desert, Rajasthan in western India and experiences an arid climate. On account of extremes of temperature ranging from -2° C in winter to about 50° C in summer, low rainfall and high velocity winds that prevail in the area, the vegetation of the area is distinctly xerophytic in nature (Sharma, 1957; Shetty & Singh, 1987; Singh & Sidhu, 1990). So far only a few fossil woods have been reported from the Mar Formation of Bikaner region. The author (1990, 1991, 1992a) has reported the following genera: *Dialium* and *Ougenia* belonging to family Fabaceae; *Lagerstroemia, Terminalia, Ziziphus* and *Duabanga* belonging to Lythraceae, Combretaceae, Rhamnaceae and Sonneratiaceae, respectively. Harsh and Sharma (1988) reported a gymnospermous wood *Araucarioxylon* from the same area considering it to be of Eocene age. Subsequently Harsh *et al.* (1993) reported some more woods from Bikaner, viz., *Barringtonioxylon rajasthanense, Careyoxylon awasthii* of Lecythidaceae and five species of combretaceous woods, three belonging to *Terminalioxylon* and two to *Anogeissusoxylon*. However, these woods need critical reinvestigation as far as their identification is concerned. They will be dealt with sepasrately at a later stage. Lately Harsh and Sharma (1995) have reported nine species of *Lagerstroemioxylon* from this area. It is difficult to conceive the occurrence of nine species of a genus at the same spot. The species reported are infact, the variations of two already described species of *Lagerstroemioxylon* from this locality by the author (1990). One of the nine species, namely, *Lagerstroemioxylon vasicentricum* Harsh & Sharma, most probably, is a wood of *Ziziphus* reported by the author (1992a) from the area.

The present fossil was collected from a 'bajri' mine of Bikaner city. The mine is situated close to Nathusar Gate on its south-eastern side. The wood was collected from a compact conglomerate sandstone layer which was found about 25 m below the surface level in the mine. The sediments belong to Mar Formation which has been assigned to Post-Eocene to Late Pleistocene or Quaternary by Shrivastava (1971). Based on the study of fossil woods recovered from the sediments of Mar Formation and their close similarity with the woods of Kankawati Series of Kutch, the author (1990) deduced the age of the formation equivalent to Kankawati Series/ Sandhan Formation of Kutch. According to Biswas and Raju (1973) and Biswas (1992) Kankawati Series/ Sandhan Formation is probably Pliocene in age. The present report of the occurrence of *Dipterocarpus* in the Mar Formation which has already been reported from the Kankawati Series of Kutch (Guleria, 1983) further supports the fact that the two formations of the western part of India may be homotaxial. The age of the "? Conglomerate beds " encountered in the subsurface of Bikaner-Nagaur area has been surmised as Plio-Pleistocene by DasGupta (1977) although without any palaeontological evidence. Accordingly, recovery of the fossil woods from a conglomerate layer is significant since they have provided a valuable clue to circumscribe the age of the Mar Formation which, on the basis of available evidences, can at best be considered as Plio-Pleistocene.

SYSTEMATIC DESCRIPTION

Family — Dipterocarpaceae

Genus — *Dipterocarpoxylon* Hold. emend. DenBerger 1927

Dipterocarpoxylon tertiarum Prakash 1965
Pl. 1, figs 1-6

1965 *Dipterocarpoxylon tertiarum* Prakash, p. 254, figs 1-3.

1973 *Dipterocarpoxylon tertiarum* Prakash, p. 49, pl. 1, figs 1, 3, 5, 6.

The species is represented by a poorly preserved small piece of secondary wood measuring 7 cm in length and 2-4 cm in width.

Description — Wood diffuse porous. *Growth rings* not seen. *Vessels* small to large, mostly medium, evenly distributed, exclusively solitary, filled with tyloses (Pl. 1, figs 1, 2), round to oval, t.d 100-300 µm, r.d. 150-400 µm, walls 8-12 µ m, perforations simple, nearly horizontal to oblique, vessel members 250-700 µm long. *Vasicentric tracheids* seen in immediate vicinity of vessels (Pl. 1, fig. 3). *Parenchyma* paratracheal and apotracheal, paratracheal parenchyma vasicentric, 1-3 cells wide around vessels, intermingled with vasicentric tracheids, sometime aliform, apotracheal parenchyma fairly abundant, diffuse to diffuse in-aggregate, parenchyma cells 20-36 µm in diameter, filled with dark contents. *Xylem rays* 1-6 (mostly 4-5) seriate (Pl. 1, figs 2, 4, 6), about 5-60 cells in height and 4-6 per mm in cross section, ray tissue heterogeneous, uniseriate rays fine, short homocellular to heterocellular consisting of upright or both procumbent and upright cells; multiseriate rays heterocellular (Pl. 1, figs 4, 5, 6). *Fibres* aligned in radial rows between two consecutive rays. *Fibre tracheids* angular, 12-28 µm in diameter, non-septate, thick walled, pits arranged in vertical row, small. *Gum canals* frequent, vertical, diffuse, round to oval, solitary or in pairs and also filled with crystalliferous or other contents, t.d 70- 130 µm (Pl. 1, figs 1, 2).

Affinities —The presence of exclusively solitary vessels, vasicentric tracheids and fibre tracheids, vertical gum canals as diffuse or in short tangential rows, vasicentric as well as diffuse parenchyma, 1-6 seriate heterogeneous rays together indicate the affinity of the fossil with the woods of modern *Dipterocarpus*.

PLATE 1 ⟶

Dipterocarpoxylon tertiarum Prakash

1. Cross-section of fossil wood showing shape, size and distribution of vessels and gum canals, x 40, slide no. BSIP 37382 - I.
2. Magnified cross-section of the fossil wood showing shape, size, distribution of vessels, parenchyma rays and gum canals, x 82, slide no. BSIP 37382-I.
3. Vasicentric tracheidal pits as seen in radial longitudinal section, x 300, slide no. BSIP 37382 - III.
4. Tangential longitudinal section of the fossil wood showing xylem rays, x 100, slide no. BSIP 37382 - II.
5. Radial longitudinal section of fossil wood showing the nature of xylem rays, x 130, slide no. BSIP 37382 - III.
6. Another tangential longitudinal section, x 100, slide no. BSIP 37382-II.

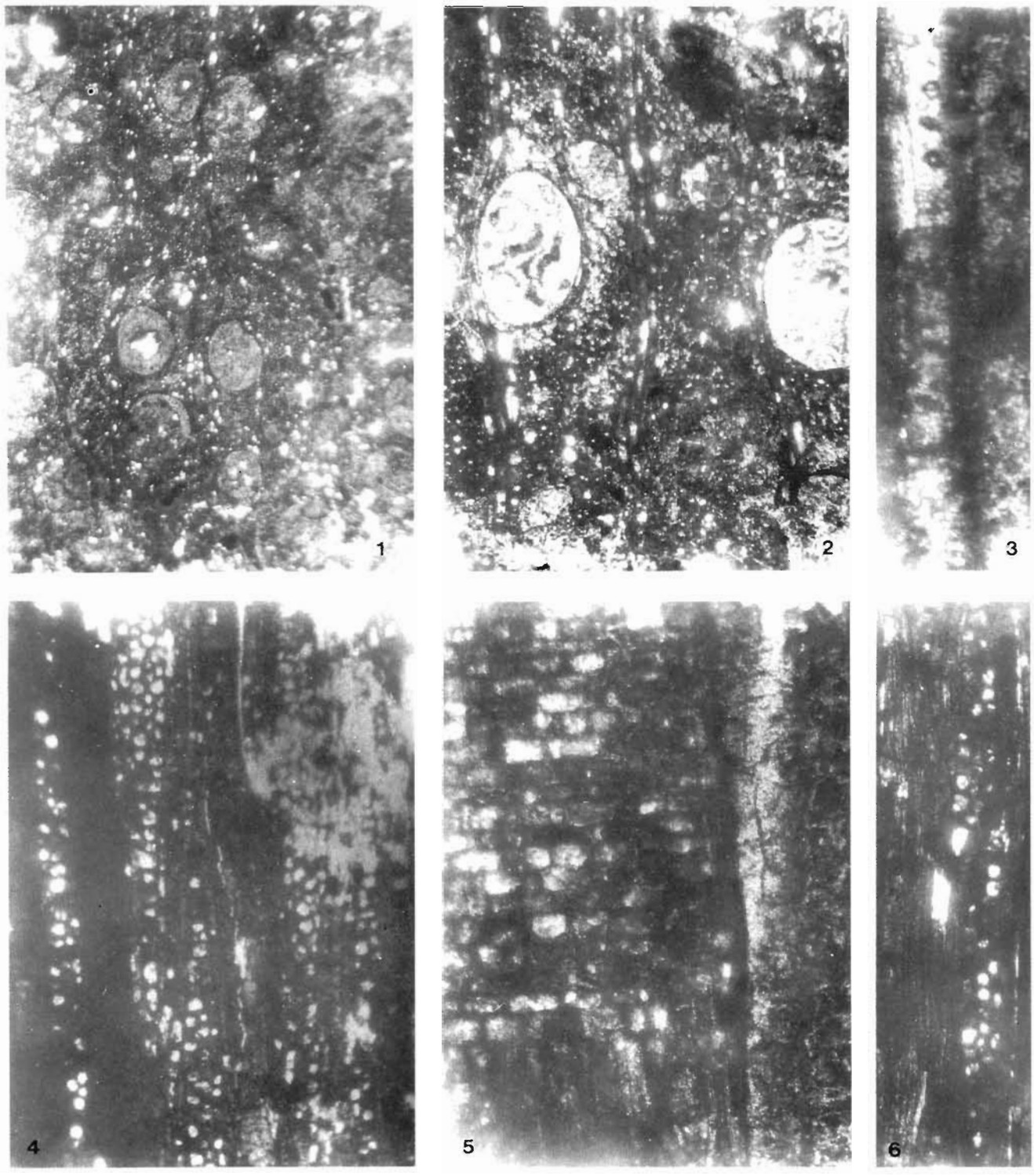

PLATE 1

A critical study of the available thin sections of woods of a large number of *Dipterocarpus* species were examined and published descriptions and figures of many other species were also consulted for comparison (Pearson & Brown, 1932; Chowdhury & Ghosh, 1958). It was found that the present fossil wood shows close similarity with the wood of *Dipterocarpus turbinatus* Gaertn.f., particularly in the size of vessels and gum canals. Among the large number of fossil woods of *Dipterocarpus* known from India (Awasthi, 1992; Awasthi & Mehrotra, 1993; Bera & Banerjee, 1990; Guleria, 1992b; Prakash *et al.*, 1994; Prasad, 1993; Prasad & Khare, 1994) and adjoining region (Prakash, 1973) the fossil shows closest resemblance with *Dipterocapoxylon tertiarum* (Prakash, 1965, 1973) described from, most probably, the Mio-Pliocene sediments of Burma (Myanmar). Hence, the present fossil is placed under the same species.

Specimen—Specimen no. BSIP 37382.

Locality—Bajri mine, situated close to and south-east of Nathusar Gate, Bikaner city.

Horizon—Mar Formation.

Age—Plio-Pleistocene.

DISCUSSION

The genus *Dipterocarpus* occurs in evergreen, well drained tropical rain forests with good amount of moisture and humidity. The genus at present is mainly confined to tropical evergreen forests of India, Sri Lanka to Western Malaysia and Bali (Willis, 1973). In India, it is found in Western Ghats as well as in Assam and Andamans (Chowdhury & Ghosh, 1958; Santapau & Henry, 1973). Contrary to its present restricted distribution, the genus was widely distributed in India during Neogene. Its fossils have already been reported as far west as Jawalamukhi in Himachal Pradesh in the northwest (Lakhanpal & Guleria, 1987) and Kutch in the western India (Guleria, 1983).

In view of the earliest known record of Dipterocarpaceae from the Oligocene of South-east Asia (Muller, 1970, 1981) and the numerical abundance of modern dipterocarpacean members in the Malaysian region, it seems that this region is the natural home of Dipterocarpaceae, especially the Dipterocarpoideae. If this contention is true then the family must have spread into India sometime in the Early Miocene when the land connections between Malaya, Myanmar and India were established as has already been suggested by Lakhanpal (1974, p. 36). In their "Atlas of Mesozoic and Cenozoic Coastlines" Smith *et al.* (1994, p. 27, map 4) have also shown the earliest connection of the Indian landmass and the Malaysian region during Early Miocene. The climatic conditions were largely equable on the Indian landmass during Neogene which provided conditions conducive for the widespread distribution of the dipterocarps. Accordingly *Dipterocarpus* moved from north-east India to north-west and south and from north-west and south to further west. It seems that from the western region of India (Rajasthan and Gujarat) *Dipterocarpus* migrated to East Africa. In this context it is worth noting that dipterocarpaceous remains have been reported in the form of *Dipterocarpophyllum* and *Dipterocarpoxylon* from the unclassified Tertiary sediments of Egypt, Ethiopia and Plio-Pleistocene deposits of Somalia (Seward, 1935; Bancroft, 1933; Chiarugi, 1933). The African Plate (including Arabia) started establishing contact with the Asian Plate sometimes in the Late Miocene (Smith *et al.*, 1994) thereby making migration of plants and animals possible from East Africa to India and vice-versa . Thus the recovery of *Dipterocarpus* fossils from Rajasthan and Gujarat (Kutch) are phytogeographically very significant. They indicate that the area was on the migratory route for the westward extension of *Dipterocarpus* to East Africa via Arabia.

Dipterocarpus turbinatus Gaertn.f., with which the fossil shows resemblance, is found in evergreen forests of Myanmar, South Vietnam, Thailand and Chittagong hill tracts in Bangladesh. In India, it occurs in the evergreen or semi-evergreen moist tropical forests of Assam and the Andamans usually below 300 m elevation (Sastri, 1952; Champion & Seth, 1968). Evidently the occurrence of a fossil wood of *Dipterocarpus* in Plio-Pleistocene sediments of the Mar Formation in the western desertic part of Rajasthan is of great significance, indicating the prevalence of tropical humid conditions around Bikaner at the time of deposition of the fossil. It is interesting to note that a wood of *Lagerstroemia speciosa* Pers. (syn. *L. macrocarpa* Kurtz), a close associate of *Dipterocarpus* in the Assam and Myanmar forests has already

been reported by the author (1990) from this area providing supporting evidence of existence of moist tropical climate around Bikaner. The gradual increase in aridity made the environment hostile for the growth of moisture loving plants and ultimately led to extermination of *Dipterocarpus* and other reported fossil plants in this area. Drastic change in the vegetation must have been due to the post-Pliocene changes in the climate. The cumulative effect of various factors such as last stage of Himalayan uplift, onset of glaciation, changes in the drainage pattern like shifting and drying of rivers and shift in the course of monsoon currents, etc., perhaps led to the change in climate of the region.

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