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Occurrence of a conifer wood in the desert of Rajasthan and its climatic significance

J.S. Guleria and Anumeha Shukla

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow-226007, India
Email: guleriajs@yahoo.com

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In the present communication a gymnospermous fossil wood resembling extant wood of the genus *Podocarpus* L' Herit.ex Pers. has been described for the first time from the Early Cretaceous sediments of the Habur village, situated about 45 km north-west of Jaisalmer in the desert of Rajasthan. The presence of growth-rings, wide early wood and a very narrow late wood indicates mild seasonality and prevalence of favorable climatic conditions for good growth of woody vegetation in the area around 130-120 my back in contrast to xeric and desertic conditions prevailing in the area today.

Key-words–*Podocarpoxylon*, Gymnosperm, Pariwar Formation (Early Cretaceous), Habur, Jaisalmer, Rajasthan, India.

INTRODUCTION

THE arid part of Rajasthan west of Aravalli hills is called the Thar desert and is largely covered by sandy tract and often punctured by isolated barren rocky exposures. During a field excursion in December 2007, the authors collected a dark coloured ferruginous fossil wood piece from sediments of the Pariwar Formation exposed infront of the Habur village ($27^0 10' : 70^0 33'$), situated about 45 km north-west of Jaisalmer in Rajasthan (see Fig. 1A). The plant fossils in the Pariwar Formation were first reported by Das Gupta *et al.* (1975). Subsequently Maheshwari and Singh (1976), Bose *et al.* (1982), described a number of megafossil impressions preserved in ochre-yellow argillaceons shale and buff coloured siltstone. The known megafossils belong to different groups namely, Filicales (*Gleichenia* sp., *Phlebopteris* sp.), Pteridosperms (*Pachypteris haburensis*, *Pachypteris* sp.), Cycadales (*Taeniopteris spp.*), Bennettitales (*Pterophyllum* sp., *Ptilophyllum acutifolium*, and *Otozamites imbricatus*), Ginkgoales (*Ginkgo*) and Coniferales. The conifers are represented by four taxa, namely *Araucarites*, *Coniferocaulon*, *Elatocladus* and *Pagiophyllum*. Of these, *Araucarites* and *Pagiophyllum* spp. belong to family Araucariaceae and *Elatocladus* spp. represent family Podocarpaceae. Based on study of the plant megafossils Maheshwari and Singh (1976, pp 116,122) opined that the age of Pariwar Formation may be older than Lower Cretaceous and may be Upper Jurassic. On the other hand, Das Gupta (1975, 1977), Lukose (1977), Pareek (1984) and Singh (1999) considered the age of Pariwar Formation as Lower Cretaceous (Neocomian) on the basis of stratigraphic correlation and fossil evidence provided by forams and ostracodes. The beds of Pariwar Formation are largely horizontal with very low dips, up to 2^0 (Pareek, 1984) and the formation represents the oldest Cretaceous sediments in the area. The outcrop thickness is about 350m and consists of thick continental and deltaic sequence of ferruginous sandstone with intercalations of shale beds. The lithological sequence as given by Das Gupta (1975) and Singh (1999) is shown in Fig 1B.

A perusal of the literature shows that no fossil wood has been described from the Lower Cretaceous sediments of Jaisalmer so far (Bose *et al.* 1982, Chandra & Tewari 1991, Maheshwari & Singh 1976, Rajanikanth & Tewari, 2004). However, older (Jurassic) gymnospermous fossil woods have been described by Sharma and Tripathi (2000) without assigning them to any family and a few Late Tertiary woods have also been reported by Guleria (1984, 1986) from this area. Thus from the Early Cretaceous sediments of Jaisalmer area a petrified wood is being described for the first time, whose occurrence was reported recently in an International Workshop on Climate Change (Guleria & Shukla, 2008).

SYSTEMATIC DISCRIPTION

Family–Podocarpaceae

Genus–***Podocarpoxylon*** Gothan, 1905

Podocarpoxylon haburensis sp. nov.

(Pl. 1, Figs 1-9)

The species is based on a single piece of permineralized secondary wood measuring 25 cm in length and 10 cm in diameter. It is dark reddish to black in colour, ferruginous in nature and shows workable preservation.

Growth-rings present but not conspicuous, transition from early wood to late wood abrupt (Pl.1, figs 1-2), wall thickness of tracheids hardly changes from early wood to late wood. *Tracheides* of early wood zone quite wide, occupying greater portion of wood, consisting of 50-60 tracheidal cells, tracheid cells thin-walled, polygonal, with wide lumen, tangential diameter 19-34μm, radial diameter 18-34μm. Late wood forming a narrow band of 2-4 thick-walled cells, tangential diameter 6-11μm, radial diameter 3.5- 11 μm, cells

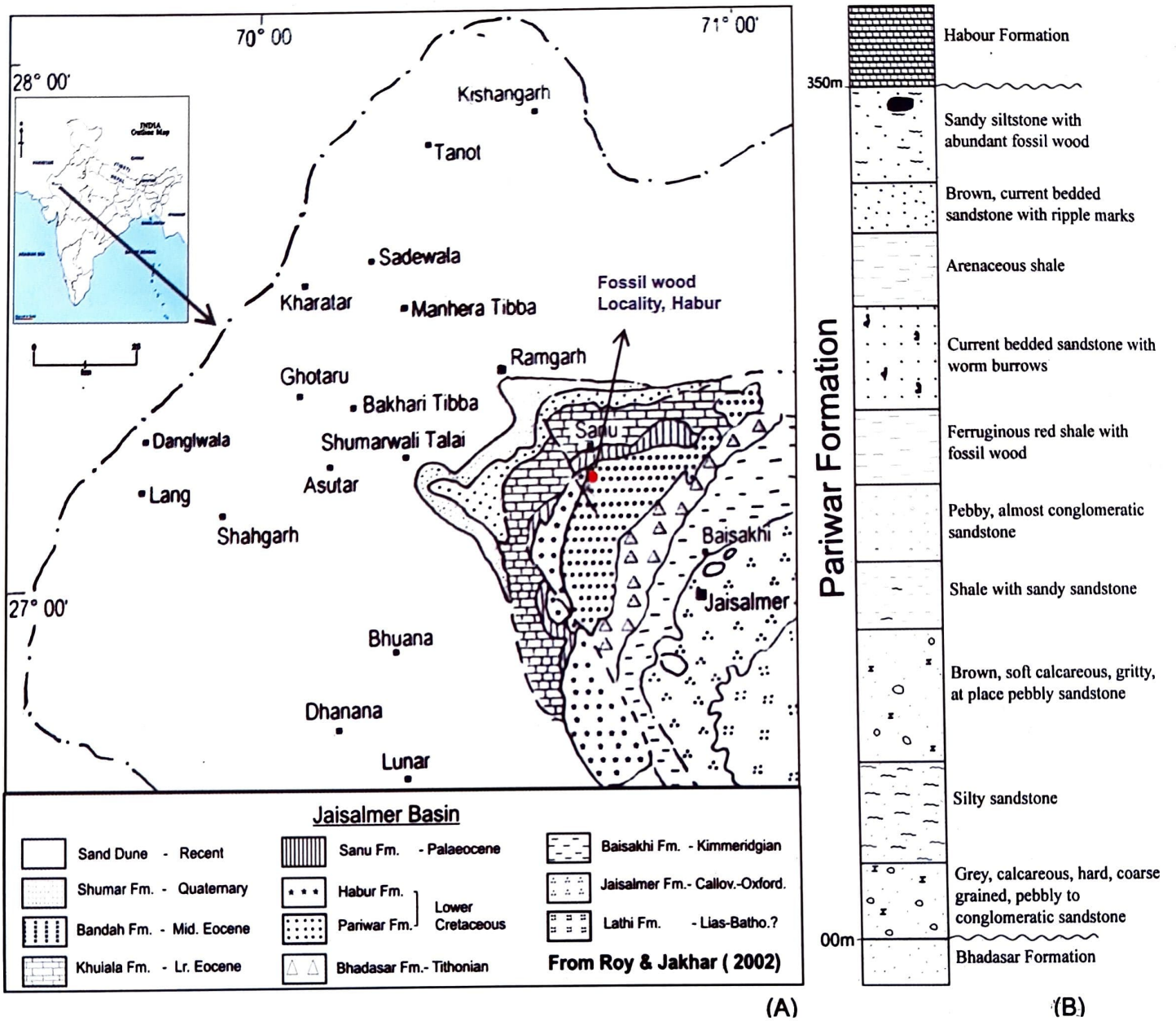

Fig 1(A)- Geological map of the area showing fossil locality
Fig 1(B)- Lithological succession of the Pariwar Formation showing occurrence of the fossil wood

flattened to elliptical, filled with dark contents, 400-550 tracheids per sq cm. (Pl.1, Figs 1-2), helical thickenings absent in tracheids (Pl.1 Figs 3-6) *Resin canals* absent. *Parenchyma* present, rarely seen, cells show normal transverse end walls in tangential section. *Xylem rays* fine, uniseriate, homocellular, 3-10 cells or 34-157/180µm in height (Pl.1, Figs 3-4). *Tracheidal pitting* abietinean (Philippe & Bamford, 2008) seen on radial walls of tracheids mostly in one row, rarely in two, in the later case opposite or sub opposite due to lateral compression; mostly solitary, sometime contiguous, oval, circular, simple and bordered (Pl.1, Figs 7-9), 7-35µm in radial diameter and 6-38µm in tangential diameter. *Cross-field pits* not seen due to poor preservation.

The anatomical structures depicted by the fossil indicate that it is a coniferous wood as it primarily consists of tracheids, rays and infrequent parenchyma cells. During Mesozoic time, conifers in India were mainly represented by two families, viz., Araucariaceae and Podocarpaceae (Bose & Maheshwari, 1974). However, the absence of araucarian tracheidal pits (Philippe & Bamford, 2008) in the fossil rules out the possibility of the wood belongi ng to family Araucariaceae. Obviously, the fossil

PLATE-1

1,2. Cross-sections showing nature and distribution of tracheids, xylem rays and growth rings. (B.S.I.P. Museum Slide No. 39549-1).
3. Enlarged cross-section showing narrow late wood cells and broad early wood cells. (B.S.I.P. Museum Slide No. 39549-1)
4,5. Tangential longitudinal sections showing short, uniseriate xylem rays. (B.S.I.P. Museum Slide No. 39549- 2, 3).
6,7. Xylem rays in radial longitudinal sections. (B.S.I.P. Museum Slide No. 39549- 4, 5).
8,10. Radial longitudinal section showing, simple, circular, bordered tracheidal pits. (B.S.I.P. Museum Slide No. 39549-5, 4).

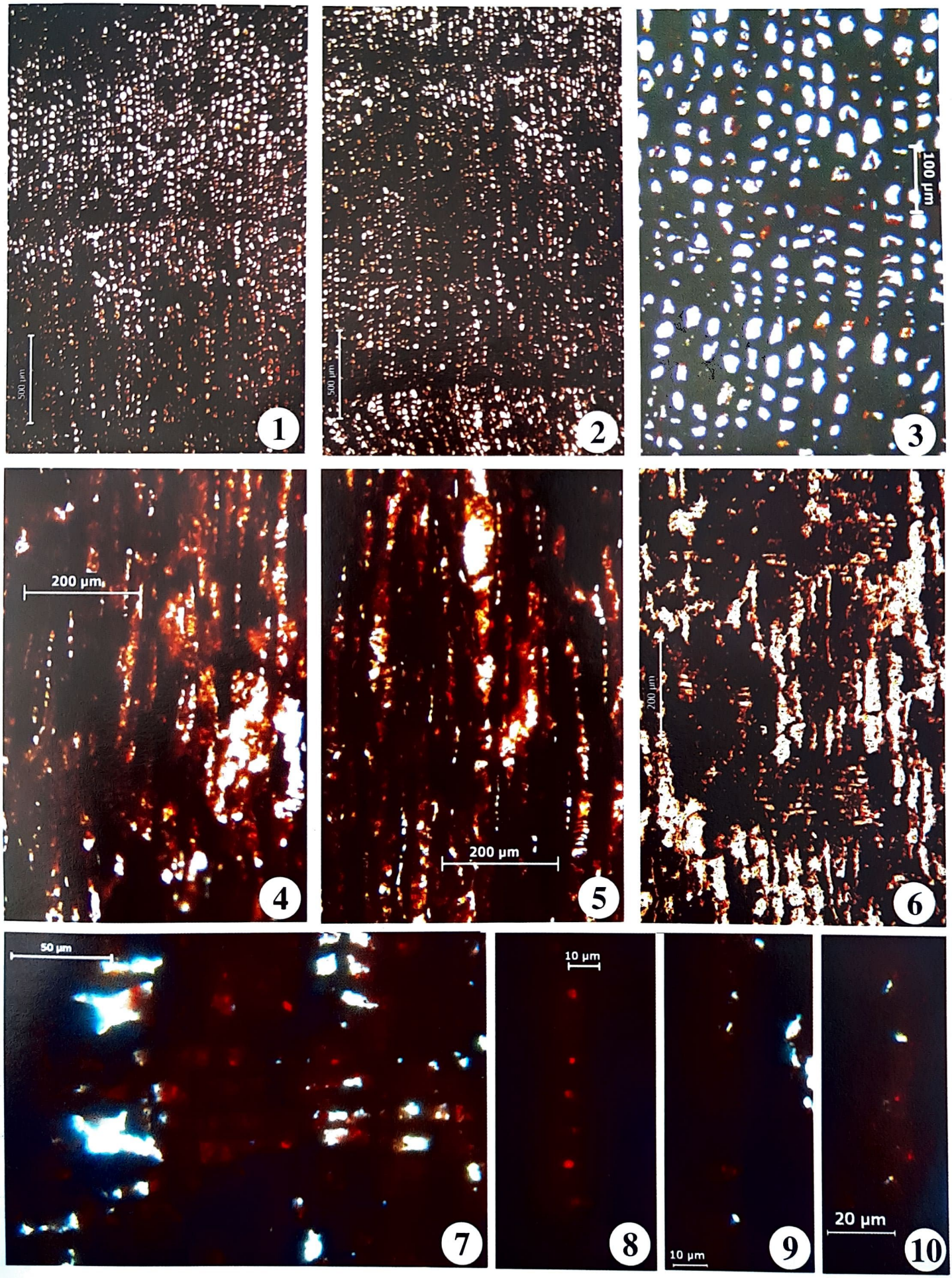
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PLATE-1

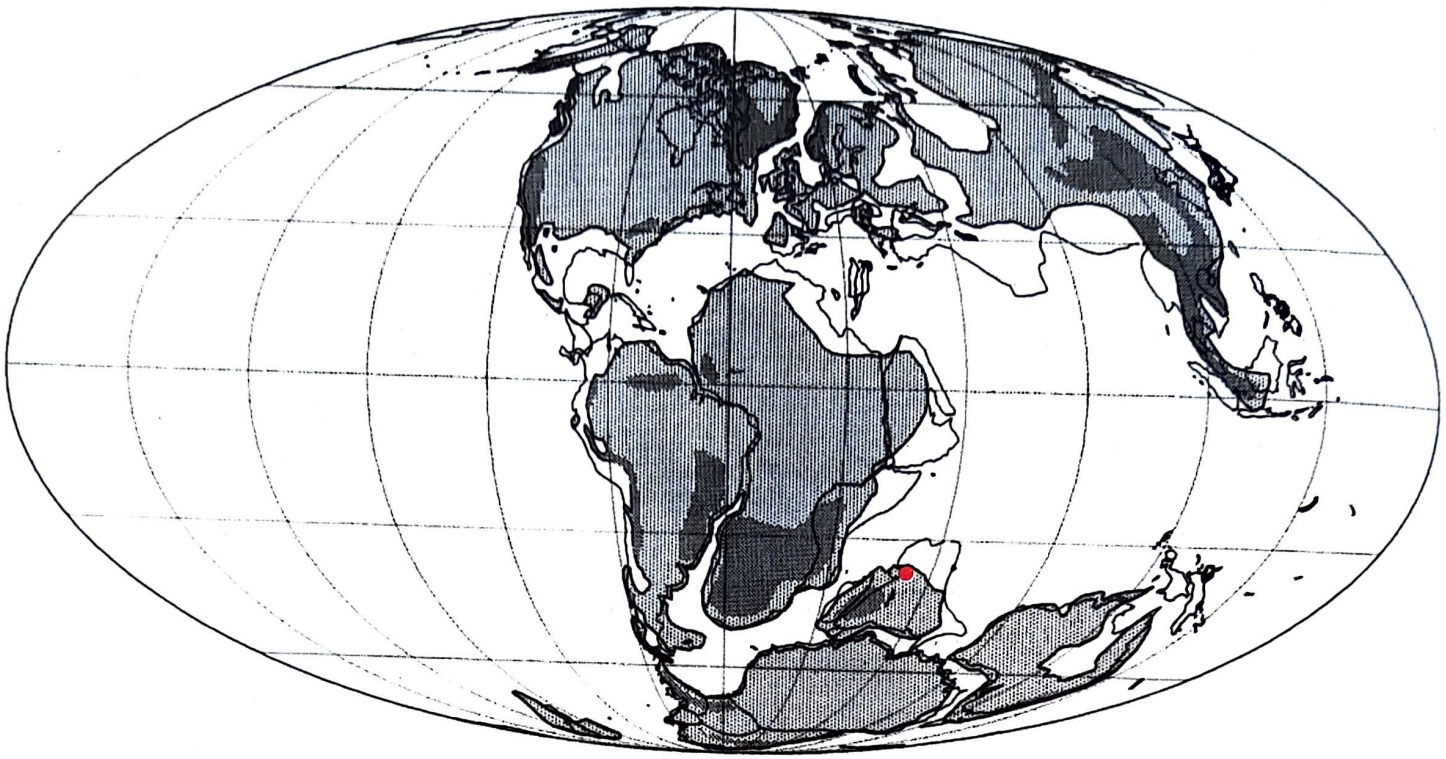

Fig 2. Position of India about 130 my ago (Smith *et al.*,1994) showing location of Jaisalmer area (red dot).

shows affinities with the wood of family Podocarpaceae particularly the genus *Podocarpus* L'Herit.ex Pers. (Greguss, 1955, 1972, Marguerier & Woltz 1977; IAWA Committee *et al.*, 2004). The xylotomical characters exhibited by the wood shows its best resemblance with *Podocarpoxylon* Gothan, hence the fossil is assigned to it.

There are four species of *Podocarpoxylon,* known so far from the Lower Cretaceous of India. Two of them, *Podocarpoxylon indicum* Bharadwaj (1953), and *P. rajmahalense* Jain (1965), are described from the Rajmahal Hills of Bihar (now Jharkhand) and the remaining two *P. tirumangalense* Suryanaryana (1953), from Sriperumbudur and *P. parthasarathyi* Sahni (1931; Manik & Srivastava, 1991), from Sriperumbudur and Gangapur in South India. The absence of axial parenchyma in all the above species differentiates them from the present fossil. Further, *P.indicum* differs in having short rays (1-5 cells) with tapering end cells and uniseriate tracheidal pits compared to relatively bigger rays (3-10 cells) and occurrence of tracheidal pits in 1-2 rows in the present fossil. Likewise occurrence of frequent biseriate rays in *P. tirumangalense* and relatively taller rays (up to 20 cells or 550μm) in *P. parthasarathyi* as compared to occurrence of uniseriate and shorter rays (3-10 cells or 150μm) in the present fossil separate these two species from it. *Podocarpoxylon rajmahalense,* although shows general resemblance with the present fossil, yet it differs in the absence of parenchyma. Thus the present fossil wood is different from all the above species of *Podocarpoxylon,* so a new specific name, *Podocarpoxylon haburensis* sp. nov., is assigned to it. The specific name is after the name of fossil locality Habur in Rajasthan.

Diagnosis

Podocarpoxylon haburensis sp. nov.

Growth rings present. *Resin canals* absent. *Paranchyma* present, scanty. *Tracheidal pits* abietinean, mostly in one row, rarely in two, oval, circular, when in two rows opposite to sub-opposite, solitary, sometime contiguous, simple and bordered. *Xylem rays* fine, uniseriate, 3-10 or 34-180 μm cells in height. *Cross-field pits* not seen.

Repository: B.S.I.P., Museum.

Holotype: BSIP Museum No. 39549.

Locality: Habur, about 45 km NW of Jaisalmer, Rajasthan.

Horizon: Pariwar Formation.

Age: Lower Cretaceous (Neocomian).

DISCUSSION

The occurrence of growth rings has been considered as one of the important climate signalling features in woods (Fritts, HC, 1976; Hughes *et al.*, 1982) and the feature in fossil conifer woods has been successfully used to infer seasonality and palaeoclimate (Creber & Chaloner, 1985; Francis, 1986; Spicer & Parrish, 1990; Yadav & Bhattacharyya, 1994; Rajanikanth & Tewari, 2004). Thus the presence of growth rings, broad early wood and very narrow (2-4 cells wide) late wood indicates mild seasonality at the time of occurrence of the fossil as is observed in any present day sub-tropical coastal region.

This view is further substantiated keeping in view the palaeoposition of India during Lower Cretaceous time (about 130-120 my ago). At that time India was situated 30°S of equator (see Fig. 2) and the geological and palaeontological evidence

indicate that the Jaisalmer area was largely surrounded by sea (Smith *et al.*, 1994; Singh, 1996, 1999). Obviously the area must have witnessed subtropical (summer hot with cool winter, MAT 17°C to 24°C) coastal climate with good amount of rainfall. It is important to mention here that Mesozoic was the period when conifer belonging to Podocarpaceae and Araucariaceae dominated the Indian landscape (Bose & Maheshwari, 1974). Thus the occurrence of plant genera belonging to Filicales, Pteridosperms, Cycadales, Bennettitales, Ginkgoales and Coniferales (see p.1) with leaves more than 25 cm long together with the present wood indicate the existence of conducive climatic conditions for good growth of plants. Obviously the area must have been covered by thick forest comprised of all these elements and many more in contrast to the present xeric vegetation and desertic conditions. Such podocarpaceous woods have also been reported from various Lower Cretaceous horizons of Andhra Pradesh, Tamil Nadu and Rajmahal in Jharkhand (formerly Bihar) indicating that the family Podocarpaceae was well represented and widely distributed in the peninsular India in the past, and today the family is represented by a single genus *Podocarpus* L' Herit.ex Pers. It consists of evergreen trees and shrubs and is represented by two species, viz., *Podocarpus neriifolius* D.Don and *P. wallichianus* C. Presl. The former is an inhabitant of evergreen climax forests of eastern Himalaya and is found up to 900m in Sikkim, Arunachal Pradesh, Khasi Hills (Meghalaya) and the Andamans whereas the latter is the only naturally occurring conifer in South India and found in Western Ghats from the Nilgiris southwards, Assam and Great Nicobar Island usually at altitude of 900- 1500 m (Sahni 1990, pp. 48-51).

Thus the occurrence of podocarpaceous wood in Early Cretaceous sediments of Rajasthan shows that drastic climatic changes have taken place in the Jaisalmer area since the time of deposition of the wood.

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