A semi-ring porous fossil wood of *Ziziphus* from the Late Tertiary of Rajasthan

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A fossil wood of *Ziziphus* Mill. showing semi-ring porosity has been reported from the outskirts of Bikaner city, Rajasthan. It belongs to the Mar Formation, age of which most probably is Pliocene. Although fossil leaves and fruits of *Ziziphus* are known, there is no authentic record of its fossil wood so far. Thus the present report forms the first definite record of a fossil wood of *Ziziphus*. The fossil has provided evidence that ring-porosity is not a modern phenomenon in *Ziziphus*, but most probably it is a genetically controlled character and not the result of adaptation to any cooler climate as has been envisaged the cause of ring porousness in woods by some workers.

Key-words—Xylotomy, Semi-ring porosity, *Ziziphus*, Late Tertiary (India)

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सारांश

राजस्थान के अनंतिम तृतीयक कल्प से जिजीफ़स की अर्ध-वलयी सरंध्री अश्मित काष्ठ

जसवन्तसिंह गुलेरिया

राजस्थान में बीकानेर के आस-पास से एकत्र **जिजीफ़स** मिल की एक अश्मित काष्ठ का वर्णन किया गया है। यह काष्ठ अर्ध-वलयी सरंध्रता प्रदर्शित करती है। उक्त स्थान मार शैल-समूह से सम्बद्ध है तथा सम्भवतः इसकी अतिनूतन आयु है। यद्यपि **जिजीफ़स** की अश्मित पत्तियाँ एवं फल पहले से ही विदित हैं तथापि इसकी अश्मित काष्ठ का अभी तक कोई अभिलेख नहीं है। अतएव **जिजीफ़स** की अश्मित काष्ठ का यह पहला अभिलेख है। इस अश्मित काष्ठ से यह प्रमाणित होता है कि इस प्रजाति में वलयी-सरंध्रता एक आधुनिक परिघटना नहीं है अपितु सम्भवतया यह एक आनुवंशिक लक्षण है जो शीत जलवायु वाली परिस्थितियों में विकसित नहीं होता जैसा कि शोध-कर्त्ताओं ने इसके विषय में पहले कहा है।

VERY little is known about the Upper Tertiary megaflora of Rajasthan. The author initiated work on the fossil woods of this area in 1984 and described a fossil wood of *Mangifera* from north-west of Jaisalmer. Subsequently, he (1986) reported the occurrence of a number of fossil woods from the sediments of Shumar Formation of Jaisalmer suggesting that the age of the formation could be older than Sub-Recent and most likely equivalent to the Kankawati Series of Kutch from where similar fossils have already been reported (Lakhanpal, Guleria & Awasthi, 1984). Lately, fossil woods of typical tropical African elements belonging to family Meliaceae (*Entandrophragma* C.DC., *Khaya* A. Juss.) and Fabaceae (*Baphia* Afzel, *Erythrophleum* Afzel ex. G.Don, *Tetrapleura* Benth.) recovered from the Shumar Formation near Jaisalmer have been reported by the author (Guleria, 1990a). In addition, fossil woods of *Lagerstroemia speciosa, L. parviflora, Ougeinia oojeinensis* and *Dialium* have been described (Guleria, 1990b) from the Mar Formation of Bikaner which is considered equivalent to Shumar Formation of Jaisalmer (Shrivastava, 1971; Das Gupta, 1977). The present paper deals with an interesting piece of fossil wood of *Ziziphus* Mill. belonging to family Rhamnaceae. The present fossil was collected alongwith many other fossil woods from the outskirts of Bikaner city about 1 km from Nathusar Gate towards Karmisar Village on left side of the road as one proceeds from Bikaner to Karmisar (approx. 28°08′ : 73°18′45″). The wood was recovered from friable and loose sandstones belonging to Mar Formation. The age of the formation has been postulated most probably Pliocene (Guleria, 1990b).

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SYSTEMATIC DESCRIPTION

Family—Rhamnaceae

Genus—*Ziziphus* Mill

Ziziphus oxyphylla Edgew.

Pl. 1, figs 1-6

Description is based on a well preserved petrified wood sample measuring about 7 cm in length and 4 cm in diameter.

Description—Wood semi-ring porous tending to be ring porous (Pl. 1, figs 1, 3). *Growth rings* distinct, delimited by fine line of parenchyma, thick-walled late wood fibres and by a row of large early wood vessels (Pl. 1, figs 1, 3). *Vessels* very small to large, mostly oval to round, more or less evenly distributed sometimes crowded in the early part of growth ring, 7-15/mm², open or sometimes plugged with gummy deposits, tyloses absent, solitary or in radial multiples of 2-8, mostly 2-4 (Pl. 1, figs 1, 3) rarely forming clusters, t.d. 36-280 μm, mean tangential diameter of larger vessels 132-180 μm, r.d. 40-200 μm, largest near the inner margin of the ring and smallest near the outer margin, vessel member length 352-640 μm with truncated or tailed ends; perforations simple; intervessel pit-pairs simple, alternate, pits circular, oval to polygonal in shape, medium to large, 7-11 μm in diameter (Pl. 1, figs 2, 5); vessel-ray pitting similar to intervessel pits in size and shape. *Parenchyma* paratracheal and apotracheal (Pl. 1, figs 1, 3), paratracheal parenchyma vasicentric to lozenge-aliform; apotracheal parenchyma forming 1-2 cells thick ill-defined lines of initial or terminal parenchyma (Pl. 1, figs 1, 3), parenchyma cells thin-walled, round to oval in shape in cross section, t.d. 12-32 μm, r.d. 20-44 μm.

Xylem rays fine, uniseriate rarely with paired cells, 3-20 cells or 80-540 μm high, 12-15 per mm, consisting of procumbent and upright cells, solitary crystals present in some of the ray cells, gummy deposits frequent in ray cells, tangential height of procumbent cells up to 20 μm, tangential height of upright cells 32-40 μm (Pl. 1, figs 2, 4, 6). *Fibres* aligned in radial rows between xylem rays, rectangular to polygonal in cross-section, t.d. 6-8 μm, r.d. 6-16 μm, thick-walled, wall 4-5 μm thick, lumen narrow, pits on the fibre walls could not be seen, non-septate.

Affinities—In gross anatomical features the fossil shows apparent resemblance with the wood structure of some of the genera belonging to Combretaceae, Lythraceae and Rhamnaceae more particularly with the woods of *Terminalia*, *Lagerstroemia* and *Ziziphus*. Amongst three genera, *Lagerstroemia* shows resemblance in having semi-ring porous wood with uniseriate rays. *Terminalia* possess similar type of parenchyma and rays as seen in fossil. However, on closer examination these woods can easily be differentiated from the present fossil. The presence of vestured pits in the wood of *Terminalia* and *Lagerstroemia* differentiate the present fossil from these woods (Metcalfe & Chalk, 1950). Moreover, crystals absent in the ray cells in *Lagerstroemia* instead they are present in fibre compartments or locules. These characters together help in differentiating the present fossil from *Lagerstroemia*. Among different species of *Terminalia, T. tomentosa* which sometimes shows semi-ring porous structure (Chowdhury, 1936, pl. V, figs 1-4; 1959, p. 72), thereby, showing close resemblance to the fossil can be differentiated on account of absence of crystals in its ray cells (Pearson & Brown, 1932, p. 521). On detailed survey of literature (Pearson & Brown, 1932; Chowdhury, 1934; Record, 1939; Metcalfe & Chalk, 1950; Ghosh & Shahi, 1963) and examination of modern wood slides it was found that the fossil shows complete agreement with the wood of *Ziziphus*. Woods of nine Indian species of *Ziziphus*, viz., *Z. glabrata* Heyne ex. Roth., *Z. incurva* Roxb., *Z. jujuba* Mill., *Z. mauritiana* Lam., *Z. nummularia* W. & A., *Z. oenoplia* Mill., *Z. oxyphylla* Edgw., *Z. rugosa* and *Z. xylopyrus* Willd. were examined from their thin sections and published literature (Ghosh & Shahi, 1963) in order to find out the closest modern ally of the fossil. It was found that *Z. mauritiana* and *Z. oxyphylla* show close resemblance with the fossil. However, the occurrence of semi-ring porous feature was observed in the woods of *Z. oxyphylla* (Forest Research Institute, Dehradun, Wood Slide nos. 4818 and 2949), hence the fossil indicates its best resemblance with *Z. oxyphylla*.

The woods of family Rhamnaceae have hardly been recorded from India. The rare occurrence of fossil woods of the family can be attributed to the fact that the family is represented in India by only two genera, *Rhamnus* and *Ziziphus*, which attain tree size. The remaining Indian genera of the family are mostly climbers and straggling or erect shrubs. The woods of climbers or shrubby plants have lesser chances of preservation as compared to the woods of trees. Obviously, they rarely get preserved in the fossil form. The genus *Rhamnus* is mainly found in the temperate regions of Northern Hemisphere and in India it is primarily confined in the Himalayas and higher elevations of south India. Thus the occurrence of fossil remains of *Rhamnus* in the typical tropical Tertiary flora of the Indian peninsula

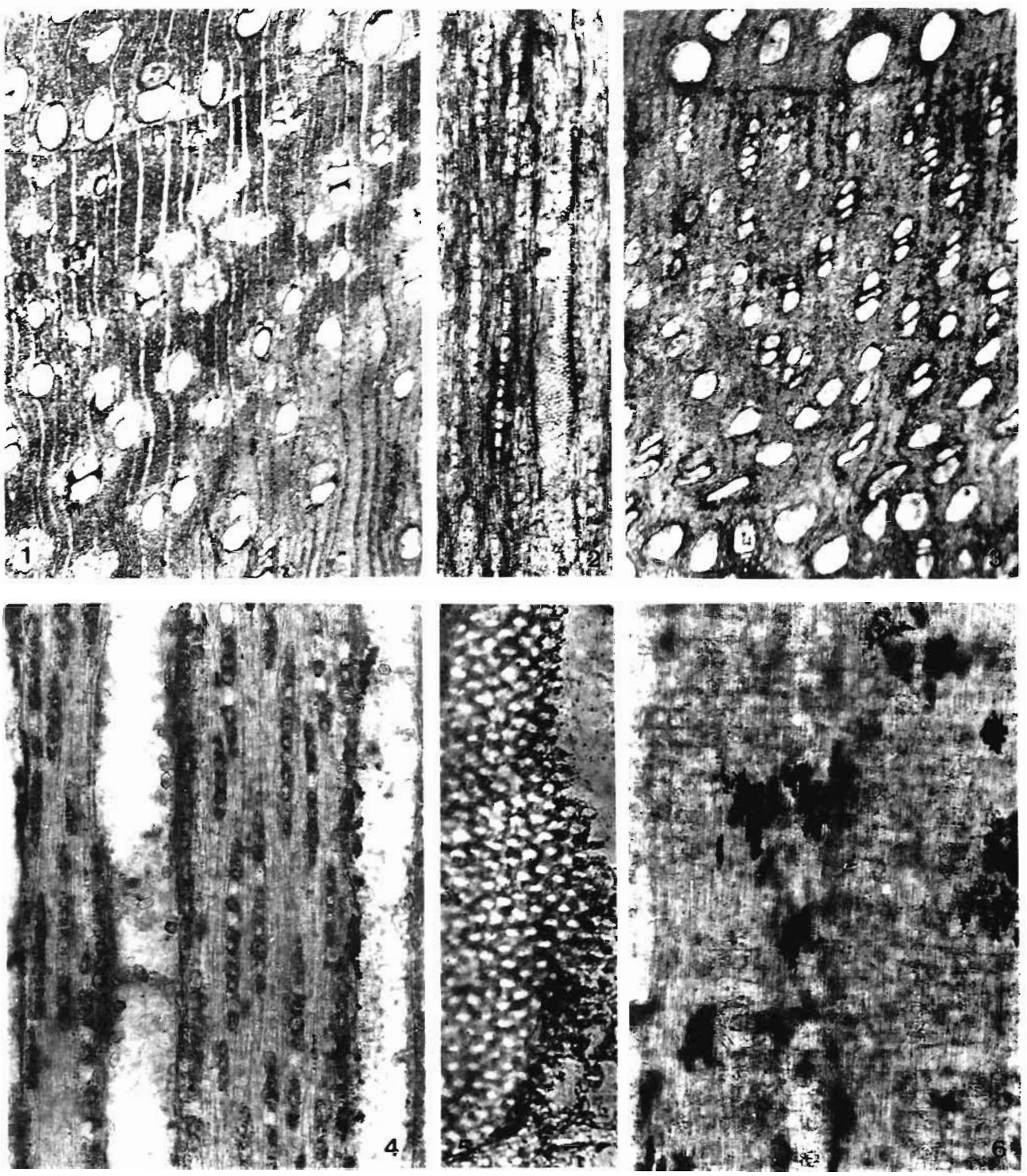

PLATE 1

Ziziphus oxyphylla

1. Cross section of the fossil wood showing semi-ring porous structure, growth rings, size and distribution of vessels, parenchyma and fibres. × 35; BSIP Slide no. 36755-1.
2. Tangential longitudinal section of the fossil wood showing fine rays, vessel and intervessel pits. × 90; BSIP Slide no. 36755-3.
3. Another cross section of the fossil wood showing tendency towards ring porosity. × 35; BSIP Slide no. 36755-2.
4. Tangential longitudinal section of the fossil wood showing almost all uniseriate rays, solitary crystals present sometimes in ray cells. × 90; BSIP Slide no. 36755-4.
5. Tangential longitudinal section of the fossil showing intervessel pits. × 350; BSIP Slide no. 36755-5.
6. Radial longitudinal section of the fossil wood showing mostly procumbent cells and sometimes upright or enlarged cells. × 120; BSIP Slide no. 36755-6.

is remote. Nevertheless, the author lately came across two records wherein seeds of *Rhamnus* have been reported from the intertrappean beds of Barangada in Mandla District of Madhya Pradesh (Udhoji, 1989; Udhoji & Verma, 1990). They did not give any description of the *Rhamnus* seeds and the accompanied photograph is also very poor. In view of the present distribution of *Rhamnus* and typical tropical fossil elements known from the area (Mehrotra, 1989) the identification of *Rhamnus* seeds seems highly erroneous and not worth considering. *Ziziphus* which is a widely distributed genus and is largely found in the tropical regions has already been reported in the fossil form alongwith other tropical genera in India. But most of its fossil records are in the form of its leaves and fruits. Fossil leaves of *Ziziphus* have been reported from the Siwalik sediments of Himachal Pradesh (Lakhanpal, 1965, 1966), West Champaran District, Bihar (Lakhanpal & Awasthi, 1984) and Siang District of Arunachal Pradesh (Singh & Prakash, 1980). Fruits of *Ziziphus* have also been reported from the Late Cenozoic sediments of Palamu District, Bihar (Bande & Srivastava, 1990). Thus the fossil leaves and fruits of *Ziziphus* are known only from the Neogene and yet to be reported from the Palaeogene sediments of India. On the contrary, the woods referable to *Ziziphus*, viz., *Z. intertrappea* and *Z. eocenus* have been recorded by Chitaley *et al.* (1970) and Upadhye and Patil (1979) respectively from the Intertrappean beds of Mohgaon Kalan in Chhindwara District of Madhya Pradesh. Subsequently, Trivedi and Srivastava (1982) described a fossil wood from the Deccan Intertrappean beds of Mandla District in Madhya Pradesh as *Zizyphoxylon mandlaensis* gen. et sp. nov.

Detailed account of fossil woods of *Zizyphus intertrappea* (Chitaley *et al.*, 1970) and *Z. eocenus* (Upadhye & Patil, 1979) is not available. Their published records are in the form of abstracts without photographs. Even after two decades their details have not been published till this date. So these records seem questionable and are not being taken into account. It is therefore suggested that such records should be overlooked to avoid further confusion and unnecessary repetition in literature, unless they are validly published. *Zizyphoxylon mandlaensis* Trivedi & Srivastava 1982 is the only validly published record of fossil wood of *Ziziphus*. However, on carefully going through the description of *Zizyphoxylon mandlaensis* and examining the accompanied photographs it can easily be said that it does not belong to *Ziziphus*, although it has been compared with the modern wood of *Ziziphus mauritiana* (= *Z. jujuba*). The parenchyma as seen in the photographs of *Zizyphoxylon mandlaensis* is scanty paratracheal, vessels much smaller in size, rays without any crystals as compared to *Ziziphus mauritiana* = (*Z. jujuba*) in which parenchyma is definitely more vasicentric to aliform, usually forming 3-4 layers of cells around vessels and occasionally becoming confluent, vessel much bigger in size and rays with crystalliferous cells. Moreover, growth rings and initial or terminal parenchyma not seen in the photographs of *Zizyphoxylon*. Besides, vessel members are very long (400-1030 μm) in it and there is no mention whether the fibres are septate or nonseptate. All these differences indubitably indicate that the fossil does not belong to *Ziziphus*. Obviously, the wood needs reinvestigation. Thus the present report forms the first definite record of the fossil wood of *Ziziphus*. In this context it is interesting to note that a wood of *Ziziphus* about four thousand years old has been reported by Chowdhury and Ghosh (1951) from Harappa situated north-west of Bikaner. Like megafossils, pollen record of Rhamnaceae are also meagre. According to Müller (1981, pp. 81-82) the oldest pollen of the family is known from Oligocene but pollen of *Ziziphus* have been reported from the Upper Miocene of Spain and from the Pliocene of Sahara. Evidently, the finding of a fossil wood of *Ziziphus* in Late Tertiary sediments of Bikaner is in complete harmony with the palynological records as well as with other megafossil (like leaves and fruits) records of the genus known from India.

REMARKS ON RING POROSITY IN *ZIZIPHUS*

Since majority of ring-porous woods are found in temperate regions it lead to the generalization that extremely unfavourable conditions prevalent in temperate climate may be responsible for the production of ring porosity. Various views have been expressed for the formation of ring porousness like cold winters or alternating very dry and wet seasons or seasonality in climates (Bailey, 1924; Haberlandt, 1928; Gilbert, 1940; Sweitzer, 1971; Wheeler & Baas, 1991; Wheeler & Matten, 1977; Wheeler *et al.*, 1978; Carlquist, 1980; Bissing, 1982). Contrary to temperate regions, the evidence about the development of ring porosity in tropical countries is different (Chowdhury, 1953). Thus our knowledge is still inadequate in this context. Carlquist (1988, p. 337) has summed the latest position in the following words "Although ring porosity has often been treated as an adaptation, if only by default, it is in fact an assemblage of phenomena." Most of the woods found in tropical climate are diffuse porous compared to very few ring porous or semi-ring

porous. Some of the well known Indian examples of the later category are *Tectona, Lagerstroemia, Gmelina* to which *Ziziphus* can be added (Chowdhury, 1939, 1940, 1953; Ghosh & Shahi, 1963). The fossil has unveiled that ring porosity is not a modern phenomenon in *Ziziphus*. Similar feature of ring porosity has been observed in the woods of *Lagerstroemia* and *Terminalia tomentosa* (Guleria, 1990b; Chowdhury, 1959, p. 72; Chowdhury & Tandon, 1964, p. 449) amongst the Indian genera. In view of the known fossil woods from Bikaner, viz., *Lagerstroemia, Ougeinia, Dialium* and some of the other elements which are being published elsewhere it can be said that the development of ring porosity in *Ziziphus* was not the result of adaptation to cooler climate or any adverse conditions, instead it may most probably be the result of its genetic character as has been inferred in the case of *Terminalia tomentosa* and *Lagerstroemia* (Chowdhury, 1959, p. 72; Chowdhury & Tandon, 1964, p. 449; Guleria, 1990b, p. 187).

Ziziphus consists of about 100 species (Willis, 1973, p. 1241) of shrubs and small to medium-sized trees widely distributed in temperate and tropical regions of the world but most numerous in Indo-Malayan region. According to Santapau and Henry (1973), there are 17 species of *Ziziphus* growing in India. *Ziziphus oxyphylla* with which the fossil is related is an erect thorny shrub or small tree 7.5-9 m high occurring in the sub-Himalayan region from Indus to Ganga at 600-1800 m elevation (Brandis, 1874; Ghosh & Shahi, 1963).

Holotype—B.S.I.P. Museum Specimen no. 36755.

Locality—About 1 km from Nathusar Gate towards Karmisar Village on the outskirts of Bikaner city.

Horizon—Mar Formation.

Age—Probably Pliocene.

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