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Fossil wood of *Duabanga* from the Siwaliks of Sindhuli area, eastern Nepal

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ABSTRACT

A fossil wood belonging to the extant genus *Duabanga* Buch-Ham of Sonneratiaceae has been represented the collection from the Siwaliks of the Sindhuli district, eastern Nepal. As the modern equivalents of the fossil wood grow now in the Indo-Malayan region, its presence in the Siwaliks of Nepal is phytogeographically important and indicates more humid climate at the time of deposition.

INTRODUCTION

The Siwalik rocks are exposed all along the Himalayan foot hills from western Pakistan in the west to Assam, India in the east covering a length of 2400 km with 20-25 km width. It lies between the Main Boundary Thrust (MBT) and the Gangetic Plain and consists of Miocene to lower Pleistocene molasse sediments deposited in the foreland basins of the Himalaya (Gansser, 1964; West and Munthe, 1981; Tokuoka et al., 1986). Throughout Nepal the Siwaliks can be divided into three lithostratigraphic units - Lower Siwaliks, Middle Siwaliks and Upper Siwaliks (West and Munthe, 1981; Herail et al., 1986; Delcaillau et al., 1987). The Middle Siwaliks are further subdivided into Lower (MS1) and Upper (MS2) units (DMG, 1987). Their contact is placed at the base of sandstone having extraformational clasts of scattered pebbles. The present fossil locality is in the Upper Middle Siwaliks (MS2) exposed at Gauri Khola, a tributary of the Kamala River in eastern Nepal (Fig. 1). The fossil wood was found in the thickly bedded, arkosic sandstone.

MATERIAL AND METHOD

The fossil wood was collected in situ from the Gauri Khola, eastern Nepal. In the outcrop, it was a single piece of petrified wood, dark brown in colour and 70 cm x 15 cm in size. The sample broke into several pieces when dug out. The specimens are semisilicified. They were sliced into thin pieces in different planes (i.e. transverse, tangential and radial). Thin sections were studied under the microscope.

SYSTEMATIC DESCRIPTIONS

Family SONNERATIACEAE
Genus DUABANGA Buch-Ham
Duabangoxylon indicum [(Navale) Awasthi] Awasthi and Prasad, 1987, Fig. 2 (a-e)

Duabangoxylon tertiarum Prakash and Awasthi, 1970, p. 38, Pl. 5, Fig. 24, 26, 27; Pl. 6, Fig. 31.
Duabangoxylon tertiarum (Prakash and Awasthi) Kramer, 1974, p. 153, Pl. 32, Fig. 148-151, 153-157.
Duabangoxylon indicum (Navale) Awasthi, 1981, p. 161-165; Pl. 1, Fig. 1, 3, 5.
Duabangoxylon indicum [(Navale) Awasthi] Awasthi and Prasad, 1987, p. 292-294, Pl. 1 Fig. 1, 3, 5.

Description
Wood diffuse porous.
Growth rings indistinct due to poor preservation,
Vessels small to medium size, t.d. 56-120 μm, r.d. 60-200 μm, solitary and in radial multiples of 2-4, almost evenly distributed, circular to oval in shape

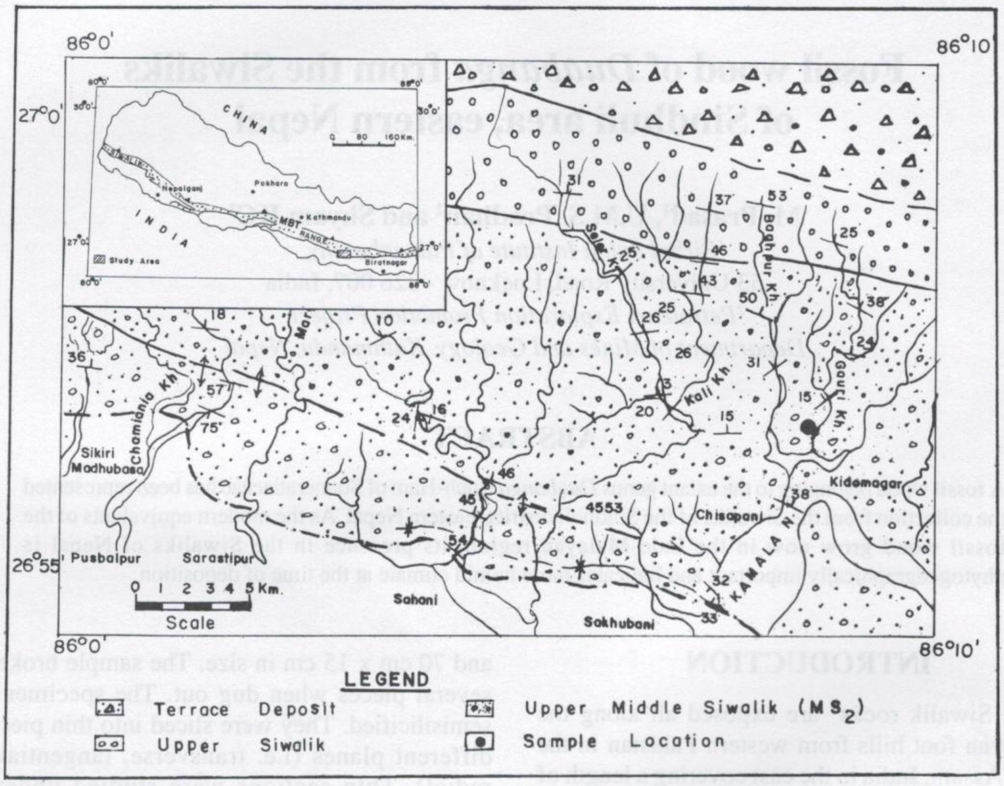

Fig. 1: Geological map of a part of Dhanusha and Sindhuli districts, eastern Nepal.

(12-20 per sq. mm); profusely tylosed (Fig. 2a,b), vessel members are 160-560 µm in length, usually with truncate ends, perforations simple; intervessel pits vestured, alternate, 8 to 12 µm in diameter, and orbicular to oval in shape with linear to lenticular apertures (Fig. 2c).

Parenchyma scanty paratracheal to vasicentric forming 1-2 seriate, complete to incomplete sheath around vessels, occasionally extending sideway, thin walled, round to oval, 16-20 µm in diameter (Fig. 2e), 70-150 µm in length.

Xylem rays fine, 1-2 seriate, (mostly 1), 3-35 µm in height, 16-36 µm in width, 140-320 µm in length, 12-16 rays per mm (Fig. 2c), ray tissues heterogeneous, rays homocellular to heterocellular, heterocellular rays consisting 1-2 marginal rows of upright or square cells at one or both the ends and rest procumbent cells; upright or square cells 25-40 µm vertical height and 18-22 µm radial length, procumbent cells 20-45 µm in vertical height and 30-60 µm radial length (Fig. 2d).

Fibres oval to angular in cross section, 15-35 µm in diameter, moderately thick-walled, nonseptate, 560-850 µm in length, pits not seen.

Affinities

The characteristic features of the present fossil wood are small to medium-sized vessels with abundant tyloses, scanty to vasicentric paratracheal parenchyma, 1-2 heterogeneous xylem rays and nonseptate fibres. They indicate the affinity with the woods of extant genus *Duabanga* of the family Sonneratiaceae (Pearson and Brown, 1932; Metcalf and Chalk 1950; Ilic, 1991).

In order to determine its specific similarity wood slides of available species of *Duabanga* and published literature were consulted. This exercise revealed that the present fossil has close resemblance with modern *D. grandiflora* (Roxb. DC) Walp (Syn.

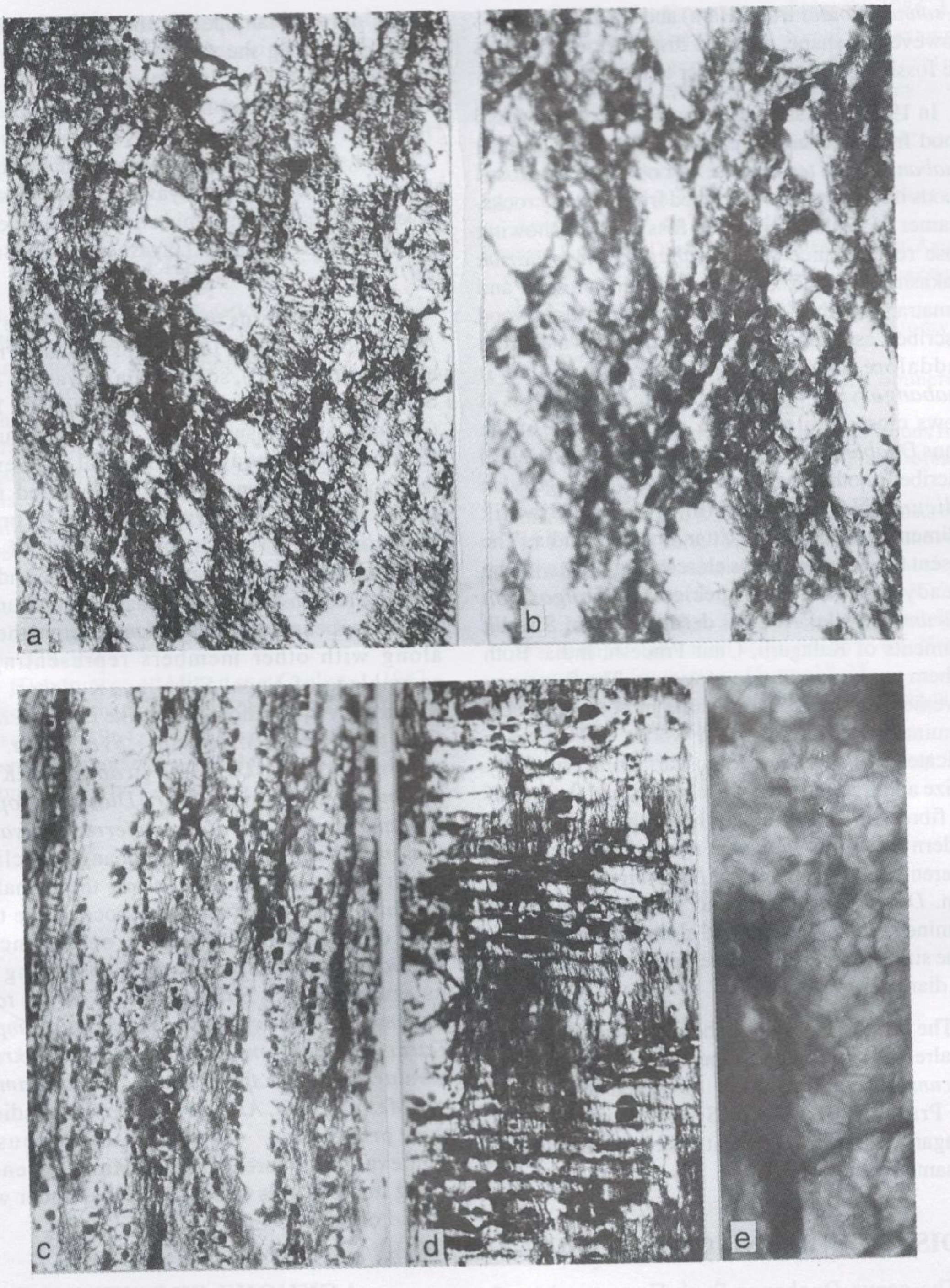

Fig. 2: ***Duabangoxylon indicum*** **[(Navale) Awasthi] Awasthi and Prasad: (a) cross-section in low power showing the nature and distribution of vessels. x 45, (b) cross-section in high power showing multiples tylosed vessels and paratracheal parenchyma. x 70, (c) tangential longitudinal section showing nature of xylem rays. x 70, (d) radial longitudinal section showing heterogenous xylem rays, (e) magnified intervessel pit-pairs. x 425.**

D. sonneratioides Buch-Ham) and *D. maluccana* Bl. However, in shape, size and distribution of vessels the fossil wood is more closer to *D. maluccana* Bl.

In 1970, Prakash and Awasthi described a fossil wood from Tertiary of eastern India and named it *Duabangoxylon tertiarum*. Later on three more fossil woods have also been described from Tertiary rocks. Kramer (1974) described a fossil wood showing close resemblance with *Duabagoxylon tertiarum* Prakash and Awasthi from Neogene of Java and Sumatra. Awasthi (1981) reinvestigated a fossil wood described as *Sapindoxylon indicum* (Navale) from Cuddalore series, south India and named it *Duabangoxylon indicum* (Navale) Awasthi as it shows close similarity with modern wood of the genus *Duabanga*. Lastly, Awasthi and Prasad (1987) described another fossil wood under *Duabangoxylon indicum* (Navale) Awasthi from the Siwalik sediments of Kalagarh, Uttar Pradesh, India. The present fossil wood shows closest similarity with the already known fossil species *Duabangoxylon indicum* (Navale) Awasthi described from Siwalik sediments of Kalagarh, Uttar Pradesh, India. Both of them possess same size of vessels. The frequency of vessels and rays is also same in both. A critical examination of known fossil woods of *Duabanga* indicates that there is certain variations especially in size and frequency of vessels, rays and the size of the fibres. In order to see these variations in the modern woods of *Duabanga* a number of section of different wood specimens of *Duabanga grandiflora* (Syn. *D. sonneratioides*) and *D. maluccana* were examined critically and found almost same variation in the size and frequency of vessel, frequency of rays and diameter of fibres.

The present fossil wood shows close affinity with the already known fossil species, *Duabangoxylon indicum* [(Navale) Awasthi] described by Awasthi and Prasad (1987) from Siwalik sediments of Kalagarh, India. Therefore, it has been identified as the same species.

DISCUSSION AND CONCLUSION

The genus *Duabanga* Buch-Ham. consists of three species distributed in the Indo-Malayan region (Willis, 1973). Out of them, *D. grandiflora* (Roxb. ex DC) Walp. (Syn. *D. sonneratioides* Buch-Ham.) is the only Indian species that grows in eastern Himalaya, along the stream banks and ravines in Assam and Burma. It also occurs in Andaman Islands, Thailand and Malaya. *D maluccana* Bl. is found in the primary forests of Java, Borneo, Celebes, Malucca, New Guinea and Philippines Islands and *D. taylorii* Jayaveera flourishes along river banks in the moist mid country at an elevation of 457m above sea level (Jayaveera 1967; Brandis, 1971).

From the records of fossil woods of the genus *Duabanga* from the Tertiary of Assam (Prakash and Awasthi, 1970), south India (Awasthi, 1981), Siwaliks of Kalagarh, Uttar Pradesh, India, (Awasthi and Prasad, 1987), Java and Sumatra (Kramer, 1974) and eastern Nepal it is evident that this genus was widely distributed in the Indian subcontinent during Neogene. At present, it is confined to the tropical forests of north eastern India (West Bengal and Assam), Andaman Islands, and in some north east Asian countries. The disappearance of *Duabanga* from the area along with other members representing the assemblage of Nepal Siwaliks (Koilabas, Surai Khola and Arjun Khola, etc.), like *Dipterocarpus, Calophyllum, Millettia ovalifolia, M. macrostachya, Ormosia robusta, Kayea floribunda, Ryparosa kunstlri, Diospyros toposia, Cinnamomum inuctum, Mesua ferrea, Polyalthia, Cynometra* etc. indicates that changes in climate might have taken place all along the Himalayan foot hills of Nepal after Mio-Pliocene due to the rise of the Himalaya. The occurrence of *Duabanga* in the Siwaliks of Nepal along with its associates like *Bauhinia sp., Cedrela toona, Eugenia sp., Dysoxylum sp., Michelia champaca, Tetrameles nudiflora, Terminalia sp., Chukrassia tabularis, Albizia sp., Dillenia indica, Bambusa sp., Mesua ferrea, Artocarpus chaplasa* indicates the prevalence of moist deciduous to semievergreen forest during Mio-Pliocene all along the foot hills of eastern Nepal under warm humid climate.

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