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GYMNOSPERM FOSSIL WOODS FROM GANGTA BET, EASTERN KACHCHH, WESTERN INDIA

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ABSTRACT

Two gymnospermous fossil woods *Araucarioxylon wagadensis* n. sp. and *Podocarpoxylon gangtaensis* n. sp. have been described for the first time from the younger part of the Gadhada formation exposed around the core of the central dome of the Gangta Bet. The ammonites recorded from the Gangta Bet by earlier workers suggest that these fossil woods come from Callovian sediments forming the basal part of the succession. These fossil woods are characterized by the presence of early and late secondary wood with small resin canals, tracheidal cells, aurocaroid or podocarpoid pits in cross field area. Dendrological data indicate that the climate was characterized by cycles of tropical wet and dry savanna climate.

Keywords: Fossil woods, *Araucarioxylon, Podocarpoxylon,* Gangta Bet, Gadhada formation, Eastern Kachchh

INTRODUCTION

The Jurassic rocks of the Kachchh Basin are globally known for their rich macro fauna (Fig. 1). The old fourfold classification of Jurassic rocks of the Kachchh Basin proposed by Waagen (1875) has been replaced by a different lithostratigraphic classification (Biswas 1980, Fürsich *et al*., 2001, 2013). Biswas (1980), in fact, distinguished three lithologic provinces in the Kachchh Basin, viz. Kachchh Mainland, Pachchham "Island" and Eastern Kachchh (Wagad, Khadir and Bela "islands" and Chorar Hill). He called all individual units the uplifts in salt marsh. The stratigraphy of the Eastern Kachchh represents a shallow marginal marine facies, whereas the rocks of the Kachchh Mainland represent comparatively deeper facies. Within the Eastern Kachchh older rocks are exposed in Khadir and Bela "islands" and Chorar Hill, whereas younger rocks are exposed in Wagad region. Lithostratigraphically, six formations have been recognized in the Eastern Kachchh (Table 1). Barring Patcham Formation, all other formations dominantly consist of siliciclatic sediments.

Wagad is the largest uplift in Eastern Kachchh (Fig. 1). Gangta Bet (N23º46' to N23º 43' and E70º30' to 70º33'), an islet, is situated very near to the Wagad Uplift, on its north-western side and connected by about a 4 km motorable road in salt marsh (Figs. 1 & 3). Gangta Bet represents a highly denuded domal structure of ca. 5 km in diameter surrounded by the Great Rann of Kachchh. Lithostratigraphically, the rocks of Gangta Bet represent the Gangta Member of the Gadhada formation (Table 1). On the basis of ammonites, Callovian to Late Oxfordian age has been assigned to the rocks exposed in Gangta Bet (Patel *et al.*, 2012, Pandey *et al*., 2013). Recently, two fossil woods belonging to the families Araucariaceae and Podocarpaceae have been recorded from the Callovian sediments forming the basal part of the succession exposed in the central part of the dome. The present paper deals with the description of these two wood fossils.

MATERIAL AND METHOD

Dark brown coloured and anatomically well preserved two pieces of petrified woods, measuring 6.0 x 4.0 cm and 8.0 x 5.0 cm in size, were collected from the Callovian part of Gadhada formation exposed at the base of central dome, southwest of Ravechi Mata Temple, Gangta Bet (Fig. 2). In order to prepare thin sections (transverse, radial and tangential), the specimens were cut and polished using carborundum powder. Slides were prepared for xylotomical studies. These slides were examined under high magnification using microscope after smearing the surface with glycerine under transmitted light. Identification of the fossil wood taxa was done using key characters, such as presence or absence of resin canals, crossfield pitting, height of rays, distinct or indistinct or absence of growth rings, the transition from early to late wood and presence of tracheids.

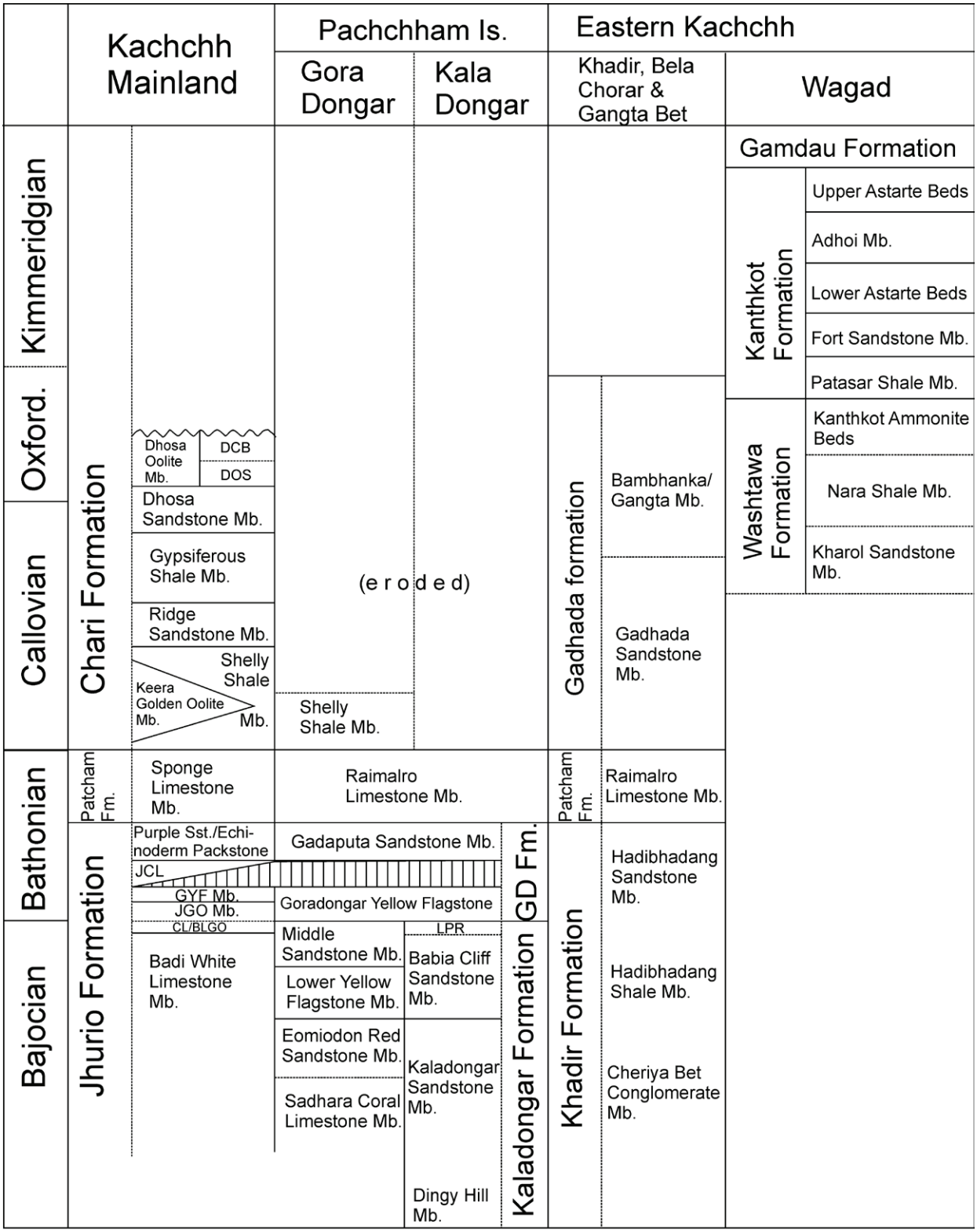
SYSTEMATIC DESCRIPTION

Class **Pinopsida** Burnett 1835
Order **Pinales** *Gorozhankin* 1904
Family **Araucariaceae** Henkel & Hochstetter, 1865
Genus ***Araucarioxylon*** Kräusel, 1870
Araucarioxylon wagadensis n. sp.
(Pl. I, figs. 1-7)

Material: One small piece of petrified wood specimen measuring 6.0 x 4.0 cm and 8.0 x 5.0 cm, basal sediments (Callovian) of Gadadha formation, Gangta Bet, Kachchh Basin. The specimen is dark brown in colour and bears good preservation of anatomical characters. BSIP Museum No. 40567 (Holotype),

Description: Growth ring indistinct, almost homogeneous, no proper distinction between early and late wood zone (Pl. I, figs. 1-2). Wood tracheids squarish to polygonal, transverse

Table 1: Lithostratigraphic framework of the Jurassic rocks of Kachchh (modified after Fürsich *et al*., 2013).



JCL: Jumara Coral Limestone Mb.; GYF: Goradongar Yellow Flagstone Mb.; JGO: Jhura Golden Oolite Mb.; CL/BLGO: Canyon Limestone/Badi Lower Golden Oolite; LPR: Leptosphinctes Pebbly Rudstone; DCB: Dhosa Conglomerate Bed; DOS: Dhosa Oolite Sandstone.

EXPLANATION OF PLATE I

Anatomical structures of ***Araucarioxylon wagadensis*** n. sp.; 1-2, Transverse section (TS); 3-6, Transverse longitudinal section (TLS); 7, Radial longitudinal section (RLS); BSIP wood slide nos. 40567 I-VI.

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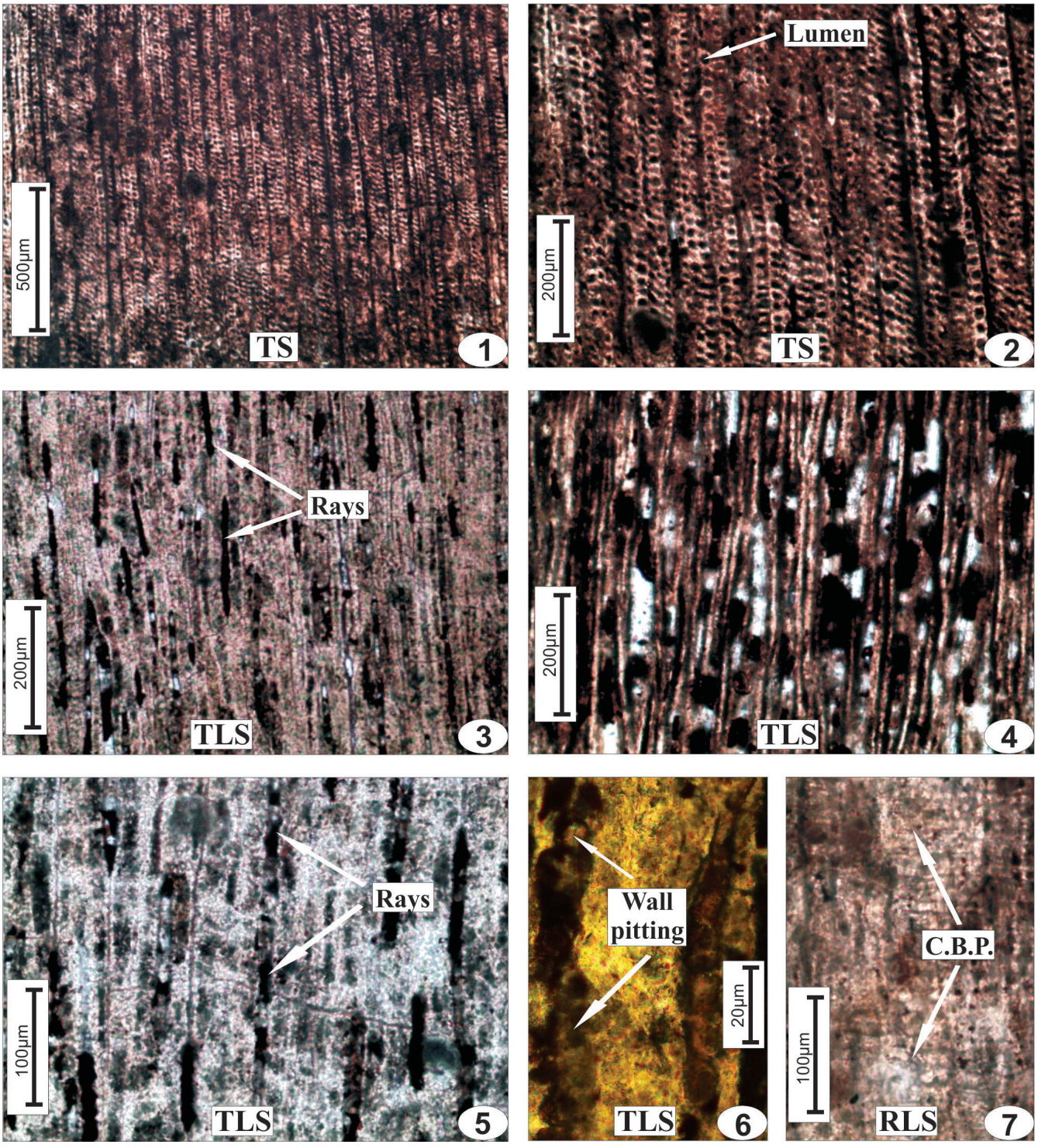
Plate I



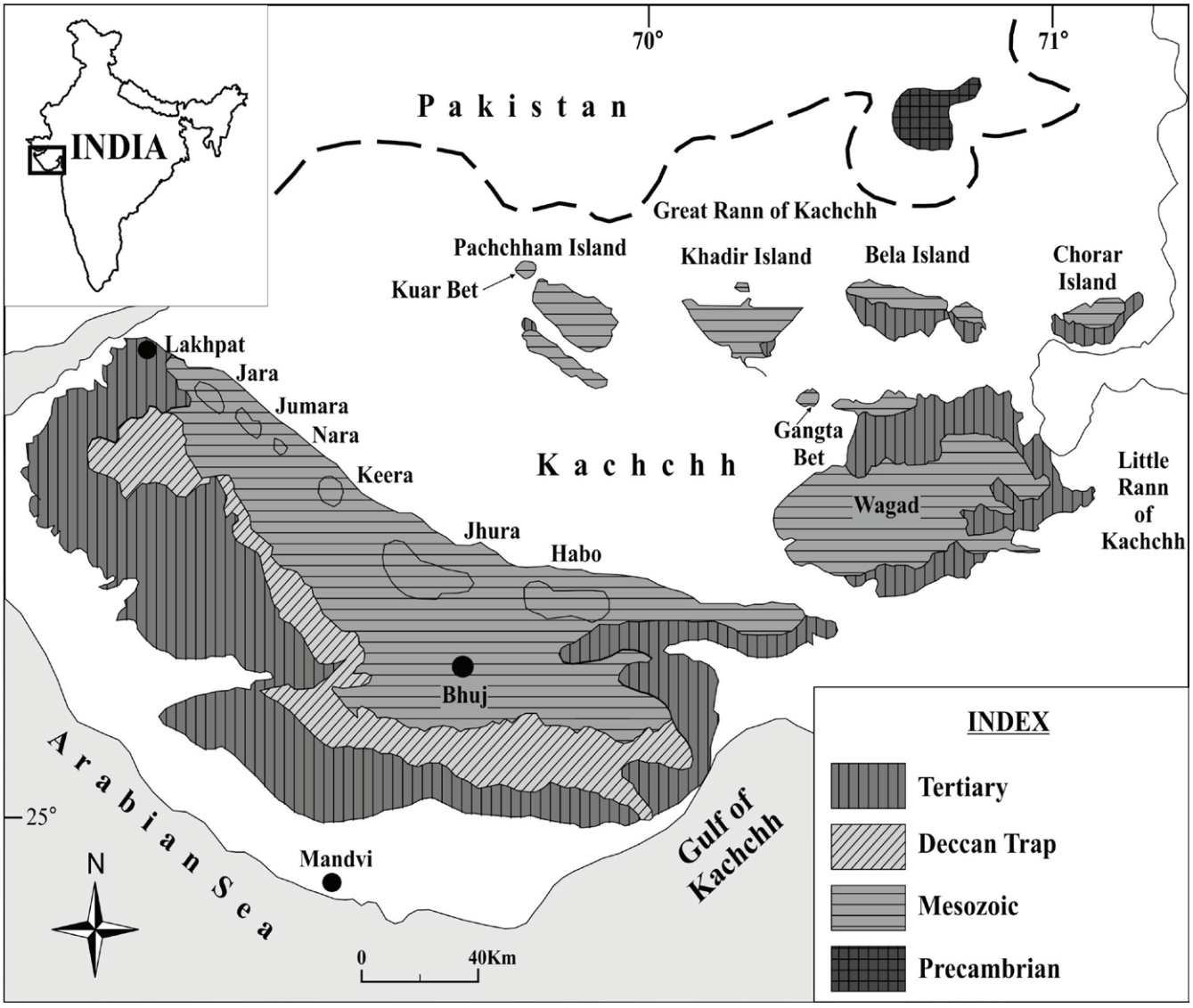


Fig. 1. Geological map of Kachchh.

dimension (t. d.) 17-40 µm, radial dimension (r. d.) 20-70 µm, wall thickness 10-15 µm, 160-200 tracheids per square mm, some tracheids filled with resinous material (Pl. I, figs. 1-2). Radial pits uni-biseriate, bordered, circular to oval in outline with usually elliptic aperture, 10-16 µm in diameter (Pl. I, fig. 6). Cross field pits 2-5, small in size, 6-8 µm in diameter, circular to elliptical in outline, usually contiguous alternate to opposite with circular to elliptic aperture (Pl. I, fig. 7). Hexagonal or araucaroid thickening occurs on tangential wall of the tracheids. Parenchyma rarely seen, scattered among the tracheids, cells are small with usually truncate to tailed ends. Xylem rays mostly uniseriate, 2-26 cells or 60-410 µm in height and about 30 µm wide (Pl. I, figs. 3-4), rays 15-20 per square mm in cross section (Pl. I, fig. 1), oval to elongated in outline, homogenous, some cells are filled with dark content. Resin canals present, small in size. At places equivalent to tracheidial cells (Pl. I; figs. 1-2).

Specific Diagnosis: Growth rings indistinct, tracheids square to polygonal, transverse dimension (t.d.) 17-40 µm, radial dimension (r. d.) 20-70 µm, sometimes filled with dark content, radial pits uni- biseriate, bordered, circular to elliptic usually contiguous alternate to opposite; xylem rays mostly uniseriate, 2-26 cell or 60-410 µm in height, oval to elongated, more than 3 times in length than in width, cells are also filled with dark content. Parenchyma rare, scattered with truncate to tailed end. Resin canal present small, sometimes as small as tracheidial cell.

Holotype: BSIP Museum No. 40567

Locality: Gangta Bet, eastern Kachchh, Gujarat, India

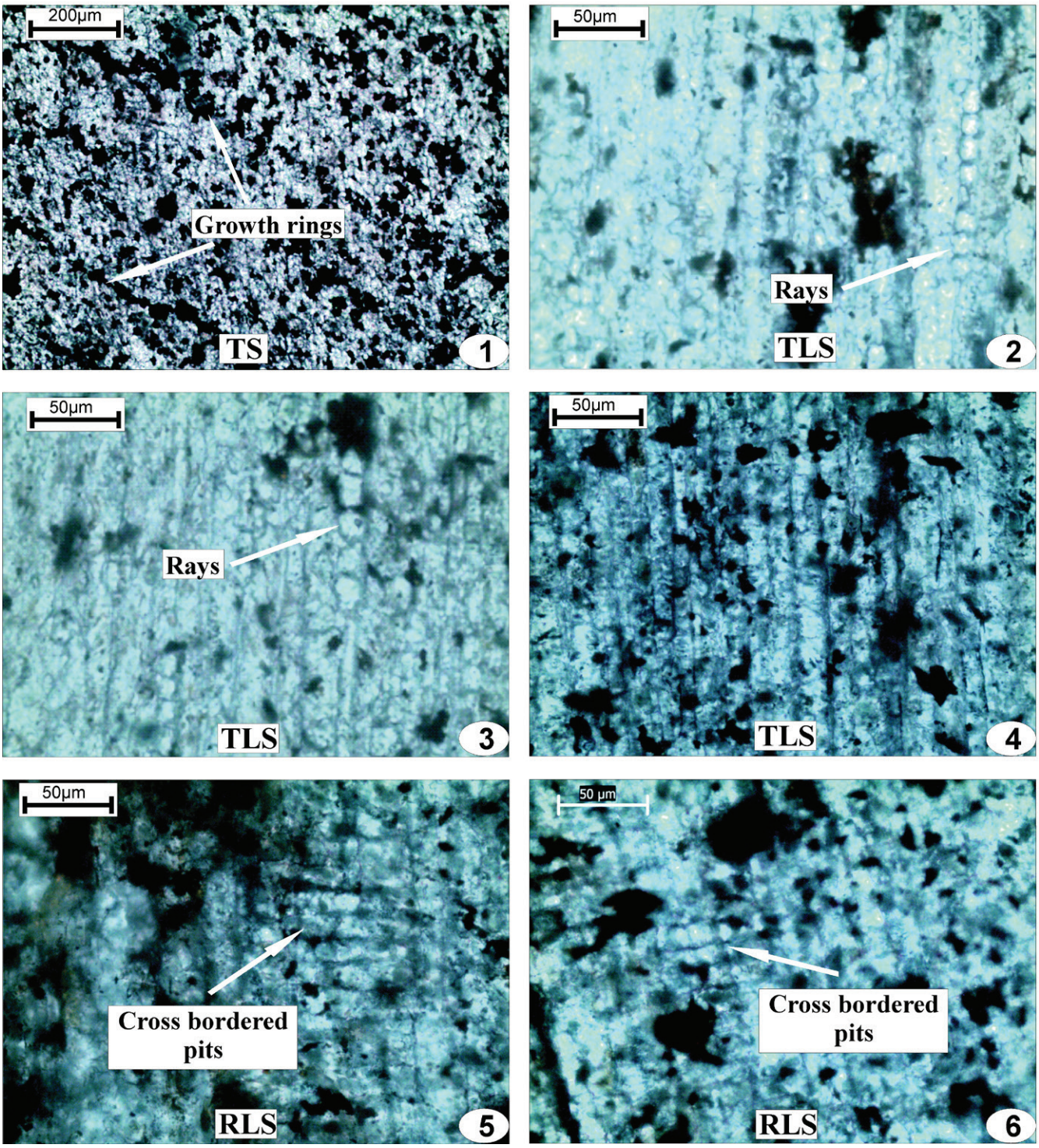
Horizon & Age: Gadhada formation, Callovian

Derivation of name: Specific epithet is based after Wagad Uplift.

EXPLANATION OF PLATE II

Anatomical structures of ***Podocarpoxylon gangtaensis*** n. sp.; 1, Transverse section (TS); 3-4, Transverse-longitudinal section (TLS); 5-6, Radial longitudinal section (RLS); BSIP wood slide nos. 40569 I-VII.

Plate II


200µm
Growth rings
TS
1
50µm
Rays
TLS
2
50µm
Rays
TLS
3
50µm
TLS
4
50µm
Cross bordered pits
RLS
5
50 µm
Cross bordered pits
RLS
6

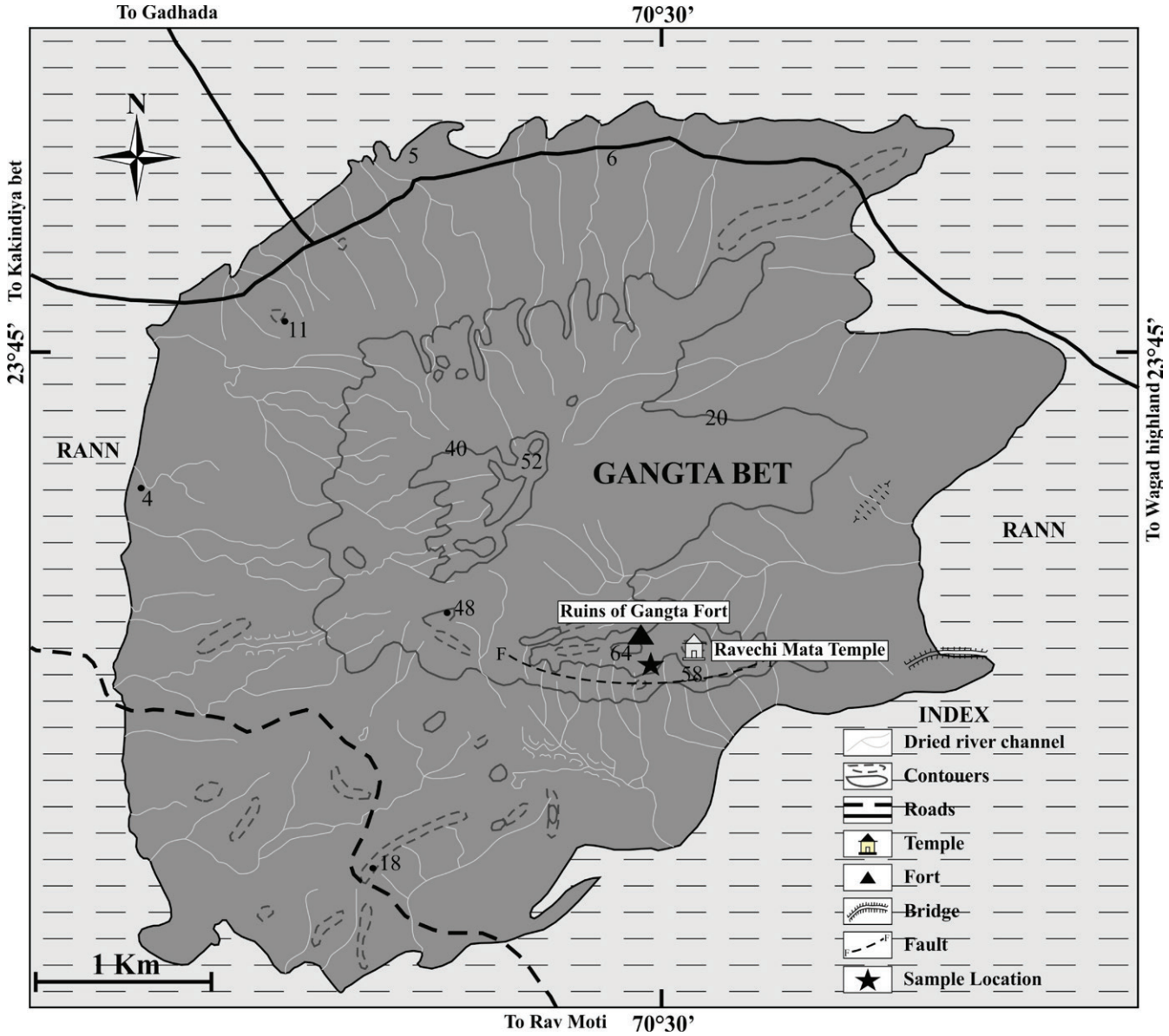


Fig. 2. Geological map of Gangta Bet. ★ indicating fossil locality.

Identification and comparison: Coniferous fossil woods are mainly described under the families Araucariaceae and Podocarpaceae (Bose and Maheshwari, 1974). The anatomical characters such as indistinct growth rings, almost uniform tracheids, exclusively uniseriate xylem rays, presence of small resinous cells and araucaroid bordered pits collectively suggests its affinities with the modern woods of the genus *Araucaria* Juss, family Araucariaceae. Critical study of available modern woods, viz. *Araucaria araucana* Koch; *A. angustifolia* Kuntze; *A. cunninghamii* Ait; *A. hunsteinii* Schum and *A. klinkii* Lauterbach suggests undifferentiated early and late woods. The tracheids vary in shape and size. *Araucaria araucana* Koch and *A. klinkii* Lauterbach possess squarish to polygonal tracheidial cells and uniseriate, 3-20 cells high xylem rays similar to present fossil wood. The remaining other species can be differentiated easily in having absence of resinous cells with smaller xylem rays.

About eight fossil woods indicating anatomical details are described under the name genus *Araucarioxylon* Kräusel from various sedimentary basins of India (Table 2). The analysis of anatomical characters of the known fossil species as well as the fossil wood described here suggests that the present fossil wood is distinct from all the known species. It differs mainly in displaying the presence of medium sized uniseriate xylem rays and resinous cells as small as trachidial cells of the wood. In view of these characteristic features, present fossil wood is described under a new specific name *Araucarioxylon wagadensis*.

Family **Podocarpaceae**, Endlicher 1847

Genus ***Podocarpoxylon*** Gothan, 1905

Podocarpoxylon gangtaensis n. sp.

(Pl. II, figs. 1-6)

Material: The species is based on one piece of petrified wood measuring 8 cm x 6 cm and 7 cm x 5 cm. It is light brown in colour and possesses well preserved anatomical structures.

Description: Growth rings distinct (Pl. II, fig. 1). Tracheids of early wood zone quite wide, occupying greater zone than late wood, tracheids, 60-85 cells wide, cell comparatively thick, oval

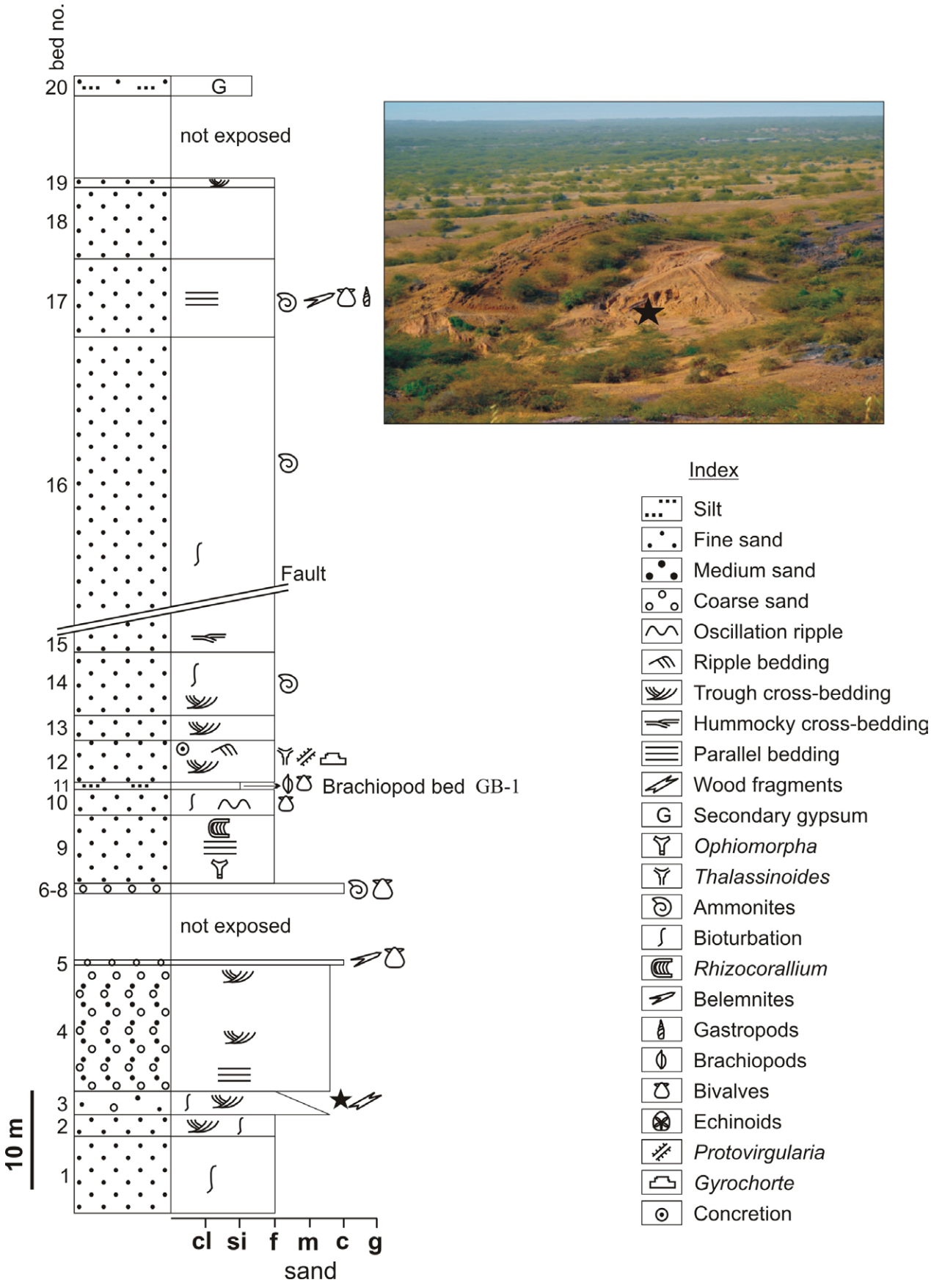


Fig. 3. Lithocolumn of the succession exposed on the southern slope of the central dome, Gangta Bet (modified after Pandey *et al.* 2013). Note the photograph showing panoramic view of south dipping beds on the central dome, Gangta Bet, with ★ indicating fossil locality.

Table 2: Comparision of Indian records of fossil woods of *Araucarioxylon* Kräusel.

Sr. No.	Name of taxa	Growth Rings	Tracheids	Paren-chyma	Rays	Resin canal	Tracheids pit	Cross field pits
1.	*Araucarioxylon pranhitaensis* Rajanikanth & Sukh-Dev, 1989	Present micro-scopically distinct	Tracheids agular, thick walled, rounded to oval, 20-40 µm in diameter	Absent	Uniseriate or rarely partially biseriate, 1-10 cells (average 4-5), cells slightly higher than broad	Resin tracheids present at places	Only radial pits mostly uniseriate and sometime biseriate contiguous, 8 X 12 to 8-25 µm in size, circular 4-6 µm biseriate pits, hexagonal alternate, contiguous	Crossfield pits 2-6 usually 4 bordered, circular separate, 6 µm
2.	*A. santalense* (Sah & Jain, 1964) Bose & Maheshwari, 1974	Present micro-scopically distinct	Trachids angular thick walled , rounded to oval 20-40 µm in diameter	Absent	Mostly uniseriate sometimes bi or tri seriate, 1-52 cells in height, cells are longer than width, thin walled	Resinous cells scattered	Radial wall pits 1-3 seriate mostly (1-2), alternate sometimes subopposite hexagonal bordered contiguous	Crossfield pits 3-6 in group, circular or elliptical, 6-8 µm in diameter
3.	*A. rajmahalensis* (Sahni, 1931) Bose & Maheshwari, 1974	Very distinct, broad tracheids thick walled	Early wood tracheids zone wide, tracheid 56 µm, late wood tracheid zone narrow 14 µm in diameter	Absent	Uniseriate distantly placed about 3-15 rows of ttracheid, 1-12 cells high. Sometimes 20 cell high, cells oblong or oval (11 X 1 µm)	Resin canal absent	Radial pits only uniseriate occasionally biseriate and triseriate contiguous or separate circular alternate hexagonal. Bar of sanio absent	Pitting not preserved
4.	*Araucarioxylon* sp. A Rajanikanth & Sukh-Dev, 1989	Present	Early wood zone 24-42 cells, late wood zone narrow, 3-5 cells wide early wood tracheid squarish to polygonal, 32-58 X 56-78 µm in size, wall thick, 16-24 µm late wood tracheid, almost squarish 14-30 X 16-40 µm	Absent	Mostly uniseriate partly biseriate, 1-18 cells or 18-430 µm in height, cells longer than broad thin walled	Resin cells scattered	Radial wall pits mostly uniseriate contiguous, 13-16 µm in size	Crossfield pits_ 2-5 bordered in groups, 4-5µm in size, oval to circular hexagonal
5.	*A. agathioides* (Krausal and Jain, 1964) Bose & Maheshwari, 1974	Present more or less indistinct	Broad, 31-48 µm	Absent	Uniseriate occasionally partly biseriate, 2-20 cell high (average 8 cells)	Resinous tracheids abundant as biconcave plate	Radial pits 1-2 seriate forming short rows or group 13 X 10-23 X 13 µm in size, biseriate pits are hexagonal and irregularly arranged	Crossfield pits 2-8 sometimes in group of 5-6, circular to angular, separate or contiguous 10 µm bordered with elliptic aperture
6.	*A. amraparense* (Sah and Jain, 1964) Bose & Maheshwari, 1974	Distinct gradual transition from early to late wood, 40 tracheids wide	Oval in shape, 28 X 44 µm to 8-16 µm in size	Absent	Uniseriate, 1-15 cells high, average 6 cell, 8x12µm in size	Resinous tracheids abundant near medullary rays	Radial pits single, 1-3 seriate, oval or circular contiguous or seprate, aperture oval, 4-6 µm in size, bi and triseriate pits usually contiguous, alternate, hexagonal with oblique pore	Crossfield pits Not very well preserved, 2-4 bordered, circular, contiguous 8µm in diameter with elliptic pore 4 X 6 µm in size.
7.	*A. mandroense* (Sah and Jain, 1964) Bose & Maheshwari, 1974	Distinct with gradual transition	Angular with rounded to oblong lumen, 20-50 µm in diameter	Absent	Uniseriate distantly placed, 1-15 cells high (3-4) higher than broad	Absent	Radial pits in early wood 1-3 seriate, oval, 4-8 µm, alternate, contiguous, hexagonal, some times in groups. In late wood pits are uni to partially biseriate circular, 12-16 µm aperture, circular 4 µm in diameter	Crossfield pits In early wood 4-12 circular contiguous 12µm in diameter, in late wood usually 3 or 4, circular, 8 µm in diameter, pit pore 4 X 6 µm in size elliptical

8.	*A. bindrabunense* (Sah and Jain, 1964) Bose & Maheshwari, 1974	Indistinct	Thick walled, triangular to squarish in shape with almost angular to rounded lumen radial diameter 20-60 µm	Absent	Uniseriate, very rarely biseriate 1-45 (average 25) cells high, rod like 8 X 12 to 24 X 32µm in size	Absent	Radial pits only, mostly biseriate sometime triseriate very rarly uniseriate, contiguous alternate and hexagonal with circular pits, 6 µm in diameter	Crossfield pits 4-12 usually (4 or 6), bordered circular or oval, separate 6-8 µm, with oval aperture
9.	*Araucarioxylon wagadensis* n. sp.	Indistinct	Thick walled squarish to polygonal, t. d. 17-40 µm, r. d. 20-70 µm, 160-200 tracheids per sq mm, wall thickness 10-15 µm, sometimes filled with resinous material	Present, scattered, rare	Uniseriate, 2-26 cells or 60-410 µm high oval to elongated, homogenous sometimes cells are filled with dark content	Present small in size	Radial pits uni-biseriate, bordered, circular to oval with elliptic aperture, 10-16 µm in diameter	Crossfield pits 2-5, small size, 6-8 µm in diameter, circular to elliptic contiguous alternate to opposite

Table 3: Comparison of Indian records of fossil woods of *Podocarpoxylon*, Gothan.

Sr. No.	Name of taxa	Growth Rings	Tracheids	Paren-chyma	Xylem Rays	Resin tracheid canal	Tracheids pits	Cross field pits
1.	*Pdocarpoxylon indicum* (Bharadwaj, 1953) Maheshwari & Kumaran, 1974	Not clearly seen	Early wood wide, 30-35 tracheids wide, thin walled subrounded-squarish, late wood narrow, 5-6 cells in width, thick walled squarish or elliptical early wood tracheids 20 X 20-24 µm, squarish-pentaangular, thick walled late wood tracheids, 20 X 12-15µm, elliptical or rounded	Absent	Uniseraite 1-5 cell high, side walls coated with resinous substance	Resin canal absent resin filled tracheids present	Only radial pits, uniseriate, bordered, separate 10-12 µm in diameter with circular pore	Cross field pits solitary, bordered, oval, inclined
2.	*P. schmidianum* (Scheiden, 1855) *M. schmidianum* (Sahni, 1931) Bose & Maheshwari, 1974	Faintly marked	Thick walled longer than broad	Scanty	Uniseriate rarely biseriate numerous 2-10, rarely upto 100 (average 36), thick walled, isodiametric or slightly higher than broad	Resin canal absent	Radial pits circular or rarely elliptical, 20µm, separate, 1-2 seriate, opposite	Cross field pits 1 or 2 large pore, slit like, poorly preserved
3.	*P. godaverianum* (Sahni, 1931) Bose & Maheshwari, 1974	Absent	Tracheid cells 20-30 µm diameter, full of resin, thick walled	Resin parynchy-ma abundant, scattered	Uniseriate 2-15 cells high, average 5 cells often containing resin	Resin canal absent	Radial pits only, 1-2 seriate, rounded, contiguous, subopposite or even alternate, rims of sanio not seen	Cross field pits 2-6 bordered, circular, 7 µm, sometimes in two rows with several pits
4.	*P. parthasarathyi* (Sahni, 1931) Bose & Maheshwari, 1974	Faintly marked	Large, thin walled, isodiametric, not distinction in early and late wood	Not seen	Uniseriate, 1-18 cells, average 8, high, higher than broad	Resin canal absent	Radial pits uniseriate, circular, separate or contiguous, 9-12 µm	Cross field pits 2-5 or 6 rounded, bordered, pore narrow, Stone cells scattered

5.	*P. bansaense* (Prakash & Rajanikant, 2004	Distinct transition between early and late wood is gradual	Early wood wide, 8-22 cells, late wood 4-7 cells wide	Scattered present with resinous material	Mostly uniseriate rarely biseriate, short, 2-14 cells high, cell oval 15-40 µm	Resin parenchyma cells	1-2 seriate, bordered, circular, opposite, 6-11 µm, tangential pits absent	Cross field pits 2-3 podocarpoid, 3-7 µm
6.	*P. sarmai* Varma, 1954	Scarcely visible, pith present, 1 mm in diameter	Late wood, 1-6 µm thick, 3-16 X 16-26 µm size, early wood tracheids, 16-32 cells, rounded to elliptical	Parenchy-ma rarely seen, cells oblong or rectangul-ar, 9-16 µm wide	Uniseriate, 3-8 cells high, maximum height 18 cells	Absent	Present only on radial wall, uniseriate, circular, separate, rarely contiguous, 13-16 µm in diameter, simple, oval to oblong, 8-6 µm, bar of sanio not observed	Cross field pits 2-4 (4) small oval to oblong and simple, in or two rows, 8 X 16 µm only
7.	*P. rajmahalense* (Jain, 1965) Bose & Maheshwari, 1974	Growth rings distinct, gradual transitio-n from early to late wood	Early wood 10-40 cell wide, late wood 2-3 tracheids wide, broad 12-20 µm in size, thick walled, angular to rounded with oval lumen	Absent	Uniseriate, 1-10 cell high (average 4) distantly placed resin plugs seen near the rays	Resin canal absent resinous tracheids sporadic	Only radial pits bordered, uniseriate, sometimes biseriate, uniseriate pits circular or oval, 12 µm in diameter, mostly separate, biseriate pits, separat, alternate to opposite, pit pore rounded or oval, 4-6 µm	Cross field pits_ Large, 1-2, pinoid type, oval to oblong or rounded, simple
8.	*P. malerianum* (*Merembrioxylon maleranum* Sahni, 1931) Bose & Maheshwari, 1974	Distinctly visible	Not distinct between early and late wood, often contain resin	Absent	Uniseriate, average height 3 cells, contiguous but circular sometimes separate 13-14 µm	Resin canal absent	Radial pits uniseriate circular, contiguous, sometime separate, 13-14 µm, pore elliptic oblique, Rim of sanio not seen	3-10, usually 4-6, bordered oval or circular, pore narrow obliquely vertical
9.	*P. Krauselii* Rajanikanth & Sukh-Dev, 1989	Distinct, transition from early to late wood abrupt	Early wood tracheids polygonal, 20-38 X 25-55 µm, late wood tracheids round or polygonal, 16-25 X 25-32 µm	Parenchy-ma cells scattered	Mostly uniseriate, 2-28 cells in height, oval or bead like wall smooth, thin	Not reported	Radial wall pits uniseriate, circular, bordered, contiguous or separate, aperture oval to round	Cross field pits 4-5 elliptical in groups, bordered
10.	*Podocarpoxylon gangtaensis* n. sp.	Distinct	Early wood 60-85 cells, thick, t. d. 15-24 µm, r. d. 18-40 µm, oval to circular, sometimes with dark content, late wood zone narrow, 2-5 µm thick, t. d. 6-18 µm, r. d. 16-22 µm, oval to squarish and polygonal also	Parenchy-ma cells scattered, small with transvers-e to tailed end	Mostly uniseriate very rarely partially biseriate, oval shaped homocellular, 3-18 cells (average 3-8 cells) or 30-250 µm in height	Absent, resinous tracheids present	Radial pits usually one or rarely two sereiate, alternate to opposite, circular to elliptic with elliptic aperture, 7-10 µm in diameter	Cross field pits 2-5 small to large, oval to circular, bordered, 6-9 µm in diameter
11.	*P. chandrapurensis* Rajanikanth & Sukh-Dev, 1989	Distinct, transition from early to late wood abrupt	Early wood tracheids 6-54 cells wide, cells squarish, 18-32 X 19-30 µm	Resinous parenchy-ma scattered	Mostly uniseriate, simple, 1-18 cell high, cells longer than broad	Resinous parenchyma cells scattered	Radial wall pits mostly uniseriate, rarely biseriate, contiguous or separate, simple, bordered, circular, 10-12 µm in diameter, aperture oval	Cross field pits 1-2 bordered, round 6-7 µm, aperture round

12.	*P. trichinopoliense* (*M. orichinopoliense* Varma, 1954) Bose & Maheshwari, 1974	Present on weathered surface	Early wood tracheids rounded or elliptical, 10-45 µm (16-32), in late wood rectangular to elliptical, 3-9 X 19-26 µm, narrow zone than early wood	Parenchy-ma rarely seen	Uniseriate, 1-10 (2-6) cell high, rounded to oblong	Absent	Early wood tracheid pits uniseriate, circular, bordered, separate usually, 13-20 µm and pore 3 µm, bar of sanio absent	Cross field pits 1-2 fusiform obliquely placed pits, 9-13 X 3 µm
13.	*P. haburensis* Guleria & Shukla, 2008	Present but not conspicuous	Tracheid of early wood zone is quite wide, occupy greater portion, 50-60 tracheid cells, thin walled polygonal, t. d. 19-34 µm, r. d. 18-34 µm, late wood 2-4 cells thick, thickwalled, t. d. 6-11 µm, r. d. 3.5-11 µm, flattened or elliptic filled with dark content, 400-550 tracheids/cm^2	Present, rarely seen with transvers-e end walls in tangentia-l section	Fine, uniseriate, homocellular, 3-10 celled or 34-157 / 180 µm in height	Resin canal absent	Obietineam on radial wall, mostly in one row rarely in two, opposite or subopposite, oval, circular, simple and bordered, 7-35 µm in radial diameter and 6-3 µm in t. d.	Cross field pits not seen due to poor preservation
14.	*P. kutchensis* Lakhanpal, Guleria & Awasthi, 1975	Present but not conspicuous	Tracheids of early wood zone occupy greater portion, 31-62 cells, thin walled, polygonal, r. d. 37-67 µm, t. d. 22-45 µm, late wood with narrow zone, 2-4 cells thick walled, r. d. 30-60 µm, t. d. 22-45 µm, flattened to elliptical, 360-500/mm^2	Small celled filled with dark content, thin walled, smooth end walls	Mostly uniseriate rarely biseriate, homocellular, 1-41 cells or 45-1350 µm in height, usual height 5-18 cells	Resinous parenchyma cells present	Pitting on both radial and transitional wall, radial pit in one row rarely in two rows, opposite to subopposite, oval-circular, bordered, 12-20 µm in diameter, aperture 4-8 µm, tangential pits unisetriate, solitary, 8-16 µm in diameter, aperture 4-6 µm	Cross field pits 1-2 small, circular, oval, simple as well as bordered podocarpoid to taxadioid, 8-12 µm, aperture 4 µm, Crystals rarely present in tracheids

to squarish, transverse diameter (t. d.) 15-24 µm, radial diameter (r. d.) 18-40 µm, sometimes cells contain dark content. Late wood tracheids forming narrow zone, 2-5 cells thick, t. d. 6-18 µm, r. d. 16-22 µm, oval to squarish and sometimes pentagonal, resinous material present, 300-350 cells per square mm (Pl. II, fig. 1). Resin canals absent. Parenchayma present (Pl. II, figs. 1-2), scattered cells small with transverse to tailed end. Xylem rays fine, mostly uniseriate, very rarely partly biseriate, homocellular, composed of upright type of cells (Pl. II, figs. 2-3), 9-12 xylem rays per mm in cross section, 3-18 cells (average 5-8 cells) and 30-250 µm in height, cells elongated. Tracheidial pits preserved on radial walls, mostly in one row rarely in two, alternate to opposite, usually separate, almost circular to elliptic, 7-10 µm in diameter with elliptic aperture, bordered (Pl. II, fig. 6). Cross field pits badly preserved, 2-5 small to large, oval to circular, bordered, 6-9 µm in diameter (Pl. II, fig. 5).

Specific diagnosis: Growth ring distinct with gradual transition of early and late wood. Early wood 60-85 cells thick, cells thick walled, transverse diameter (t. d.) 15-20 µm, radial diameter (r. d.) 18-40 µm, oval to circular, late wood narrow, 2-5 cells in thickness, transverse diameter (t. d.) 6-18 µm, radial diameter (r. d.) 16-22 µm, oval to polygonal. Radial pits usually uniseriate, rarely biseriate, 7-10 µm in diameter, alternate to opposite, circular to elliptic, with usually elliptic aperture, cross field pits 2-5, small to large, oval or circular, bordered, 6-9 µm in diameter. Xylem rays mostly uniseriate, rarely partially biseriate, oval shaped homogeneous, 3-8 cells or 30-250 µm in height. Parenchyma sparse. Resin canal absent.

Holotype: BSIP Museum No. 40569

Locality: Gangta Bet, eastern Kachchh, Gujarat, India

Horizon and Age: Gadhada formation, Callovian

Derivation of name: Specific epithet is based after Gangta Bet locality from where the fossil wood is collected.

Identification and comparison: The characteristic features of the present fossil wood undoubtedly suggest its affinity with the modern woods of the family Podocarpaceae. Further, the presence of xylem parenchyma and the smaller xylem rays (upto 18 cells in height) shows affinity with the genus *Podocarpus* (*L'Hérit*) (also Presl of the family Podocarpaceae. Critical study of the slides of the modern woods of different species of the genus *Podocarpus* viz. *P. amara* Blune; *P. falcatu* R. Br. Et Mirb.; *P. imbricatus* Blune; *P. henpepelii* Stapf.; *P. latifolius* R. Br.; *P. eumphii* Blune; *P. wallichianus* Presl and *Podocarpus* sp. has been carried out in order to identify upto specific level. Among all the modern species *P. wallichianus* and *P. imbricatus* show resemblance with the fossil wood in having marked growth rings differentiating in early and late wood as well as with same length of xylem rays which are sometimes paired. However, in other species the rays are exclusively uniseriate and sometimes with upto 50 cells in height.

Fossil woods showing resemblance with the genus *Podocarpus* (*L'Hérit*) Presl have been incorporated under the form genus *Podocarpoxylon* Gothan. So far, 13 fossil woods (Table 3) have been described from various sedimentary basins of India. The comparative study suggests that the *Podocarpoxylon gangtaensis* is quite different from the earlier known fossil

woods in the nature of early and late wood tracheids, xylem rays and biseriate nature of xylem rays. Thus, the wood described here is different from all the known species (Table 3) of *Podocarpoxylon*, so a new specific name *Podocarpoxylon gangtaensis* is assigned to it.

CONCLUDING REMARKS

Only two conifer wood taxa, *Araucarioxylon* and *Podocarpoxylon*, have been recorded for the first time from Gangta Bet. The other Mesozoic floral components have so far not been recorded from here. Although, during Jurassic-Cretaceous periods, conifers, bennettitales, cycadales along with filicales were the chief components of the palaeo-vegetation as known from Kachchh Mainland (Bose and Banerji, 1984), indicating thereby that *Podocarpus* and *Araucaria* might be the main canopy forming trees as they evolved in response to major extinction phase of arid conditions at the end of Permian (Bose and Banerji, 1984). Both the families (Araucariaceae and Podocarpaceae) increased in abundance and diversity during Jurassic-Cretaceous periods and maintained presence in the vegetation of the southern hemisphere landmasses. It was likely that the rising sea levels through the Jurassic resulted in both precipitation and temperature that facilitated the development of forest vegetation (Kreshaw, 2001). The coniferous canopy was almost certainly evergreen as indicated by leaf physiognomy and its comparison with modern podocarps and araucarians as they show major adaptability in light of competition with angiosperms. The environmental conditions are reflected in growth rings. The ring width ratio of early – late wood and other anatomical features are directly influenced by ambient environmental conditions such as sunlight, water and related ecological factors during the growth period resulting in the formation of wider growth rings. The weakly defined growth and interruptions, that cannot be traced, are characteristics of growth under humid tropical climates and consistent with the broad tropical belt that existed in the Jurassic-Cretaceous periods (Peralta-Medina and Falcon, 2012). Dendrological data indicate that the climate was characterized by tropical wet and dry cycles of savanna climate.

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