
Plant fossils from Dubrajpur Formation, Bihar and their significance in stratigraphy

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The paper deals with the plant fossils of Dubrajpur Formation exposed at Khatangi Hill in the Rajmahal Basin, Bihar. The assemblage is dominated by cycadophytes, though pteridophytes are quite frequent. Conifers are poorly represented. The genera *Onychiopsis*, *Ctenis*, *Taeniopteris* and *Pagiophyllum* are recorded for the first time. In view of the present finding the age of the Khatangi sediments is discussed. The dominance of cycadophytes and poor representation of conifers indicate subtropical to tropical climate prevailing at that time.

Key-words—Megafossils, Pteridophytes, Cycadophytes, Conifers, Dubrajpur Formation, Upper Jurassic (India).

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साराँश

बिहार में दुबराजपुर शैल-समूह से पादप-अवशेष तथा स्तरविन्यास में इनका महत्व

जयश्री बैनर्जी

बिहार में राजमहल द्रोणी में खातंगी पहाड़ी में अनावरित दुबराजपुर शैल-समूह से उपलब्ध पादपाशमों का वर्णन किया गया है। हालाँकि टैरीडोफाइट पौधे इस समुच्चय में काफी अधिक संख्या में मिलते हैं, साइकेडोफाइट पौधों की बाहुल्यता है। कोनिफरी पादपाशम अल्प संख्या में पाये गये हैं। ओनाइकिऑप्सिस, टीनिस, टीनिऑप्टेरिस एवं पेजिओफिल्लम नामक प्रजातियाँ इस समुच्चय से पहली बार अभिलिखित की गई हैं। इन पादपाशमों के आधार पर खातंगी अवसादों की आयु की विवेचना की गई है। साइकेडोफाइटों की बाहुल्यता तथा कोनिफरों की अल्प संख्या से निक्षेपण के समय उपोष्णकटिबन्धीय से उष्णकटिबन्धीय जलवायु का होना इंगित होता है।

OLDHAM (1863 *in*: Oldham & Morris, 1963) first recognised Dubrajpur beds as a distinct horizon and named it after the village Dubrajpur in the Rajmahal Hills. Ball (1877) mapped this area and reported *Ptilophyllum* fronds from Dubrajpur beds. Later, Srivastava (1958), Sah (1965) and Sen Gupta (1988) recorded various fossil assemblages from Dubrajpur Formation exposed at Khatangi Hill near Kharikasol Village, Rajmahal Hills, Bihar (see Table 1) and proposed various ages for the *Ptilophyllum*-bearing beds of Dubrajpur Formation

Sah and Shah (1974) made two biozones within Dubrajpur Formation. The basal zone-A, comprising *Glossopteris communis*, *G. ampla*, *G. retifera*, *G. parallela* and *Vertebraria indica* of Upper Permian affinity and the upper zone-B consisting of *Marattiopsis macrocarpa*, *Gleichenites gleichenoides*,

Ptilophyllum acutifolium, *Nilssonina princeps*, *Macrotaeniopteris lata* and *Williamsonia* sp. of early Middle Jurassic age. Sen Gupta (1984, 1985) carried out extensive work on Khatangi Hill section as well as the designated type section of Dubrajpur Formation at Sarwan Pahar near Dubrajpur Village. According to him, basal zone-A of Sah and Shah (1974), i.e., *Glossopteris-Vertebraria* assemblage, belongs to the Barakar Formation and the upper zone-B comprising *Ptilophyllum-Gleichenites* assemblage belongs to Dubrajpur Formation (Lower Jurassic). Sukh-Dev (1988) assessed an Early Cretaceous age for the latter assemblage. Tiwari *et al.* (1983) recognized six palynoassemblage zones from the subsurface sequence of Dubrajpur Formation as well as Intertropical beds. They dated palynoassemblage zones A-C as Carnian-Norian, and

zones D-F as Late Jurassic/Early Cretaceous, Singh and Venkatachala (1988) reassigned zones D-F to be Early Cretaceous.

The present investigations are based on plant fossils collected from Khatangi Hill. These plant remains are preserved as impressions on greyish-white shales. All the specimens have been deposited at the Birbal Sahni Institute of Palaeobotany Museum.

DESCRIPTION

Filicales

Genus—*Gleichenites* Goeppert 1836

Gleichenites gleichenoides (Oldham & Morris)
Seward & Sahni 1920
Pl. 1, fig. 1

Remarks—In gross morphological features, the present specimens are similar to those of

Gleichenites gleichenoides (Oldham & Morris) Seward & Sahni 1920.

Genus—*Culcitites* Appert 1973

Culcitites madagascariensis Appert 1973^a

- 1965 ?*Thinnfeldia* sp., Sah, p. 219, pl. 1, fig. 3.
1965 *Microphylopteris* sp., Sah, p. 219, pl. 1, fig. 5.
1988 *Thinnfeldia khatangiensis*, Sen Gupta, p. 75, pl. 12, fig. 32; pl. 15, fig. 40; text-fig. 17 (for details see Banerji, 1988).

Unclassified ferns

Genus—*Onychiopsis* Yokoyama 1889

Onychiopsis sp.
Pl. 1, figs 2, 3; Text-fig. 1A

Description—Fronds probably tripinnate, best available specimen about 2.5 cm in length. Ultimate pinnae sub-oppositely attached at an angle of 60°.

Table 1—Plant fossil assemblages recorded by different authors from Dubrajpur Formation at Khatangi Hill

Srivastava, 1958	Sah, 1965	Sen Gupta, 1988	Present assemblage
FILICALES: <i>Gleichenites</i> sp. <i>Marattiopsis</i> sp.	FILICALES: <i>Gleichenites gleichenoides</i> (Oldham & Morris) Seward & Sahni	FILICALES: <i>Gleichenites gleichenoides</i> (Oldham & Morris) Seward & Sahni	FILICALES: <i>Gleichenites gleichenoides</i> (Oldham & Morris) Seward & Sahni <i>Culcitites madagascariensis</i> Appert
UNCLASSIFIED FERNS: <i>Cladophlebis</i> sp. <i>Sphenopteris</i> sp. <i>Pecopteris</i> sp.	UNCLASSIFIED FERNS: <i>Cladophlebis indica</i> (Oldham & Morris) Sahni & Rao <i>Cladophlebis</i> sp. <i>Microphylopteris</i> sp.	UNCLASSIFIED FERNS: <i>Cladophlebis indica</i> (Oldham & Morris) Sahni & Rao	UNCLASSIFIED FERNS: <i>Cladophlebis indica</i> (Oldham & Morris) Sahni & Rao <i>Onychiopsis</i> sp.
CYCADALES: <i>Nilssonia</i> sp.	PTERIDOSPERMALES: <i>?Thinnfeldia</i> sp.	PTERIDOSPERMALES <i>Thinnfeldia khatangiensis</i> sp. nov.	
BENNETTITALES: <i>Otozamites</i> sp.	BENNETTITALES: <i>Pterophyllum</i> sp. <i>Williamsonia</i> sp. <i>Ptilophyllum acutifolium</i>	BENNETTITALES: <i>Ptilophyllum acutifolium</i> Morris <i>Pterophyllum fissum</i> Feistmantel	BENNETTITALES: <i>Ptilophyllum cutcbense</i> Morris <i>Ptilophyllum acutifolium</i> <i>Williamsonia</i> sp. <i>Pterophyllum distans</i> Morris <i>Pterophyllum</i> sp. cf. <i>P. footeanum</i> Feistmantel
	CYCADALES: <i>Nilssonia princeps</i> (Oldham & Morris) <i>Nilssonia</i> sp. <i>Macrotaeniopteris lata</i> (Oldham & Morris) Sahni	CYCADALES: <i>Taeniopteris crenata</i> McClelland	CYCADALES: <i>Nilssonia</i> sp. <i>Ctenis rajmahalensis</i> n. sp. <i>Taeniopteris</i> sp. cf. <i>T. oldhamii</i> Bose & Banerji <i>Taeniopteris</i> sp.
	CONIFERALES: <i>Elatocladus conferta</i> (Oldham & Morris) Sahni		CONIFERALES: <i>Pagiophyllum</i> sp.

70°, linear to lanceolate in shape, largest ultimate pinna 1 cm long and 2.5 mm broad. Pinnule-lobing towards base complete but towards distal end lobing incomplete at places. Pinnules oblanceolate to elliptical in shape, measuring 1.5-2 × 1-1.5 mm, margin entire, apex subacute to obtuse, attached by broad decurrent base. Venation mostly inconspicuous. Proximal pinnules with forked or unforked veins; rest, at places, showing keeled midvein appearing to be fertile.

Remarks—Five frond fragments have been recovered but their fertile nature is uncertain. The specimens are comparable with *Onychiopsis elongata* (Geyler) Yokoyama (1889, pl. 12, fig. 10) in size and shape of sterile pinnules. Sukh-Dev (1970) considered *O. elongata* and *O. paradoxus* Bose & Sukh-Dev 1959 as junior synonyms of *O. psilotoides* (Stokes & Webb) Ward but Kimura and Aiba (1986) maintain *O. elongata* as the type species of this genus.

Genus—*Cladophlebis* Brongniart 1849

Cladophlebis indica (Oldham & Morris) Sahni & Rao
1933
Pl. 1, fig. 4

Comparison—*Cladophlebis indica* is common in the assemblage. These forms are similar to the sterile frond of *Todites indicus* (Oldham & Morris) Bose & Sah described from various other localities of Rajmahal Basin. But due to lack of fertile fronds from this locality, they are being placed provisionally under *Cladophlebis indica* (Oldham & Morris) Sahni & Rao 1933.

Bennettitales

Genus—*Ptilophyllum* Morris 1840

Ptilophyllum cutchense Morris 1840
Pl. 1, fig. 6

Remarks—According to Sen Gupta (1988, p. 103) *Ptilophyllum cutchense* Morris is restricted to

Cladophlebis indica-*Dictyozamites indicus* assemblage zone of Middle to Upper Jurassic and absent in *Ptilophyllum acutifolium*-*Gleichenites gleichenoides* zone of Khatangi Hill.

Ptilophyllum acutifolium Morris 1840
Pl. 1, fig. 9

Remarks—A few specimens resembling *P. acutifolium* are present in the collections.

Genus—*Williamsonia* Carruthers 1870

Williamsonia sp.
Pl. 1, figs 5, 7

Description—Flower large, incomplete, about 10-14 cm in length and 7 cm in width; base of the flower probably rhomboidal, gradually tapering towards apex, bracts numerous, more than 12 in number, 5-6 mm broad, surface of bracts striate, proximal portion of bracts hairless but distal portion hairy; hairs up to 8 mm long.

Comparison—Only two specimens are found, one (Pl. 1, fig. 5) showing proximal part with hairless bracts and the other (Pl. 1, fig. 7) showing distal part of bracts with profuse hairs. Although both the specimens are described here as *Williamsonia* sp., there is a possibility of existence of two different species.

In their large size, the present specimens resemble *Williamsonia indica* Seward 1917 and *W. sabnii* Gupta 1943. But the specimen with profuse hairy bracts resembles *W. sabnii* and the other one compares with *W. indica* having hairless bracts.

Genus—*Pterophyllum* Brongniart 1828

Pterophyllum distans Morris 1863
Pl. 1, fig. 10

Comparison—The specimen of *Pterophyllum distans* from Khatangi Hill, except for smaller pinnae is similar to those of the same species from Kutch

PLATE 1 →

1. *Gleichenites gleichenoides* (Oldham & Morris) Seward & Sahni, a fragment of frond bearing small deltoid pinnules, Specimen no. BSIP 36244, × 1
2. *Onychiopsis* sp. a frond fragment, Specimen no. BSIP 36245B, × 2.
3. *Onychiopsis* sp., a frond with sterile and probable fertile pinnules at the distal end, Specimen no. BSIP 36245, × 2.
4. *Cladophlebis indica* (Oldham & Morris) Sahni & Rao, pinnule showing venation pattern, Specimen no. BSIP 36246A, × 2.
5. *Williamsonia* sp., a large incomplete flower showing overlapping bracts without hairs, Specimen no. BSIP 36250, × 1
6. *Ptilophyllum cutchense* Morris, showing overlapping pinnate leaves, Specimen no. BSIP 36262 A, × 1.
7. Distal portion of *Williamsonia* flower with hairy bracts, Specimen no. BSIP 36249, × 1.
8. *Ptilophyllum acutifolium* Morris, frond showing pinnae with acuminate apex, Specimen no. BSIP 36262 B, × 1.
9. *Pterophyllum* sp. cf. *P. footeanum*, Specimen no. BSIP 36252, × 1.
10. *Pterophyllum distans* Morris, pinnate leaf showing distantly placed pinnae, Specimen no. BSIP 36251, × 1

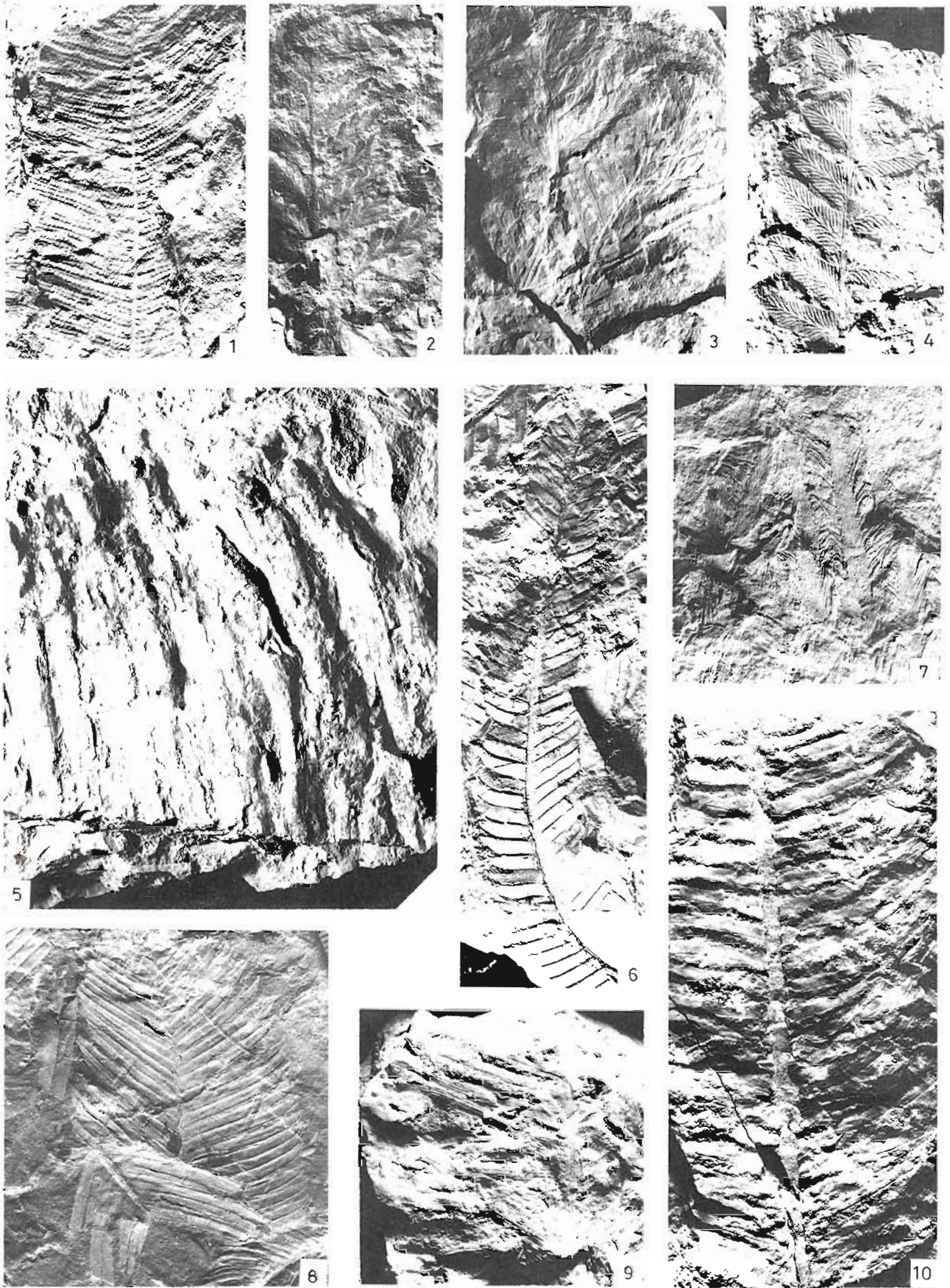


PLATE 1

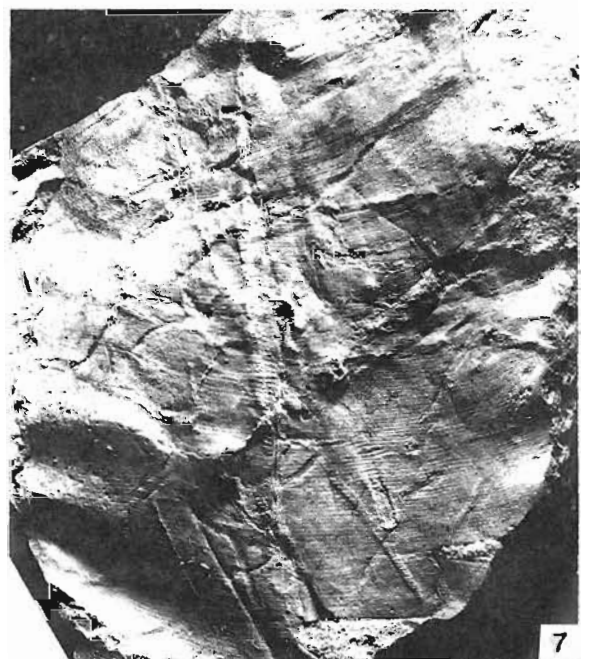
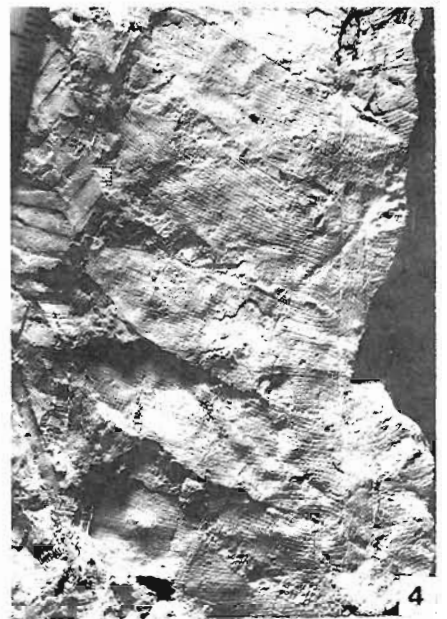
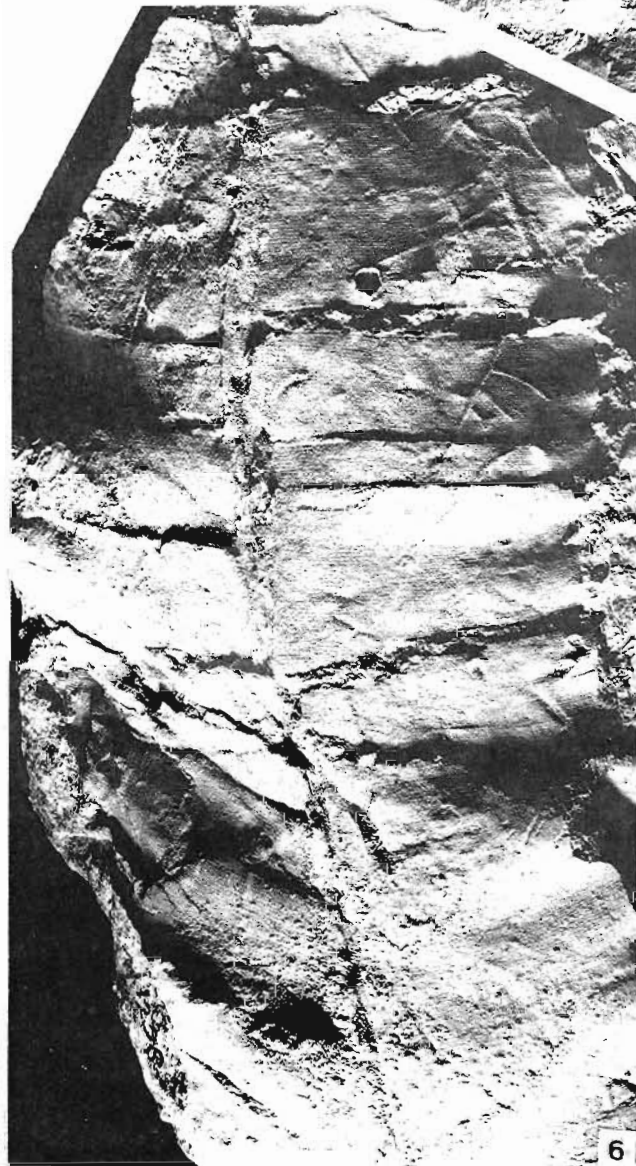
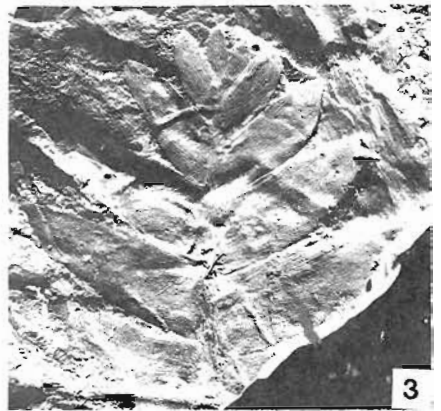
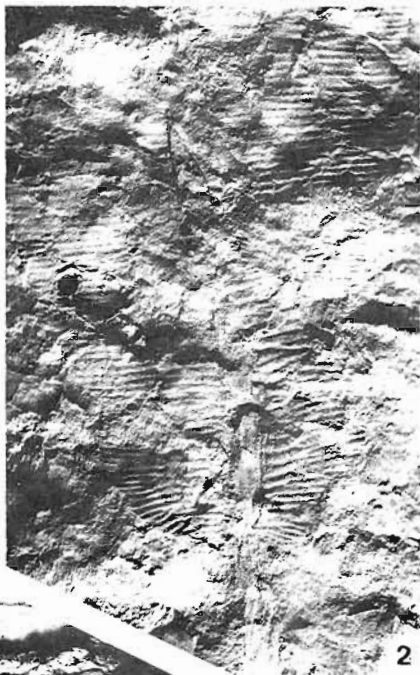


PLATE 2

(Bose & Banerji, 1984). The Khatangi specimen probably represents a juvenile leaf.

Pterophyllum sp. cf. *P. footeanum* Feistmantel 1879
Pl. 1, fig. 9; Text-fig. 1B

Description—Specimens incomplete, 3.5 cm long; rachis 1 mm broad, finely striate. Pinnæ alternate to sub-opposite, attached on lateral sides of rachis at angles of 80°-90°, linear, largest pinna fragment about 3.5 cm in length and 3-4 mm in width, apex mostly not preserved but in one specimen it seems to be obtuse; base broad, acroscopic and basiscopic basal margins turned upwards and downwards respectively and perhaps jointed with the bases of adjacent pinnæ of same side; veins 3-8 per pinna, mostly forked at various levels.

Remarks—The specimens resemble *Pterophyllum footeanum* Feistmantel 1879 except for less concentration of veins.

Cycadales

Genus—*Nilssonia* Brongniart 1825

Nilssonia sp.
Pl. 2, figs 6, 7; Text-fig. 1C

Description—Leaves simple, incomplete, largest 20 cm in length and 9 cm in width, elongate, oblanceolate to spatulate. Rachis 0.6 cm broad near base. Lamina rather delicate with flecks of resin, corrugated, occasionally divided into irregular rectangular segments in middle region. Segments with lateral margin truncated and straight, slightly wavy at places. Apex obtuse, lamina gradually tapering towards base. Veins mostly simple, arising at right angle and running straight across lamina, slightly curved upwards towards apex, 20-30 veins/cm at margin.

Remarks—In most of the specimens studied, the attachment of lamina is not clear. A specimen (Pl. 2, fig. 7) shows lamina which almost covers the midrib leaving a narrow groove. Another specimen shows flecks of resin (Pl. 2, fig. 6), which is also a

characteristic feature of the genus *Nilssonia*; veins are mostly unforked. Though the stomatal features are not known, yet the concentration of veins is unlike the genus *Pterophyllum* Brongniart.

Comparison—*Nilssonia orientalis* Heer described by Jacob and Shukla (1955) from Saighan Series of Afganistan is nearest to the present specimens in gross features and vein concentration, but differs by its less-segmented lamina.

Genus—*Ctenis* Lindley & Hutton 1834

Ctenis rajmabalensis sp. nov.
Pl. 2, figs 3, 4; Text-fig. 1D

Diagnosis—Fronds paripinnate, more than 12 cm in length and 10.7 cm in width. Rachis up to 6 mm broad, smooth or finely striate. Pinnæ laterally attached at angles of 80°-90°, 0.6-5.8 cm in length, 2.5-2 cm in breadth, attached by broad base, margin entire, apex subacute to obtusely rounded, basal basiscopic and acroscopic margins extended upward and downwards on the rachis joining the adjacent pinnæ. Rarely at places basal basiscopic margin slightly constricted and upper one straight. Veins arising at wide angles, forking at various levels, sub-parallel throughout the lamina with slight divergence towards lateral margins, 10-12 per cm at base, 16-18 per cm in middle region and 20-25 per cm towards distal end.

Holotype—Pl. 2, fig. 4, Specimen no. BSIP 36259.

Remarks—All the specimens are incomplete and show either apical or middle portion of the frond. Cross-connections between veins are rarely visible. *Ctenis rajmabalensis* is somewhat comparable to *Ctenis imjhiriensis* Bose & Zeba-Bano 1979 in having rare cross-connections but the Khatangi Hill specimens differ by smaller pinnæ and decurrent basal margins. In *Ctenis imjhiriensis* basiscopic and acroscopic margins are contracted.

Genus—*Taeniopteris* Brongniart 1828

Taeniopteris sp. cf. *T. oldbamii* Bose & Banerji 1981
Pl. 2, fig. 1; Text-fig. 1E-G

Description—Leaf petiolate, petiole incomplete, 1-2.5 mm broad. Lamina ovate, 2.2-6 cm in length

PLATE 2

1. *Taeniopteris* cf. *T. oldbamii* Bose & Banerji showing leaves with cordate bases, Specimen no. BSIP 36253, × 1.
2. *Taeniopteris* sp., incomplete leaf showing coarse nature of lateral veins, Specimen no. BSIP 36254, × 1.
3. *Ctenis rajmabalensis* sp. nov. showing paripinnate nature of leaf, Specimen no. BSIP 36260, × 1.
4. *C. rajmabalensis* sp. nov. holotype showing venation pattern, Specimen no. BSIP 36259, × 1.
5. *Pagiophyllum* sp., Specimen no. BSIP 36258, × 1.
6. *Nilssonia* sp., showing corrugated irregularly segmented lamina of leaf with simple parallel lateral veins and fleck of resin, Specimen no. BSIP 36257, × 1.
7. Another specimen of *Nilssonia* sp. showing middle region of lamina fully covering the rachis except for a narrow median groove, Specimen no. BSIP 36256, × 1.



Text-figure 1—**A**, *Onychiopsis* sp. showing elliptical pinnules with forked or unforked veins, specimen no. B.S.I.P. 36261, $\times 4$; **B**, *Pterophyllum* sp. cf. *P. footeanum*, linear pinnae showing venation, specimen no. B.S.I.P. 36252 $\times 1$; **C**, *Nilssonia* sp., lamina almost covers the midrib except a narrow median groove and lateral veins are mostly unforked, specimen no. 36259, $\times 1$; **D**, *Ctenis rajmahalensis* sp. nov., holotype showing shape and venation pattern of pinnae, specimen no. 36259, $\times 1$; **E-G**, *Taeniopteris* sp. cf. *T. oldhamii* Bose & Banerji—**E**, leaf showing cordate base and venation pattern, specimen no. B.S.I.P. 36253, $\times 1$. **F-G**, small leaf of the above species showing emarginate apex and cordate base, specimen nos. 36247, 36247 (C.P.), $\times 1$.

and 2.2-4 cm in width, margin appears to be entire, apex probably emarginate, base cordate. Midrib 1-2 mm thick, distinct up to apex, veins arising at 60°-80° angles, simple or forked, forking at various levels; vein concentration near midrib region 8-14 per cm and towards margin 13-20 per cm.

Remarks—The specimens though resemble *T. oldhamii* Bose & Banerji 1981 in general, yet differ in having emarginate apex and more or less entire margin. *Taeniopteris emarginata* Oishi 1940 has emarginate apex, but is distinguished by an obovate-elliptical shape and high concentration of veins.

Taeniopteris sp.
Pl. 2, fig. 2

Description—Leaf incomplete, petiolate, 9.6 cm long, maximum width 6.2 cm. Petiole 2.6 cm long, 0.5 cm broad, surface showing wrinkles. Lamina probably thin, base constricted, margin entire. Petiole continued as midrib of the lamina. Lateral veins coming out almost at right angles to midrib, mostly bifurcated once in middle region, concentration of veins 7-10 per cm near midrib and 10-14 per cm near margin.

Comparison—*Taeniopteris* sp. resembles *T. buskoghataensis* Bose & Banerji 1981 in coarse nature of lateral veins.

Coniferales

Genus—*Pagiophyllum* Heer 1881

Pagiophyllum sp.
Pl. 2, fig. 5

Description—Twig 2.5 cm long, 3 mm wide, leaves spirally disposed at angles of 30°-45°, linear to falcate, 4 × 0.5 mm, apex acute, margin entire, acroscopic basal margin straight, basiscopic basal margin decurrent, medianly keeled. Keel distinct up to apex.

Remarks—*Pagiophyllum* has been recorded from Khatangi Hill for the first time. The specimen compares best with *Pagiophyllum araucaroides* Vishnu-Mittre 1959, but the latter is based on anatomical details.

DISCUSSION

In Dubrajpur Formation at Khatangi Hill, the cycadophytes are represented by nine species belonging to six genera. *Ptilophyllum* is the most dominant element. *Nilssonina* and *Ctenis* are quite frequent, whereas *Pterophyllum* and *Taeniopteris* are meagrely represented. Lycopods and sphenopsids are absent in this assemblage. Ferns are represented

TAXA	JURASSIC			CRETACEOUS
	LOWER	MIDDLE	UPPER	LOWER
<i>Gleichenites</i>				
<i>Cladophlebis</i>				
<i>Ptilophyllum</i>				
<i>Williamsonia</i>				
<i>Pterophyllum</i>				
<i>Nilssonina</i>				
<i>Ctenis</i>				
<i>Taeniopteris</i>				
<i>Pagiophyllum</i>				
<i>Elatocladus</i>				
<i>Onychiopsis</i>				
<i>Culcitites</i>				

Text-figure 2—Distribution of various taxa in Khatangi Hill, Dubrajpur Formation

by *Gleichenites*, *Culcitites*, *Onychiopsis* and *Cladophlebis*. Conifers are extremely rare and represented by a fragment of *Pagiophyllum* and *Elatocladus conferta*. The assemblage is characterised by frequent occurrence of *Culcitites*, *Onychiopsis*, *Ctenis* and *Nilssonina* along with the preponderance of *Ptilophyllum* and *Gleichenites*. Frequent occurrence of *Onychiopsis* along with abundance of *Gleichenites* indicates a Lower Cretaceous affinity. However, unlike other Lower Cretaceous assemblages the conifers are relatively infrequent. An Upper Jurassic affinity cannot be ruled out as the flora is dominated by cycadophytes and contains an Upper Jurassic marker genus *Culcitites* (Text-fig. 2). The overall dominance of cycadophytes over the conifers depicts that a tropical to subtropical climate was prevailing at the time of deposition.

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