
Some Mesozoic plant remains from Bhuj Formation with remarks on the depositional environment of beds

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The paper deals with some plant remains from Pur and Pat River sections exposed near the villages Trambau and Nangor in Kutch District. These are *Trambauatballites sukhpurensis* comb. nov., *Isoetes janaianus* sp. nov., *Cycadospadix* sp. and *Allocladus patensis* sp. nov. Due to the presence of *Trambauatballites sukhpurensis* and *Isoetes janaianus* the fossiliferous beds are considered to be of fresh water origin.

Key-words—Mega-fossils, Liverworts, Pteridophytes, Bhuj Formation, Middle-Upper Jurassic (India).

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सारांश

भुज शैल-समूह से कुछ मध्यजीवी पादप-अवशेष तथा संस्तरों के निक्षेपणीय वातावरण पर टिप्पणियाँ

जयश्री बैनर्जी

कच्छ जनपद में ट्राम्बू एवं नानगोर नामक गाँवों के समीप विगोपित पुर एवं पट नदी खंडों से प्राप्त कुछ पादप-अवशेषों का इस शोध-पत्र में वर्णन किया गया है। ये ट्राम्बूआथैलाइटिस सुखपुरेन्सिस नव संयोजन, आइसोइटीज़ जानाइनस नव जाति, साइकेडोस्पेडिक्स जाति एवं ऐल्लोक्लेडस पटेन्सिस नव जाति नामक अवशेष हैं। ट्राम्बूआथैलाइटिस सुखपुरेन्सिस एवं आइसोइटीज़ जानाइनस की उपस्थिति के कारण ये संस्तर अलवणी जल के प्रस्तावित किये गये हैं।

FROM the Pur River Section (Map 1) a large number of megafossils have been described by Bose and Banerji (1984). From the Pat River Section only megaspores are so far known (Banerji, Jana & Maheshwari, 1984) The newly discovered fossiliferous bed in Pur River Section contains a species of liverwort associated with fine filamentous algal remains. This part extends more than 120 m in length, though quite thin throughout the outcrop area. About 30 cm below is a bed characterized by the presence of only root impressions which are both vertical and horizontal in position, indicating *in situ* deposition. Between the liverwort zone and the zone with root markings, another zone is present which is characterized by the presence of fragmentary fern fronds, fragments of *Ptilophyllum* leaves, conifer shoots and *Araucarites*. This assemblage is also present, though rare, above the liverwort zone and below the root zones.

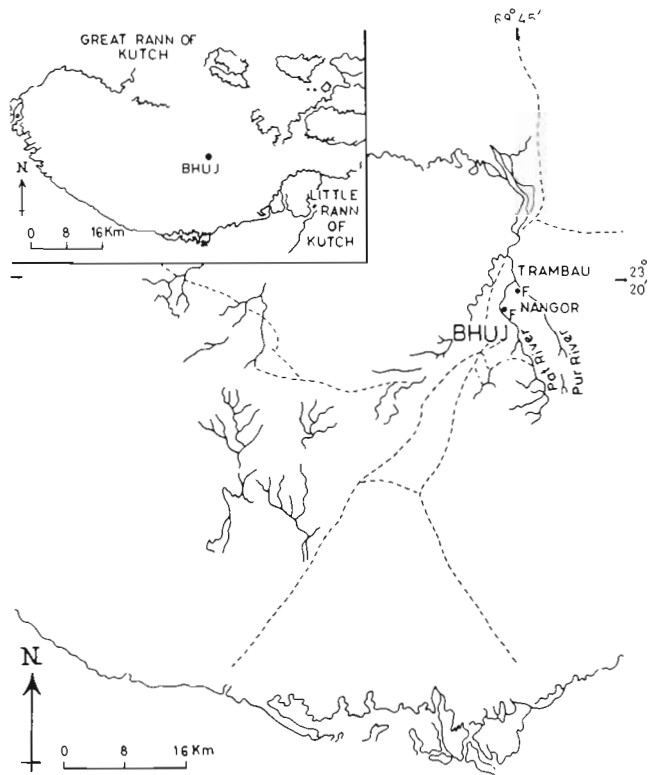
In Pat River Section, which is about 8-10 km south-east of Pur River, the complexion gets

changed. Here one of the lower beds contains fossils of *Isoetes* only, indicating a fresh water environment. The bed overlying the *Isoetes* bed has stray occurrences of fragmentary *Ptilophyllum* leaves and conifer shoots.

DESCRIPTION

Genus—*Trambauatballites* gen. nov.

Diagnosis—Plants thalloid, showing rosette habit, usually 3-4 lobed (rarely 5), radiating from centre, lobes diverging at an angle of 45°-60°, dichotomously branched, linear, further each lobe near apex slightly or deeply notched, sometimes apex obtuse; margin mostly entire, occasionally at places slightly wavy or undulated, substance of thallus extremely thin, but midrib region slightly thicker than rest of lamina, represented by a median groove. Lobes of most of the fertile thalli at their terminal ends bearing a globular or spheroidal sporogonium on (?) dorsal surface. Each



Map 1—Showing fossiliferous beds (F) near Trambau and Nangor villages, Kutch, Gujarat.

sporogonium bearing more than 20-25 spores. Spores trilete, sub-triangular in shape, with well-developed perine, exine showing fairly large irregular reticulations, lumina finely reticulate, trilete distinct, rays almost reaching up to margin.

Type species—*Trambauathallites (Hepaticites) sukhpurensis* (Bose & Banerji) Comb. nov

Discussion—Rosettes forming thalli have been described from Sukhpur and Kera as *Hepaticites sukhpurensis* (Bose & Banerji, 1984). Similar thalli have been collected from Trambau. The entire bed is full of sterile as well as fertile thalli which externally resemble *Ricciopsis scanica* Lundblad 1954. However, in none of the specimens from Kutch

ventral scales, rhizoids and pores have been observed. Though the Kutch specimens look very much like the extant species *Riccia natans*, yet in the former the position of sporogonium is more like the one met with in most species of the genus *Cyatbodium*. The spores in the Kutch species are quite unlike spores met within various species of *Cyatbodium* which are mostly apiculate. In the absence of any rhizoids in Kutch specimens, at present, I prefer not to place these specimens under *Hepaticites* Walton which has been referred to the Order Jungermanniales (Jovet-Ast, 1967). The genus *Marchantites* Brongniart as emended by Walton (1925) is characterized by the presence of rhizoids, scales and marchantiaceous air chambers. None of these characters are known in the specimens from Kutch. The characteristic *Riccia*-like thallus, with sporogonium lying dorsal side (?) near tip of each lobe with reticulate spores separates *Trambauathallites* from all the existing fossil and living genera belonging to Hepaticopsida (Rothmaler, 1951).

Trambauathallites sukhpurensis (Bose & Banerji)
comb. nov

Pl. 1, figs 1-8; Text-fig. 1 C-E

1984 *Hepaticites sukhpurensis* Bose & Banerji, p. 4,
pl. 1, figs 1, 15, text-fig. 2A, B

Description—More than 100 pieces of shale samples with closely placed thousands of thalli were collected from Trambau, whereas, from Sukhpur and Kera only two shale pieces with *Trambauathallites sukhpurensis* were obtained. Between some of the thalli, at places, one can also see fine filamentous algal remains (Text-fig. 1A) without showing any definite character. In sterile thalli, lobes are more distantly radiating, whereas in fertile thalli lobes are more closer to each other. Overall shape of most of the complete thalli is circular to oval (Pl. 1, figs 3, 4). The substance of thallus is extremely thin, so from them it is difficult to make out whether the sporogonium is lying on dorsal side or on the

PLATE 1

- 1, 2. Showing a few sterile and fertile thalli of *Trambauathallites sukhpurensis* (Bose & Banerji) comb. nov.; Specimen nos. BSIP 35826, 35827. × 1
3. A sterile thallus of *Trambauathallites sukhpurensis* (Bose & Banerji) comb. nov.; Specimen no. BSIP 35828. × 1.
4. A fertile thallus of *Trambauathallites sukhpurensis* (Bose & Banerji) comb. nov.; Specimen no. BSIP 35827. × 4.
- 5-7. Isolated spores of *Trambauathallites sukhpurensis* (Bose & Banerji) comb. nov.; Slide nos. BSIP 35829-(4), 35830-(1), 35829-(6). × 200.
8. A spore of *Trambauathallites sukhpurensis* (Bose & Banerji) comb. nov. under SEM, left hand side figure shows the complete spore and the figure on the right hand shows a portion of exine enlarged in order to highlight the lumina of the reticulation.
- 9-12. *Isoetes janaianus* n. sp., laterally and vertically compressed specimens showing 5-lobed rhizomorph with roots and sporophylls (fig. 10, a few roots on maceration showing tracheids; Slide no. BSIP 35834-1. × 100; Specimen nos. BSIP 35831, 35832, 35837. × 1.

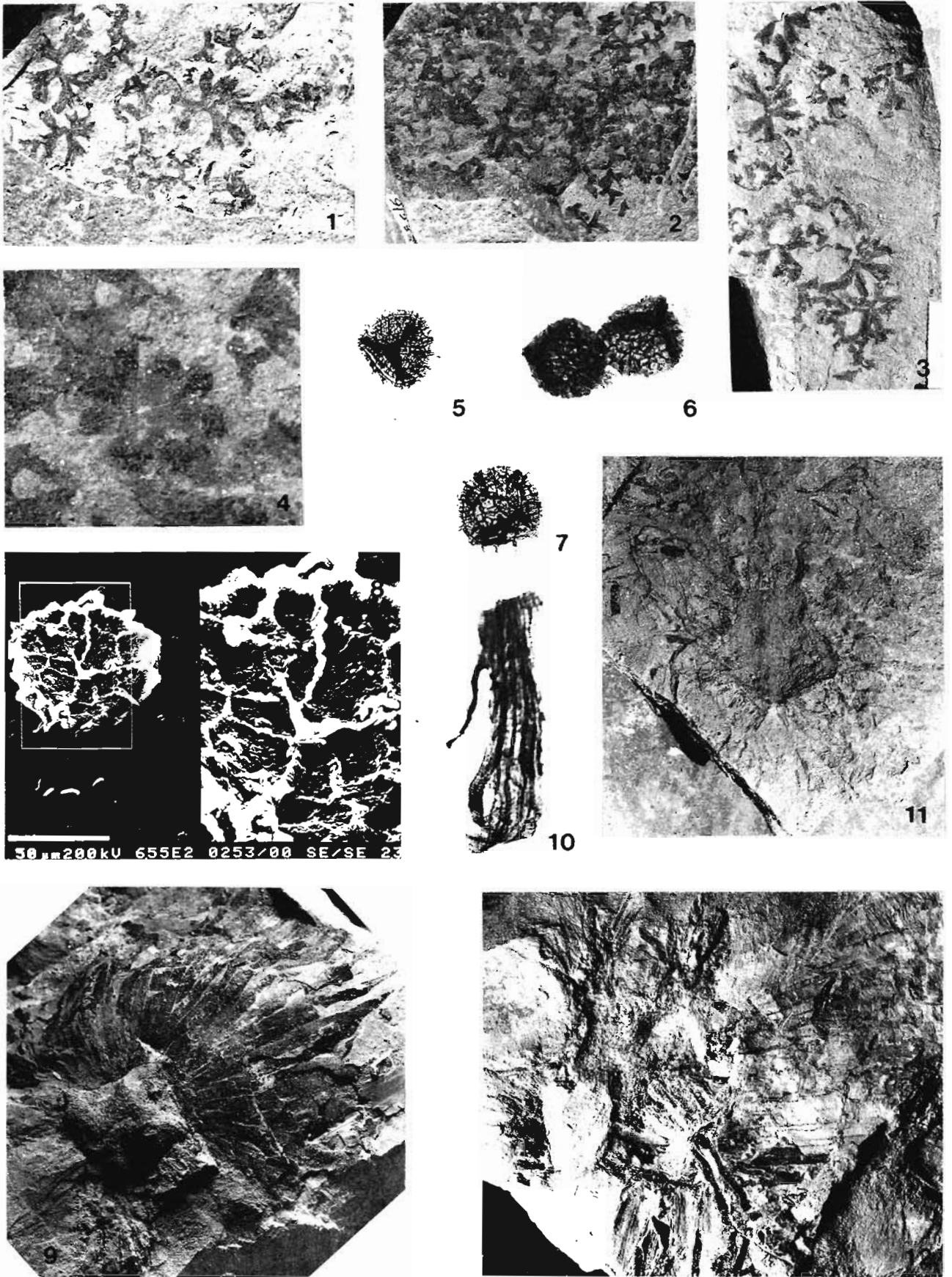
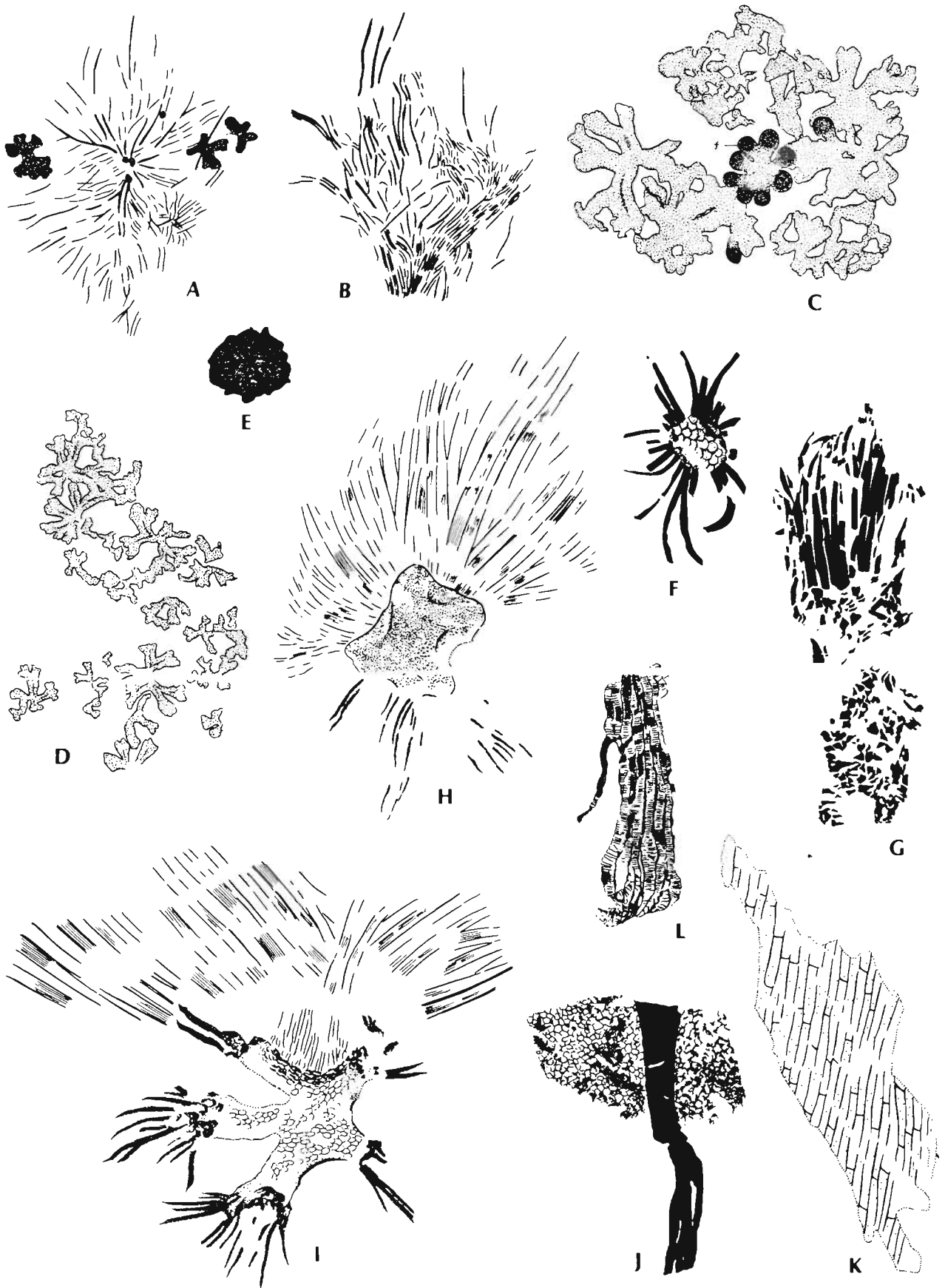


PLATE 1



TEXT-FIGURE 1

ventral side. In some cases, they seem to be lying on dorsal side. Upper SEM lumina of spores show fine reticulations (Pl. 1, fig. 8).

Genus—*Isoetes* Linnaeus

Isoetes janaianus sp. nov.

Pl. 1, figs 9-12, Pl. 2, figs 1-6; Text-figs 1F-L, 2A-G

1964 *Isoetites indicus* Bose & Roy, p. 226, pl. 1, figs 6-17

1966 *I. indicus* Bose & Roy: Surange, p. 21, fig. 9.

1974 *I. indicus* Bose & Roy: Sukh-Dev, p. 73.

1984 *I. indicus* Bose & Roy: Bose and Banerji, p. 7, pl. 1, figs 9-14; text-fig. 30.

Diagnosis—Plant as a whole elongate-oval in shape, about 14 cm long and 5.7 cm wide at its broadest region. When dorsiventrally or vertically compressed 18 cm in diameter (including central portion, representing rhizomorph which is about 2-3.5 cm in diameter). Rhizomorph 5-lobed, surface showing irregularly packed polygonal cells. Root scars prominent, roots unbranched or branched, majority unbranched, at places, showing (?) spiral pittings. Sporophylls numerous, about 30-125 in number, spirally arranged, in dorsiventrally compressed state forming a sort of rosette. Sporophylls about 10-12 cm long, near base about 3-4 mm wide, gradually tapering towards apex; margin entire; surface showing fine striations in longitudinal direction. Sporophyll cuticle showing more or less serially arranged elongated rectangular cells; anticlinal walls straight, periclinal wall smooth. Mega- and microsporophylls externally indistinguishable. Megasporangium oval or oblong in shape, 3.5-6 mm long and 2-3 mm wide; sporangial wall comprising mostly elongate-rectangular cells, rarely polygonal but much longer than broad; anticlinal walls undulated, periclinal wall smooth. Megaspores 100-1500 in number, trilete, amb subtriangular, size 390-450 × 340-430 μm, inner body indistinct, equatorial flange 40-50 μm wide, slightly more broader at apical region; membranous, trilete laesurae membranous, more or less of same width as equatorial flange, extending up to equatorial margin. Exine 6-7 μm thick; reticulate, lumina irregularly polygonal, showing infragranulate structure, muri 6-7 μm high. Microsporangium oval

or oblong in shape, 4-5.5 mm in length and 3.5-4 mm in width; epidermal cells like cells of megasporangium. Microspores numerous, elliptical or subcircular in shape, usually 20-30 × 16-20 μm in size, alete, exine rough or finely granulose, mostly associated with 1-2 semilunar folds.

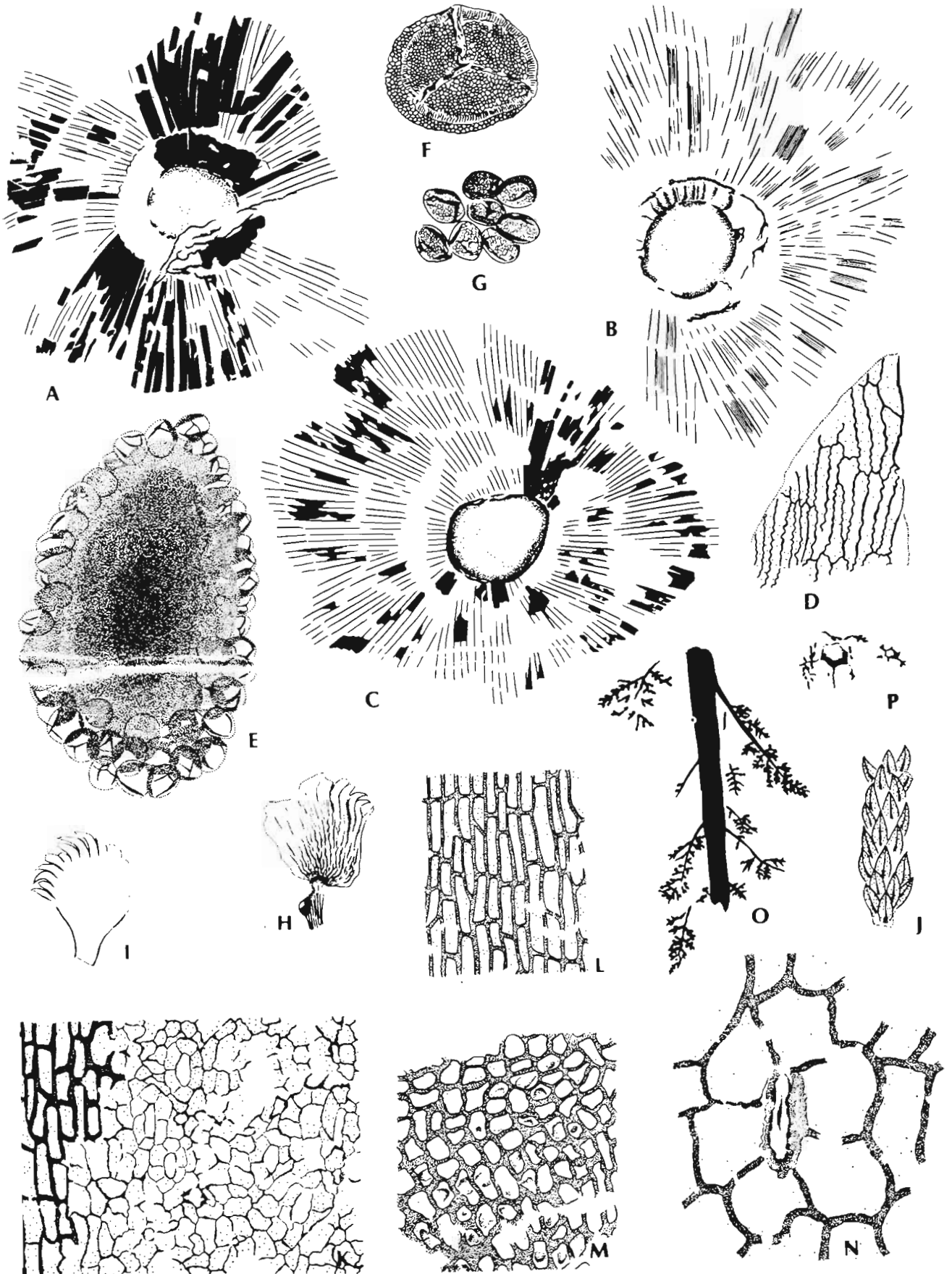
Derivation of name—Earlier fossil specimens resembling *Isoetes* were placed under the genus *Isoetites* Münster. Now when more information is available on roots, rhizomorph, mega- and microsporophylls the generic name *Isoetes* has been adopted here. Bose and Roy (1964) had described one of their species as *Isoetites indicus*. With the transfer of the fossil species to the genus *Isoetes*, a change in the name of species is required as an extant species of the genus already bears this species epithet, i.e., *Isoetes indica* Pant & Srivastava 1962. The fossil is therefore renamed as *Isoetes janaianus* after Dr B.N. Jana who first discovered the fossiliferous bed containing *Isoetes* at Pat River.

Holotype—Specimen no. BSIP 35831; Pat and Pur River Section exposed near Nangor and Trambau villages respectively; Bhuj Formation.

Description—From Pat River Section quite a few specimens complete with roots, rhizomorph and sporophylls have been collected. Almost all the specimens from Pur River Section are incomplete, they have only the bases of sporophylls which are arranged in rosettes. But from this locality a young plant with sporophylls attached to rhizomorph has been collected (Text-fig. 1F). This specimen consists of a broadly oval rhizomorph and a few sporophylls. The rhizomorph surface also shows scars of detached sporophylls.

One of the best preserved specimens (Pl. 1, fig. 9; Text-fig. 1H) from Pat River shows 5-lobed nature of the rhizomorph distinctly. Its surface clearly shows the root scars. Another specimen (Text-fig. 1I) from the same locality shows rather deeply lobed rhizomorph. A dorsiventrally compressed specimen with largest diameter has been shown in Text-fig. 2B. The impression of the rhizomorph is somewhat circular and in the sporangial bases are fairly distinct. Text-figure 2C shows specimen with maximum number of sporophylls. The sporophylls of the specimens from Pat River yielded both mega- and microspores occurring in mega- and

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Text-figure 1—A, B, Showing filamentous algae occurring in association with *Trambauathallites sukhpurensis* (Bose & Banerji) comb. nov., Specimen nos. BSIP 35839 and 35840, × 1; C, D, *Trambauathallites sukhpurensis* (Bose & Banerji) comb. nov., Specimen nos. BSIP 35827, 35828-C. × 2, D, × 1 (f = fertile thallus); E, showing a spore under SEM; F, G, *Isoetes janaianus* n. sp. F, showing a young plant, Specimen no. BSIP 35841, × 1 and G, laterally compressed plant, Specimen no. BSIP 35842, × 0.5; H, I, showing rhizomorph with roots and sporophylls, Specimen nos. BSIP 35831, 35837, × 1; J, showing surface cells of a rhizomorph and roots, Slide no. BSIP 35834-2, × 1; K, showing epidermal cells of sporophylls, Slide no. BSIP 35835-1, × 75; L, roots showing tracheids, Slide no. BSIP 35834-1, × 100.



TEXT-FIGURE 2

microsporophylls belonging to the same plant, whereas, from the Pur River specimens only megaspores could be isolated. Megaspores, recovered from the specimens from both the localities are similar in nature. The megaspores were isolated from megasporangium in oval masses (Text-fig. 2E) and the microspores got detached after they were separated from the microsporangium.

Comparison—Among the living species of *Isoetes* from India, *I. janaianus* resembles *I. panchanani* Pant & Srivastava 1962. In both the species the megaspores have reticulate ornamentation. In *I. panchanani* the rhizomorph is bilobed and its microspores have so far not been described. *I. coromandaliana* L. (Pfeiffer, 1922) though resembles *I. janaianus* in gross features, yet differs in having tuberculate megaspores. *I. pantii* Goswami & Arya 1970 differs in having 3-lobed rhizomorph, tuberculate megaspores and trimorphic microspores. *I. sampathkumarani* Rao, *I. dixiti* Shende, *I. sabidri* Mahabale and *I. indica* have 2-3 lobed rhizomorph and dimorphic megaspores (Pant & Srivastava, 1962).

I. janaianus also resembles *I. engelmanni* Brown, *I. foveolata* Eaton and *I. tuckermanni* Brown (Pfeiffer, 1922). All the species have reticulate megaspores. All the latter species, however, have bilobed rhizomorphs.

Genus—*Cycadospadix* Schimper

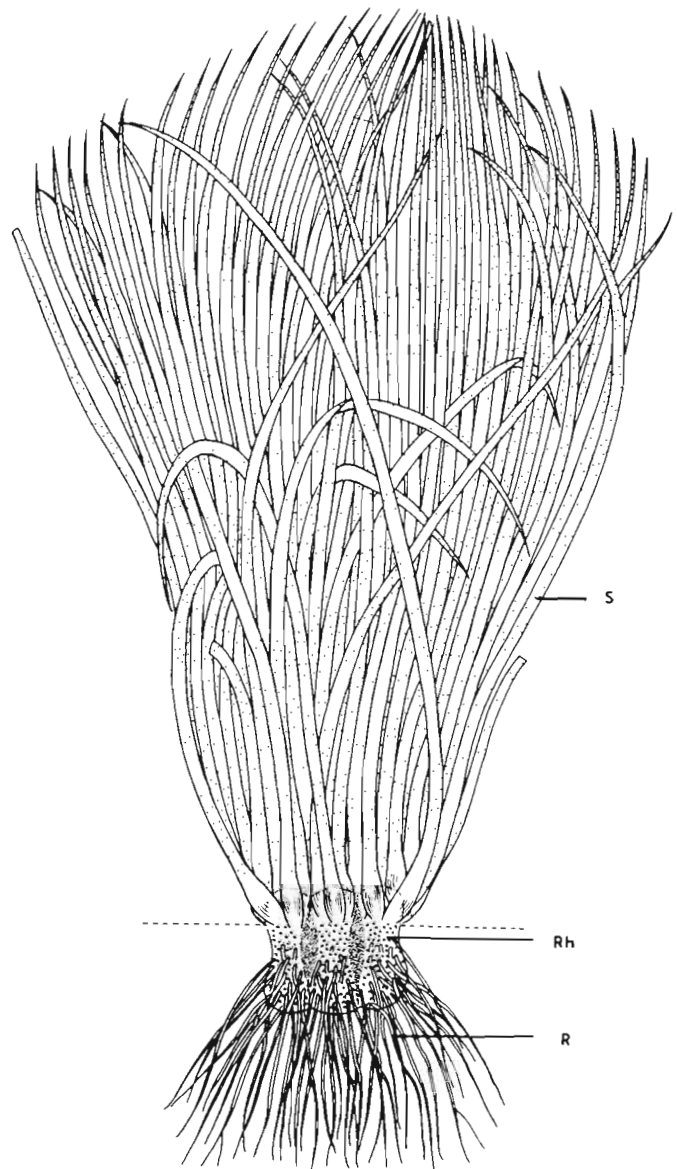
Cycadospadix sp.

Pl. 2, fig. 7; Text-fig. 2H-I

Description—Megasporophylls somewhat wedge-shaped, 2.3-2.8 cm long, 1.8-2 cm wide, narrowing towards base; preserved part of basal region finely striated; surface of megasporophylls pleated, on apical side margin deeply notched, forming finger-like projections, projections 1-1.5 cm long (?). Basal part of one of the specimens (Pl. 2, fig. 19; Text-fig. 2H) shows on one side an oval depression. This may be a scar of a fallen seed base.

Occurrence—Pur River Section near Trambau.

Comparison—*Cycadospadix* sp. may be compared with *Cycadospadix bennoquei* Saporta 1875 and *C. moraeana* Saporta 1875, but Saporta's species differ from the Kutch specimens in being



Text-figure 3—Reconstruction of *Isoetes janaianus* (S—Sporophyll; Rh—Rhizomorph; R—Root).

larger in size and in having lanceolate shape. The present specimens, in gross features, also match the specimens of *Cycalacis saportae* Barale 1981. Due to lack of epidermal features in Kutch specimens a detailed comparison is not possible. *C. scopulina* Zhou 1983, too looks like *Cycadospadix* sp.

Text-figure 2—*Isoetes janaianus* n. sp. **A-C**, Dorsiventrally compressed specimens showing rhizomorphs and sporophylls, Specimen nos. BSIP 35833, 35843 and 35844, $\times 0.5$; **D**, showing cells of sporangial wall, Slide no. BSIP 35835-5, $\times 75$; **E**, showing a mass of megaspores, Slide no. BSIP 35835-5, $\times 18$; **F**, megaspore under SEM showing reticulate exine; **G**, showing a few microspores, Slide no. BSIP 35835-3, $\times 300$; **H, I**, *Cycadospadix* sp., Specimen nos. BSIP 35836 and 35845, $\times 1$; **J-N**, *Allocladus patensis* n. sp., J, showing a fragmentary twig, Specimen no. BSIP 35838, $\times 1$; **K**, upper surface showing stomatiferous and nonstomatiferous zones, Specimen no. BSIP 35838-1, $\times 150$; **L**, cells of lower surface, Slide no. BSIP 35838-3, $\times 150$; **M**, cell of lower surface from basal region of a leaf, Slide no. BSIP 35838-3, $\times 150$; **N**, a stoma, Slide no. BSIP 35838-3, $\times 400$; **O, P**, showing horizontally and vertically preserved root markings respectively Specimen nos. BSIP 35846 and 35847, $\times 0.5$.

Bennettitolepis dactylota (Harris) Florin 1933 resembles *Cycadospadix* sp. in external features.

Genus—*Allocladus* Townrow

Allocladus patensis sp. nov.
Pl. 2, figs 8-11. Text-fig. 2J-N

Diagnosis—Coniferous shoot with helically borne leaves, about 2 cm long and 0.5 cm wide. Leaves closely appressed, dorsal side distinctly keeled, rhomboidal in shape, mostly longer than broad, 3-5 mm long, 1.5-2 mm broad at base; apex acute; margin scarios; entire to microscopically fringed towards base; keeled:

Leaf cuticle moderately thick, upper surface comparatively slightly thinner than lower surface, stomata confined to upper surface. On upper surface stomata distributed along middle region flanked on either sides by non-stomatic zones, epidermal cells along non-stomatiferous zones rectangular, mostly 2-4 times longer than broad, anticlinal walls thick and straight, periclinal walls smooth, rarely at places unevenly thickened, cells towards basal region mostly polygonal to squarish in shape with straight and thick anticlinal walls, periclinal wall occasionally thickened towards centre, cells near apex also somewhat similar to basal cells; cells along stomatal region polygonal with straight anticlinal walls, periclinal wall mostly smooth, rarely at places unevenly thickened; cells towards basal region mostly polygonal to squarish in shape with straight and thick anticlinal walls, periclinal wall occasionally thickened towards centre, cells near apex also somewhat similar to basal cells; cells along stomatal region polygonal with straight anticlinal walls, periclinal wall mostly smooth, rarely at places unevenly thickened; trichome bases also present. Stomata longitudinally orientated, at places tending to form short discontinuous files, closely placed, subsidiary cells mostly 6, polygonal in shape, anticlinal walls mostly straight, rarely undulated, periclinal wall smooth, stomatal pit more or less squarish, guard cells sunken, less cutinized

than subsidiary and epidermal cells, inner margin slightly more cutinized; stomatal aperture slit-like. Cells on lower surface similar to those of non-stomatiferous zones of the upper surface.

Holotype—Specimen no. BSIP 35838; Pat River Section exposed near Nangor; Bhuj Formation.

Comparison—In *Allocladus biswasianus* Bose & Banerji 1984 the leaves are rhomboidal, more or less similar in length and width and the stomata are confined to two lateral zones. In the present species, the leaves are longer than broad and the stomata are confined only to the middle region. In gross features, *A. patensis* looks very much like *A. bansaensis* Sukh-Dev & Zeba-Bano 1979. In the latter species stomata are irregularly distributed over the entire upper surface. In *A. townrowii* Sukh-Dev & Zeba-Bano stomata are present in two vague zones closer to margin. *A. sehoraensis* Sukh-Dev & Zeba-Bano also differs from *A. patensis* in having two irregular stomatal zones on lateral sides, leaving a nonstomatal zone along the middle region.

DISCUSSION

Both Pur and Pat River sections, exposed near Trambau and Nangor, respectively, expose the Bhuj Formation. According to Biswas (1977), the Bhuj Formation consists mainly of non-marine sediments which represent deltaic deposits with the front of delta towards west and fluvial region lying towards east. He also suggested that Bhuj Formation ranged in age from Post Oxfordian to Lower Cretaceous and it was the period of regression. Krishna *et al.* (1983) on the basis of numerous wave built sedimentary structures, marine trace fossils and highly bioturbated and glauconite rich beds considered the entire Mesozoic Sequence in Kutch to be of marine origin. Their observations were based on nine sections of Mesozoic rocks in Kutch, they, however, did not mention the exact locations of these sections. During my field trips to Kutch, I also saw numerous marine trace fossils, but they were all

PLATE 2

1. *Isoetes janaianus* n. sp., epidermal cells of a sporangium. Slide no. BSIP 35835-2. × 100.
2. A megaspore of *Isoetes janaianus* n. sp. after partial maceration; Slide no. BSIP 35835-4. × 100.
3. A megaspore under SEM.
4. A mass of megaspores of *Isoetes janaianus* n. sp. under SEM.
5. *Isoetes janaianus* n. sp. showing epidermal cells of a sporophyll; Slide no. BSIP 35835-1. × 100.
6. A mass of microspores of *Isoetes janaianus* n. sp.; Slide no. BSIP 35835-5. × 300.

7. *Cycadospadix* sp.; Specimen no. BSIP 35836. × 1.
8. A portion of a twig of *Allocladus patensis* n. sp.; Specimen no. BSIP 35838. × 1.
9. *Allocladus patensis* n. sp., showing stomata; Slide no. BSIP 35838-3. × 500.
10. *Allocladus patensis* showing scalloped margin towards base of lower surface; Slide no. BSIP 35838-5. × 150.
11. Upper cuticle of *Allocladus patensis* n. sp., showing stomatiferous and non-stomatiferous zones; Slide no. BSIP 35838-1. × 150.

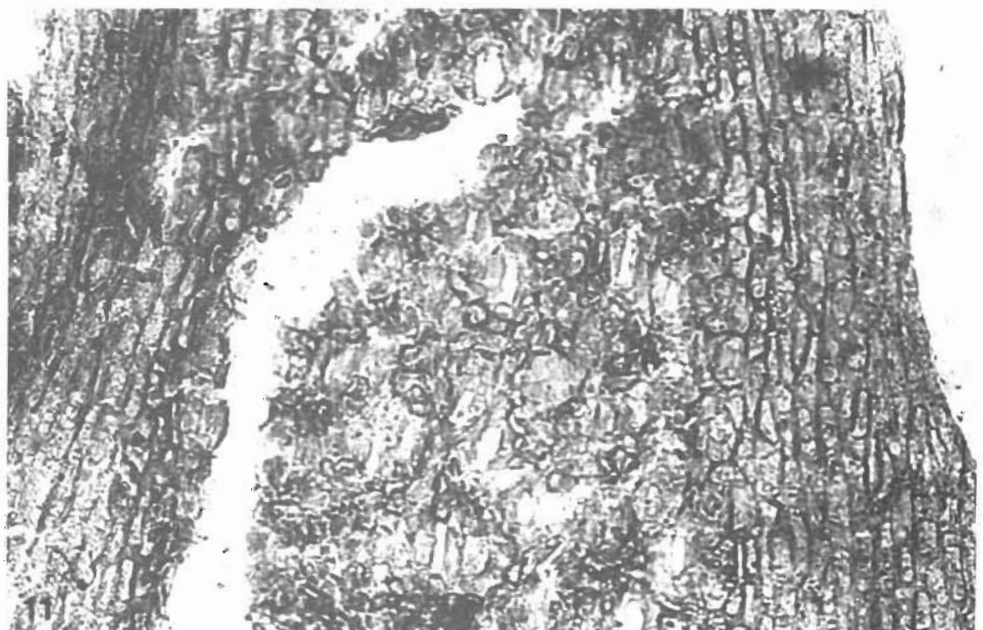
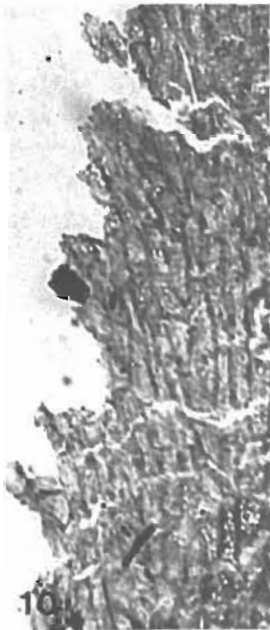
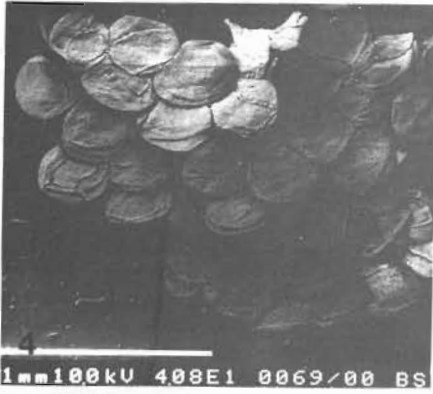
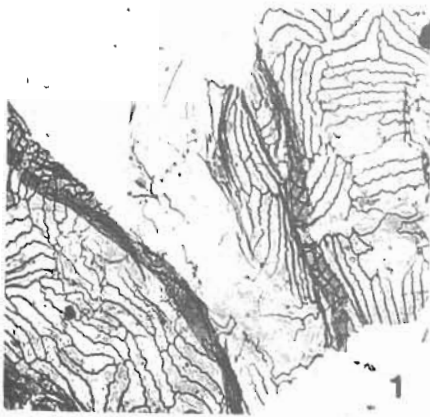


PLATE 2

observed in the Jhuran Formation of Biswas (1977) or in other older Mesozoic rocks. Trace fossils are abundant along the Bhuj-Mandvi Road (section exposed in the hillocks or in the road cuttings).

The presence of *Trambauathallites sukhpurensis* in thin bed, within an exposed section exceeding 120 m in length, in Pur River Section is indicative of humid and non-marine condition. Here *T. sukhpurensis* had formed a complete mat allowing only at places a few filamentous algae to grow. It seems that this liverwort mat was washed out during a single flood. In the bed lying below *T. sukhpurensis* I came across *Isoetes janaianus* and below it a bed containing only root markings (Text-fig. 20P) both along longitudinal and horizontal beddings. The genus *Isoetes* is typically a fresh water plant. The root markings clearly indicate that there were the plants which were actually growing there. Moreover, the presence of *Isoetes janaianus* in a bed in the Pat River Section (quite a few were found in actual position of growth) further supports the view that the fossiliferous bed near Trambau and Nangor were definitely of fresh water origin, though there was perhaps a depositional time gap between the bed having *Trambauathallites* and the one with *Isoetes* near Nangor.

So far from the Bhuj Formation no Wealden plant megafossil like *Weichselia* has been recorded. Even the genus *Gleichenites* which is abundant in the Upper Jurassic-Lower Cretaceous beds of the Rajmahal, Gangapur, Gardeshwar, Than and Bansa formations, is completely missing in the Bhuj Formation. The overall plant assemblage of Bhuj Formation is more like those from other known Middle-Upper Jurassic formations.

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