

Permineralized fossils from the Early Cretaceous sediments of Rajmahal Hills, Jharkhand, India

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ABSTRACT

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Fragmentary, petrified, pieces of Early Cretaceous fossils, observed in thin sections of silicified cherts from Nipania, Sonajori and Chilgajari in Rajmahal Hills, Jharkhand, are described. The fossils belong to *Chromista* (*Vaucheriaceae*), *Fungi* (saprophytic fungus, lichens) and plants (*Volvocaceae*, *Marchantiaceae*, *Metzgeriaceae*, *Jungermanniaceae*, *Rhodomelaceae*, *Isoetaceae*, *Ophioglossaceae*, *Schizaeaceae*) and others, e.g. glossopteroid leaf, cycadean and conifer pollen, median longisection of a rootlet, section of a monocot leaf and an isolated phloem cell with distinct sieve areas. Some of these are new and reported for the first time.

Keywords: Mesozoic Forest floor, Permineralized fossils, Early Cretaceous, Rajmahal Hill, Jharkhand, India.

INTRODUCTION

The localities situated in the southern portion of the Rajmahal Hills, e.g. Nipania, Sonajori, Amarjola, Chilgajari and Hiraniduba, are well known for the preservation of petrification of plants (Sahni 1932a, b, Srivastava 1945, Bose 1953, Bose & Sah 1954, Vishnu-Mittre 1953, 1955, 1959, Gupta 1970, Sharma 1970a, 1997, 2001, 2004, 2014a, Sharma & Bohra 1976, Sharma & Harsh 1987, 1994, Sharma & Tripathi 1997, Bohra & Sharma 1979, 1980, Suthar & Sharma 1988a, 1988b, Banerji 2000). The permineralized flora includes algae (Sharma 2014b, c, Sharma & Harsh 1994, Sharma & Tripathi 1997), lichens (Sharma et al. 2001, 2015a), bryophytes (Sharma et al. 2015a), pteridophytes (Srivastava 1945, Jacob

1950, Vishnu Mittre 1955, 1959, Gupta 1970, 1971, Sharma 1971, 1973, Bohra & Sharma 1979, Sharma et al. 2015a, b), gymnosperms (Sahni 1932a, b, 1948, Srivastava 1945, Bose 1953, 1968, Bose & Sah 1954, Bose et al. 1985, Vishnu Mittre 1953, 1957, 1959, Sharma 1967, 1970a, b, 1974, 1980, 2001, 2014a, Sharma et al. 2001, 2013, Suthar & Sharma 1988a, b) and angiosperms (Sharma 1997, Sharma et al. 2001, Banerji 2000). At Nipania, the debris portion of the forest is well preserved in yellow to dark brownish yellow portion of the chert. For understanding the exact picture of Mesozoic vegetation of the area both known and the new materials are described in the present investigation.

MATERIAL AND METHOD

The materials of the silicified cherts were collected from Nipania, Sonajori and Chilgajari localities (Figure 1) of the Santhal Pargana, Jharkhand. Sections were cut by a diamond edge wheel and slides were prepared by the usual technique of grinding and polishing methods and mounted in dilute Canada balsam.

DESCRIPTION AND DISCUSSION

Kingdom: *Chromista*

Phylum: *Ochrophyta*

Class: *Xanthophyceae*

Order: *Vaucheriales*

Family: *Vaucheriaceae* Dumortier

Genus: *Vaucheria* A.P. de Candolle

Vaucheria sp.: Sharma (2014b) described bunch/clump of the filaments of fossil *Vaucheria*

sp. (Figure 2.3) observed in thin sections prepared of the Nipania chert. It has both vegetative as well as fertile filaments with akinetes, male reproductive structure antheridium and female reproductive structure oogonium. Vegetative filaments are non-septate. Akinetes are produced in a uniseriate row. On liberation and germination, akinetes produce new offsprings of *Vaucheria*.

Kingdom: *Fungi*

Septate saprophytic fungus: The seed-bearing cones of *Araucarites mittrei* Bohra & Sharma 1980 occur frequently in the Sonajori chert. Seed scales are produced spirally on cone axis and each bears an inverted ovule which has a thick integument (seed coat) differentiated into three layers (Suthar et al. 1988). The middle one is thick and parenchymatous. It is in this layer that the septate fungal hyphae and mycelia are visible (Figure 2.4). Conidia are only few and

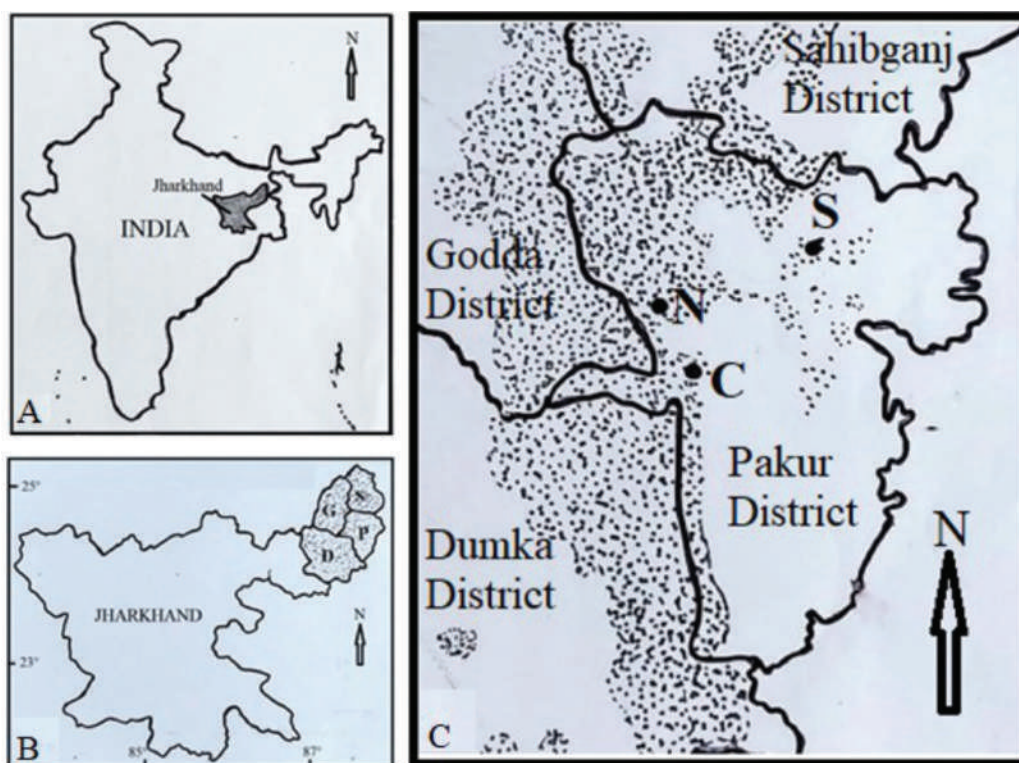


Figure 1. A Map of India showing location of Jharkhand. B. Map of Jharkhand showing location of four districts, e.g. Dumka (D), Godda (G), Pakur (P) and Sahibganj (S) in north-eastern Jharkhand. C. Map of Pakur District showing location of fossiliferous localities, e.g. Nipania (N) in Litipara Block; Sonajori (S) in Pakur Block; and Chilgajari (C) in Amarapara Block.

produced terminally. The fungus is saprophytic as it has not damaged the tissue of the host. Further investigations are needed on this fungus and its behavior.

Lichens: Sharma et al. (2001) described for the first time the presence of a fossil lichen in the Nipania chert (Figure 2.8). It has circular dark-coloured algal colonies (a) embedded in fungal matrix (f). Sharma et al. (2015a) called it lichen type A. They described two more type of lichens, i.e. lichen type B and lichen type C. The former is pyrenocarpous type while the latter has a distinct apothecium. Occurrence of these lichens in the Rajmahal Hills suggests humid condition during the upper Jurassic and lower Cretaceous periods in the area.

Kingdom: *Plantae*

Phylum: *Chlorophyta*

Class: *Chlorophyceae*

Order: *Chlamydomonadales*

Family: *Volvocaceae* Ehrenberg

Genus: *Eudorina* Ehrenberg

***Eudorina* sp.:** Sharma and Tripathi 1997 described the presence of a number of petrified globular coenobial algal bodies in thin sections prepared of the Nipania chert and identified as *Eudorina* sp. (Figure 2.1). In a coenobium of *Eudorina* sp., there are four little large sized cells in the centre than those of the surrounding layers. Total numbers of cells in a colony vary from 12–28 depending on the age and size of the coenobium. Coenobia range from 200–280 µm in size.

Genus: *Volvox* L.

***Volvox* sp.:** In a number of thin slides prepared of the Nipania chert *Volvox*-like globular coenobia are seen, a good one is described here (Figure 2.2). It is 0.8–0.9 mm in size and has large number of dark-coloured small sized cells placed at regular distances. There are also visible 3, 4 dark coloured bigger sized daughter colonies or gonidia (d) similar to those exist in living material of *Volvox*

sp. (Bold & Wynne 1985, Bold et al. 1987). Protoplasmic connections and flagellae are not preserved. *Volvox* has been described from Eocene lignite of Barsinghsar (Harsh & Shekhawat 2020) but this is the first report of a fossil *Volvox* sp. from the Rajmahal Hills.

Phylum: *Marchantiophyta*

Class: *Marchantiopsida*

Order: *Marchantiales*

Family: *Marchantiaceae* Lindl.

Genus: *Marchantia* L.

***Marchantia* sp.:** In Chilgajari chert, a vertical section of a marchantiaceous thallus was described by Sharma et al. (2015a). It is more or less a solid thallus with only a few small scattered cavities (Figure 2.7). Upper surface has distinct epidermal cells. For want of good preservation its affinities remain unknown. In the present paper, two closely appressed lobed thalli are described, each producing a stalked receptacle (arrow). The stalk of the receptacle (r) (Figure 2.6) originates from the dorsal surface of the thallus identical to those of *Plagiochasma* sp. or *Athalamia* sp. of the *Marchantiales* (Kashyap 1929). However, the thalli are not well preserved and cellular details remain unknown.

Class: *Jungermanniopsida*

Order: *Metzgeriales*

Family: *Metzgeriaceae* H. Klinggr.

Genus: *Metzgeriites* Steere

***Metzgerites/ Pallavicinites* sp. (?) Thalloid type:** A number of thalloid filamentous bryophytic structures are present in thin sections prepared of the Nipania chert. The present filament is 9.5 mm in length and 2.5 mm in width. It has a distinct dark coloured costa (x) on either side of which is attached a thin lamina (Figure 2.9, 11) which has patches of rhizoid at the margins and black threads, one of which bears a globose black structure terminally probably the sporangium.

From the costa arises a number of dark-coloured bodies (Figure 2.9) probably these are archegonial cluster (o). The material has been compared with the extant taxa *Metzgeria* or *Pallavicinia* (Kashyap 1929, Parihar 1965, Udar 1976, Bold 1987). Comparison was also made with *Hepaticites pantii* Bose & Pal 1982, which was an impression and not petrification.

Leafy Jungermanniales: From the fossil debris of Nipania, two leafy Jungermanniales are seen (Figure 2.10). One is a young unbranched plant while the other is a branched or bifurcated mature leafy structure in which three rows of leaves are visible (Figure 2.12). i.e. two lateral rows and third on the upper side resembling to some extent the living taxon *Porella* (?) (Udar 1976, Bold et al. 1987). For exact correlation more and better-preserved material is needed. In addition to the two specimens of leafy Jungermanniales the debris also have two patches of cellular scales of Marchantiales (Figure 2.10). A number of spores of pteridophytes and pollen of gymnosperms are also preserved in the debris.

Phylum: *Rhodophyta*

Class: *Florideophyceae*

Order: *Ceramiales*

Family: *Rhodomelaceae* J.E. Areschoug

Genus: *Polysiphonia* Greville

***Polysiphonia* sp.(?):** Sharma and Harsh (1994) reported for the first time the existence of an extinct specimen of *Polysiphonia*-like alga from the non-marine cherts of Nipania, Rajmahal Hills. Filament is long, 2–5 cells thick, non-

twisted or twisted (Sharma et al. 2015c, plate 1A) Tubular or siphonous peripheral cells are visible. Tetrasporangia are produced in rows (Sharma et al. 2015c, Plate 1K, L).

Red alga with fertile bodies: Sharma (2014c) described a red alga with cylindrical, branched, multi-cells thick filaments resembling those of *Callthamnion* sp. (Bold et al. 1987) from the non-marine cherts of Sonajori locality. In the present material a small stalked cystocarp (C) is seen attached to a filament (Figure 2.5). Non-ciliated spores are seen scattered in association with the filaments, a red alga character.

Phylum: *Tracheophyta*

Pteridophytes occur frequently in petrification form in the localities of the southern portion of the Rajmahal Hills. (Sharma 2004, Sharma et al. 2015b). Here are described some new and interesting fossil forms seen in thin sections of the cherts collected from the area.

Class: *Lycopodiopsida*

Order: *Isoetales* Prantl

Family: *Isoetaceae* Rchb.

Genus: *Isoetes* L.

***Isoetes* sp.:** Sharma et al. (2015a) described a Longi section of the leaf of *Isoetes* sp. showing ligule and an embedded portion glossopodium (g, u) (Figure 3.2) on the adaxial side in a thin section prepared of Chilgajari chert. This specimen is comparable to that of an extant taxon *Isoetes coromandelina* Lf. (Bhambie 1963, Sharma & Singh 1984, Pant et al. 2000). However, the associated sporangium is yet to be discovered

Figure 2. 1. *Eudorina* sp., Six-seven coenobial bodies are seen. **2.** *Volvox* sp., An oval to globular body having many small dark-coloured cells and 3-4 dark coloured gonidia or daughter colonies. **3.** *Vaucheria* sp., A clump or bunch of filaments and fertile bodies. **4.** Saprophytic septate mycelium and hyphae. **5.** Red algae with a cystocarp (c). **6.** Marchantiales thallus with a stalked receptacle. **7.** V.S. Marchantiales thallus. **8.** Lichen with dark-coloured circular algal groups (a) embedded in fungal matrix (f). **9** A thalloid filament (*Metzgerites/Pallavicinites*) having black costa(x) and thin lamina containing thread like structure, one terminating into a black globular structure (n). Archegonial cluster (o) also presents. **10.** Young an immature bifurcated leafy Jungermanniales, cellular scales, etc. **11.** Same as 9. **12.** Enlargement of leafy bifurcated plant having 3 rows of leaves.

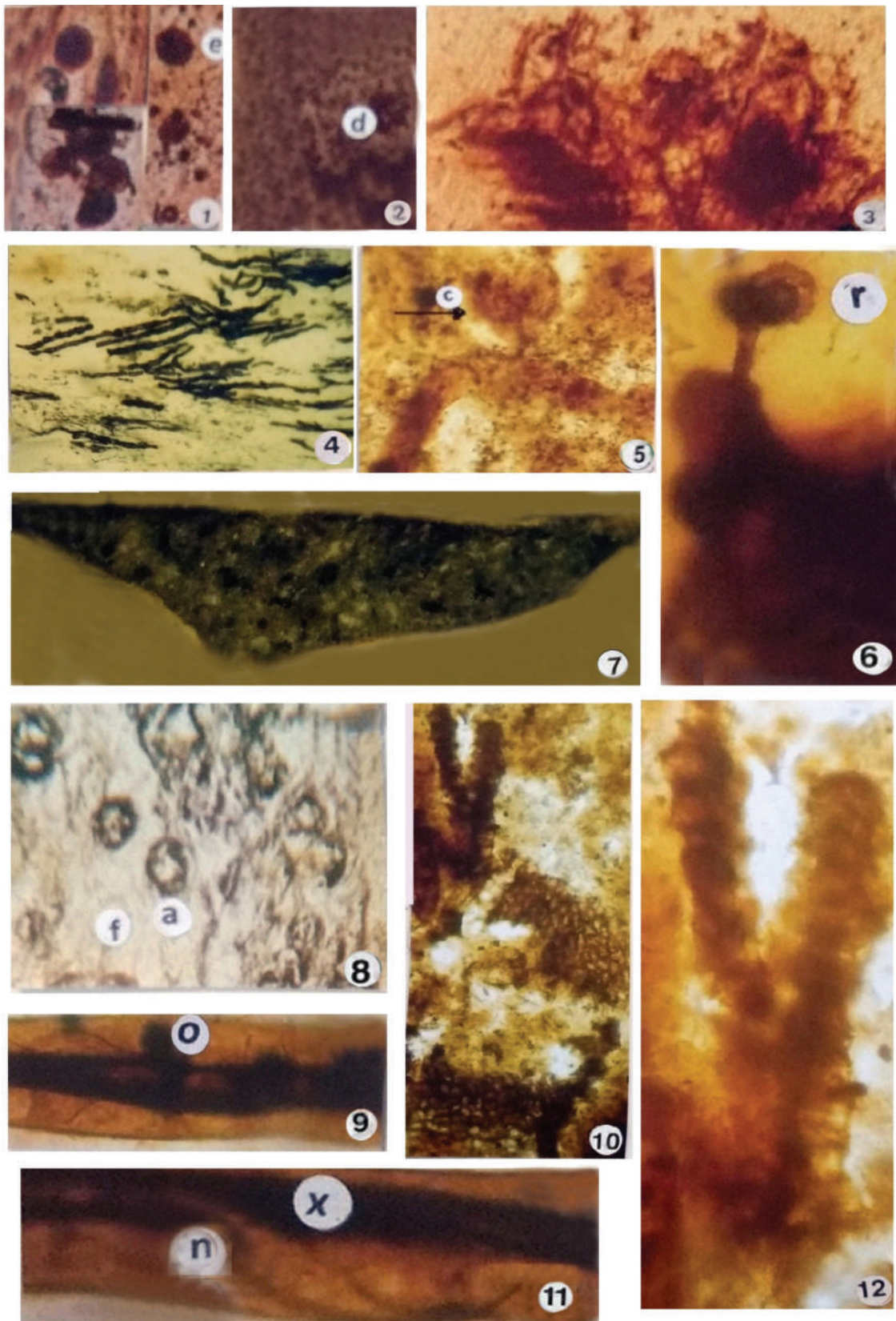


Figure 2

from the area.

Class: *Polypodiopsida*

Order: *Ophioglossales*

Family: *Ophioglossaceae* Martynov

Genus: *Ophioglossum* L.

***Ophioglossum* (?) sp.:** In the debris of the Nipania chert, half portion of an *Ophioglossum*-like spike has been discovered (Figure 3.1). The specimen is 12.5 mm in length and 3.5 mm in width consisted of a number of sessile, closely adhered circular sporangia (s), empty or filled with dark-coloured spores(?). The outer wall of sporangia is thick and dark (w) more or less identical to an extant material of *Ophioglossum* sp. (Bierhorst 1971, Sharma 1992, Sharma et al. 2007). The sporangia are attached to a thick dark coloured axis(x). This is the first record of an *Ophioglossum* spike in paleobotany literature. However, Sharma et al. (2015 a, b) have described a cross section of a rhizome of this taxon from the Rajmahal Hills and the localities of the Nipania. Epidermis with stomata: The epidermis is closely adhered to the axis (x) of the spike of *Ophioglossum* described above. That is on one side of the axis are sporangia and the other side is an epidermis bearing longitudinally oriented stomata (Figure 3.3). Epidermal cells are non-sinuuous but thin walled. Stomata are open and each has two distinct guard cells. Subsidiary cells are undifferentiated. The upper surface of tropophyll in some of the species of *Ophioglossum*, like *O. gramineum* and *O. petiolatum*, have similar kind of epidermal cells and orientation of stomata (Sharma & Vangani 1988) but it needs further confirmation.

Order: *Schizaeales*

Family: *Schizaeaceae* Kaulf.

Genus: *Schizaeangium*

***Schizaeangium jurassica*:** Bohra and Sharma (1978) recorded, in many thin sections prepared of the Sonajori chert, spikes as well as isolated sporangia of schizaeaceous plant (Figure 3.4). Annulus is apical made up of 6–8 cells. Spores are of *Cicatricosisporites* type (Figure 3.7, 8) having similar ornamentation (Suthar & Sharma 1986, Sharma et al. 2015a).

Class: *Glossopteridopsida*

Order: *Glossopteridales*

Family: *Glossopteridaceae* Trapl

Genus: *Glossopteris* Brangn.

***Glossopteris* sp.:** A permineralized *Glossopteris*-like leaf is seen in a thin section prepared of the Nipania chert (Figure 3.5). It measures 15 mm in length and 5 mm in width. It is an elliptical leaf with ovate/obtuse apex. Base is distinct. Midrib is 2–4 cells thick and runs from the base to the apex. Veins arise from the midrib on either side at an acute angle, divide and unite and form hexagonal to rectangular aerieles. Similar kind of aerieles and midrib are known in some of the species like *Glossopteris* sp. (Arber 1905, Chandra & Surange 1979). *Glossopteris* is found in lower Gondwana and middle Gondwana rocks. Rajmahal Hills belong to upper Gondwana System (Sen Gupta 1988).

Other plant fossils

Cycadean and conifer pollen: A number of monosulcate pollen of cycadean plants (including



Figure 3. 1. *Ophioglossum* sp. spike longi section one side only. Sessile, circular, closely appressed sporangia(s) attached to axis(x), empty or with spores. Outer wall (w) thick. **2.** *Isoetes* sp. Longisection leaf, Ligule (li) and glossopodium (g) visible. **3.** Epidermis with longitudinally oriented stomata. It is attached to axis (x). **4.** *Schizaeangium jurassica* 4 sporangia filled with spores. Annulus apical. **5.** Glossopteroid leaf with reticulate venation. **6.** Median longisection of a rootlet showing root cap (k), apical meristem (m), vascular zone (z) and pith (p). **7, 8.** *Cicatricosisporites* sp. schizaeaceous spores **9.** *Stapilinisporites cominus* (?). **10, 11.** Podocarpean tri and bi sactate spores (?). **12.** Spores with pores (?). **13-14.** Cycadean monolete spores of different sizes. **15.** Cross section monocot leaf vascular bundles (v) in parallel lines. **16.** Cycadean monolete spores. **17.** Phloem cell with distinct uniseriate sieve areas, in some sieve pore visible.

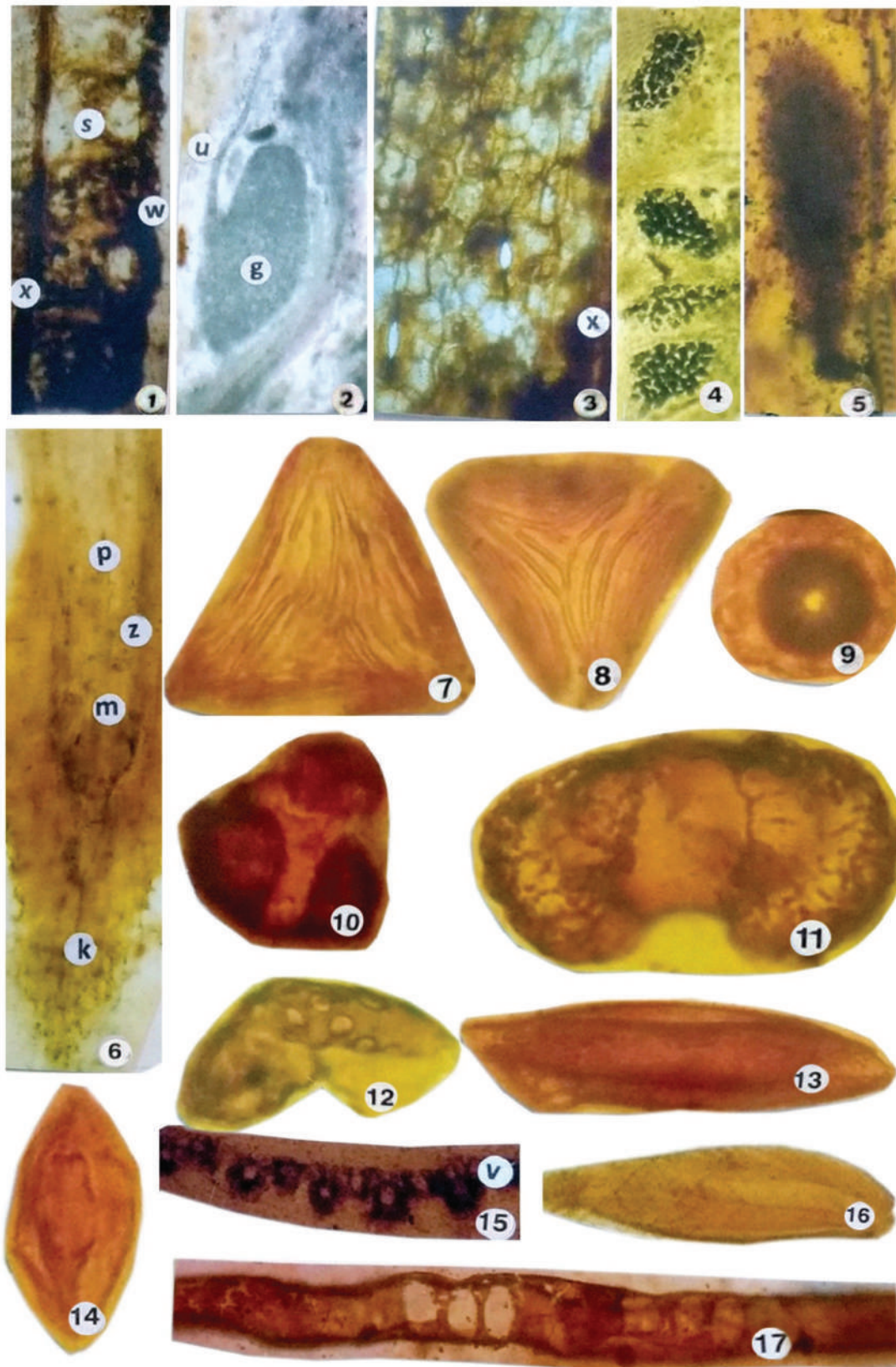


Figure 3

Bennettitales) are seen in thin sections prepared of Nipania chert (Figure 3.13–14, 16). These vary in shape and size (Vishnu Mittre 1954, Sah & Jain 1966).

Podocarpian bi- and tri-saccate pollen: These pollen occur frequently in Nipania chert (Figure 3.10, 11). Bisaccate pollen are assigned to *Podocarpidites* while tri-winged pollen to *Microcachrydites*.

Unidentified spores: In Figure 3.9, the spore is circular with a ring of ornamentation. There is a thick darker ring which encloses the central pore or cavity. It resembles to some extent *Stapilinisporites cominus* (Venkatachala 1968). Figure 3.12 has small circular pores in the spore or pollen (?), wall identification unknown.

Rootlet (median longi-section): In slide no. BDN 204/Raj N, there is a median longi section of a rootlet (Figure 3.6). It has a distinct well developed and preserved root cap (k) which covers distinct and cellular apical meristem (m) consisted of many rectangular cells from which originates the vascular tissue (z), Pith (p) and the cortex. Probably it is a median longi section of a gymnosperm rootlet (Esau 1965, Fahn 1967, Pillae 1972). This is the first record of a petrified median longi section of a gymnosperm rootlet in the Rajmahal Hills.

Monocot leaf: Sharma (1997) discovered a petrified magnoleean fructification resembling *Lesqueria* Crane & Dilcher from Amarjola in the Rajmahal Hills. Sharma et al. (2001) described a cross section of a monocot leaf (Figure 3.15) having parallel vascular bundle (v) and buliform cells, a characteristic of monocot leaves.

Phloem cells: An isolated sieve cell was observed in a thin section of petrified debris of Nipania chert (Figure 3.17). The sieve cell is long, cylindrical with oblique end walls. It has uniseriate row of distinct sieve areas some of which are empty while in others sieve plates are visible with sieve pores. Sharma (1970a) had described presence of

sieve areas in the phloem of *Bucklandia dichotoma* Sharma. To which group of plant this phloem group belongs, remains unknown.

The above account makes it clear that the recovered assemblage is represented by variety of groups, e.g. *Chromista*, *Fungi*, and plants. Among plants, pteridophytes and gymnosperms were common whereas other groups were rare and restricted to only few areas. The area had lakes and ponds in which the vegetation was buried by the lava flow from northern to the southern portion of the area.

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