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Thinnfeldia indica Feistmantel and associated plant fossils from Tiruchirapalli District, Tamil Nadu

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ABSTRACT

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Plant mega-and microfossils recovered from the Teraini clay pits and a tube well near Naicolam, both in Tiruchirapalli District, have been listed. Cuticular features of *Thinnfeldia indica* Feistmantel have been described in detail and its affinities traced to the cycads. On the basis of totality of characters, an independent taxonomic status of the genus *Thinnfeldia* vis-a-vis the genera *Dicroidium* and *Pachypteris* is confirmed. Data pertaining to the age of Utatur plant beds are briefly reviewed.

Key-words—*Thinnfeldia*, Cuticle, Cycadales, Sivaganga Formation, Palynofossils, Lower Cretaceous (India).

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सारांश

तमिलनाडु में तिरुचिरापल्ली जनपद से थिन्फ़ेल्डिआ इन्डिका फ़ाइस्टमैन्टॅल एवं सहयुक्त पादपाश्म

हरिकृष्ण माहेश्वरी

तेरानी मृत्तिका गर्त्तों एवं नैकोलम् के समीप एक नलकूप से उपलब्ध गुरु-एवं सूक्ष्मपादपाश्मों की तालिका दी गई है। ये दोनों स्थान तिरुचिरापल्ली जनपद में हैं। थिन्फ़ेल्डिआ इन्डिका फ़ाइस्टमैन्टॅल के उपचर्मीय लक्षणों का विस्तृत वर्णन किया गया है तथा साइकेडेल्स से इसकी सजातीयतायें अन्वेषित की गई हैं। सम्पूर्ण लक्षणों के आधार पर डाइक्रोयडियम और पेकिप्टेरिस की तुलना में थिन्फ़ेल्डिआ प्रजाति का एक स्वतन्त्र वर्गीकरणिक स्थान सुनिश्चित किया गया है। उत्तातुर पादप संस्तरों की आयु सम्बन्धी आँकड़ों की संक्षिप्त रूप से समीक्षा भी की गई है।

INTRODUCTION

ON the East Coast of India, in the districts of Cuttack, Krishna Godavari, Nellore, Guntur, Chingleput, Tiruchirapalli and Ramanathapuram, occurs a series of small exposures of 'Upper Gondwana' rocks. Some of these contain plant fossils associated with marine animals. The plant remains usually occur as impressions though carbonaceous matter is not entirely unknown, having been found in Siddheswar Hill near Cuttack, and in the subsurface near Naicolam. A majority of the plant fossils recovered from these sediments resembles the ones from the Rajmahal Intertrappean Beds, though a few species are allied to the Jabalpur forms.

In the Tiruchirapalli District, the Upper Gondwanas are represented by the 'Uttatur Plant Beds' which directly rest upon the Archaean gneiss. These beds, which occur in five small isolated patches along a 20 kilometer long north-south strip, are unconformably overlain by the marine beds (Utatur Formation) of Upper Cretaceous age. These beds, later named as "Terani Beds" by Shah and Singh (1972) after the village Teraini (Terani, Terany, 11°6′ : 18°52′30″) have a white and ash-grey clay as the predominant lithology.

Acharyya, Singh and Ghosh (1977, p. 85) include the Uttatur Plant Beds and Teraini Beds in the Sivaganga Formation whose outcrop thickness is not known but in subsurface is estimated to be more than 1090 meters. That the Uttatur Plant Beds occur within the Sivaganga Formation is yet to be convincingly demonstrated. The type section of the Sivaganga Formation is exposed near Paiyur (9°51′ : 78°31′) which is more than 75 kilometers south of Uttatur (11°04′ : 78°55′). In the type area the formation comprises a basal conglomerate overlain by alternating shales and grits. The "Uttatur Pland Beds" on the other hand comprise predominantly white and ash-grey clays with subordinate ferruginous and argillaceous sandstones.

The plant fossils from the Utatur Plant Beds of the Tiruchirapalli District were first reported by Foote (1878). Plant fossils recorded from different locations were listed by Feistmantel (1879, p. 9-11). Somehow, all these records were missed by Lakhanpal *et al.* (1976) in their *Catalogue of Indian Fossil Plants.* Feistmantel's list, with names updated, is as follows : (numerals in parentheses represent the localities, 1. Naicolam, 2. Utatur, 3. Teraini, 4. Between Teraini and Kari, 5. North of Kalpadi, and 6. Marvatur).

Todites indicus (Oldham & Morris) Bose & Sah (2, 3)
Ptilophyllum acutifolium Morris (1, 2, 3, 6)
P. cutchense Morris (?2, 5)
P. cutchense var. *minimum* Feistmantel (4)
Otozamites angustatus Feistmantel (1, 3)
Dictyozamites indicus Feistmantel (3, 6)
Taeniopteris spathulata McClelland (2, 3, 5, 6)
Macrotaeniopteris ovata Schimper (6)
Araucarites ?indicus (6)
Elatocladus conferta (Morris) Seward & Sahni (3)
E. jabalpurensis (Feistmantel) Sahni (3)
Echinostrobus (3)
Pachyphyllum? (2)
Pterophyllum? Macrotaeniopteris? (5)

Gopal, Jacob and Jacob (1957, p. 494, table 3) listed following additional forms from the "Uttatur" of Tiruchirapalli :

Otozamites rarinervis
Dictyozamites falcatus
Taeniopteris ovata
Elatocladus plana
Araucarites cutchensis
Actinopteris sp.

Some more taxa were added to the flora of the Teraini bed by Mamgain, Sastry and Subbaraman (1973). They also found three taxa of ammonites associated with *Ptilophyllum cutchense* in a 2 meter thick ash-grey clay and sandy clay. The fossils recorded include :

Ptilophyllum cutchense
Pseudoctenis footeanum
Nilssonia fissa
Rhizomopteris sp.
Desmiophyllum sp.
Araucarites sp. cf. *A. cutchense*
?Ginkgoites sp., and the ammonites
Pascoeites sp. cf. *P. crassus*
Gymnoplites sp. cf. *G. simplex*, and
? Inoceramus sp.

In the present communication plant fossils are recorded from two of Foote's localities, and the cuticular structure of one of the species is also illustrated.

MATERIAL

The plant fossils, both mega- and micro-, reported here were collected from (1) Teraini clay pits, and (ii) shale dumps of a tube well near Naicolam, Tiruchirapalli District, Tamil Nadu. The fossils from the Teraini clay pits are impressions on a grey-buff, micaceous sandy shale. The Naicolam fossils occur in a grey, micaceous-carbonaceous, carbonaceous, coarse- to fine-grained shale. Sometimes, the carbonified crust of the fossil is also present, though very rarely it yielded the cuticle. All hand specimens and cuticular preparations are in the repository of Birbal Sahni Institute of Palaeobotany, Lucknow.

CHECKLIST OF FOSSIL PLANTS

Leaves (*with well-preserved cuticle)

Ptilophyllum acutifolium Morris
P. cutchense Morris
Dictyozamites indicus Feistmantel
Otozamites sp.
**Thinnfeldia indica* Feistmantel
Taeniopteris spathulata McClelland
**Elatocladus heterophylla* Halle
E. conferta (Morris) Seward & Sahni
**Pagiophyllum marwarensis* Sukh Dev & Bose
Araucarites cutchensis Feistmantel

Pollen and spores—(figure in parentheses indicates the per cent occurrence of the genus as calculated from a count of 600 identifiable specimens) :

Cyathidites minor Couper
Deltoidospora hallei Miner (1.66%)
Biretisporites sp.
Gleicheniidites sp.
Osmundacidites wellmanii Couper (0.33%)
Neoraistrickia sp.
Klukisporites sp.
Contignisporites fornicatus Dettmann (2.83%)
C. glebulentus Dettmann
Cooksonites sp. (0.8%)
Trilites tuberculaeformis Dettmann
Monolites grandis Dev (0.33%)
Thymospora sp. (1.5%)
Callialasporites dampieri (Balme) Dev (24.5%)
C. trilobatus (Balme) Srivastava
Araucariacites + *Inaperturopollenites* (47.0%)
Podocarpidites ellipticus Cookson (7.0%)
Alisporites spp. (9.5%)
Vitreisporites pallidus Reissinger (1.83%)
Cedripites nudis Kar & Sah (0.66%)
Microcachryidites antarcticus Cookson

DESCRIPTION

Thinnfeldia indica Feistmantel

Pl. 1, figs 1, 4; Pl. 2, figs 1-6

1876 *Thinnfeldia indica* Feistmantel, *Rec. geol. Surv. India* **9**(2) : 35.

1877 *Thinnfeldia indica* Fstm. : Feistmantel, *Mem. geol. Surv. India Palaeont. indica* **2** : 35, pl. 39, fig. 1, 1a; pl. 47, figs 1, 2, 2a.

1914 *Thinnfeldia indica* Feistm. : Antevs, *K. svenska VetenskAkad. Handl.* **51**(6) : 36, pl. 5, fig. 3.

1979 *Thinnfeldia indica* Feistmantel, 1876 : Zeba-Bano, Maheshwari & Bose, *Palaeobotanist* **26** : 145, pl. 1, figs 1-6; pl. 2, figs 8, 9; text-fig. 2 A-D.

Morris (in Oldham & Morris, 1863) reported an incomplete specimen possibly representing the apical part of a fern frond, from Teladuni near Ghutiari, Rajmahal Hills, Bihar, under the name *Pecopteris* (?) *salicifolia* n. sp., though he found it rather nearer to *Kirchneria trichomanoides* Braun. Feistmantel (1876, 1877) described and illustrated a number of similar specimens from Burio and Buskoghat in the Rajmahal Hills, with which is also identified Morris' *P. salicifolia*. However, for reasons unknown, he gave a new species epithet, *indica*, to his specimens and described these under the genus *Thinnfeldia*.

Zeba-Bano, Maheshwari and Bose (1979) reported similar well-preserved specimens from Pathargama, Rajmahal Hills, but again included these under *Thinnfeldia indica* Feistmantel. Their work does not refer to Morris' species.

A specimen from Amarjola, Rajmahal Hills, referred to *Thinnfeldia lancifolia* (Morris) Walkom, 1925 by Sharma *et al.* (1971) possibly represents the apical part of a *T. indica* frond. A definite statement can not be made without examining the hand specimen as there is a discrepancy in the magnifications of illustrations [cf. Sharma, Surana & Singh, 1971, pl. 1, fig. 3 (x 2) and text-fig. 6 (x 6)] and as the venation pattern has not been described by these authors.

Morphologically, all the specimens referred to above from Burio, Buskoghat and Pathargama conform to the delimitation of the genus *Thinnfeldia*. The Tiruchirapalli specimens conform to the circumscription of *Thinnfeldia indica* in overall morphography. Diagnosis of the taxon as given by Zeba-Bano *et al.* (1979) is accepted here.

Cuticular features—Cuticle stiff, well-preserved, though infected with many species of fungi, equally thick on both surfaces, characteristically amphistomatic, i.e. on lower surface stomata present all over except over midrib and secondary veins (Pl. 2, figs 2-3), whereas on upper surface stomata distributed only in midrib region (Pl. 2, fig. 1). Abnormally, however, a stoma or two present over midrib region of lower surface or very sparse over midrib region of upper surface.

Vein and intervein areas clearly decipherable over both surfaces. Basically, epidermal cells on both surfaces polygons, but those of upper surface of relatively shorter dimensions. Veins, however, distinguished by elongate polygonal or rectangular cells, mostly arranged end-to-end in 4-19 rows (Pl. 2, fig 3). Cell walls 2.5-3.75 μm thick, both lateral and end walls straight, surface walls unspecialised, with a granulate texture. Angles between adjacent cells sharp or rounded. Cells over midrib region of upper surface not much different than other cells, but on lower surface 4-6 times longer than broad, arranged end-to-end in 16-51 rows.

Stomata similarly constructed on both surfaces, irregularly distributed but oriented more or less parallel to course of midrib on upper surface. On lower surface stomata irregularly distributed but oriented mostly along course of veins (Pl. 2, fig. 3).

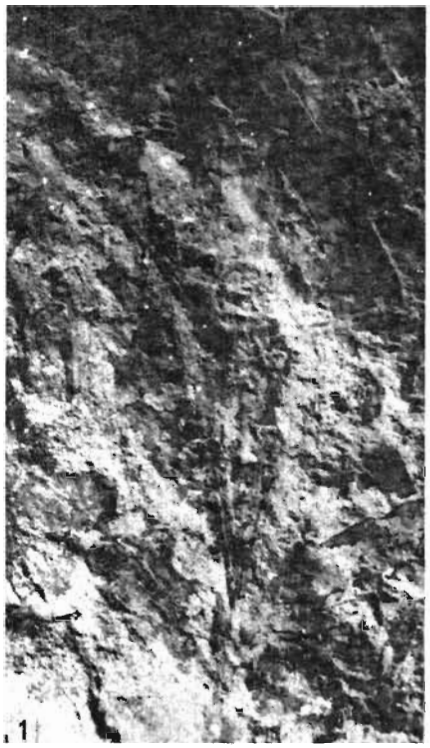
Stomata haplocheilic, varying considerably in size and shape. Guard cells bean-shaped, cutinised, deeply sunken, 26-58 μm long, encircled by 5-6 (rarely more) subsidiary cells which overarch stomatal pit forming a "crater"-like structure (epistomal chamber) (Pl. 2, figs 5, 6). On compression overarching part of subsidiary cells usually forms a thick rim around stomatal pit encompassing an isodiametric to ellipsoid opening (Pl. 2, fig. 6), 15-25 μm wide and 25-55 μm long, usually eccentrically placed over stomata. Possibly encircling cells also play a part in formation of epistomatal chamber.

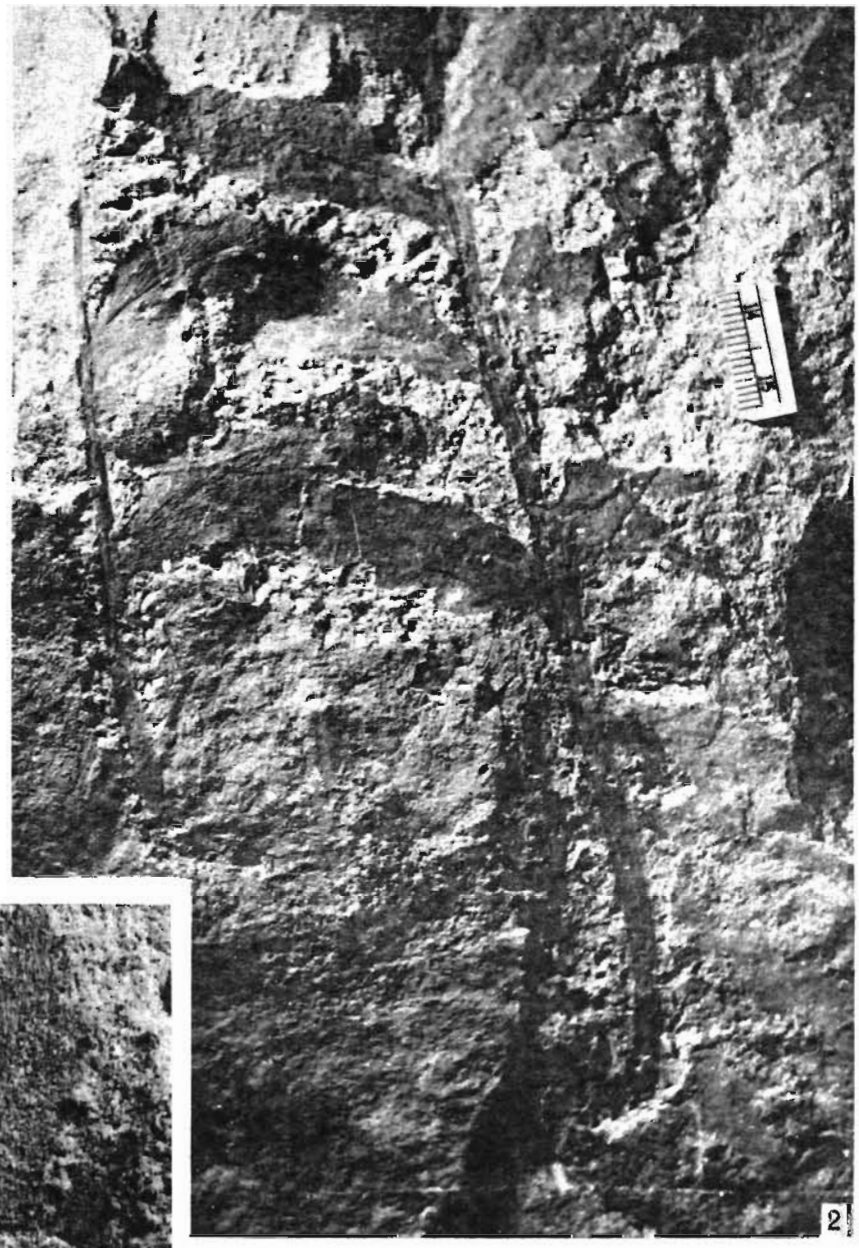
Remarks—The case with which fairly large pieces of cuticle could be recovered from the fossil shows that the epidermis was highly cutinised giving a characteristic leathery texture to the leaf compression. The stomatal apparatus with its characteristic overarching cutinized subsidiary cells is reminiscent of cycadalean stomatal apparatus, particularly those of *Zamia muricata* (Arnold, 1953, figs 1-3), *Dioon edule* (Greguss, 1957, pl. 3, figs 11, 12) and *Cycas revoluta* (Greguss, 1957, pl. 3, figs 7, 8). In the last two species, however, the stomatal pit is formed by overarching of encircling cells. In *Dioon edule* the encircling cells have lignitized walls. There is some

PLATE 1 →

Thinnfeldia indica Feistmantel, 1877

1. Near apical part of a frond. Locality—near Naicolam. Specimen no. 54/2117B. × 1.
2. An impression showing a pinnate leaf, longitudinally striated rachis, longish petiole, subopposite, lanceolate pinnules with decurrent basiscopic margins, a faint midrib and distinct lateral veins. Locality—near Naicolam. Specimen no. 26/2117 × 1.
3. Near apical part of a frond with well-preserved carbonified crust. Locality—near Naicolam. Specimen no. 57/2117. × 2. (counterpart no. 58/2117, not figured here).
4. A single pinnule showing a feeble midrib and bifurcating lateral veins. Locality—Teraini Clay Pits. Specimen no. 44/2118. × 2.





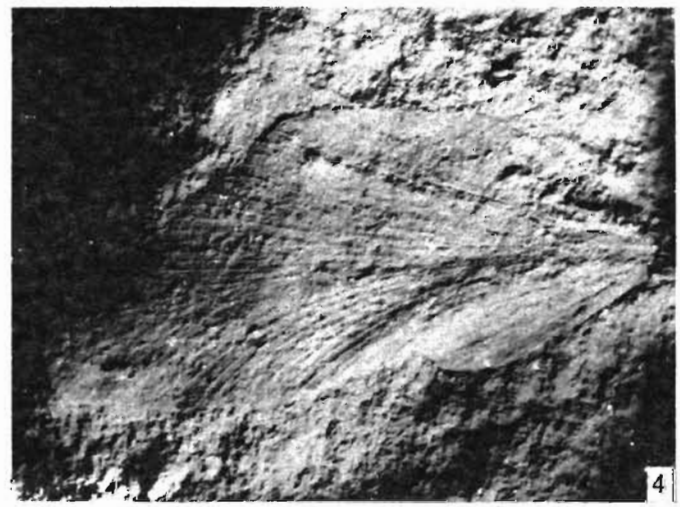


PLATE 1

evidence of lignitization of subsidiary cells in *Thinnfeldia indica* as evidenced by the different texture of their inner halves. However, it can not be proved without a microchemical analysis. The stomatal apparatus is remarkably similar to that of *Ticoa lamellata* Archangelsky (1966, pl. 2, fig. 11; pl. 3, figs 15, 16).

Epidermal features of *Thinnfeldia indica* are indicative of xerophytic environment. The heavy cutinization of epidermis was probably in response to an arid or semiarid climate (Arnold, 1953, p. 54). The low frequency of stomata, 15-44 per sq mm and the protection of the stomatal aperture by overarching cells also point towards conditions of water loss (Eames & MacDaniels, 1947, pp. 167, 333).

TAXONOMIC POSITION OF THE GENUS *THINNFELDIA*

The genus *Thinnfeldia* was established by Ettingshausen (1852, p. 2) for a plant fossil from the Liassic of Steierdorf, which he presumed was related to the conifer *Phyllocladus*. Ettingshausan identified four species, viz., *T. rhomboidalis* and *T. speciosa* from the Liassic of Banat (Rumania) and *T. muensteriana* and *T. parvifolia* from the Liassic of Germany. Andrae (1855, p. 43) opined that the genus *Thinnfeldia* was indistinguishable from the genus *Pachypteris* Brongniart. A thorough investigation of *Thinnfeldia* was undertaken by Schenk (1867, p. 105) whose circumscription of the genus was based on uniformity of characters, i.e. alethopteroid venation. However, soon thereafter forms with odontopteroid venation were also included in this genus, e.g. *T. crassinervis* Geinitz (1876, p. 4) and *Pecopteris odontopteroides* Morris. Seward (1904, p. 31) significantly emended and amplified the genus so much so that *Cycadopteris brauniana* Zigno, *C. heterophylla* Zigno, *Lomatopteris jurensis* (Kurr) Schimper and *Stenopteris desmomera* Saporta were also included.

Gothan (1912) recommended that the genera should be based on homogeneous characters and accordingly he separated forms with forked rachides under a new genus *Dicroidium* Antevs (1914), however, did not agree with this approach as he felt that forking of rachis is a universal character and has been found in entirely different forms. He also did not support Gothan's surmise that the two genera differed in the characters of the epidermis, too. In a specimen of *Dicroidium feistmantelli* which he investigated (Antevs; 1913, p. 4) the cells have thick and straight walls as in *Thinnfeldia*. Townrow (1957) placed Antevs' specimen in his new genus *Hoegia* as *H. papillosa*. Dicroidia with straight-walled cells of the epidermis have also been reported from the Nidhpuri beds of South Rewa Gondwana Basin and Ischigualasto Formation of Argentina (Bose & Srivastava, 1971; Archangelsky, 1968). However, few of these specimens show the forking rachides, presumed to be characteristic of the genus *Dicroidium*. According to Archangelsky (1968, p. 501) it is not easy to find the forked main rachis as the fronds were large and commonly got broken. Interestingly, one of several typical *Dicroidium* specimens illustrated by Flint and Gould (1975, pl. 3, fig. 10) shows an unusual double dichotomy of the rachis.

All the same, Antevs found some remarkable differences between the genera *Thinnfeldia* and *Dicroidium*. For example, the pinnules of *Thinnfeldia* in general are more or less elongate-rhomboid with alethopteroid venation, whereas the smaller and broader pinnules of *Dicroidium* have typically odontopteroid venation. However, *D. lancifolium* (Morris) Gothan (=*Thinnfeldia lancifolia* Morris) shows both types of venation and consequently represents a connecting link between the two genera.

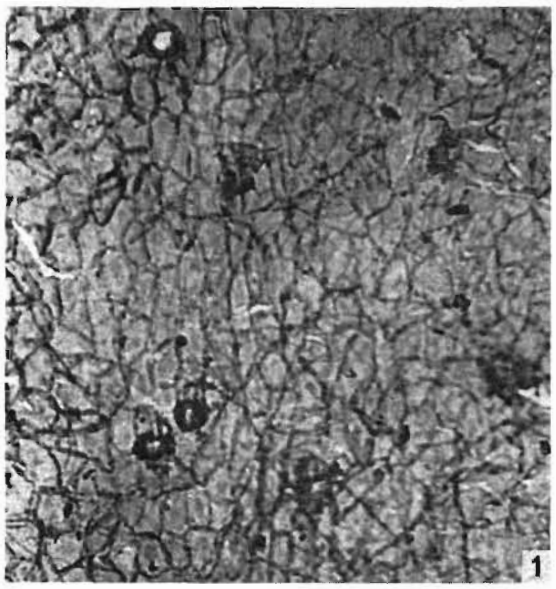
Antevs believed that the stomatal apparatus has a complete analogy with the recent xerophytes as the stomata occur in a pit.

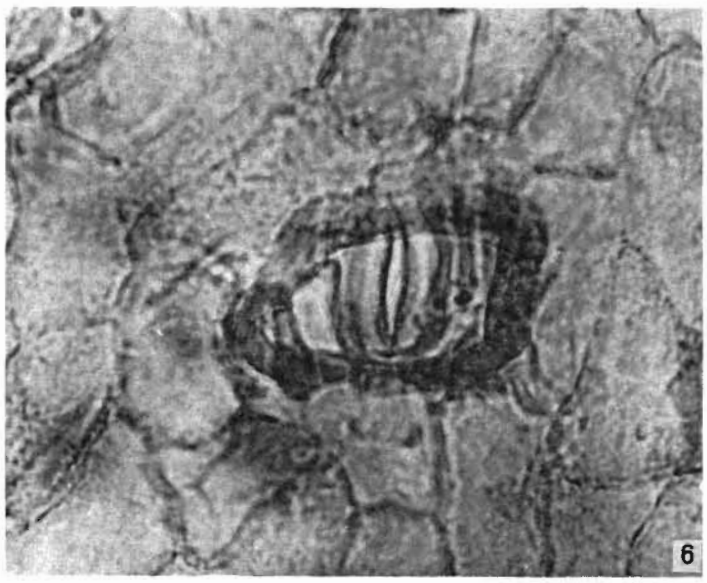
Thinnfeldia indica Feistmantel, as defined morphologically by Zeba-Bano, Maheshwari and Bose (1979) and with its cuticular features described in the present paper, matches in all major characters the genus *Thinnfeldia* as defined above by Antevs (1914). Of course, there is a noticeable difference in the distribution of the stomata. In *T. indica* these are characteristically found on the entire lower epidermis except for the midrib and lateral vein areas, while confining themselves to midrib region only of the upper surface. Thus the occurrence of the genus *Thinnfeldia* in the southern hemisphere is confirmed. *Thinnfeldia* was possibly widely distributed in Gondwanaland at one time (Jack & Etheridge, 1882; Shirley, 1898; Seward, 1904; Halle, 1913; Jain & Delevoryas, 1967).

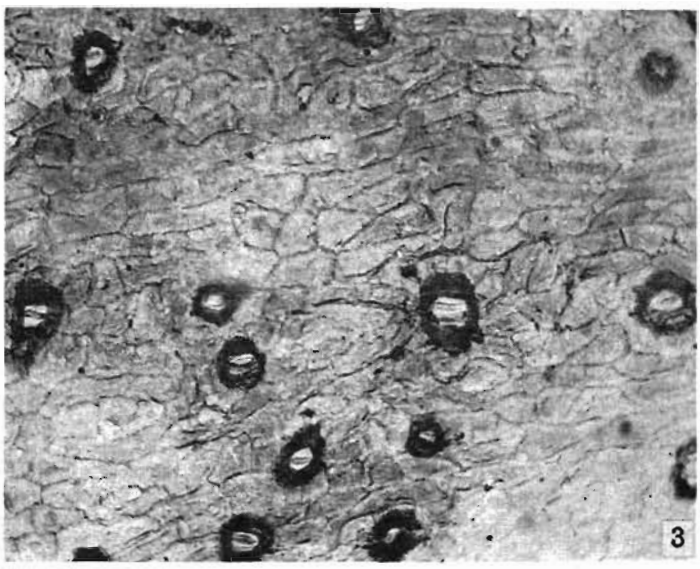
PLATE 2

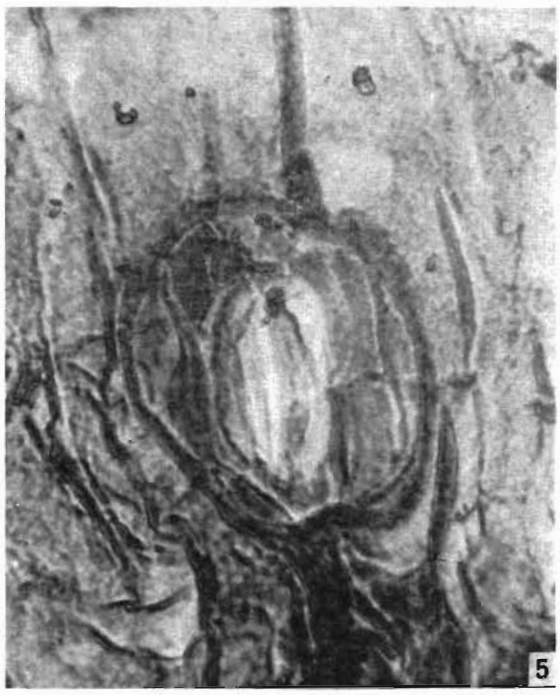
Thinnfeldia indica Feistmantel, 1877

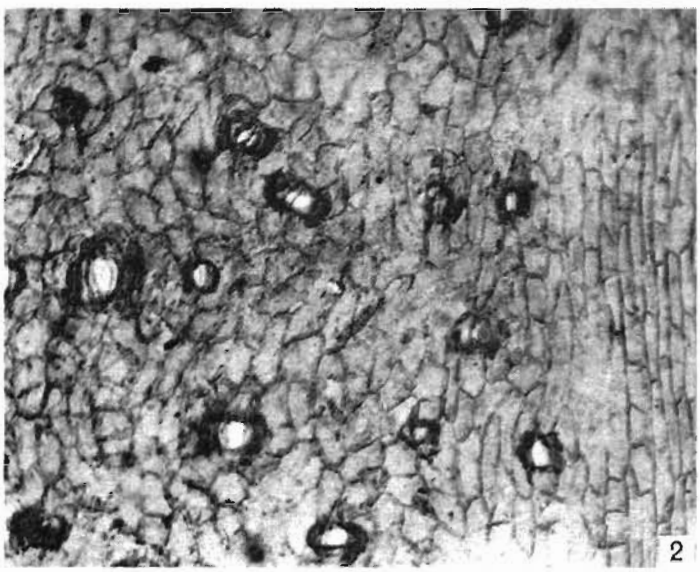
1. Cuticle of the midrib region of upper surface showing very sparsely distributed stomata. Slide no. 58/2117-1. × 120.
2. Lower cuticle showing region near midrib. Slide no. 58/2117-2. × 120
3. Lower cuticle showing stomatiferous and nonstomatiferous regions corresponding to intervein and vein areas respectively. Slide no. 54/2117A-1, × 120.
4. Lower cuticle of a leaf showing a near nonstomatiferous midrib flanked by stomatiferous intervein regions. Slide no. 58/2117-2. × 50.
5, 6. Stomata on the lower surface. 5, slide no. 58/2117.2; 6, slide no. 54/2117B-2. All × 470.











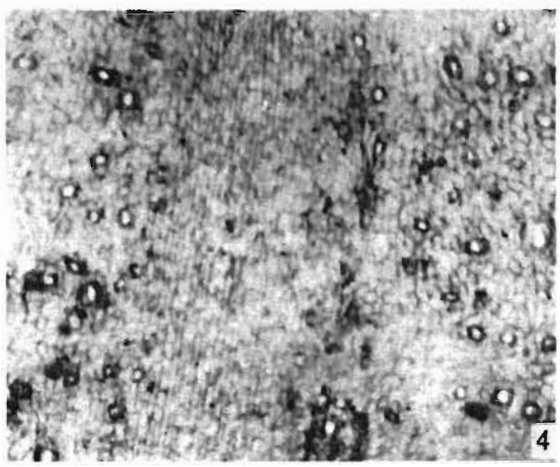


PLATE 2

Doludenko (1967, 1969, 1974) believes that the leaves of the genus *Thinnfeldia* do not differ from those of *Pachypteris*, either in external morphology or in epidermal features. She bases this conclusion on a comparison of the epidermal features of a specimen of *Thinnfeldia* from the collection of Faculty of Geology and Geophysics, Bucharest University and that of *Pachypteris lanceolata* from the type locality. However, according to Harris (1964) the subsidiary cells of *Thinnfeldia* are arranged in a neat collar while in *Pachypteris* their arrangement is not so regular and the number is also comparatively less. Epidermal features of several other species of *Thinnfeldia* are also known (Bose, 1959; Vladimirovich, 1965, etc.). Their epidermal features do seem to be similar to species of the genus *Pachypteris* (Delle, 1967; Doludenko, 1969; Doludenko & Svanidze, 1969). The epidermis of *Thinnfeldia indica* has characteristic stomata which are rather like those of *Pachypteris holdenii* Bose & Roy, 1968 and to a lesser extent like those of *Pachypteris indica* (Oldham & Morris, 1863) Bose & Roy, 1968. Similar stomata had also been reported for *Thinnfeldia rhomboidalis* from Yorkshire (Thomas, 1915). The common feature in stomata of all these species is the heavy cutinization of the inner half of subsidiary cells which form the stomatal pit. It would thus seem that the cuticular features are a result of ecological niches in which the plants grew and can not be taken as characters of taxonomic value on an inter-regional basis.

Morphologically it is not difficult to separate *Thinnfeldia* from *Pachypteris*, the latter being bipinnate (excepting *Pachydermophyllum papillosum* cf. Harris, 1964) with extremely feeble midrib and obscure lateral veins (Barnard, 1965; Zeba-Bano, Maheshwari & Bose, 1979, p. 148). While *Thinnfeldia* possesses leathery, comparatively thin pinnules, *Pachypteris* shows mostly small and very thick, sometimes almost round and succulent pinnules. The genera *Cycadopteris* Zigno and *Lomatopteris* Schimper also differ from the genus *Thinnfeldia* in having either linear, long and narrow or very small and broad pinnules with the characteristic margin and imperceptible venation.

AFFINITIES OF THE GENUS *THINNFELDIA*

The affinities of this genus have been traced to almost all groups of vascular plants, e.g. Pteridophyta, Pteridosperms, Cycadophyta, Coniferophyta, etc. Ettingshausen (1852, p. 2) and Andrae (1855, p. 43) placed *Thinnfeldia* with the conifers. Schenk (1867, p. 107) considered it to be a cycadean plant, particularly so on the basis of the stomatal structure but later (Schenk, 1888, p. 44) he seemingly changed his opinion and regarded *Thinnfeldia* as a fern. This view was also held by Schimper (1869, p. 495), Saporta (1873, p. 341), Nathorst (1878, p. 491), Raciborski (1894), Zeiller (1900, p. 97; 1907, p. 191). Seward (1910, p. 537) observed that *Thinnfeldia* answers to the Pteridosperms. Gothan (1912, p. 79) opined that the structure of stomata, thick texture and characteristic habit, all show that *Thinnfeldia* could not have been a fern. According to Antevs (1914) the resemblance between some species of the genus *(Thinnfeldia* and twigs of *Phyllocladus* in habit, venation and epidermal structure is so impressive that such *Phyllocladus* twig, when found as a fossil, will certainly be described as a *Thinnfeldia*. There is, however, one very important and major difference that in *Thinnfeldia* one never finds twigs in spiral attachment or in whorled simulations, which shows that these are leaves and not twigs.

If we leave aside the typical amphistomatic distribution of stomata, other characters, particularly those of the epidermis, as observed in *Thinnfeldia indica* point towards a cycadean affinity.

AGE OF THE UTATUR PLANT BEDS OF TIRUCHIRAPALLI

As mentioned earlier, the fossil flora of the Utatur Plant Beds of Tiruchirapalli District has a fairly large percentage of elements of the Mesozoic flora of the Rajmahal Hills, Bihar. Latest addition to the list of common plants is *Thinnfeldia indica* Feistmantel. Feistmantel (1877) regarded the Rajmahal flora to be of Liassic age while Sah and Jain (1965) palynologically dated it as Upper Jurassic. The palynological age has now been revised to Lower Cretaceous by Maheshwari and Jana (1984). Occurrence of the genus *Thinnfeldia* also supports a Lower Jurassic age. However, in recent years a radiometric Lower Cretaceous age has been advocated for the Rajmahal Traps (McDougall & McElhinny, 1970). Therefore, the Utatur Plant Beds could also be of the same age if the radiometric age of the Rajmahal Traps also encompasses the fossiliferous intertrappean layers. A Lower Cretaceous age is further indicated by the associated ammonites (Pascoe, 1959, p. 998; Mamgain, Sastry & Subbaraman, 1973, p. 199). The association, on the East Coast, of plants indicating a Jurassic age and ammonites indicating a Lower Cretaceous age was attributed by Bhalla (1972) to reworking. I find it difficult to visualise reworking of plant megafossils on such an extensive scale and that too resulting in their alignment parallel to overall bedding plane, as in the Teraini clay pits. Overall evidence from ammonites, plant megafossils and palynofossils suggests a Lower Cretaceous (Neocomian) age to these sediments.

REFERENCES

Acharyya, S. K., Singh, G. & Ghosh, R. N. 1977. Sivaganga Formation, pp. 85-88 in Sastry *et al.* (eds.)—*Stratigraphic lexicon of Gondwana formations of India. Geol. Surv. India Misc. Publ.* (36).

Andrae, K. J. 1985. Beitrage zur Kenntnis der fossilen Flora Siebenburgens und des Banates. II. Lias-Flora von Steierdorf im Banate. *Abh. geol. Bundesanst, Wien* **2**(3/4) : 27-48.

Antevs, E. 1913. Some Mesozoic plants. Pt. V. *in Results of Dr E. Mjobergs Swedish scientific expeditions to Australia 1910-1913.* Almqvist & Wiksells, Uppsala & Stockholm.

Antevs, E. 1914. Die Gattungen *Thinnfeldia* Ett. und *Dicroidium* Goth. *K. svenska VetenskAkad. Handl.* **51**(6) : 1-72.

Archangelsky, Sergio 1966. New gymnosperms from the Ticó flora, Santa Cruz Province, Argentina. *Bull. Br. Mus. (nat. Hist.) Geol.* **13**(5) : 259-295.

Archangelsky, Sergio 1968. Studies on Triassic fossil plants from Argentina. IV. The leaf genus *Dicroidium* and its possible relation to *Rhexoxylon* stems. *Palaeontology* **11**(4) : 500-512.

Arnold, C.A. 1953. Origin and relationships of the Cycads. *Phytomorphology* **3** : 51-65.

Barnard, P. D. W. 1965. Flora of Shemshak Formation. Part 1. Liassic plants from Durad. *Riv. Ital. Palaeont.* **71**(4) : 1123-1268.

Bhalla, S. N. (1972). Upper age limit of the East Coast Gondwanas, India. *Lethaia* **5** : 271-280.

Bose, M. N. 1959. Leaf-cuticle and other plant microfossils from the Mesozoic rocks of Andrya, Norway. *Palaeobotanist* **8** : 1-7.

Bose, M. N. & Roy, S. K. 1968. On the occurrence of *Pachypteris* in the Jabalpur Series of India. *Palaeobotanist* **16** : 1-9.

Bose, M. N. & Srivastava, S. C. 1971. The genus *Dicroidium* from the Triassic of Nidpur, Madhya Pradesh, India. *Palaeobotanist* **19**(1) : 41-51.

Brongniart, Adolphe 1828-1836. *Histoire des végétaux fossiles, ou recherches botaniques et géologiques sur les végétaux dans les diverses couches du globe.* **1**. Paris.

Delle, G.V. 1967. Srednejurskaya flora Tkvarchelckova uglenosnava bassiyna. *Trudy bot. Inst. Akad. Nauk SSSR*, ser. 8, *Palaeobot.* (6) : 1-132.

Doludenko, M. P. 1969. On the relation of the genera *Pachypteris* and *Thinnfeldia. Trudy geol. Inst. Akad. Nauk SSSR* **190** : 14-34.

Doludenko, M.P. 1971. *Thinnfeldia*—junior synonym of *Pachypteris. Palaeont. zh.* **1971**(2) : 99-104.

Doludenko, M. P. 1974. On the relation of the genera *Pachypteris, Thinnfeldia* and *Cycadopteris*, pp. 8-16 in Bose, M. N. (ed.)—*Symposium on morphological and stratigraphical Palaeobotany.* Birbal Sahni Institute of Palaeobotany, Lucknow, Spec. Publ. No. 2.

Doludenko, M. P. & Svanidze, T. I. 1969. The late Jurassic flora of Georgia. *Trudy geol. Inst. Akad. Nauk SSSR* **178** : 1-116.

Eames, A. M. & MacDaniels, R. 1947. *Plant Anatomy.* McGraw Hills, New York.

Ettingshausen, C. 1852. Begrundung einiger neuen oder nicht genau bekannten Arten der Lias und Oolith Flora. *Abh. geol. Bundesanst, Wien* **3**(3) : 1-10.

Feistmantel, Ottokar 1876. Notes on the age of some fossil floras of India. *Rec. geol. Surv. India* **9**(2) : 28-42.

Feistmantel, Ottokar 1877. Jurassic (Liassic) Flora of the Rajmahal Group in the Rajmahal Hills, India. *Mem. geol. Surv. India Palaeont. indica*, ser. 11, **2** 53-162.

Feistmantel, Ottokar 1879. The fossil flora of the Upper Gondwanas. Outliers on the Madras Coast. *Mem. geol. Surv. India, Palaeont. indica*, ser 12, **3**(1) : 1-48.

Flint, J. C. E. & Gould, R. E. 1975. A note on the fossil megafloras of the Nymboida and Red Cliff Coal Measures, southern Clarence-Moreton Basin, N. S. W. *Jl. Proc. R. Soc. N. S. W.* **108** : 70-74.

Foote, F. B. 1878. *Rec. geol. Surv. India* **11** : 247.

Geinitz, H. B. 1876. Ueber rhaetische Pflanzen- und Thierreste in den argentinischen Provinzen La Rioja, San Juan und Mendoza. *Palaeontographica*, suppl. 3.

Gopal, V., Jacob, C. & Jacob, K. 1957. Stratigraphy and palaeontology of the Upper Gondwana of the Ramnad District on the East Coast. *Rec. geol. Surv. India*, **84**(4) : 477-496.

Gothan, W. 1912. Uber die Gattung *Thinnfeldia* Ettingshausen. *Abh. naturhist. Ges. Nurnberg* **19**(3) : 91-186.

Greguss, Paul 1957. The leaf-epidermis of the Cycadales. *Acta biol. Szeged*, n.s., **3** : 151-156.

Halle, T. G. 1913. The Mesozoic flora of Grahamland, pp. 1-123 in *Wissenschaftliche Ergebnisse der schwedischen Sudpolar-Expedition 1901-1903*, **3**(4). Stockholm.

Harris, T.M. 1964. *The Yorkshire Jurassic Flora. II. Caytoniales, Cycadales* and *Pteridosperms.* Br. Mus. nat. Hist., London.

Jack, R.L. & Etheridge, R. 1882. *The geology and palaeontology of Queensland and New Guinea.* **1** & **2** Brisbane.

Jain, R. K. & Delevoryas, T. 1967. A Middle Triassic flora from the Cacheuta Formation, Minas de Petroleo, Argentina. *Palaeontology* **10**(4) : 564-589.

Lakhanpal, R. N., Maheshwari, H. K. & Awasthi, N. 1976. *A Catalogue of Indian fossil plants.* Birbal Sahni Institute of Palaeobotany, Lucknow.

Maheshwari, H. K. & Jana, B. N. 1984. Cretaceous spore-pollen complexes from India, pp. 158-192 *in* Maheshwari, H. K. (ed.)-*Cretaceous of India.* Indian Assoc. Palynostrat., Lucknow.

Mamgain, V. D., Sastry, M. V. A. & Subbaraman, J. V. 1973. Report of ammonites from Gondwana plant beds at Terani, Tiruchirapalli District, Tamil Nadu. *Jl geol. Soc. India* **14**(2) : 198-200.

McDougall, I. & McElhinny, M. V. 1970. The Rajmahal Traps of India. K-Ar ages and palaeomagnetism. *Earth planet. Sci. Letts* **9** : 371-378.

Nathorst, A. G. 1878. Om floran i skånes kolforande bildningar. I. Floran vid Bjuf. *Sver. geol. Undersokn*, ser. C, (27).

Oldham, T. & Morris, J. 1863. Fossil flora of the Rajmahal Series in the Rajmahal Hills. *Mem. geol. Surv. India Palaeont. indica*, ser. 2, **1**(1) : 1-52.

Pascoe, E. H. 1959. *A manual of the geology of India and Burma.* New Delhi.

Raciborski, M. 1894. Flora koplana ogniotrwalych glinek krakowskich. I. Archaeogoniatae. *Pam. m.-przyr. Akad. umiei. Krakow* **18**.

Sah, S.C.D. & Jain, K.P. 1965. Jurassic spores and pollen grains from the Rajmahal Hills, Bihar, India, with a discussion on the age of the Rajmahal Intertrappean beds. *Palaeobotanist* **13** : 264-290.

Saporta, G. 1873. Plantes jurassiques. I. Algues, Equisetacées, Characées, Fougeres, *in Paleontologie franscaise*, 2nd ser. Vegetaux Paris.

Schenk, A. 1867. *Die fossile Flora der Grenzschichten des Keupers und Lias Frankens.* Wiesbaden.

Schenk, A. 1888. *Die fossilen Pflanzenreste.* Breslau.

Schimper, W. P. 1869. *Traite de palentologie végétale ou la flore du monde primitif dans scs rapports avec les formations geologiques et la flore du monde actuel.* **2** J. B. Bailliere et Fils, Paris.

Seward, A. C. 1904. On a collection of Jurassic plants from Victoria. *Rec. geol. Surv. Vict.* **1**(3) : 155.

Seward, A. C. 1910. *Fossil plants.* **2**. Cambridge Univ. Press.

Shah, S.C. & Singh, G. 1972. Terani beds (Utatur Plant bed); *in* Stratigraphic Lexicon of India. *Indian Minerals* **26**(4) : 118-119.

Sharma, B. D., Surana, A. C. & Singh, A. P. 1971. Jurassic plants from Amarjola in the Rajmahal Hills. *J. palaeont. Soc. India* **16** : 27-34.

Shirley, J. 1898. Additions to the fossil flora of Queensland. *Bull. geol. Surv. Qld* (7) : 1.

Thomas, H.H. 1915. The *Thinnfeldia* leaf-bed of Roseberry Topping. *Naturalist*, Jan. 1, 1915 : 7-13.

Townrow, J. A. 1957. On *Dicroidium*, probably a pteridospermous leaf, and other leaves now removed from the genus. *Trans. Proc. geol. Soc. S. Afr.* **60** : 1-36.

Vladimirovich, V. P. 1965. Ostatki nekotorykh predstaviteliy roda *Thinnfeldia* iz restkikh otolozhniy vostochnova Urala. pp. 238-249 in Modzalievskaya, E. A. (Ed.)—*Ezhevodnik Vsesoyuznovo palaeontologixheskova obscheshtva* **17**.

Walkom, A. B. 1925. Fossil plants from the Narrabeen Stage of the Hawkesbury Series. *Proc. Linn. Soc. N. S. W.* **50** : 214-224.

Zeba-Bano, Maheshwari, H. K. & Bose, M. N. 1979. Some plant remains

from Pathargama, Rajmahal Hills, Bihar. *Palaeobotanist* **26**(2) : 144-156.

Zeiller, R. 1900. Sur quelques plantes fossiles de la chine meridionale. *C. r. Acad. Sci., Paris* **130** (4).

Zeiller, R. 1907. Note sur quelques empreintes vegetals des gites de charbon de Yunnan meridional. *Ann. Mines*, ser. 10, **2**.