

Morphological and cuticular studies of Permian *Noeggerathiopsis*-leaves

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Cordaitales in Indian Gondwana flora is known only by the presence of linear-lanceolate leaves, possessing dichotomizing, parallel running veins, assigned to the genus *Noeggerathiopsis*. In the absence of Cordaitalean fructification, it has often been argued that Cordaitales is absent in Gondwana. Recently, some leaves have been discovered from Raniganj and South Rewa Gondwana Basin which are distinct from *Noeggerathiopsis* in having interstitial veins in between major veins, a character comparable with the leaves of *Cordaites* of Euramerian flora.

The cuticular investigation of leaves of *Noeggerathiopsis hislopii* (Bunbury) Feistmantel (1879) suggests that the morphologically similar leaves possess three distinct types of cuticles. A perusal of all the known species of *Noeggerathiopsis* also indicates that species based on cuticular features bear identical morphological character. Accordingly, it has been suggested that morphologically identical leaves with different cuticular structures be considered as morphotypes of a single species.

Key-words—Permian, *Noeggerathiopsis*-leaves, Lower Gondwana.

INTRODUCTION

THE genus *Noeggerathiopsis* was instituted by Feistmantel (1879) for the leaves described under *Noeggerathia?* (*Cyclopteris*) *hislopii* from Kamthi beds of Maharashtra, India. The leaves are simple, linear, lanceolate to spatulate in shape, apex obtuse, base tapering, margin entire, veins arise from base, straight to slightly arched towards margin, dichotomize frequently during upward course and run parallel to each other.

The leaves are very common in the Talchir and Karharbari formations of Lower Gondwana and at times *Noeggerathiopsis* has been attributed as the characteristic plant fossil of Lower Permian (Feistmantel 1879; Surange 1975; Srivastava 1997). Practically, the genus is absent in the Upper Permian horizons i.e. Upper Barakar, Barren Measures and Raniganj formations (Surange 1975; Srivastava 1997). However, recurrence of such leaves is noticed in the uppermost part of Permian, i.e. Kamthi Formation and Lower Triassic beds of India (Bunbury 1861; Lele 1956, 1962; Bose & Banerji 1976). It has been discussed by Chandra and Srivastava (1991) that leaves known from Kamthi and Triassic are distinct in pos-

sessing once or twice forked, parallel running veins, whereas leaves recorded from Lower Permian show frequently dichotomizing, parallel veins.

The external morphological features of *Noeggerathiopsis*-leaves of Lower Barakar seams of South Rewa Gondwana and Raniganj Coalfield indicate two different types of venation pattern. One type is typically represented by dichotomizing, parallel running veins, whereas other type shows finer veins in between major veins, a feature common with *Cordaites*-type leaves known in the contemporaneous flora of northern hemisphere, i.e. Euramerian and Angara (Chandra & Srivastava 1991; Srivastava 1996). Similar features have also been noticed in leaves discovered from South America (Archangelsky & Leguizamon 1980; Archangelsky & Cuneo 1981). The structural features of anatomically preserved *Noeggerathiopsis*-leaves further support the presence of two types of leaves in Gondwana flora (McLoughlin & Drinnan 1996).

Institution of the genus *Pantophyllum* (Rigby 1984) to accommodate the species based on cuticular features is not plausible and rightly rejected by McLoughlin and Drinnan 1996.

Cuticular studies on leaves identified as *Noeggerathiopsis hislopii* were carried out by Zeiller (1903), Seward & Sahni (1920), Høeg & Bose (1962) and Saksena (1963), but they did not consider the features important enough for specific circumscription. Lele and Maithy (1964) instituted three species, e.g. *N. indica*, *N. gondwanensis* and *N. zeilleri* on the basis of three distinct types of cuticle. On similar ground, Pant and Verma (1964) also made three new species, *N. bunburyana*, *N. papillosa* and *N. fibrosa*. However, *N. fibrosa* is morphologically distinct in having fibres in between major veins (like *Cordaites*). Although Lele and Maithy (1964) and Pant and Verma (1964) have found some differences in external features of leaves but our examination of type and figured specimens indicates that gross morphology of all the leaves assigned to different cuticular species are similar to each other.

MATERIAL

The samples for present study were collected from lower Barakar seams exposed in Rawanwara Khas, Rawanwara incline and Pench-East collieries of Pench Valley Coalfield, Satpura Gondwana Basin situated in Chhindwara district, Madhya Pradesh. The geology and stratigraphic succession of the area has been studied by Raja Rao (1983). The leaves are preserved as coalified compression on sandy carbonaceous shale. Besides *Noeggerathiopsis*-leaves, the flora is represented by different species of *Gangamopteris*, *Glossopteris*, *Euryphyllum*, *Neomariopteris*, *Burialdia*, *Vertebraria*, *Samaropsis* and *Cordaicarpus*-type seeds.

The cuticular preparations from coalified compression specimens were made as method adopted by Lele and Maithy (1964) and Pant and Verma (1964). All the figured specimens and slides are preserved in the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

OBSERVATION

Well preserved leaves of *Noeggerathiopsis* showing distinct venation pattern were sorted out to examine the morphological and cuticular features. Well defined cuticles having lower, upper surfaces with stomatiferous and nonstomatiferous cells are recovered from fourteen specimens.

Leaves are mostly incomplete, measure 3 to 14 cm in length and 0.5 to 3.3 cm in width, normally narrow-linear, lanceolate-spatulate in shape; apex obtuse, base tapering, margin entire; 3-8 veins present in basal region, dichotomize normally 4-5 times, run parallel to subparallel, arch towards margin, veins 15-30 per cm in middle portion of leaf. The general shape, size and venation pattern of the leaves are comparable with *Noeggerathiopsis hislopii* (Bunbury) Feistmantel (1879).

The microscopic examination of cuticles having stomatiferous and nonstomatiferous surfaces indicates presence of three types of cuticles in leaves identified as *Noeggerathiopsis hislopii*.

Type-1

Upper cuticle thick, cells rectanguloid to polygonal, longitudinally elongated, nonpapillate, cell walls straight, stomata few; lower cuticle differentiated into stomatiferous and nonstomatiferous bands, cells elongate, polygonal, papillate; stomata arranged in 1-6 longitudinal rows, surrounded by 4-8 heavily cutinized subsidiary cells, guard cell sunken.

The cuticular features are comparable with *Noeggerathiopsis indica* Lele & Maithy (1964).

Type-2

Cells of upper cuticle rectanguloid, longitudinally elongated, cell walls straight, nonpapillate, stomata ab-

PLATE 1

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| <p>1-3. Leaves of <i>Noeggerathiopsis hislopii</i> showing similar type of venation pattern but yielding different types of cuticles x1.5 BSIP Museum Nos. 39073, 39074, 39075</p> <p>4-8. Type-1; Cuticles recovered from leaf shown in fig.1 BSIP Slide nos. 12989, 12990, 12991</p> <p>4. Cells of nonstomatiferous band with papillae x110</p> | <p>5. Stomatiferous band showing linearly arranged stomata with highly cutinized guard cells x100</p> <p>6. Stomatiferous band x100</p> <p>7. Enlargement of stomata to show highly cutinized subsidiary cells and guard cells x180</p> <p>8. Cells of upper cuticle x100</p> |
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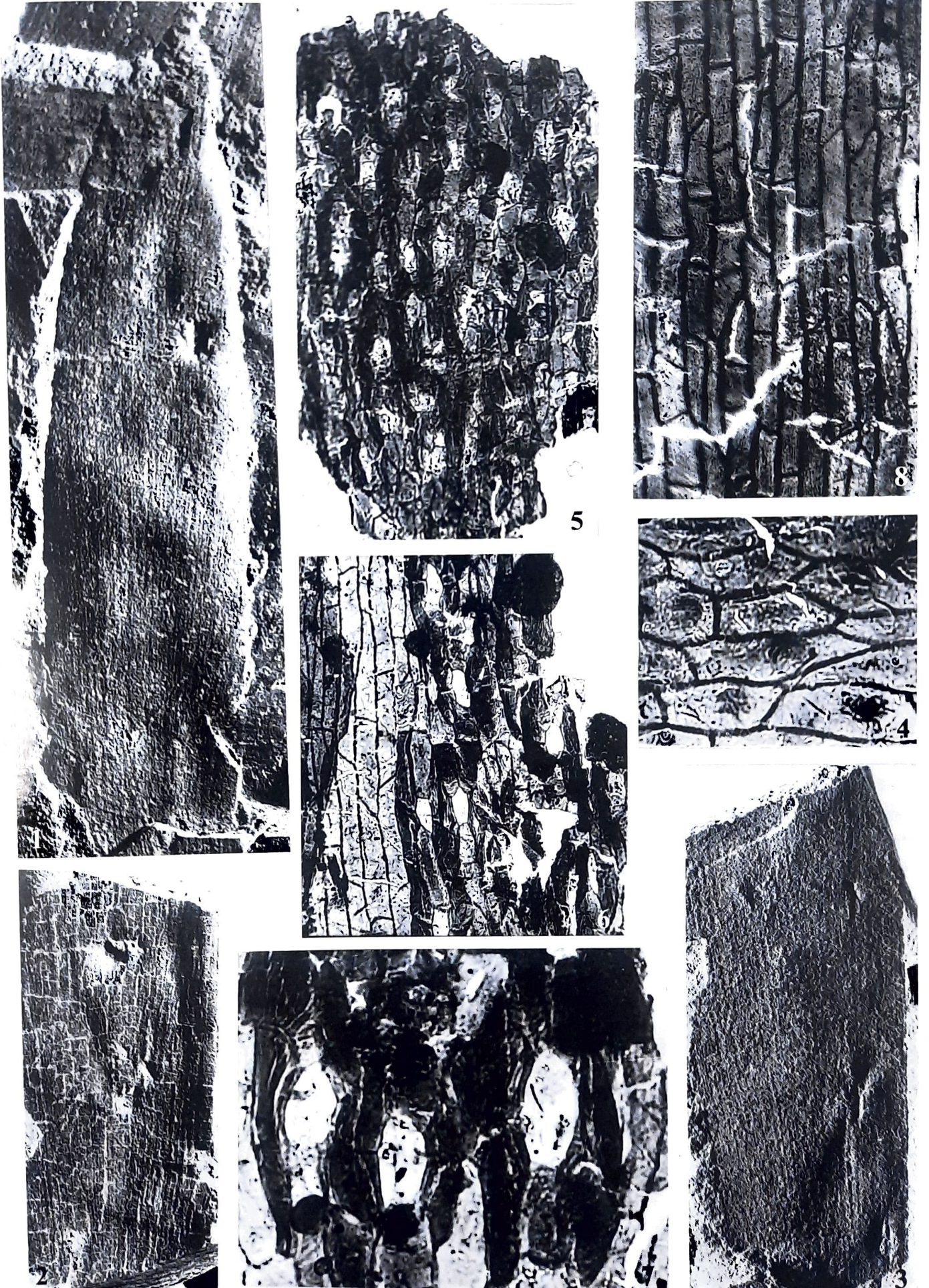


PLATE 1

sent; lower cuticle thick, cells of nonstomatiferous area like that of upper cuticle but possess hollow papillae, cells of stomatiferous area polygonal, rectanguloid, irregularly arranged, papillate; stomata longitudinally arranged, surrounded by 4-6 less cutinized, papillate subsidiary cells.

Cuticles are similar to *N. gondwanensis* Lele & Maithy (1964).

Type-3

Upper cuticle thick, cells rectanguloid to polygonal, linearly arranged, cell wall straight to arched, flexuous, nonpapillate; lower cuticle differentiated into stomatiferous and nonstomatiferous areas, cells of nonstomatiferous areas elongate, rectangular, arranged in longitudinal rows; cells of stomatiferous area rectangular, polygonal; stomata sparse, encircled by 6 nonpapillate subsidiary cells.

The cuticles of *N. zeilleri* Lele & Maithy (1964) are comparable with present cuticular features.

DISCUSSION

The observation of type and figured specimens and slides of earlier described cuticular species amply demonstrate that the leaves of *Noeggerathiopsis hislopii* possess three types of cuticle. It is just a chance that the finding of Lele and Maithy (1964) and Pant and Verma (1964) appeared simultaneously and being unaware of Lele and Maithy's work, Pant and Verma maintained their species without making detailed comparison (see footnote of Pant & Verma, 1964). Cuticular species described by Lele and Maithy (1964) and Pant and Verma (1964) are similar to each other and amongst them *N. bunburyana* possesses the same type of cuticle as that of *N. indica* whereas *N. papillosa* is similar to *N. gondwanensis* in cuticular

features. However, *N. zeilleri* Lele & Maithy is distinct in having nonpapillate cells and sparsely distributed stomata and *N. fibrosa* Pant and Verma is also different in possessing fibres in between major vein and longitudinal surface striations in cells of upper cuticle (Pant & Verma, 1964). The comparative cuticular features of different *Noeggerathiopsis* species as discussed by Pant and Verma show similarities between the species based on cuticular features. The variation in size of cells and concentration of veins have not been found to be constant characters.

The variable types of cuticle as observed in *Noeggerathiopsis hislopii* are also known in the leaves of *Glossopteris* and *Gangamopteris* where morphologically identical species yielded different types of cuticles (Pant & Gupta 1968, 1971; Pant & Singh 1971, 1974; Maheshwari & Tewari 1992). Earlier, while studying the cuticles of *Glossopteris*, *Gangamopteris* and *Palaeovittaria* Surange and Srivastava (1956) observed six types of cuticles and found it difficult to distinguish genera on the basis of cuticles. However, later work proved that cuticles of glossopterid leaves e.g. *Gangamopteris*, *Glossopteris*, *Palaeovittaria*, share the common characters (Pant & Verma 1964, Pant & Gupta 1968, 1971, Pant & Singh, KB 1968, 1971, Pant & Singh, RS 1974). Variability in epidermal morphology in a single species is well known in the leaves of *Cordaites* recovered from Angara and Euramerian floras and leaves possessing similar types of venation pattern have been found to contain number of cuticle types (Barthel 1962, 1964, 1976). Recently, studies have been carried out by Simunek (2000) and Zodrow *et al.* (2000a, b) about the taxonomic and nomenclatural problems of the genus *Cordaites* on the basis of fossil cuticles. They extracted five different types of cuticles from the

PLATE-2

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| <p>1-4. Type-2: Cuticles recovered from leaf shown in Pl.1, fig.2. BSIP Slide no 12992</p> <p>1. Lower cuticle showing alternate stomatiferous and nonstomatiferous bands x100</p> <p>2. Stomatiferous cells enlarged to show the distribution of stomata and papillate cells x120</p> <p>3. Enlargement of stomatal apparatus to show the subsidiary cells and guard cells x200</p> | <p>4. Cells of upper cuticle x100</p> <p>5-7. Type-3: Cuticles recovered from leaf shown in Pl.1, fig. 3. BSIP Slide no. 12993</p> <p>5. Lower cuticle showing sparsely distributed stomata x100</p> <p>6. Enlargement of stomatiferous band showing stoma with non-papillate subsidiary cells x200</p> <p>7. Cells of upper cuticle x150</p> |
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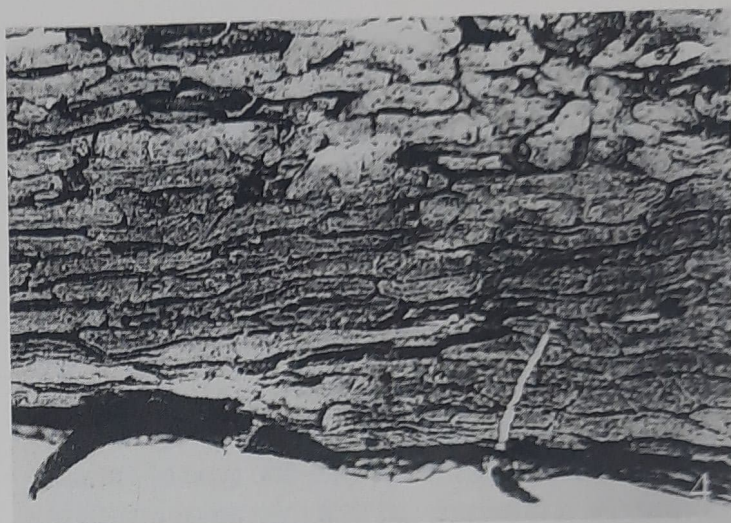


PLATE 2

leaves of *Cordaites principalis* (German) Geinitz and observed that "Cordaitalean species - based on leaf and vein morphology show more than one cuticular morphology." They have considered these differences as cuticular morphotypes in the leaves of *Cordaites principalis*.

The leaves of *Noeggerathiopsis hislopii* possibly represent the Cordaitalean form in Gondwana (Surange 1975; Chandra & Srivastava 1991; Srivastava 1996) and like northern species of *Cordaites* also contain more than one type of cuticles. Accordingly, it is suggested that instead of instituting species on cuticular features, the cuticular variations be considered as intraspecific morphotypes in the species of *Noeggerathiopsis hislopii* (Bunbury) Feistmantel (1879).

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