STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA— 20. *NOEGGERATHIOPSIS* AND ALLIED REMAINS FROM THE KARHARBARI BEDS, GIRIDIH COALFIELD, INDIA

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ABSTRACT

The genera *Noeggerathiopsis* Feistmantel and *Euryphyllum* Feistmantel are described from the Karharbari beds, Giridih Coalfield, with some remarks on their systematic position.

INTRODUCTION

NOEGGERATHIOPSIS Feistmantel (1879) is an important constituent of the Glossopteris flora of India and is widely known from Australia (ETHERIDGE, 1918; FEISTMANTEL, 1890; WALKOM, 1921), Belgian Congo (Hϕeg & Bose, 1960; SEWARD, 1931), South Africa (SEWARD, 1908) and South America (DOLIANITI, 1948; KURTZ, 1896; FRENGUELLI, 1946). Stratigraphically it is more common in the Lower part of the Indian Lower Gondwanas, viz. the Talchir and the Karharbari stages, where it is associated with abundant remains of *Gangamopteris*. It becomes increasingly rarer in the overlying Barakar and Raniganj stages. The Triassic records of *Noeggerathiopsis* are extremely few and rather imperfect. The leaves belonging to this genus are characterized by simple, linear to spathulate shape, narrow tapering or contracted base, apex broadly obtuse to pointed apex, with distinct veins arising from the base, frequently dichotomising, more or less straight to divergent, meshes or interconnections absent.

The leaves were first described by Bunbury (1861) from Bharatwada, Nagpur, under *Noeggerathia* ? (*Cyclopteris*?) *hislopi*. However, the original collector of this collection Mr. Hislop identified these specimens as *Cyclopteris*, a fern genus. But Bunbury considered them to be a cycad and placed it under *Noeggerathia* Brongniart due to coarse nature of the veins and rigid appearance of leaves. However, he also remarked that the characteristic forked nature of veins is uncommon among the cycadaceae, except for *Ceratozamia mexicana* and *Stangeria paradoxa*.

The name *Noeggerathia* was adopted at ne time by Feistmantel (1876), but in 1879 he transferred it under a new genus, viz., *Noeggerathiopsis*. The grounds for separation are that in *Noeggerathia* the veins are equal or alternately thicker or thinner, simple, not forked, but increasing their numbers by interposition between others, whereas in *Noeggerathiopsis* veins are distinctly forked. However, Feistmantel (1879) could not ascertain the systematic position of these leaves and, therefore, he proposed a new family name ' Noeggerathiopsideae ' under the group Cycadaceae. The same author in 1881, pointed out that *Noeggerathiopsis* shows a close morphological structural resemblance with that of *Rhiptozamites* Schmalhausen described from the Permian of Russia.

Zeiller (1896) opined *Noeggerathiopsis* to be a Cordaitalean member, closely allied to *Cordaites* but distinct. His arguments for placing it separate are as follows:

(i) the fine longitudinal lines which occur in between the veins of *Cordaites*-leaves are not found in *Noeggerathiopsis*.

(ii) the stomata do not occur in regular lines as in *Cordaites*, but are scattered irregularly in between veins.

Zeiller (1902) further strengthened his view for placing *Noeggerathiopsis* under *Cordaitales* due to the constant occurrance of the Cordaitean seeds of the genera *Cordaicarpus* in association with *Noeggerathiopsis*. This view of Zeiller has also been supported by Arber (1905).

Zeiller (1896) has also made a careful study of the genus *Rhiptozamites* Schmalhausen. He considers them to be a true *Cordaites* but distinct from *Noeggerathiopsis*.

In contrary to the above view Seward (1908) considers *Noeggerathiopsis* an allied genus to *Cordaites* and strongly favoured for a common generic name for both the leaves showing striking agreement in their shape and venation; together with their frequent

association of gymnospermic seeds. He further strengthened his view by the record of stumps of trees with spreading roots surrounding by rocks containing abundant leaves of *Noeggerathiopsis* from Vereneging. Seward also pointed out that the anatomy of roots were similar to those of *Cordaites* figured by Grand Eury (1890). However, Seward (1917: 243-244) and Seward & Sahni (1920) remarked on the basis of epidermal studies carried out by Miss Holden on *Noeggerathiopsis* and *Cordaites* that there are certain distinguishing features which support Zeiller's view that the Gondwana leaves are, though, superficially similar to those of *Cardaites* are probably distinct. Even this cuticular distinction was evident, Seward (1917) and Seward and Sahni (1920) still emphasized to retain them together on the basis that in the absence of well preserved cuticles no satisfactory distinguishing feature is exhibited by the impressions of *Noeggerathiopsis*. But Walkom (1921) expressed that it will be more justifiable to keep both of them separate in view of the cuticular differences exhibited by the two genera.

The recent studies of *Noeggerathiopsis* by Lele & Maithy (1964) supports that the genus *Noeggerathiopsis* stands apart from *Cordaites* on distinct morphological and epidermal characters. In addition they had also supported for the retention of *Noeggerathiopsis* as separate from *Cordaites*, in view of the lack of knowledge of the anatomical characters and reproductive structure in the former. Further, it is worthwhile to mention that the morphological characters merit consideration when the relationship, if any, between the members of the northern and southern flora, is not well understood. This separate retention of *Noeggerathiopsis* separate from *Cordaites* has also been supported by Pant & Verma (1964). However, Meyen (1964) opined that the generic separation on geographical basis is not justifiable, even on basis of his finds that some Angara forms, though, superficiallally looking alike to *Noeggerathiopsis* differs in anatomical features.

The assignment of *Noeggerathiopsis* under the group Cordaitales on basis of gross external characters is not free from doubt. The epidermal study of *Noeggerathiopsis* (Lele & Maithy, 1964) presents several differences from *Cordaites*. Besides, Zeiller's (1902) argument for placing under Cordaitales is also now untenable, because it has been pointed by Maithy (1965a) that the gymnospermic seeds of the Lower Gondwanas show a range of diversity in structure, which suggests that all of them may not belong to a single group of plant but probably to different groups of plants found in association. Further, the habit of these plants are unknown, therefore, it is difficult to assign these leaves to a definite group. A number of peculiar specimens are, however, on record, in which several leaves are arranged round a central point in radial manner suggesting that the leaves were borne in a sort of a whorl or close spiral (Etheridge, 1918; Seward & Sahni, 1920; Walkom, 1921). The preservation of these specimens raises interesting question specially because in no cases any recognizable axis is found in the same plane which contains the leaves. The Karharbari specimens are all preserved in dispersed state and, therefore, do not throw any significant light on this aspect. Therefore, it seems desirable in the present state of knowledge to consider *Noeggerathiopsis* as a plant, allied to some Cordaitean members till more evidence come up by future discoveries.

DESCRIPTION

Noeggerathiopsis Feistmantel emend.

Emended Diagnosis — Leaf simple, symmetrical, linear, lanceolate, ovate or spathulate in shape, base narrow tapering or contracted, apex broadly rounded, acute or acuminate, margin entire; midrib or median subparellel veins absent; veins arising from base, dividing by dichotomy at very acute angle, ± straight, do not show any curvature, anastomosis absent. Cuticle amphistomatic or hypostomatic; (?) Lower cuticle distinguishable into alternating stomatiferous and non-stomatiferous band, stomata sunken, longitudinally orientated, subsidiary cells forming a ring, cells of the lower surface papillate or non-papillate; upper surface relatively thicker with very rare and scattered stomata, cells ± rectangular arranged end to ends.

Comparison and Discussion — The diagnosis of the genus is emended in view of the knowledge of the epidermal structure. *Noeggerathiopsis* is distinguished from *Euryphyllum* Feistm. (1879) an allied genus by the symmetrical shape of leaf and straight veins all over the leaf, where as the leaf of *Eury-*

phyllum is assymmetrical and the veins of the margin region exhibit a curvature. *Rubidgea* (Tate) Maithy (1965) agrees with *Noeggerathiopsis* in the absence of anastomosis in between the veins but it differs by the presence of distinct median subparallel veins. A large number of leaves have been assigned to *Noeggerathiopsis* from the Angara flora (ZALESSKY 1937, NEUBURG, 1948). The assignment of them is not free from doubt, because so far the relationships between the two floras, i.e. the Angara and the Gondwana is not well established. Recent studies of Meyen (1964) of the Angara leaf forms have demonstrated that some of the leaves differ from *Noeggerathiopsis* and *Cordaites* by presence of dorsal furrow and the generic name *Ruffloria* has been proposed for them.

The genus *Noeggerathiopsis* is now represented by about eight species from the Lower Gondwanaland strata. The identification of these species is based upon chiefly the external characters. However, recently the cuticle of three species has been described (LELE & MAITHY, 1964). It is obvious to us that the cuticular structure of leaves is better suited for delimitation of species. But generally the leaves are preserved in form of impressions only and they occur in such abundance that one cannot neglect their study. The problem is what should be done? For the present most convincing course seems to place specimens with a cuiticle and without cuticle separately under two distinct names, i.e. in one case the circumscription will entirely base upon the external characters alone, whereas in the second case upon both the epidermal and the external characters; but the epidermal characters will be the main basis for identification. Although, this method of approach will give rise to a duplication of names, but I believe it will resolve much confusion in between the cuticular and non-cuticular forms.

Thus, the species assigned to *Noeggerathiopsis* from the Gondwana land can be broadly classified into two groups on basis of the characters taken into consideration for specific delimitation.

A. Species based only on external morphographic characters, viz.
   N. hislopi (Bunb.) Feistm.
   N. hislopi var. *subrhomboidalis* Feistm.
   N. stoliczkanus (Feistm.) Arber
   N. spathulata Dana
   N. prisca Dana

Of the above mentioned impression species *Noeggerathiopsis hislopi* (Bunb.) Feistmantel includes the largest number of leaves from the Gondwanaland. This is apparently because Feistmantel made this species rather more comprehensive to cover a wide range of variation in size and shape of leaves, their apex, base and venation character. Later Arber (1905) merged several other above mentioned species under *N. hislopi* considering the characters are not sharp enough for specific delimitation. This was supported by Walkom (1921) as a result of which later several workers placed leaves showing a range of variations under *N. hislopi*. Due to this we find that the species has become too much unwieldy and incorporates different types of leaf forms under one specific name. A critical survey of the literature of the records of *N. hislopi* from the Gondwanaland strata shows that the leaves are either linear, lanceolate, ovate, spathulate or rhomboidal in shape. The apex is broadly rounded, rounded, bluntly pointed to acuminate. The veins are very sparse to very close, straight to divergent and in some of the specimens the marginal veins are arching. Therefore, we find that under the species *N. hislopi* also the leaves with morphological characters of different species and genera are placed. Thus, in view of this it became increasingly necessary that the species *N. hislopi* should be redifined and forms showing distinct morphographic characters should be separated. The recent evidences have also pointed that the shape, apex, base and the venation characters play an important role for specific determination. Thus, in the present study the species *N. hislopi* has been restricted as was originally proposed by Bunbury and the specimens showing distinct morphographic characters have been separated under different names.

B. Species based on cuticle and external morphographic characters, viz.,
   N. indica Lele & Maithy
   N. gondwanensis Lele & Maithy
   N. zeilleri Lele & Maithy
   N. fibrosa Pant & Verma

Pant and Verma (1964) described three new species of *Noeggerathiopsis* from unknown horizons of the Lower Gondwanas of the Madhya Pradesh. A careful assessment of the different cuticular characters presents that the differences between *N. bunburyana* Pant & Verma (*l. c.*) and *N. papillosa* Pant & Verma (*l. c.*) are not sharp

enough and the two species seem to be identical. According to them the former is amphistomatic, few cells of lower surface have papillae and the subsidiary cells are non-papillate, whereas the latter is hypostomatic, all the cells of the lower surface and subsidiary cells papillate. A careful examination of the photographs of the two species shows that in *N. bunburyana* the subsidiary cells have the same amount of cutinization as in *N. papillosa* and some rudimentary papillae are marked on some subsidiary cells. Besides, the papillae on the lower surface are not very uncommon, as thought to be by the authors. Furthermore, the presence of stomata on the upper surfaces is not always recorded due to their presence in less number. In addition both the leaves have nearly similar external morphological features. Pant and Verma (*l. c.*) refrred the earlier described cuticle of *Noeggerathiopsis* by Saksena (1963) to *N. bunburyana* and that of Seward & Sahni (1920) to *N. papillosa*. Lele & Maithy (1964) considered both the earlier described cuticles alike and referred them to a new species, *N. indica*. Thus, it becomes increasingly evident that the two species of Pant & Verma (*l. c.*) are alike and synonymous to the earlier known species *N. indica* Lele & Maithy possessing the same epidermal features.

A careful examination of the three cuticular species of *Noeggerathiopsis* shows that the epidermal structure of these species show a fundamental agreement in the fact that the (?) lower surface has regular alternation of stomatiferous and non-stomatiferous bands, and the stomata are longitudinally orientated but do not occur in regular files, but still the cuticle of three species points out clearly their distinctiveness from each other.

The three species *Noeggerathiopsis indica, N. fibrosa* and *N. gondwanensis* are more closely related due to the presence of papillae on the ? lower surface both in stomatiferous and non-stomatiferous band and cutinization of subsidiary cells, whereas in case of *Noeggerathiopsis zeilleri* the papillae are absent both in the stomatiferous and non-stomatiferous band and the subsidiary cells are more or less non-cutinized. Thus, it becomes clear that the latter cuticle differs markedly from the former three. Thus, the cuticles described under *Noeggerathiopsis* can be broadly classified into two distinct groups: (1) Papillate, (2) Non-papillate. It may be possible to visualize, as our knowledge increases, whether these groups can serve as basis for further splitting the genus.

Noeggerathiopsis hislopi (Bunb.) Feistm. emend.

Pl. 1, Figs. 1-3

Emended Diagnosis — Leaf impression, simple symmetrical, linear to lanceolate shape, apex obtuse, base narrow tapering to a point, margin entire, veins arise from the base, frequently dichotomise, ± parallel, angle of divergence commonly less than 5°, density 14-16 veins per cm.

Description — In the collection there are large number of specimens. The leaves vary in size from 4·5 × 1·2 cm. to 12 × 2·5 cm. The shape of leaves vary from linear to lanceolate in outline. The apex of the leaves are obtuse, but it also shows a certain extent of variation. In leaves with linear-lanceolate shape the apex is attenuately rounded (Pl. 1, Fig. 2) whereas in lanceolate forms it is broadly rounded (Pl. 1, Fig. 1). The leaf base is narrow tapering to a point (Pl. 1, Fig. 3). Margin of the leaves are entire and both the margins show equal curvature. From the base arises errect, ± parellel veins, dichotomise frequently during their upward course. The angle of divergence between the two veins is less than 5°, the density of veins is 14-16 per cm.

Comparison — The species *N. hislopi* is now restricted for the specimens as was proposed by the original author (Sensu. restrictus Bunbury, 1879). Therefore, it will be of great value to mention here those records which confirm with the present emended diagnosis. The records are as follows:

Feistmantel (1879) *N. hislopi*, Pl. 19, Figs. 2-6; Pl. 28, Figs. 1, 6, 7; Pl. 29, Figs. 1, 2; Pl. 30, Fig. 9.

Feistmantel (1882) *N. hislopi*, Pl. 13, Fig. 2; Pl. 21, Figs. 6, 10.

Feistmantel (1890) *N. hislopi*, Pl. 6, Figs. 4, 7 & 8.

Kurtz (1894) *N. hislopi*, Pl. 3, Fig. 2; Pl. 4, Fig. 2.

Dolianiti (1948) *N. hislopi*, Pl. 8, Fig. 1.

Surange & Lele (1956) *N. hislopi*, Pl. 1, Figs. 1, 2, 11.

The following records of *N. hislopi* are regarded distinct:

Feistmantel (1879) *N. hislopi*, Pl. 19, Fig. 6.

Feistmantel (1879) *N. hislopi* var. *subrhomboidalis*, Pl. 20, Fig. 2.

Feistmantel (1882) *N. hislopi*, Pl. 9, Fig. 2; Pl. 14, Fig. 6; Pl. 18, Fig. 1.

Kurtz (1894) *N. hislopi* var. *euryphylloides*, Pl. 4, Fig. 3.

Seward (1903) *Cordaites hislopi*, Pl. 13, Fig. 3.

Seward (1908) *Cordaites hislopi*, Figs. 9, 10.

Lundqvist (1919) *N. hislopi*, Pl. 1, Figs. 19-22.

Kurtz (1922) *N. hislopi* var. *typica*, Pl. 13, Figs. 30, 32, 34, 37.

Kurtz (1922) *N. hislopi* var. *subcueformis*, Pl. 4, Figs. 33, 36.

Kurtz (1922) *N. hislopi* var. *cuneformis*, Pl. 4, Figs. 42, 42a.

Walton (1929) *Cordaites hislopi*, Pl. C, Fig. 27.

Noeggerathiopsis spathulata (Dana) emend.

Synonymy:

1847 *Noeggerathiopsis media* Dana

1905 *Noeggerathiopsis hislopi* Arber

Emended Diagnosis — Leaf simple, symmetrical, broadly spathulate or rhomboidal in shape, apex acute, base narrow tapering, entire margin; veins arise from base, errect, frequently dichotomizing, ± divergent, the angle of divergence between the two veins is in between 9°-13°, density of veins 16-18 per cm.

Description — There are about ten specimens in the collection. All of them are incomplete. The size ranges from 4-8 cm. in length and 2-2·8 cm. in breadth. Leaves are broadly spathulate or rhomboidal in shape (Pl. 1, Fig. 4). The apex is acute and the apical region of leaf is ± broadly triangular. The widest region of the leaf is near the apex. In all specimens the basal most part is missing, however, the nature of convergence of two margins towards basal zone suggests a narrow tapering base. Veins are fairly thick, they arise from the basal part and dichotomise frequently as they move towards apical part. Veins are divergent; the angle of divergence between the two veins is in between 9°-13°. Veins are not very close, their density is 16-18 per cm.

Comparison and Discussion — *Noeggerathiopsis spathulata* Dana is distinguishable from *N. hislopi* by the spathulate shape of leaf, acute apex and more divergent veins.

The specimens from the Karharbari stage agrees well with the specimens of Feistmantel from Australia (1890, Pl. 21, Figs. 3-5).

The following specimens described by earlier workers are referable to *N. spathulata* Dana.

Feistmantel (1879) *N. hislopi* Feistm. Pl. 19, Fig. 6.

Feistmantel (1879) *N. hislopi* var. *subrhomboidalis*, Pl. 20, Fig. 2.

Feistmantel (1882) *N. hislopi*, Pl. 18, Fig. 1; Pl. 19, Fig. 2; Pl. 14, Fig. 6.

Noeggerathiopsis densinervis sp. nov.

Pl. 1, Figs. 6-8

Diagnosis — Leaf simple, symmetrical, lanceolate shape, apex acute, base narrow, tapering, margin entire; veins arise from base, thin, errect, frequently dichotomising ± divergent, fairly closely placed, density of veins 20-24 per cm., angle of divergence between two angles not more than 7°.

Holotype — 20391, Birbal Sahni Institute of Palaeobotany.

Locality — Central pit, Srirampur Colliery, Giridih Coalfield.

Horizon — Karharbari Stage.

Description — About 8 specimen in the collection. The leaves size vary from 3 to 5 cm. in length and 1 to 2 cm. in width. Leaf lanceolate in shape with acute apex. In holotype (Pl. 1, Fig. 6) the basal part is missing, however, the other specimens show narrow tapering base (Pl. 1, Fig. 8). Both the margins of leaf show equal curvature. Veins are very thin, fairly close, density of veins 20-24 per cm. The veins show certain amount of divergence, the angle of divergence between two veins is not more than 7°.

Comparison — *N. densinervis* sp. nov. is comparable to *N. spathulata* Dana by the acute apex, however, the former differs by the lanceolate shape and fairly close thin nerves.

The specimen of *Cordaites hislopi* described by Walton (1920. Pl. C, Fig. 27) agrees to the present species in its form and venation.

Euryphyllum Feistmantel

Feistmantel (1879) proposed the generic name *Euryphyllum* for a specimen from the Karharbari beds consisting of two leaves closely associated with partial flattened axis suggesting original attachment. The

leaves are characterized by ovate-spathulate shape, rounded apex, gradually contracted at the base, unsymmetrical, veins strong, radiating from the base at acute angle, with frequent dichotomy, nerves in the median region are subparallel and those in the lateral regions are arched towards the margin. Arber (1905: 108) considers that the venation characters, i.e. arching of lateral veins of these leaves are not enough sharp for a separate generic identity from that of *Noeggerathiopsis*, therefore, he prefers to retain them under *Noeggerathiopsis*. The arching veins is also implied in the resemblance noted by Seward & Sahni (1920) between *Euryphyllum* fronds and *Gangamopteris major*. Since *Noeggerathiopsis* leaves are not known to possess arched veins (which in my opinion, is a good generic criteria), it would be reasonable to keep *Euryphyllum* leaves distinct from those of *Noeggerathiopsis* as was done by Seward and Sahni (l.c.). It is hoped that the generic status of *Euryphyllum* will become more clear with the discovery of greater number of specimens and the knowledge of the cuticle.

Euryphyllum whittianum Feistmantel
Pl. 1, Figs. 9, 10

Synonymy:

1879 *Euryphyllum whittianum* Feistmantel
1905 *Noeggerathiopsis whittiana* Arber
1920 *Euryphyllum whittianum* Seward & Sahni

Description — Only few specimens in the collection. The one leaf figured in Pl. 1, Fig. 9 measures 6 × 2 cm., ovate-spathulate, asymmetrical with narrow tapering base and obtuse apex. Veins erect, dichotomous, subparallel in the median region and ± arched towards margin in the lateral region. Near the base a flattened axis-like structure is preserved, but no definite connection is seen between the axis and leaf. The other figured specimen (Pl. 1, Fig. 10) is an incomplete one and comparatively much larger, measures 14 × 4 cm. Only the basal part is preserved. The leaf shows clear character of *Euryphyllum* type, i.e. one of the margin of leaf sows much greater curvature than the other, contracted tapering base, the veins in the median region are subparallel, whereas that of lateral region broadly arched. The density of veins is 13-16 veins per cm.

Comparison and Remarks — The specimens agree in the shape and venation with the drawings of Feistmantel (1879, Pl. 21, Figs. 1, 1a). The leaf of *Noeggerathiopsis prisca* Dana (for figure *see* Feistmantel, 1880, Pl. 13, Fig. 2) from Australia resembles with *E. whittianum* in shape and venation. The specimens described by Kurtz (1894, 1922) from the Argentina under *N. hislopi* var. *euryphylloides* (1894, Pl. 4, Fig. 3), *N. hislopi* var. *typica* (1922, Pl. 3, Figs. 30, 32, 34, 37), *N. hislopi* var. *subcueformis* (1922, Pl. 4, Figs. 37, 38) and *N. hislopi* var. *cuneformis* (1922, Pl. 4, Figs. 42, 42a) shows striking resemblance in their venation character with *Euryphyllum.* and seems to be allied.

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EXPLANATION OF PLATE

PLATE 1

1. *Noeggerathiopsis hislopi,* A lanceolate leaf with broad obtuse apex. Specimen No. 8572, Central pit. × 1.

2. *Noeggerathiopsis hislopi,* A specimen showing attenuately rounded apex. Specimen No. 20458, Central pit. × 1.

3. *Noeggerathiopsis hislopi,* A small leaf with tapering base and broadly rounded apex. Specimen No. 320879/503, Jubille pit. × 1.

4. *Noeggerathiopsis spathulata* Dana, showing acute apex and divergent veins. Specimen No. 19921, Central pit. × 1.

5. *Noeggerathiopsis spathulata,* another incomplete leaf. Specimen No. 320880/499, Central pit. × 1.

6. *Noeggerathiopsis densinervis* sp. nov. ,the holotype, note the acute apex closely placed nerves. Specimen No. 20391, Central pit. × 1.

7. *Noeggerathiopsis densinervis* sp. nov., Another incomplete specimen showing acute apex. Specimen No. 31329/424, Cnetral pit. × 1.

8. *Noeggerathiopsis densinervis* sp. nov., Only the basal part showing tapering base. Specimen No. 31372/424, Central pit. × 1.

9. *Euryphyllum whittianum* Feistm; A small complete frond, note the asymmetrical shape. Specimen No. 31414/426, Jubille pit. × 1.

10. *Euryphyllum whittianum* Feistm; Another incomplete frond showing median veins running parallel and the marginal ones arching. Specimen No. 20451, Central pit. × 1.

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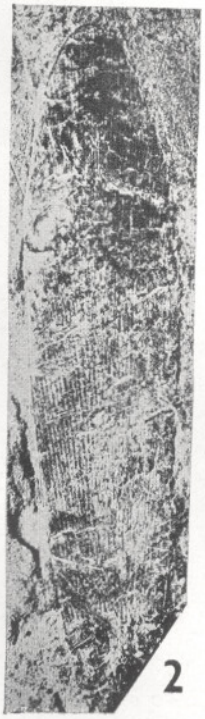

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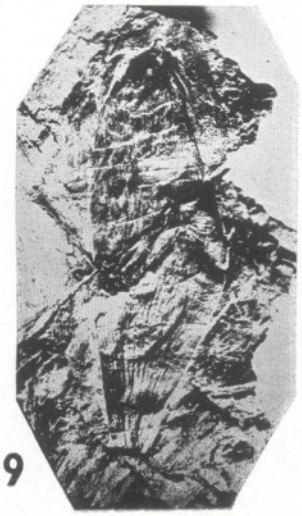

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