

STUDIES IN THE GLOSSOPTERIS FLORA OF INDIA — 43. SOME NEW PLANT FOSSILS FROM THE LOWER GONDWANA SEDIMENTS OF AURANGA COALFIELD, BIHAR

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ABSTRACT

Five new plant elements from the Barakar and Raniganj stages of Auranga Coalfield are described. The Barakar plants include a new dimorphic leaf whorl genus *Diphyllopteris* and two new species *Neomariopteris barakarensis* sp. nov., and *Ottokaria biharensis* sp. nov. *Plumsteadia lanceolata* sp. nov. represents a new type of fructification from the Raniganj Stage.

INTRODUCTION

THE megafloreal assemblages of the Lower Gondwana sediments of Auranga Coalfield have earlier been reported by Feistmantel (1881a, b, 1882, 1886), Bhattacharyya (1959), Bhattacharyya (1963), Maithy (1971) and Srivastava (1977a, b, in press).

The assemblage consists of various species of *Gangamopteris*, *Glossopteris*, *Noeggerathiopsis*, *Rhipidopsis*, *Macrotaeniopteris*, *Schizoneura*, *Pseudoctenis*, *Barakaria*, *Sphenophyllum*, *Neomariopteris*, *Rhabdotaenia*, *Euryphyllum*, *Samaropsis*, and *Vertebraria*. The present palaeobotanical investigation further adds three genera, viz., *Diphyllopteris*, *Ottokaria*, and *Plumsteadia* to the Lower Gondwana assemblages of Auranga Coalfield, Bihar.

The plants like *Barakaria*, *Pseudoctenis*, and *Diphyllopteris* have not so far been recorded from any other Lower Gondwana basins. Such a characteristic flora suggests that during Lower Gondwana time the flora was sufficiently rich and diversified in Auranga Basin.

MATERIAL

The Barakar plant fossils have been recorded from the Churia fire-clay pit section and the Raniganj plant fossils have been recorded from a section exposed in the north-east bank of Sukri River about 20 km north-west of Rajbar Village (for detail and map; see Srivastava, 1977b).

All the figured specimens and negatives are preserved at the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

DESCRIPTION

Genus — *Diphyllopteris* gen. nov.

Type Species — *Diphyllopteris verticillata* gen. et sp. nov.

Generic Diagnosis — Two different pairs of leaves attached in a whorl; one pair possesses spatulate to lanceolate leaves; another pair has segmented, ribbon-shaped leaves.

Generic Comparison — *Diphyllopteris* gen. nov. differs from all the known Lower Gondwana genera in having two different pairs of leaves in a single whorl.

Diphyllopteris verticillata sp. nov.

Pl. 1, figs. 1-3; Text-fig. 1

Holotype — Specimen no. 53/1392, B.S.I.P. Museum, Lucknow.

Locality — Churia fireclay pit, Auranga Coalfield, Bihar.

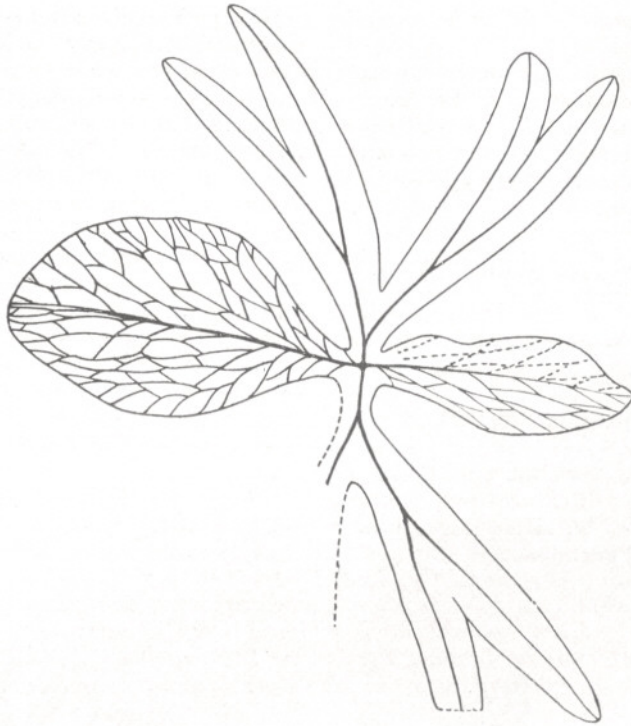
Horizon & Age — Barakar Stage, Lower Gondwana, Lower Permian.

Specific Diagnosis — Four leaves in two distinct pairs present in a whorl; one pair has spatulate, lanceolate leaves with net venation; other pair has linear, ribbon-shaped leaves with a single vascular strand.

Description — There are 6 complete or partly incomplete whorls of leaf impressions found on a slab. All the whorls are separate from each other. An axis, which could have borne them, is not preserved.

In an individual whorl there are four leaves in two pairs. Each pair is morphologically distinct.

In one pair, the type of leaf is simple, small, lanceolate, 6 to 9 mm long and 4 to 5 mm



TEXT-FIG. 1 — *Diphyllopteris verticillata* gen. et sp. nov. (Holotype) enlarged line drawing of the whorl represented on Pl. 1, fig. 2 showing two distinct pairs of leaves $\times 5$.

broad at its widest part. The apex is obtuse, base contracted and the margin entire. Midvein is thin and present throughout the preserved length. The secondary veins arise from the midvein at an angle of 45° . They dichotomise and anastomose to form 2-3 open, square-shaped, hexagonal meshes. The meshes are 1 to 1.5 mm long and 1 mm broad.

In the second pair the form of leaf is linear, ribbon-shaped, 8 to 10 mm long and 2 to 3 mm broad. Close to the base it divides into two major divisions. Each of these divisions again dichotomises at a distance of 3 to 4 mm away from the base. Thus a single leaf in one pair has 4 linear ultimate segments. The primary vein emerges from the base, dichotomises twice to form 4 secondary veins which supply the ultimate segments.

All the leaves are attached in the centre to form a whorl but such whorls are not found attached to any axis or stem. It may, however, be noted that there are some thin,

fragile, 2 to 3 mm broad, axis-like impressions, present near these whorls on the same rock (Pl. 1, fig. 1). Perhaps the whorls could have been borne on these or similar axes.

Comparison — One of leaf-pairs has a net venation comparable with that of *Glossopteris*, but leaves of that genus are generally very large, simple and possess a strong midrib. Accordingly there is practically no chance of mistaking even detached leaf-pairs of *Diphyllopteris* with *Glossopteris* foliage. The leaves of *Barakaria dichotoma* Seward & Sahni (1920) compare with the linear, ribbon-shaped leaves of *Diphyllopteris verticillata*. But dichotomy of *Barakaria* is indefinite whereas in *Diphyllopteris* it is invariably twice. Heteromorphous leaf-pairs are unknown in *Barakaria* and so also in the whorled arrangement.

Dimorphic leaves of this kind are not so far reported in any fossil plant. Some modern plants do possess dimorphic leaves but even there the two kinds of leaves are

not attached in a single whorl as in *Diphyllopteris*.

The whorls of leaves in the new genus are reminiscent of *Arthrophyta* but the organization and affinity of *Diphyllopteris* are open to question and they can be decided only when we have more and better preserved material of this plant.

Genus — *Neomariopteris* Maithy emend., 1975

Neomariopteris barakarensis sp. nov.

Pl. 2, figs. 6-8; Text-fig. 2A-B

Holotype — Specimen no. 70/1311, B.S. I.P. Museum, Lucknow.

Locality — Churia fireclay pit, Auranga Coalfield, Bihar.

Horizon & Age — Barakar Stage, Lower Gondwana, Lower Permian.

Diagnosis — Fronds bi- to tripinnate, imparipinnate, primary rachis winged; secondary rachis arises at an angle of 45°-60°, alternately to subopposite; pinnae linear, elongate, lanceolate, arise at 45°; sterile and fertile pinnules alike, alternately arranged, lanceolate to spatulate in shape, with a decurrent base, apex rounded, margin crenulate, fused near the base; apical pinnae possess fertile pinnules, a single sorus present at the junction of two pinnules; situated \pm half way between the pinna margin and pinna rachis; each sorus shows a circular impression of 5-6 free sporangia, arranged in a ring around a central point.

Description — There are about 50 specimens preserved as impressions in the collection.

Fronde — The fronds are large bi- to tripinnate and imparipinnate in nature. The figured frond is incomplete, compound, im-



2A



2B

TEXT-FIG. 2A — *Neomariopteris barakarensis* sp. nov. (Holotype) line drawing of the sterile and fertile pinnules \times Ca 2.5.

TEXT-FIG. 2B — Line drawing to show the position of sori \times 8,

paripinnate and tripinnate in construction. The primary rachis is winged, 10 cm long and 1.7 cm broad at its widest part. Secondary rachis arises from the primary rachis alternately to subopposite at an angle of 45° to 60°. They are 7 to 8 cm long and 2 mm broad. The distance between two consecutive secondary rachis is 3 to 4 cm.

There are 8 to 11 pairs of pinnae, emerge alternately from the secondary rachis at an angle of 45° to 50°. The size of pinnae ranges from 8 to 25 mm in length and 5 to 10 mm in breadth. The pinnae are widely placed in the lower portion and are closer towards the apical region.

The apical part of the frond possesses fertile pinnules, whereas the lower parts are sterile.

The lower 3 to 4 pairs of pinnae bear 6 to 7 pairs plus 1 terminal sterile pinnule. The pinnules are arranged alternate to opposite. The size is 3 to 10 mm long and 1 to 4 mm broad. The apex is broad to acute and the base is decurrent. They show variation in their shape. The apical 2 to 3 pairs are small, linear in shape and show slight crenulation in the margin whereas the basal pinnules are lanceolate to spatulate in shape and show deep crenulate margin.

The apical 4 to 5 pairs of pinnae possess 2 to 4 pairs of fertile pinnules, besides one sterile terminal pinnule. The pinnules are broadly lanceolate to spatulate in shape. They are 3 to 5 mm in length and 3 to 1 mm in breadth. The apex is broad and base decurrent. The margin is slightly crenulate to straight. The basal lateral margin of two pinnules are generally fused.

Venation — Each pinnule, i.e. fertile and sterile is supplied by one common vein, arises from the pinnae rachis at an angle of 45°. After its emergence, it bifurcates to give rise alternate, subopposite secondary veins, which dichotomise once or twice before reaching the margin.

Position of Sorus — At the junction of two pinnules, between the margin of the pinna rachis, a little away from the margin, there is a single row of oppositely arranged sori situated on the lateral branchlets of the pinnules. The sori are circular and 0.5 to 1 mm in diameter. Each sorus contains 5 to 6 sporangia which are probably free and appear to be arranged around a central point (?stalk). Sometimes there are impressions which show the irregular margin of

the sorus as if the sporangia have been dehisced, but the nature and structure of the fertile pinnules remain the same.

The sporangia have not been recovered from these sori as carbonaceous crust is not present. Outer protective covering of the sporangia, i.e. indusium is not recognizable.

Comparison — The present species in their nature of fronds and pinnule characters compare with *Neomariopteris hughesi* (Feistmantel) Maithy (1974, pl. 2, fig. 7). However, it differs remarkably in the position and arrangement of sori from the fertile fronds of *N. hughesi* described by Maithy (1975, pl. 2, figs. 10, 11).

In the fertile frond of *N. hughesi* as described by Maithy (1975), the sori are present on the pinnules, very near to the margin of pinnules, whereas in the present species the sori are present at the junction of two pinnules, and between margin and rachis of pinna. Maithy (1975) has illustrated that the sori are situated on the end of the primary vein of pinnules, however, in *N. barakarensis* sori are found on the anadromic branchlets of the primary vein of pinnules.

Pant and Khare (1974) described sterile and fertile fronds of a new genus *Damudopteris polymorpha* (Feistmantel) Pant & Khare from the Raniganj Coalfield, Bengal. The fronds contain dispersed sporangia distributed all over the surface of pinnules and do not form a sorus, whereas *Neomariopteris barakarensis* sp. nov. is distinct in the presence of a definite sorus on each fertile pinnule. As the present species is based on fossil impressions only, further details of sporangia are not available.

Thus, the position of sori in the present specimens is quite distinct from the sori position of *N. hughesi* and *D. polymorpha*. Hence to accommodate such fronds a new species *N. barakarensis* has been proposed.

Genus — *Ottokaria* Zeiller, 1902

Zeiller (1902) instituted this genus from the Karharbari Stage of the Karharbari Coalfield, Bihar and misinterpreted it as a leaf. Seward and Sahni (1920) reinvestigated the type specimen and considered it as the cupular investment of the seed. Later, Plumstead (1956), Pant and Nautiyal (1966) and Mukherjee, Banerjee and Sen (1966) expressed various views regarding the nature and affinities of this genus. Recently, Surange and

Chandra (1975) have reviewed all the observations and presented a reconstruction of *Ottokaria*. They have stated "*Ottokaria* in our opinion, could be regarded as multiovulate organ, which is morphologically similar to that of *Scutum*. The receptacle could be oval to round on which the ovules are attached (text-fig. 14B). This ovule bearing head could be covered by a protective veined, concave fertile scale, fitting the convexity of the ovuliferous head and both these organs were carried on a common stalk (text-fig. 14A)". The structure and nature of the present species also support the view expressed by them. They have placed this genus under the order Glossopteridales and family Ottokariaceae.

Ottokaria biharensis sp. nov.

Pl. 2, figs. 9-11; Text-fig. 3A-B

Holotype — Specimen no. 11/1311 with counterpart no. 3/1311, B.S.I.P. Museum, Lucknow.

Locality — Churia fireclay pit, Auranga Coalfield, Bihar.

Horizon & Age — Barakar Stage, Lower Gondwana, Lower Permian.

Diagnosis — Fructification oval to circular; scale leaf fan-shaped, radially striated, margin toothed; receptacle circular to oval, bearing irregularly arranged seed-like scars; scars oval with faint striations over the surface.

Description — There is a solitary specimen with counterpart preserved mostly as im-

pression and in part as a cast. The specimen is small, oval to circular in shape, measuring 1.2 cm in diameter. The pedicel or stalk is not preserved.

One part contains the well-preserved impression of scale leaf which is broad and sub-circular in outline. There is no midrib or vein. Along the margin the scale is divided into 14 to 16 short (1.5 to 1.75 mm long & 0.75 mm broad) lanceolate, closely spaced tooth-like processes. The tips are generally broken but a complete process shows rounded to acute apex. The surface of the leaf is uneven and rounded. There are radially placed thick and thin striations present all over the surface. Striations arise from the base and radiate towards the apex. They dichotomize and anastomose during upward course and nearly 6 to 8 striations reach the toothed margin of the leaf. It seems that some thick striations have resulted in the splitting of the leaf. The base of the leaf is broken but probably had a rounded base.

The counterpart shows two regions. The upper 1/3 portion contains the negative impression of the toothed margin of the scale leaf showing striations. The lower 2/3 portion possesses what appears to be the cast of a thin, circular receptacle. The margin of the receptacle is indistinct. It bears irregularly arranged 14 to 16 circular to oval scars which may represent seeds or ovules. The diameter of the scars is generally 0.5 to 0.8 mm and the surface is faintly striated.

Comparison — The species is distinct from all the known species of *Ottokaria* in its small



3A



3B

TEXT-FIG. 3A — *Ottokaria biharensis* sp. nov. (Holotype) line drawing of the specimen showing the receptacle containing seed scars $\times 4$.

TEXT-FIG. 3B — Line drawing of counterpart showing the striated nature of scale leaf $\times 5$.

size and a circular receptacle bearing irregularly arranged seeds or ovules. *Ottokaria bengalensis* Zeiller (1902) differs in showing almost circular, cup-shaped scale leaf in which the margin is more frequently divided into a large number of thin, linear processes (about 30-32 along the outline). Besides, the surface shows a net venation. *Ottokaria ovalis* White (1908) is comparable in its oval and a striated scale leaf with toothed margin. The specimen is broken near the apex. However, it differs in having the much dissected scale leaf containing about 30-35 short, spatulate, 1 to 1.5 mm long round tipped processes (20 in the preserved portion). *Ottokaria leslii* Thomas (1921) contains wing, head and stalk. The wing probably corresponds with the scale leaf of the present species. However, it shows a smooth margin where the surface is covered by rectangular-shaped cellular structure, whereas in *Ottokaria biharensis* the scale leaf has a toothed margin and the surface, though uneven or rough but without any cellular structure. *Ottokaria kathwaensis* Virkki (1943) differs from the present species in the absence of a receptacle containing seed scars. Moreover, the scale leaf is nearly smooth in the former species. Pant and Nautiyal (1966) described some *Ottokaria*-like fossils from the Karharbari Coalfield, Bihar. The specimens differ from the present species in showing distinct, discoid head which originally bore the seeds all over the face. *Ottokaria transvaalensis* and *Ottokaria buriadica* described by Plumstead (1956) are found attached to the leaves of *Gangamopteris obovata* and *G. buriadica* respectively. Both the species differ in an almost circular shape, where the fertile half is completely covered with a number of small oval to circular scars of 2 mm diameter and the surrounding rim consists of 15 to 20 bracts, 4 to 5 mm long and 2 to 6 mm broad. The veined half which Plumstead recognized as bracts is comparable with the scale leaf of the present species in showing the radially placed venation which branches upwards, outwards and at the base downwards towards the divided rim.

Genus — *Plumsteadia* Rigby, 1963

Plumstead (1958) proposed a name *Cistella* for a glossopterid fructification. Subsequently, in 1963 Rigby described a glosso-

pterid fructification under *Plumsteadia* that has since been considered synonymous with *Cistella* Plumstead (1958) by White (1964).

Rigby (1968) accepted the conclusion of White (1964) and pointed out that the name *Cistella* had been used twice earlier — *Cistella* Blume, 1825 (Orchidaceae) and *Cistella* Quelet, 1886 (Hyaloscyphaceae).

Therefore, he (Rigby, 1968) proposed to include all the species of *Cistella* Plumstead (1958) under *Plumsteadia* Rigby (1963) as this name has been used already for such type of fructification.

For similar reasons, a new name *Gonophylloides* has been proposed by Maheshwari (1968) for the fructification described under *Cistella* Plumstead. But the name *Plumsteadia* Rigby has been used here as it has nomenclatural priority over *Gonophylloides* Maheshwari (1968).

The following new combinations have been proposed by Rigby (1968):

Plumsteadia stricta (Plumstead) Rigby, 1968.

P. waltonii (Plumstead) Rigby, 1968.

P. bowenensis (White) Rigby, 1968.

P. ampla (White) Rigby, 1968.

P. indica (Maheshwari) Rigby, 1968.

Plumsteadia lanceolata sp. nov.

Pl. 1, figs. 4-5; Text-fig. 4

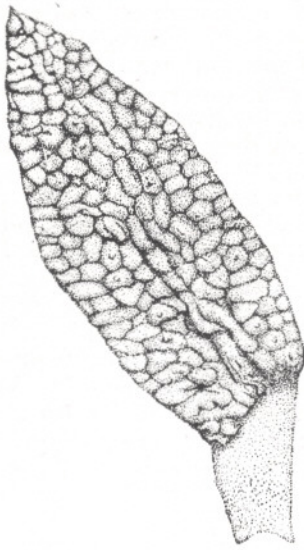
Diagnosis — Fructification lanceolate in shape, pedicellate; apex acute, base broad; rim absent; scars regular, elongate to oval, 1 mm in diameter.

Holotype — Specimen no. 15/1391 with counterpart no. 16/1391, B.S.I.P. Museum, Lucknow.

Locality — Rajbar Village Section, Auranga Coalfield, Bihar.

Horizon & Age — Raniganj Stage, Lower Gondwana, Upper Permian.

Description — There is a solitary complete, detached specimen preserved with counterpart. The shape is elongate to lanceolate. The apex is acute, base broad, contracted, rounded and the margin entire. There is a thick well-preserved 6 mm long and 2.5 mm broad pedicel present. The attachment zone of the pedicel is swollen. The wing or rim-like structure is entirely absent. The scars are elongated, rounded, 1 mm in diameter. Each scar shows in its centre a round raised impression that obviously represents the base of the seed stalk.



TEXT-FIG. 4—*Plumsteadia lanceolata* sp. nov. (Holotype) line drawing of the fructification showing oval to elongated seed scars $\times 3$.

Comparison—The present specimen in absence of wing compares with *Plumsteadia* (= *Cistella*) type of glossopteridalean fructification.

The present species in its lanceolate shape and broad base compares with *Plumsteadia bowenensis* (White) Rigby but the latter is attached to the leaf of *Glossopteris communis* whereas *P. lanceolata* sp. nov. is an unattached fructification. *P. ampla* (White) Rigby and *P. waltonii* (Plumstead) White compare in their pedicellate nature but they are distinct from the present species in having a broad shape and comparatively big size scars. *P. lanceolata* sp. nov. differs from *P. stricta* (Plumstead) White and *P. indica* (Maheshwari) Rigby in its lanceolate shape and acute apex.

ACKNOWLEDGEMENTS

I express my sincere thanks to Drs K. M. Lele and Shaila Chandra for their valuable suggestions.

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EXPLANATION OF PLATES

PLATE 1

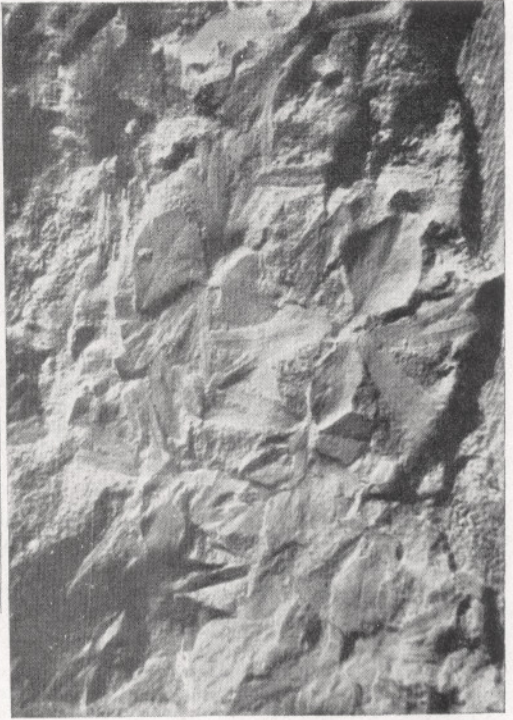
1. *Diphylopteris verticillata* gen et sp. nov. Holotype showing number of leaf whorls on a slab. Specimen no. 53/1392. × Nat. Size.
2. *Diphylopteris verticillata* gen. et sp. nov. showing a whorl of two distinct pairs of leaves. × 4.
3. Counterpart of the whorl shown in fig. 2. Specimen no. 52/1392. × 4.
4. *Plumsteadia lanceolata* sp. nov. Holotype showing a complete detached specimen. Specimen no. 15/1391. × 4.
5. Counterpart of the specimen shown in fig. 4. Specimen no. 16/1391. × 4.

PLATE 2

6. *Neomariopteris barakarensis* sp. nov. Holotype showing the sterile and fertile parts of frond. Specimen no. 70/1311. × Nat. Size.
7. A part of the frond in fig. 6 enlarged to show the position of fertile pinnae. × 2.
8. Enlarged portion of the pinnae showing nature of fertile pinnules. × 4.
9. *Ottokaria biharensis* sp. nov. Holotype showing a rounded receptacle, specimen no. 11/1311. × 4.
10. Counterpart of the specimen in fig. 9 showing radiating, striated and toothed margin scale leaf. Specimen no. 3/1311. × 4.
11. The specimen in fig. 9 enlarged to show the details of receptacle containing seed scars. × 6.



3



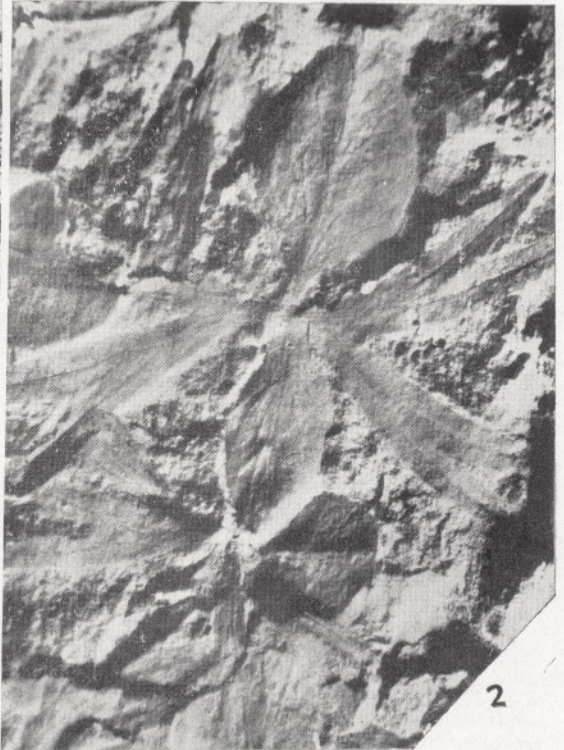
1



4



5



2



6



7



11



8



10



9