

SOME PTERIDOPHYTIC REMAINS FROM THE RAJMAHAL HILLS, BIHAR

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ABSTRACT

The paper describes geological observations made on a few important fossiliferous localities in the Rajmahal hills and some old and new pteridophytic remains found in them.

INTRODUCTION

THE Rajmahal hills is named after the town of Rajmahal in the Santhal Parganas of Bihar. The range consists of low hills and plateaux formed of basaltic trap extending within an area roughly between 86°15' to 88° Long. and 24° to 25°30' Lat. This area is demarcated on the north-east by the river Ganga and on the south by the river Brahmini. The entire area amounts to about 6400 square kilometres. The general elevation varies from 151 to 242 metres above sea-level, but some of the hills reach up to an altitude of even 454 metres in height.

The geology of the area is characterized by a succession of basaltic lava flows or traps with inter-stratified shales and sandstones. The bedded basaltic traps of these hills, with their associated sedimentary beds attain a thickness of at least 604 metres of which the non-volcanic portion never exceeds 30 metres in the aggregate. A detailed account of the geology of the Rajmahal hills has been given by Ball (1877). In the present account the lithology of the rock types studied in some of the important fossiliferous localities (MAP. 1) has been briefly dealt with. The pteridophytic remains described here have been collected over a number of years. Besides describing a few new species, a description of certain better preserved specimens of previously known species has also been included.

GEOLOGICAL OBSERVATIONS ON THE IMPORTANT FOSSILIFEROUS LOCALITIES OF THE RAJMAHAL HILLS

Mirzachowki — The three main fossiliferous outcrops south of Mirzachowki railway station are located at Balbhadri hill, about

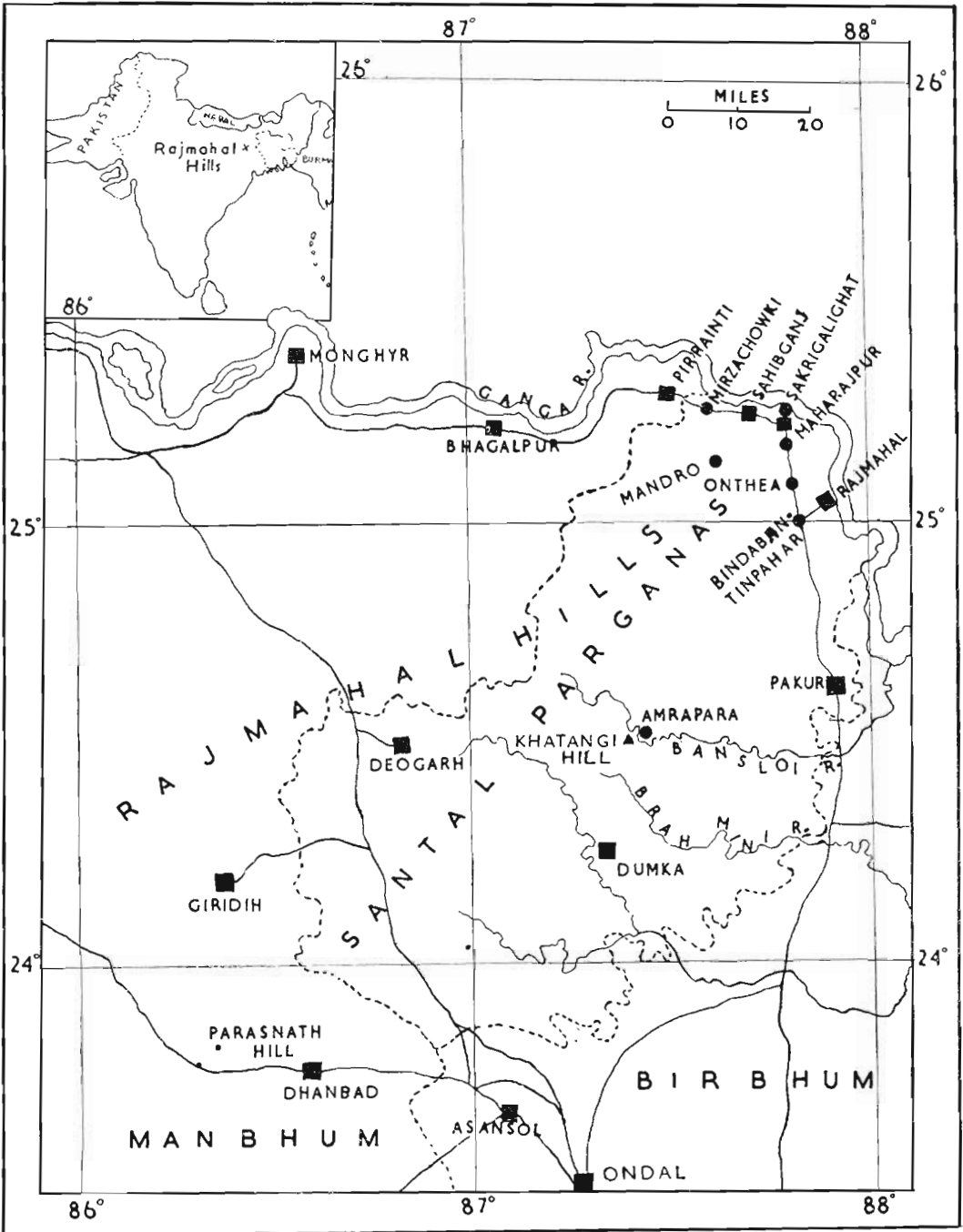
3.6 Km. south of Mirzachowki, Bindaban and Chunakhal; previously the locality Chunakhal was known as Khairbani.

The fossiliferous outcrops are found in the chain of hills south of Mirzachowki railway station. Several small outcrops at Balbhadri hill are exposed at a slightly higher level from the base while at Chunakhal and Bindaban they are exposed at the base of the hills. The intertrappean shale at Balbhadri hill is soft and light yellowish-brown in colour. The constituent minerals are quartz, feldspar and limonite embedded in a fine clayey matrix. The yellowish colour is due to limonite. A few fossils have been recovered of which the majority belong to *Nilssonina* sp.

The Bindaban shale is soft and whitish in colour. The rock has a fine-grained texture. Angular grains of quartz and feldspar laths are embedded in a clayey matrix. Iron-ore is also present in subordinate amount. From the position of the outcrop it appears that this intertrappean bed is older than the ones found at Balbhadri hill.

The Chunakhal rock is megascopically very fine-grained and greyish in colour. It is composed of angular grains of quartz, small laths of feldspar and whitish or yellowish glass. Chalcedony is present with typical aggregate and spherulitic structure, embedded in a fine clayey matrix. Needles of rutile are also common along with irregular grains of magnetite and zircon. The rock in its composition is much similar to volcanic ash.

The trap in Mirzachowki area was noticed as two distinct flows. At Balbhadri hill the trap is compact, at a higher level and dips towards east. It is of a dark colour and coarse texture. The constituent minerals are augite, feldspar and mica. Feldspar shows albite and carlsbad twinning and is probably labradorite. Some olivine grains are also present. Magnetite grains are irregular and fairly common. Augite grains are covered with feldspar laths.



Map of the Rajmahal Hills (Santhal Parganas), Bihar, showing the Fossiliferous Localities.

The second flow is at a lower level and composed of soft trap, comparatively coarse grained in texture. Spheroidal weathering is characteristic.

Mandro — The village of Mandro, previously known as Murrero, is about 16.2 Km. south of Mirzachowki. At the back of the Mandro Dak-bungalow is a small solitary hillock, almost entirely barren. In it three intertrappean beds are noticed at different levels. Petrified woods lie scattered all over in large numbers and give the place an appearance of a small petrified forest. Two fairly large blocks of secondary wood belonging to *Sahnioxylon rajmahalense* have been described (BOSE & SAH, 1954) from this locality. The general succession in this area is as follows:

- Trap, fine grained and compact.
- 3 Gritty sandstone (2-3 m. approx.) — unfossiliferous.
- 2 Whitish hard shale (? thickness) — a few fossils.
- Trap, coarse-grained.
- 1 Whitish soft shale (? thickness) — a few fossils.

The uppermost intertrappean bed is a buff coloured, coarse-grained gritty sandstone. It is composed of quartz and feldspar cemented by calcite. Magnetite is present in small amount. Calcite is mostly altered.

The underlying bed is a hard whitish, shale, fine-grained in texture and showing plication of the laminae. The fine folded laminae are suggestive of intense pressure accompanied by heat. The condition of fossils found in this bed and their fragmentary nature also supports it. The constituent minerals are quartz, magnetite and rutile. Quartz grains are angular and embedded in a fine clayey matrix. Rutile is present in subordinate amount.

The lowermost bed is a soft, fine-grained shale, dirty white in colour. It consists mostly of quartz and feldspar laths embedded in a clayey matrix. Magnetite is also fairly common. Glass is present in a subordinate amount. The shale is fairly compact and has an admixture of volcanic ash.

The upper trap at Mandro is compact, fine-grained and black in colour. In thin section it exhibits a typical ophitic structure, with small laths of plagioclase enveloped within pyroxene. The constituent minerals are plagioclase feldspar, augite, uraltite and iron-ore. Plagioclase feldspar occurs in sub-hedral laths of varying sizes, and is probably

oligoclase. The feldspar laths show weakly developed carlsbad and albite twinning. Augite occurs as small anhedral to sub-hedral grains. Some large tabular plate-are also not uncommon. Cleavage lines are well developed, and sometimes double-pyroxene cleavages are also seen. Uralite is present as light green fibres rimming the amygdules filled with chalcedony. Iron-ore is irregular and usually occupies inter-granular spaces. The trap appears to be a *basaltic-dolerite* very similar in composition to the Amarjola trap.

The lower trap is coarse grained and decomposed. At places spheroidal weathering is noticed. The rock is composed of crystals of plagioclase embedded in augite. The other constituent minerals are uraltite, iron-ore and some brownish grains of palagonite.

Sakrigalighat — The area where the plant-bearing beds are found at Sakrigalighat (Lat. 25°15', Long. 87°43') is about 1.8 Km. north of Sakrigali railway station and about half a mile west of Sakrigalighat railway station. It is on the south side of the river Ganga. There is a small hillock about 20 metres high which presents a more or less steep slope towards the river side and from the base of the hill to the river's edge is a gentle slope about 30 metres in width. All the plant-bearing beds are located in this sloping stretch. They are mostly under water during rains and exposed only during the winter and summer months. This has resulted in much denudation and alternation of the rocks. The ones nearer the river are more soft, fragile and covered with alluvium, than the ones farther away. Five intertrappean beds have been recognized in this stretch, two of them being richly fossiliferous. The beds dip at an angle of 5° to 6° towards north. According to the order of super-position the oldest bed is nearest the river bank and mostly under water. The beds farthest are the youngest.

The general succession in the locality is as follows:

- Alluvium
- Trap
- 5 Gritty sandstone (10-14 m. approx.) — unfossiliferous.
- 4 Greyish-white, bluish and yellowish shale (1.60-2 m.) — a few fossils.
- 3 Whitish, hard and silicified shale (30-60 cm.) — richly fossiliferous.

2 Fragile shale (2.5-3 m.) — richly fossiliferous.

1 Greyish shale with a few and scattered coaly lenses (partly under water, 2-3 m.) — a few fossils but rich in spores and pollen grains.

The trap is exposed at the eastern edge of the stretch in which the intertrappean beds are located. It lies vertically across the sedimentary beds and is much folded and compressed on the upper regions alongside the gritty sandstone bed. The general appearance of the upper trap at first glance is suggestive of an intrusive nature, but from the study of the folding it becomes clear that the trap occupied a position over the gritty sandstone bed and was later dislocated to its present position. The rocks of the area are so much weathered, decomposed and filled with alluvium that more details regarding the nature of the trap could not be ascertained, although its general nature is suggestive of a flow.

The trap shows fine nodular and spheroidal weathering. It is fine-grained, greenish-black in colour and much weathered. Thin sections of the rock shows equi-granular and subhedral grains with a few big crystals of plagioclase. The other constituent minerals besides plagioclase, are augite, palagonite, uralite and iron-ore. Plagioclase occurs as small elongated laths of labradorite, with an extinction angle of 30°. Some crystals show well developed carlsbad twinning. Augite occurs as colourless or greenish grains which are mostly rounded. Cleavage is indistinct. Polarization colours are of the second order. Some grains of augite have altered to uralite. Palagonite is present as yellowish-brown grains. Some of these show a tendency towards Oolitic structure. The rock shows a basaltic composition. In its general composition it considerably resembles the Deccan Trap except for the complete absence of olivine.

Bed No. 5 is a thick band of gritty sandstone. The rock is light brown in colour and has become much decomposed due to weathering. This bed is covered by bushes and undergrowths. The sandstone is composed of quartz, plagioclase, calcite, chlorite and iron-ore. No fossils were recovered from this bed.

Bed. No. 4 is 1.60-2 m. thick, of whitish grey or yellowish shale with intercalated bluish bands. The constituent minerals

are quartz, uralite, mica and iron-ore. A few fossils have been recovered from this bed. *Ptilophyllum acutifolium* is the commonly found species.

Bed No. 3 is formed of whitish hard shale about 30-60 cm. thick. The shale is highly silicified and hardened, but the impressions in it are fairly well preserved. This bed being composed of hard porcelainic shale has withstood denudation and so stands out as the most prominent bed of the section. Iron is present in sufficient quantity and has imparted the exposed surfaces a rusty brown colour. This bed is richly fossiliferous. *Ptilophyllum* and *Pterophyllum*-like leaves are the dominant forms. *Williamsonia santhalensis* Sitholey & Bose (1953) and a large number of *Bucklandia* have been recovered from this bed. Besides leaf-impressions, vertically placed root impressions have also been noticed at several places. Unfortunately the wood pieces are too poorly preserved to show any structure.

Bed No. 2 is about 2-3 m. thick and composed of very brittle and fragile shale. The general colour of the shale is grey but the exposed surfaces are stained rusty brown, brownish or yellowish probably due to iron-oxide. The other constituent minerals are quartz, biotite and feldspar. Quartz occurs as subhedral to subangular grains. Plagioclase feldspar is greatly decomposed and altered. This bed is also very rich in fossils. *Todites indicus* is the dominant species. *Ginkgoalean* leaves and *Dictyozamites falcatus* are also quite common. Vertically placed root markings have also been noticed in this bed.

The basal part of bed No. 2 is much weathered and covered with alluvium. In general appearance it looks like an altered sandstone. Under the microscope the rock consists of irregular pieces of basalt cemented in a calcitic matrix. The feldspars are mostly thin laths and are probably andesine. The ferro-magnesian minerals have greatly altered to green chloritic matter and in some basalt pieces a greenish margin is present. Calcite occurs as irregular grains. It has no cleavage but exhibits twinning. The basalt pieces are fine-grained and show typical basaltic texture.

Bed No. 1 is partly under water and partly exposed. During summer the exposed portion of the bed is about 2-3 m. thick. How much remains always under the water could not be ascertained. A

few scattered lenses of carbonaceous (coaly) shale were noticed in this bed. From these a few impressions of *Ptilophyllum* and a few fragments of indeterminate leaves have been obtained. Transfers of these have yielded cuticle pieces. Maceration of this shale has yielded a rich microflora, which has already been described (SAH & JAIN, 1964). The shale is greyish green in colour and is composed chiefly of quartz, calcite and iron-ore. Mica is also present in small quantity. The greenish colour is due to altered chlorite.

Maharajpur — On the northwestern side of the Maharajpur railway station is a small hillock stretching along north-south direction. The intertrappean beds are found along its base till railway pole No. 209/8. Only a few recognizable fossils were found. Three intertrappean beds could be seen in the following sequence:

Trap

- 3 Whitish sandstone (thickness ?) — fragmentary fossils.
- 2 Whitish compact shale (approx. 1.30-2 m. thick) — fragmentary fossils.
- 1 Greyish frangible shale (thickness ?) — richly fossiliferous.

The Maharajpur trap is a fairly compact rock greenish black in colour and coarse grained in texture. It is composed of triclinic feldspar, which is hornblende. Other minerals are magnetite, apatite, quartz and some rhombic pyroxene (? enstatite). A few grains of mica are also present. Magnetite is abundant and embedded in hornblende. The rock is granitic and holocrystalline and is probably a *hornblende-diorite*.

The uppermost whitish sandstone is soft, comparatively coarser and easily scratched. The rock has a fine-grained texture and is essentially composed of quartz and feldspar, both showing well-marked cleavages. Relatively larger grains of both are embedded in a fine-grained matrix. Iron-ore is speckled all over the rock. Sericite, biotite and rutile are present as accessories. Rutile is present in aggregate amounts showing blood-red interference colours under crossed nicols.

The middle whitish shale is more compact and less coarse. Quartz grains and feldspar laths are embedded in a fine-grained matrix. Magnetite is fairly common. Rutile and zircon are also present, but very rare. *Taeniopteris*-like leaves are the only forms found in this bed.

The lowest bed is formed of a very fragile and brittle shale. The bed is covered by alluvium and dense vegetation. Fragmentary fossils could be obtained only after digging. The rock is greyish in colour, the exposed surfaces being rusty brown or yellowish. It is composed of quartz, biotite, feldspar and iron-oxide. Quartz grains are angular to subhedral. Plagioclase feldspar is much altered. *Todites indicus* is most frequent in this bed. In its mineral composition, rich colour and floral assemblage this bed appears to be the same as bed No. 2 of the Sakrigalighat section.

Onthea — The fossiliferous bed in this locality is met with at the base of the hill east of Bara-Hirankol village (Lat. 27° 9'; Long. 87° 45'). The hill is much longer than high and stretches along a north-south direction. A single intertrappean bed was noticed in this locality in the form of huge boulders lying scattered along a north-south trend.

Onthea trap is a compact *vesicular-dolerite*, medium grained and dark-grey in colour. Vesicular cavities of different patterns are abundant. Under the microscope the rock is holocrystalline and hypidiomorphic. Labradorite is mostly unaltered occurring abundantly as small laths. Some big laths altering into Palagonite were also observed. Albite and periclinic twinning is commonly seen in the feldspars. It shows ophitic relation with augite. Magnetite grains are common. The vesicular cavities are lined with palagonite.

The intertrappean shale is whitish grey in colour, compact, hard and porcelainic. It is composed of fine grains of quartz, feldspar and magnetite, embedded in a clayey matrix. Rutile and zircon are also present. *Ptilophyllum acutifolium*, *Nilsson* sp. and *Elatocladus conferta* are commonest forms found here. In its lithological characters and floral contents this bed is comparable to Bed. No. 3 of the Sakrigalighat section. Petrified woods were found scattered but there is no indication of their 'in-situ' deposition. Some specimens of *Sahnioxylon rajmahalense* were also found in this locality.

Tinpahar — The name Tinpahar is derived from a solitary hillock with three prominent ridges on the western side of the Tinpahar railway station. The hill is about 145-150 metres high, running along a northwest-southeast direction. The hill is entirely

barren except for some undergrowths and solitary trees. The entire hill is mainly composed of trap. Well formed hexagonal and columnar joining is seen at the top of the northern ridge. Here, two intertrappean beds were found, one in the form of two small outcrops of chert at the middle of the southern ridge facing the railway station and the other at the base of the hill on the south side with impressions of fossil stems. However, no fossil leaf impressions were recovered from the bed at the base of the hill.

The Tinpahar trap is a fine-grained holocrystalline rock showing ophitic structure. Plagioclase feldspar forms the bulk, and is labradorite. It occurs as small laths and shows albite twinning. These laths show ophitic relation with augite, which is also present as small grains. Some augite grains have altered to palagonite. Olivine is also present in appreciable quantity. Except for a few phenocrysts, olivine is present as small grains. Some large patches of magnetite have enclosed feldspar grains which suggest late crystallization. The rock appears to be *olivine-basalt*. The presence of olivine in Tinpahar trap is rather an important feature. McMahon (1887) while comparing Rajmahal and Deccan trap has stressed the complete absence of olivine from the former. Oldham and Morris (1863) also mention the presence of olivine in the Rajmahal trap. The Tinpahar trap shows olivine as a regular constituent.

The intertrappean chert is a compact rock, very hard and almost porcelanic. The rock is fine-grained, whitish in colour and composed chiefly of quartz grains with subordinate chloritic matter. Quartz grains are angular to subhedral. Lamination is fairly prominent. The compactness of the quartz grains is probably due to baking. Contortion of the laminae indicates certain amount of pressure accompanied by heat. The outcrop is almost entirely composed of a tree-fern, *Tinpaharia sinuosa*. A few shoots of *Brachyphyllum* have also been recovered which show fairly well preserved anatomy.

Recently from a new locality at Murli-pahar, about 7.2 Km. east of Tinpahar and by the side of the Murli Mission Church some carbonized impressions of *Sphenopteris* along with some Ginkgoalean leaves have been recovered from a very fragile greyish-green shale. The shale is composed of

quartz, feldspar, iron-ore and altered chlorite.

Brindaban — The village of Brindaban is about 3.6 Km. north-west of Tinpahar railway station. Here the fossiliferous outcrop is found at the base of the hill, at the back of the Dak-bungalow. The outcrop is formed of a soft and fragile shale. The shale is fine-grained and light greenish-grey in colour. The constituent minerals are quartz, kaolin, chlorite and magnetite. Quartz is present as subhedral grains. *Coniopteris* sp. is the commonest here. Several sterile and fertile specimens of this species have been collected. The other important genera are *Cladophlebis* and *Ptilophyllum*. Fossil petrified woods are found scattered all around in the fields near this hill.

The Brindaban trap is a medium grained compact rock, dark greyish-green in colour. The rock is composed of triclinic feldspars belonging to the labradorite-anorthite group. The feldspar laths show albite and carlsbad twinning and ophitic relation to augite. Augite is present as small grains. Magnetite and olivine are also present as regular constituents. Zeolite, chalcedony and quartz are formed in the amygdules.

Localities near Amrapara — The nearest fossiliferous locality is Amarjola, about 1.8 Km. northeast of Amrapara village. The intertrappean bed is more prominent owing to the brownish colour and pisolitic matrix of the rock. The bed is fairly long and can be traced to several hundred metres. The bed is about 5 m. thick. The rock is very friable and has a dull yellowish-brown colour. In this section it shows spherules of various sizes, zoned by thin bands of chalcedony. The central part of the spherules are dark brown in colour, followed by yellowish and orange coloured bands. The outermost band is light green in colour. The central body is isotropic but the bands show a weak birefringence. These spherules are oolites of limonite with concentric shells cemented by chalcedony. Some magnetite grains are also present. The rock is an *Oolitic ironstone*. Plant fossils are embedded in the matrix of the rock. They are petrified in a fine-grained, yellowish matrix. *Ptilophyllum amarjolense*, *Bucklandia sahnii* and *Pentoxylon* sp. are quite common in this locality.

About 1.8 Km. further north of Amarjola is Chilgojuri where fossils in petrified condition were found. Unfortunately they are rather

badly preserved for anatomical details. Intertrappean shales were found scattered in the fields. *Ptilophyllum cutchense* and *Bucklandia* sp. are the common forms found in this locality, besides a large number of wood pieces.

The Amarjola trap is a fine-grained compact rock, blackish in colour. The amygdules are common and filled with chalcedony, glauconite or zeolite. In thin section the trap shows ophitic texture and is composed of plagioclase felspar, pyroxene, uralite, iron-ore, calcite and mica. Plagioclase is present as subhedral laths, varying in size and enveloped in augite grains. It shows well developed albite and carlsbad twinning and is probably oligoclase. Pyroxene monoclinic which is present as anhedral to subhedral grains. Large tabular plates are fairly common, but the grains are not pleochroic. Uralite is secondary and shows faint pleochroism. Iron-ore occurs as irregular grains, calcite and mica being rare. The rock appears similar to a dolerite but considering the basaltic country the use of the name *basaltic-dolerite* may perhaps be more appropriate.

Nature and occurrence of plant-bearing beds—The sedimentary beds of the Rajmahal hills, which yielded plant fossils, are composed chiefly of silicified or soft greyish shales and sandstones. In some places like Nipania and Chilgojuri, all the fossils are silicified. These beds are believed to have been deposited during intervals which elapsed between various fissure eruptions and are also intertrappean in nature. The intertrappean beds are generally met with along the hill ranges, a little above the base. The plant beds can sometimes be traced for several hundred metres but usually it is difficult to see them beyond a small lateral extent.

Nature of the fossil material—The Rajmahal plant fossils are preserved mostly as impressions and casts. These are commonly found in hard or soft shales and at times in sandstones. Petrifications due to silicification are met with in several of the localities, but the silicification is sometimes only partial. Nipania and Amarjola, both in the Amrapara district, have so far yielded the best preserved petrifications. Incrustations with a thin film of carbonized matter have so far been discovered only at Sakrigalighat and Murlipahar but they are extremely rare.

DESCRIPTION

Family LYCOPODIALES

Genus — *Lycopodites* Lindley & Hutton

- Lycopodites gracilis* (Oldham & Morris)
Feistmantel
(Pl. 1, Figs. 7, 8)
- 1863 *Araucarites* (?) *gracilis* Oldham & Morris, pl. 33, figs. 1, 2, pl. 35, figs. 1, 2.
- 1877a *Cheirolepis gracilis* Feistmantel, p. 87.
- 1880 *Lycopodites gracilis* Feistmantel, p. xix (preface).
- 1881 *Lycopodites gracilis* Oldham & Morris Feistmantel, p. 150, pl. 2.
- 1920 *Lycopodites gracilis* Morris: Seward & Sahni, p. 18, pl. 7, figs. 77, 77a.
- 1965 *Lycopodites gracilis* (Oldham & Morris) Seward & Sahni: Surange, p. 16 fig. 7 A-C.

Emended diagnosis—Shoots heterophyllous, branched. Branches slender about 1 mm. thick, forking unequally in one plane. Lateral leaves bigger and spreading; dorsal and ventral leaves small and appressed. Leaves ovate—lanceolate, apex acuminate, base decurrent, margin entire. Median vein distinct.

Locality—Bindaban.

Lectotype—No. 4487, Geological Survey of India, Calcutta.

Comparison—A large number of specimens have been collected from Bindaban. They all resemble the previously described specimens by Seward and Sahni (1920). Among them only two specimens (Pl. 1, Figs. 7, 8) show midrib distinctly. *L. gracilis* has been compared by Seward and Sahni with *L. falcatus* L. & H. But according to Harris (1961) the latter species is different from *L. gracilis*.

Family EQUISETALES

Genus — *Equisetum* Linnaeus

- Equisetum rajmahalense* (Oldham & Morris)
Feistmantel
(Pl. 1, Figs. 1-6)
- 1863 *Equisetites rajmahalensis* Oldham & Morris, pl. 2, figs. 2-5; pl. 35, figs. 3, 4
- 1877a *Equisetum rajmahalense* Schimper, O. M.: Feistmantel, p. 11.
- 1933 *Equisetites rajmahalensis* Oldham & Morris: Sahni & Rao, p. 188.
- 1934 *Equisetites* cf. *rajmahalensis* Oldham & Morris: Sahni & Rao, p. 260.

- 1946 *Equisetites rajmahalensis* Oldham & Morris: Ganju, p. 56, pl. 1, fig. 1.
Equisetites sp.: Ganju, p. 57, pl. 1, fig. 2.
- 1965 *Equisetites rajmahalensis* Oldham & Morris: Surange p. 56 fig. 30 A-B.
- 1877a *Asplenites macrocarpus* Oldham & Morris: Feistmantel, p. 39, pl. 36, figs. 5-7, pl. 37, figs. 3, 3a-c, 4, pl. 48, figs. 2, 2a.
- 1877b *Pecopteris (Asplenites) macrocarpa* Oldham & Morris: Feistmantel, p. 9, pl. 1, figs. 1, 1a, 2.
- 1920 *Marattiopsis macrocarpa* Morris: Seward & Sahni, p. 20, pl. 7, figs. 71, 71a-b.
- 1933 *Marattiopsis macrocarpa* Morris: Sahni & Rao, p. 184, pl. 11, figs. 1, 2.
- 1934 *Marattiopsis macrocarpa* Morris: Sahni & Rao, p. 262, pl. 35, figs. 5-7, pl. 36, figs. 8-10, text-fig. 4.
- 1946 *Marattiopsis macrocarpa* Morris: Ganju, p. 59.
- 1965 *Marattiopsis macrocarpa* (Oldham & Morris) Seward & Sahni: Surange, p. 81, fig. 48A, B.

Emended diagnosis — Rhizome horizontal, without any clear distinction between nodes and internodes, measuring 22-25 cm. in length and 2-2.5 cm. in breadth. Rhizome showing longitudinal ridges and grooves, sometimes discontinuous at places. Rhizome also showing a few nodal diaphragms, each lying from one another at a distance ranging from 3-8 cm.

Vegetative stem erect, unbranched, 0.8-4 cm. in diameter. Nodes and internodes at short intervals. Nodes slightly swollen, internodes smooth, without ridges or grooves. Leaf-sheaths borne at the nodes, approximately 25-30 in number, appressed, about 1-1.5 cm. in length. Leaf-teeth large, linear, pointed, slightly keeled.

Nodal diaphragm showing a single ring of tubercles, about 18-45 in number.

Localities — Balbhadri hills, Bindaban, Chunakhal, Bartala, Borio, Sakrigalighat, Onthea, Chilgojum and Nipania.

Lectotype — No. 4487a Geological Survey of India, Calcutta.

Comparison — Unlike the rhizomes of *Equisetites gracilis* (Nathorst) described by Halle (1908) and *E. arenaceus* (Jaeger) Schenk, *E. conicus* Sternberg and *E. elegans* (Kräusel) described by Kräusel (1959), the rhizomes of the present species do not show any clear distinction between nodes and internodes.

According to Sahni and Rao (1933), *E. rajmahalense* resembles most *E. ferganensis* described by Seward (1912) from Afghan-Turkestan. The erect stems of *E. rajmahalense* are very fragmentary, so it is rather difficult to compare them with any of the well known species, especially with the ones from the Jurassic of Yorkshire described by Harris (1961).

Family — MARATTIACEAE

Genus — *Marattiopsis* Schimper

Marattiopsis macrocarpa (Oldham & Morris)
Seward & Sahni
(Pl. 1, Figs. 9, 10, Pl. 2, Figs. 11-13)

1863 *Pecopteris (Asplenites) macrocarpa*: Oldham & Morris, p. 51, pl. 28, figs. 2, 3, 3a.

Emended diagnosis — Leaves sterile or fertile, both agreeing with each other in form and venation. Leaf form and size as a whole unknown, largest available leaf measuring 11 cm. in length, width commonly 1.4-3 cm. Rachis prominent, 0.5-1 mm. wide, with a median groove. Pinnae arising at an angle of 70°-90°, falcate, 10-20 mm. long 3-5 mm. wide, apical pinnae pinnatifid (in case of fertile fronds mostly devoid of synangia), apex bluntly rounded or acuminate, basiscopic margin slightly decurrent, margin entire. Midrib 0.5-1.5 mm. broad, secondary veins mostly forking once, sometimes undivided.

Synangia crowded, 8-18 on either side of the midrib, oval, some showing radial ridges representing the boundaries of the sporangial compartments. Spores not preserved.

Localities — Banchappa, Bindaban, Onthea, Brindaban and Ghutiari.

Lectotype — No. 4508 and isotype no. 4/452 of the Geological Survey of India, Calcutta.

Comparison — A large number of specimens of *M. macrocarpa* have been collected from time to time, but all of them are extremely fragmentary. From them it is very difficult to make out the exact shape and size of the leaves. *M. macrocarpa* is quite distinct from the other Mesozoic and the living species of *Marattia* belonging to Marattiaceae. The leaves are extremely narrow and the pinnae are very small. The details of synangia and spores of *M. macrocarpa* are not known. So, for the present,

we have retained the generic name *Marattiopsis*, instead of transferring it to *Marattia*.

Family — OSMUNDACEAE

Genus — *Todites* Seward

Todites indicus (Oldham & Morris)
comb. nov.

(Pl. 2, Figs. 14-18, Pl. 3, Figs. 19, 20; Text-fig. 1 A-D)

1863 *Pecopteris* (*Alethopteris*) *indica*
Oldham & Morris, p. 47, pl. 27, figs. 1-3.

1877a *Alethopteris indica* Oldham & Morris:
Feistmantel, p. 37, pl. 26, figs. 4, 4a, pl. 46, figs. 3, 4.

1877b *Alethopteris* (*Cladophlebis*) *indica*
Oldham & Morris: Feistmantel, p. 7, pl. 1, figs. 3-5.

1879 *Alethopteris indica* Oldham & Morris:
Feistmantel, p. 15, pl. 1, fig. 1.

1882 *Asplenium whitbyense* Heer: Feistmantel, p. 28, pl. 1, figs. 2-7.

1932 *Alethopteris indica* (Oldham & Morris):
Deb, p. 104, pl. 7, figs. 1, 2.

1933 *Cladophlebis indica* Oldham & Morris:
Sahni & Rao, p. 189, pl. 11, figs. 3-5.

1934 *Cladophlebis indica* Oldham & Morris:
Sahni & Rao, p. 263, pl. 35, fig. 7.

1946 *Cladophlebis indica* Oldham & Morris:
Ganju, p. 61.

1965 *Cladophlebis indica* (Oldham & Morris)
Sahni & Rao: Surange, p. 87, figs. 52, 53A, B.

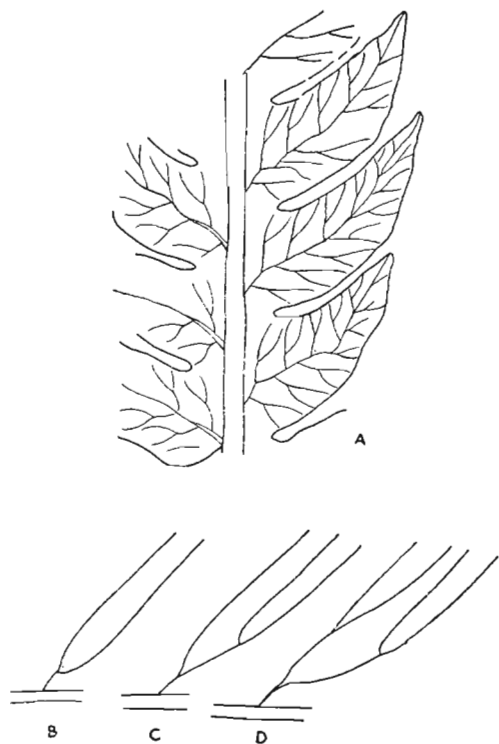
Emended diagnosis — Fronds bipinnate, sterile and fertile leaves separate.

Sterile leaves fragmentary, largest available sterile leaf measuring 20.5+20 cm. Rachis with a median ridge, finely striated, measuring upto 7 mm. in width (perhaps wider below). Pinnae rachis grooved, about 1.5-2 mm. wide, a few showing a median ridge, arising alternately at an angle of 35°-60°, about 2.2-2.8 cm. apart; pinnules belonging to adjacent rachae touching each other or overlapping. Sterile pinnules alternate or sub-opposite arising at an angle of 58°-65°, 6-17 mm. long (mostly about 12-15 mm.), 3-6 mm. broad at the base, falcate, apex acute or bluntly rounded, base slightly expanded on acroscopic side, decurrent on basiscopic side. Margins entire or crenulate near the basal region, mostly denticulate or crenulate near the apex, teeth small, pointing forward. Midrib prominent, traversing the entire length, basal pair of secondary veins mostly forked once or twice (in some only one arm divide and the other may remain undivided), other veins forked once, uppermost one or two pairs may be undivided. Branch veins slightly curved (convex), reaching the margins.

Fertile pinnae imperfectly preserved, largest available pinnae measuring 7.8×2.5 cm. Rachis about 1.5 mm. wide. Pinnules arising almost at right angles (or slightly less), alternate or sub-opposite, 10 mm.-12 mm. long, 3 mm. broad basally, apex bluntly pointed. Veins not visible, margin crenulate. Sporangia imperfectly preserved, when visible 4-7 sporangia forming a round or elliptical sorus, spores not preserved.

Localities — Banchappa, Bindaban, Chunnakhal, Mandro, Sakrigalight, Onthea, Maharajpur, Brindaban, Murlipahar, Soorojbera and Sugadiah.

Lectotype — No. 4448 of the Geological Survey of India, Calcutta.



TEXT-FIG. 1 — *Todites indicus* (Oldham & Morris) comb. nov. — A, a few pinnules showing venation No. 4681. × 3. B-D, showing mode of bifurcation of secondary veins in different leaves. × ca. 10.

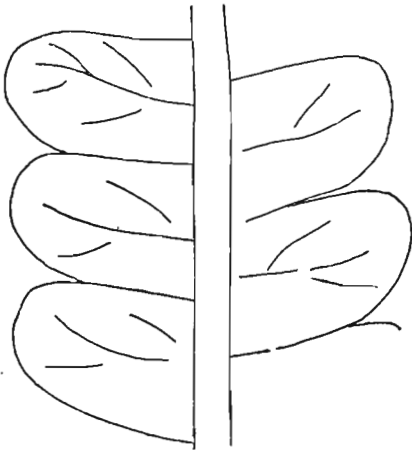
Comparison — *Todites indicus* is one of the commonest fern in the Rajmahal hills. Although a large number of sterile leaves have been collected from various localities, fertile leaves are very rare. So far only two extremely badly preserved specimens have been collected. In them the sporangia can be made out only at places. The other details are completely missing. The sterile leaves show closest resemblance with the sterile leaves of *Todites denticulatus* (Brongniart) Krasser or *Cladophlebis denticulata* (Brongniart) Fontaine described by Harris (1961) from the Jurassic of Yorkshire. The pinnules of *T. denticulatus* are bigger in size than *T. indicus*. Due to the imperfect preservation of the fertile fronds in *T. indicus* it is difficult to compare them with any of the known fertile species of *Todites*.

Family — GLEICHENIACEAE

Genus — *Gleichenia* Smith

Gleichenia gleichenoides (Oldham & Morris)
n. comb.

(Pl. 3, Fig. 24, Pl. 4, Figs. 25-30, Pl. 7, Fig. 41;
Text-fig. 2)



TEXT-FIG. 2 — *Gleichenia gleichenoides* (Oldham & Morris) comb. nov. — a few sterile pinnules to show venation No. 2654. $\times 10$.

- 1863 *Pecopteris* (*Gleichenites*) *gleichenoides* Oldham & Morris, p. 45, pl. 25, figs. 1, 1a, 2, pl. 26, figs. 1, 3.
1869 *Gleichenia bindrabunensis* Schimper, p. 670.

- 1877a *Gleichenites* (*Gleichenia*) *bindrabunensis* Schimp., Oldham & Morris: Feistmantel, p. 41.
1882 *Gleichenia rewahensis* Feistmantel, p. 24, pl. 1, figs. 15-19, pl. 20, figs. 7-9.
1920 *Gleichenites gleichenoides* Oldham & Morris: Seward & Sahni, p. 19, pl. 7, fig. 67.
Gleichenites rewahensis Feistmantel: Seward & Sahni, p. 19, pl. 7, figs. 68-70.
1933 *Gleichenites gleichenoides* Oldham & Morris: Sahni & Rao, p. 187.
1934 *Gleichenites gleichenoides* Oldham & Morris: Sahni & Rao, p. 263, pl. 36, fig. 10.
1946 *Gleichenites gleichenoides* Oldham & Morris: Ganju, p. 59, pl. 2, figs. 6-8, text-figs. 3-5.
1965 *Gleichenites gleichenoides* (Oldham & Morris) Seward & Sahni: Surange, p. 98, figs. 62A, B, 63A, B, *Gleichenites rewahensis* Feistmantel: Surange, p. 100, fig. 64A, D.

Emended diagnosis — Both sterile and fertile leaves with similar habit, form and size of a leaf as a whole not known, at least tripinnate. Main rachis about 5 mm. broad, broader at the point of bifurcation, surface smooth. Branches of the first order (primary pinnae) as a whole long-lanceolate, exceeding 25 cm. in length, 6-14 cm. in breadth, rachis 2-4 mm. broad at the base, less than 0.5 mm. above, smooth. Branches of the second order (secondary pinnae) arising almost at right angles (sometimes at 80°), alternate, closely set, linear, 3-7 cm. long, 2-3 mm. broad, gradually decreasing towards the apex, rachis very thin, less than 0.3 mm. broad. Ultimate branches (pinnules) arising at an angle of 70°-90° alternate, closely set, basal region touching each other. Pinnules small, more or less wedge-shaped, 1-2+1-2 mm., attached by their entire breadth, apex rounded, margin entire; midrib prominent, secondary veins few, 5-6, mostly not forking, in some rarely forking once, mostly reaching the margin.

Each fertile pinnule with a single large sorus, placed near the base, slightly less than 1 mm. in diameter, occupying more than half the basal area, number of sporangia not clear, probably 12-15. Spores not preserved.

Localities — Bindaban and Onthea.

Lectotype — No. 4444 of the Geological Survey of India, Calcutta.

Comparison — The largest number of specimens of *G. gleichenoides* have been collected from Bindaban. They are all fragmentary. Only three specimens show the main rachis. It seems the main rachis divided into three branches. The detached branches of the first order are fairly big, they are mostly sterile, only a very few fertile specimens have been collected. Both sterile and fertile leaves are similar. The leaves from South Rewa Gondwana basin described by Feistmantel (1882) and Seward and Sahni (1920) are extremely fragmentary. They resemble the specimens from the Rajmahal hills. The substance of lamina of the specimens from South Rewa seems to be slightly thicker, their rachis is also slightly thicker than the specimens from the Rajmahal hills. But there are specimens from the Rajmahal hills which have almost equally thick rachis and pinnules.

Forking of the main rachis of *G. gleichenoides* is somewhat similar to *G. gieiseckiana* and *G. porsildi* described by Seward (1926) from Western Greenland. According to Seward in *G. porsildi* the main rachis divides into two branches and in the angle of the fork there is either a bud, or a bud-scale or an axis. In *G. gleichenoides* neither a bud nor a bud-scale has been observed so far. Here, in all the specimens so far collected, between the two divergent branches a thick axis is preserved (Pl. 7 FIG. 41). In *G. gieiseckiana* between the branches no bud, or a bud-scale or an axis is present.

Family — MATONIACEAE

Genus — *Phlebopteris* Brongniart

Phlebopteris sp.

(Pl. 5, Figs. 31-33, Pl. 6, Fig. 40)

1950 *Laccopteris* (*Phlebopteris*) sp.: Rao, p. 379, figs. 3, 4.

1965 *Phlebopteris* sp.: Surange, p. 113 fig. 72A, B.

The description is based on two fragmentary pinnae and a few detached pinnules. Venation in most of them is not clear. Some of them show the position of the sori but in none of them sporangia are clearly marked. So at present they are described here as *Phlebopteris* sp. For description they are assumed to be bipinnate.

Description — The largest available pinnae measures 17.5 cm. in length and 11 cm. in breadth. Pinnae rachis grooved, about 3 mm. broad. Pinnules arising alternately

at an angle of about 75°, largest pinnule measuring 8 cm. in length, shorter towards the base and apex, breadth mostly at the base 5-6 mm. Pinnules straight or curved, gradually tapering down to an acute or obtusely pointed tip, base of adjacent pinnules touching each other. Margins of pinnules entire, seems to be recurved. Midrib grooved, reaching the apex, about 0.5 mm. broad, lateral veins arising almost opposite one another, branching at all levels, anastomosing at places; basal meshes inconspicuous, rarely visible.

Sori in two rows on both sides of the midrib, about 1 mm. apart from each other, placed slightly away from the midrib. Sporangia not clearly marked, at places visible in groups of six. Spores not preserved.

Figured specimens — Nos. 31093 and 2676, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Chunakhal.

Comparison — *Phlebopteris* sp. described here resembles most some of the specimens of *P. polypodioides* Brongniart described by Hirmer and Hoerhammer (1936, PL. 7, FIGS. 2, 2a & 3). The size and shape of the pinnules in both the species seem to agree with each other. Also the lateral veins of the pinnules show somewhat similar branching and anastomosing. But in *P. sp.* anastomosing is not so regular as *P. polypodioides* and also the basal meshes are inconspicuous in the former species. Further comparison is not possible due to imperfect preservation of *P. sp.* The specimens of *P. polypodioides* described by Harris (1961 from Yorkshire differ from *P. sp.* in having pinnules where the lateral veins anastomose more frequently and there is a prominent basal web. Also in the Yorkshire specimens there are 14 sporangia in each sorus, whereas, in *P. sp.* only 6 are visible. The pinnules of *P. takahashii* Huzioka (1938) also shows less anastomosing of the secondary veins. In this respect it may be compared with *P. sp.* As the other details are not preserved in *P. takahashii* so further comparison is not possible.

Family — DIPTERIDACEAE

Genus — *Hausmannia* Dunker

Hausmannia crenata (Nathorst) Möller

(Pl. 6, Figs. 36, 37)

1955 *Hausmannia indica* Gupta, p. 147, pl. 15, figs. 1, 2, text-fig. 1.

1965 *Hausmannia indica* Gupta: Surange, p. 108, fig. 69A, B.

A single specimen in counterpart has been collected. The specimen is incomplete near the base.

Description — Substance of lamina thick and leathery in appearance, more or less orbicular, about 4.5 cm. broad, margin slightly thick and distinctly crenulate. Veins distinct, (?) two prominent veins arising from the base, forking repeatedly and radiating in a palmate manner; lateral veins arising almost at right angles forming more or less square or polygonal meshes. These meshes are further subdivided by veinlets into ultimate meshes 0.5-1 mm. wide.

Figured specimen — No. 31064, Birbal Sahni Institute of Palaeobotany, Lucknow.

Localities — Chilgojuri and Nipania.

Note — Gupta's (*l.c.*) figured specimen no. K/192 is missing in Sahni collection. The specimen was not present in Sahni collection in 1955 when the paper was published.

Comparison — The Rajmahal specimen of *H. crenata* resembles the specimen described by Nathorst (1878) as *Protorhipis crenata* and redescribed by Möller (1902) and Richter (1906) as *Hausmannia crenata*. In both, the margin and venation is similar. It also resembles the specimen of *H. crenata* described by Prynada (1928) in general form, margin and venation.

FERNS OF DOUBTFUL AFFINITIES

Genus — *Cladophlebis* Brongniart

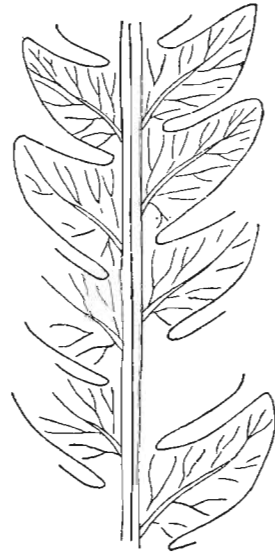
Cladophlebis srivastavae Gupta

(Pl. 6, Figs. 38, 39, Pl. 7, Fig. 42; Text-fig. 3)

1954 *Cladophlebis srivastavae* Gupta, p. 21, pl. 2, figs. 7, 8, text-figs. 1, 2.

1965 *Cladophlebis srivastavae* Gupta: Surange, p. 89, fig. 54A, B.

Emended diagnosis — Frond, bipinnate. Rachis slender, about 1.5-2 mm. wide, with a prominent median ridge. Pinnae alternate, opposite or sub-opposite, arising almost at right angles to the rachis near middle, 55°-60° near the apex. Pinnae rachis straight or slightly curved, 8.5-12 cm. long and less than 1 mm. in width, with a prominent median ridge. Pinnae as a whole linear, very gradually tapering towards apex. Pinnules arising at an angle of about 60°, closely arranged mostly touching each



TEXT-FIG. 3 — *Cladophlebis srivastavae* Gupta — a few pinnules showing the venation No. 2661. \times ca. 10.

other, rarely overlapping, sub-opposite or alternate. Pinnules deltoid, 2.5-3.5 mm. long, about 1.5-2 mm. broad at the base, apex bluntly pointed, lateral margins entire. Midrib persisting to the apex, secondary veins few, forking only once.

Locality — Bartala, about 1.8 Km south-east of Mirzachowki and Bindaban.

Lectotype — No. 17340, Birbal Sahni Institute of Palaeobotany, Lucknow.

Comparison — Quite a few specimens have been collected. Unfortunately all are fragmentary so it is rather difficult to make out the shape of the frond as a whole. Most of the specimens seem to belong to the middle region only. Gupta's (1954) specimen belongs to the apical region. The largest frond, so far collected, is 7 cm. in length and it is estimated that its breadth was about 19 cm. Pinnae in all the specimens are of uniform width.

C. srivastavae is characterized by its long, linear pinnae arising almost at right angles from the rachis and also as compared to the size of the frond the main rachis is very slender.

In *C. srivastavae* the pinnules are much smaller than in *Todites indicus* (Oldham & Morris). Also the rachis in *C. srivastavae* is much slender. In its linear pinnae, the deltoid form of the pinnules and its venta-

tion *C. srivastavae* may be compared with *Alethopteris lobifolia* (this species perhaps belongs to *Cladophlebis*) described by Feistmantel (1877c, PL. 3, FIG. 1) from the Satpura basin. The latter species is, however, different from the present species in having much smaller pinnae and bigger pinnules. In the form of the pinnules and their venation *C. srivastavae* is comparable to *C. (Todites) roesserti* (Presl) described by Seward (1908) from South Africa. But *C. roesserti* has comparatively larger pinnules and the pinnae arise at a much smaller angle. In its linear pinnae and small pinnules *C. srivastavae* resembles *C. fontainei* Seward (1907) described from Turkestan. But in the latter species the shape of the pinnule is different and also the secondary veins fork more than once.

In the general form of the pinnules *C. srivastavae* may be compared with *Todites williamsoni* (Brongn.) Seward and *T. princeps* (Presl) Gothan described by Harris (1961) from Yorkshire. But in the present species, pinnules are smaller and the main rachis is much slender. In the absence of fertile fronds the comparison cannot be taken further.

Cladophlebis sp. A.

(Pl. 3, Fig. 23; Text-fig. 4)

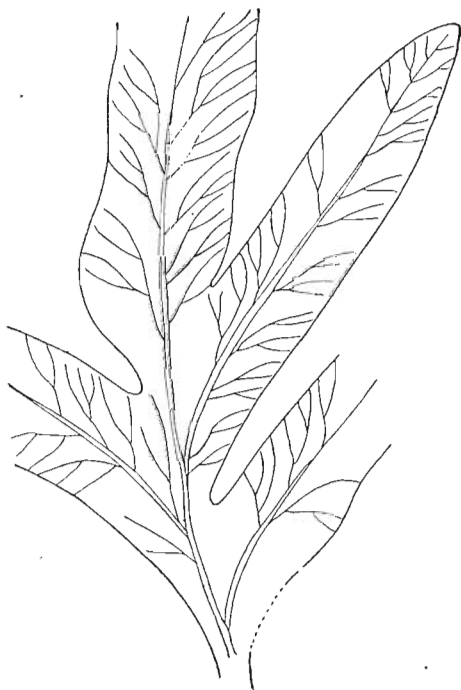
The description is based on a single specimen collected in counterparts. Only the terminal part of a pinna is preserved.

Description — Habit of the frond not known, probably bipinnate. Pinnules about 3 cm. long and ca. 9 mm. wide at the base, gradually tapering towards the apex. Apex slightly rounded, bases decurrent and confluent with the lamina of the next lower pinnule. Margin entire. Terminal pinnule rather large. Midrib distinct in all the pinnules, persisting to the apex, secondary veins forked more than once.

Figured specimen — No. 16700, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Sugadih, near Amrapara.

Comparison — This species is characterized by having rather large, somewhat elongate oval pinnules. In this respect *Cladophlebis* sp. A. is comparable with *C. australis* described by Arber (1917) from New Zealand. In the latter species pinnules are smaller in the terminal region than the pinnules of the former species.



TEXT-FIG. 4 — *Cladophlebis* sp.— a few pinnules showing venation No. 16700. \times ca. 3.

Cladophlebis sp. B.

(Pl. 5, Figs. 34, 35)

Several specimens have been collected, but unfortunately all are very fragmentary.

Description — Habit of the frond unknown, for description assumed to be bipinnate. Pinnae rachis slender, less than 1 mm. broad. Pinnae delicate, linear, preserved length about 2-6 cm., gradually tapering towards apex. Pinnules small, 3×2.5 mm. in size (basal pinnules slightly larger), opposite or sub-opposite, possessing a broadly rounded apex. Midrib slender, about 3 secondary veins on either sides, forking only once.

Figured specimens — Nos. 16444 and 16403, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Sugadih, near Amrapara.

Comparison — *Cladophlebis* sp. B. is characterized by the small, broadly rounded and opposite or sub-oppositely attached pinnules. Moreover, the terminal pinnules

are also a noteworthy feature in being slightly bigger than the rest.

Genus — *Gleichenites* Goeppert

Gleichenites sp.

(Pl. 7, Fig. 45)

Only two sterile specimens have so far been collected. In the absence of fertile fronds the generic name *Gleichenites* has been adopted here.

Description — Leaf probably tripinnate, form and size as a whole not known. Largest pinnae (? branches of the first order) 13 cm. long and 12 cm. broad, rachis slender less than 1 mm. in breadth. Branches of the second order arising at an angle of about 55°-60° sometimes at about 90°, alternate, curved, shape as a whole linear, more than 6.5 cm. long, 6-8 mm. broad, gradually decreasing towards apex; rachis very fine, less than 0.3 mm. in breadth. Pinnules alternate, triangular, somewhat falcate, length more than two times the breadth, 3.5 × 1.5 mm., apex bluntly pointed; midrib arising at an angle of about 70°-80°, secondary veins few, 7-9 or more in number, except near apex mostly dividing once, reaching almost the margin.

Figured specimen — No. 31092, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Bindaban.

Comparison — The present species shows a fairly close similarity with *Gleichenia gleichenoides* in the general habit of the fronds. However, a marked difference is seen between the two in the form and venation of the pinnules. While in *G. gleichenoides* the pinnules are small with approximately same length and breadth, in *G. sp.* the pinnules are bigger in size and the length is more than twice the breadth. Also the pinnules in the former species have more round apex than the present species. In *G. gleichenoides* the secondary veins of the pinnules generally do not divide, whereas in *G. sp.* the secondary veins mostly divided once. In the general shape of the pinnules *G. sp.* may be compared with *G. nordenskiöldi* Heer described by Seward (1926) from western Greenland. Like the present species, in *G. nordenskiöldi* the secondary veins are also forked once. But *G. nordenskiöldi* is different from *G. sp.* in having pinnules with asymmetrical bases.

Genus — *Sphenopteris* Sternberg

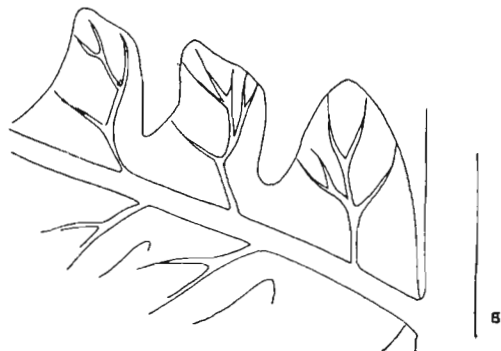
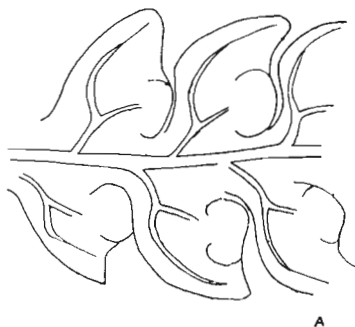
Sphenopteris bindrabunensis (Feistmantel) comb. nov.

(Pl. 7, Figs. 43, 44; Text-fig. 5A-B)

1877a *Dicksonia bindrabunensis* Feistmantel, p. 24, pl. 37, figs 1, 2, 2a.

1965 *Sphenopteris* sp. Surange, p. 119, fig. 77

Diagnosis — Sterile and fertile fronds fragmentary, similar in size and shape, for description assumed to be bipinnate. Pinnae length not known (largest piece measuring about 3 cm.), breadth 1.6-2 cm., rachis about 1 mm. wide, grooved. Pinnules alternately arranged, linear, 8-10 mm. long, gradually tapering towards apex. Each pinnule divided into 7-8 well marked lobes on either side. Each lobe somewhat deltoid in appearance, tip bluntly pointed, upper margin markedly concave. Midrib prominent, secondary veins entering each lobe, each secondary vein giving off a few lateral branches.



TEXT-FIG. 5 — *Sphenopteris bindrabunensis* (Feistmantel) comb. nov. — A, part of a fertile frond to show the venation and the form of the sporangia No. 4487, × 15. B, part of a sterile frond to show the venation No. 4484. × 15.

Sporangia situated near the basal portion of each fertile lobe on the anterior side, more or less kidney-shaped.

Localities — Bindaban, Mandro, Sripur and Brindaban.

Lectotype — No. 4/502 of the Geological Survey of India, Calcutta.

Comparison — Feistmantel (1877a) compared his specimens with *Dicksonia*. Due to imperfect preservation, in our opinion, these fronds are best placed in *Sphenopteris*. *S. bindrabunensis* resembles in gross features, to some extent *S. princeps* described by Seward (1907) from Turkestan.

Sphenopteris patagonica Halle

(Pl. 3, Figs. 21, 22; Text-fig. 6A-B)

All the specimens collected are fragmentary. They have a very thin carbonized crust over them but the preservation is not good enough for cuticular preparations.

Description — Fronds repeatedly dissected, rachis flattened. Pinnules alternately arranged, linear, apex pointed, base slightly

contracted, margins dissected into several well formed lobes. Lobes broadly rounded. Veins indistinct, midrib giving off secondaries which may be forked.

Figured specimen — No. 16401, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Sugadih near Amrapara.

Comparison — The Rajmahal specimens resemble very much the specimens of *S. patagonica* described by Halle (1913).

CONCLUDING REMARKS

During the last 15 years a very rich collection of fossil pteridophytic remains has been made from the various localities in the Rajmahal hills. Of all the localities, Bindaban has yielded the largest number of species. It is one of the best localities for the Mesozoic pteridophytic remains in India. Almost all the species described here can be collected in a day from this locality. In Bindaban, among the pteridophytes, *Gleichenia gleichenoides* is the commonest species. Next to *Gleichenia* comes *Sphenopteris*. Here, about 8 distinct species of *Sphenopteris* can be recognized. But, unfortunately, most of them are sterile or badly preserved fertile specimens. So, for the present, the descriptions of most of these have been withheld. In Bindaban, *Todites indicus* and *Marattiopsis macrocarpa* are also very common. These two species are fairly common in Onthea as well. No other locality in the Rajmahal hills is so rich in pteridophytic remains, most of them have fragmentary remains and they are rather poor as far as number of species is concerned. They have mostly species of *Cladophlebis*, *Sphenopteris* or *Coniopteris*.

So far in the Rajmahal hills none of the localities have yielded well preserved carbonized plants. So our knowledge of the structure of synangia, sori, sporangia and spores, in them, is far from complete. From a few localities petrified plants have been collected. They have mostly been collected at Tinpahar, Borio, Chilgojuri and Nipania. From Tinpahar only a single species of *Tinpaharia* (*T. sinuosa*) has been described by Jacob (1950). The associated species of *Coniopteris* remains yet to be described. From Borio, Chilgojuri and Nipania only a few fragmentary specimens have been collected. The preservation of the ferns from Borio and Chilgojuri is extremely bad. *Hausmannia crenata*, here described,



TEXT-FIG. 6 — *Sphenopteris patagonica* Halle, showing the general form and venation No. 16401. $\times 3$.

is from Chilgojuri but there is no anatomical details preserved in it. From Nipania a few petrified pteridophytic remains have already been described by Vishnu-Mittre (1959).

ACKNOWLEDGEMENTS

The authors are grateful to Professor G. S. Verma for the loan of some of the

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EXPLANATION OF PLATES

PLATE 1

1. *Equisetum rajmahalense* (Oldham & Morris) Feistmantel, showing a rhizome. No. 31074. $\times 1$.
- 2-3. Nodal diaphragms as seen on a rhizome of *E. rajmahalense*. No. 31976. $\times 4$.
4. *E. rajmahalense*, showing three nodes. No. 16712. $\times 1$.
5. *E. rajmahalense*, showing a part of a nodal diaphragm. No. 16711. $\times 1$.
6. *E. rajmahalense*, showing leaf-sheaths. No. 16712. $\times 1$.
7. *Lycopodites gracilis* (Oldham & Morris) Seward & Sahni, leaves showing the median veins. No. 25575. $\times 1$.
8. A portion of the above magnified. $\times 4$.
- 9-10. *Marattiopsis macrocarpa* (Oldham & Morris) Seward & Sahni. Nos. 4662 and 4626. $\times 1$.

PLATE 2

11. *M. macrocarpa*, showing a few fertile pinnae and the sterile apical region. No. 4594. $\times ca. 2.5$.
12. *M. macrocarpa*. No. On. 2 (45). $\times 1$.
13. A portion of the above magnified. $\times 5$.
14. *Todites indicus* (Oldham & Morris) n. comb. No. 4681. $\times 1$.
15. A portion of the above showing venation. $\times 3$.
16. *T. indicus*. No. 4667. $\times 1$.
17. A portion of the above magnified. $\times 3$.
18. *T. indicus*, showing the thick rachis. No. 4660. $\times 1$.

PLATE 3

19. *T. indicus*, showing a fertile leaf. No. D 67a. $\times 1$.
20. A portion of the above magnified. $\times 5$.
21. *Sphenopteris patagonica* Halle. No. 16401. $\times 1$.
22. A portion of the above magnified. $\times ca. 3$.
23. *Cladophlebis* sp. No. 16700. $\times 1$.
24. *Gleichenia gleichenoides* (Oldham & Morris) n. comb. No. 2654. $\times 1$.

PLATE 4

25. *G. gleichenoides*, a fertile leaf. No. 4614. $\times 1$.
26. A portion of the above magnified. $\times 2$.
27. *G. gleichenoides*, a portion of a sterile leaf. No. 4625. $\times 1$.
28. A portion of the above magnified, showing the venation. $\times ca. 12$.
29. *G. gleichenoides*, a portion of a fertile leaf. No. 31083. $\times 1$.
30. A portion of the above magnified, showing sori. $\times 10$.

PLATE 5

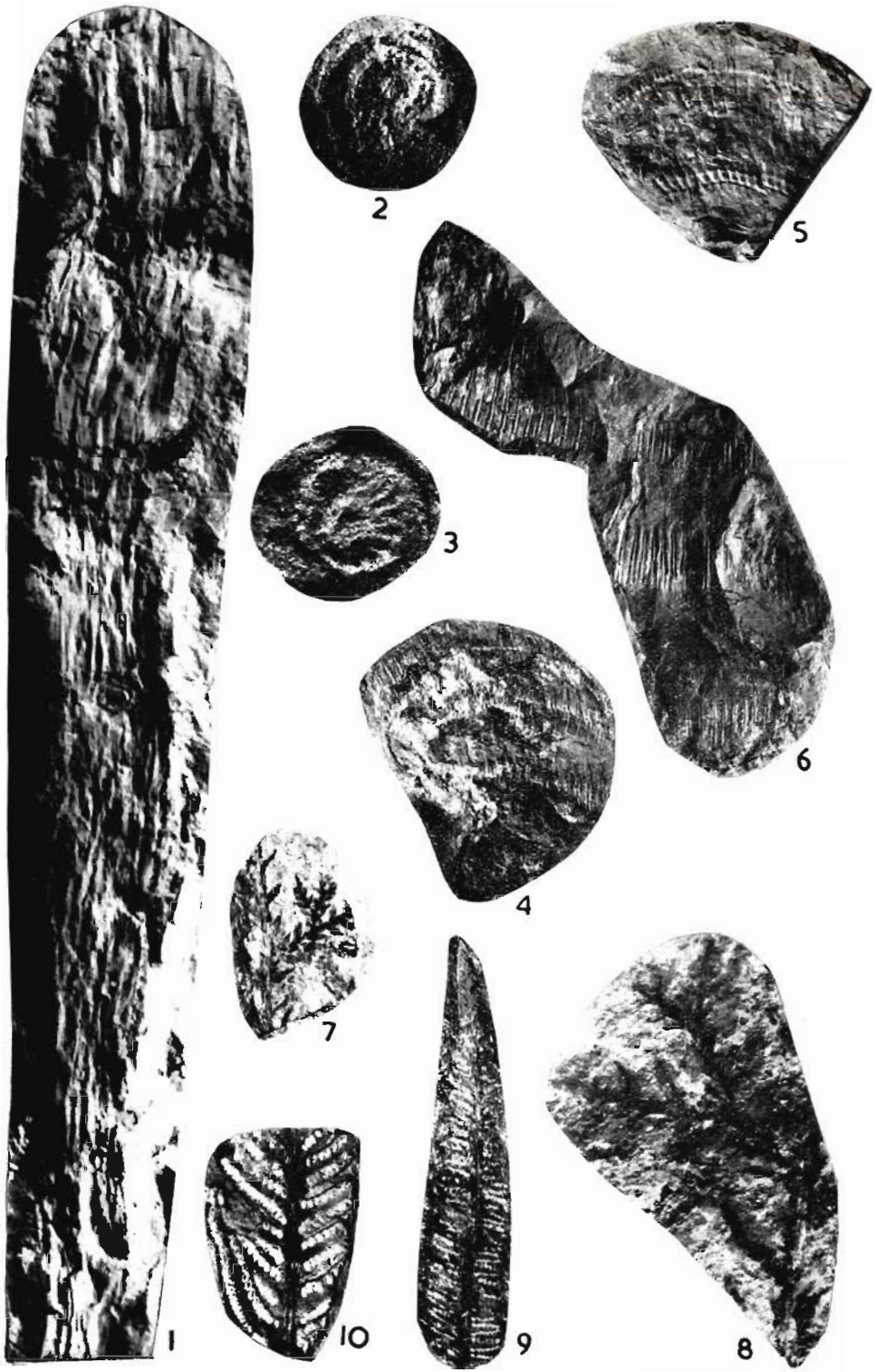
31. *Phlebopteris* sp. No. 31093. $\times 1$.
32. *Phlebopteris* sp., a detached pinnule. No. 2676. $\times 1$.
33. A portion of the above magnified. $\times ca. 7$.
34. *Cladophlebis* sp. B. No. 16444. $\times ca. 1.5$.
35. *Cladophlebis* sp. B., showing the venation. No. 16403. $\times 3$.

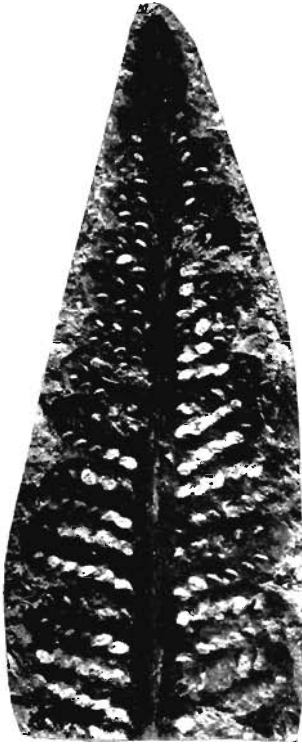
PLATE 6

36. *Hausmannia crenata* (Nathorst) Möller. No. 31064. $\times 1$.
37. Counterpart of the above. $\times 2$.
38. *Cladophlebis srivastavae* Gupta. No. 25709. $\times 1$.
39. *C. srivastavae*, a few pinnules magnified. No. 2661. $\times ca. 5$.
40. *Phlebopteris* sp., a portion of the specimen shown in Pl. 5, Fig. 31, magnified in order to show the venation. $\times 5$.

PLATE 7

41. *G. gleichenoides*, basal region of a leaf showing the main rachis and its branches. No. 25680. $\times 1$.
42. *C. srivastavae*, a few pinnules magnified. No. 2661. $\times 2$.
43. *Sphenopteris bindrabunensis* (Feistmantel) n. comb. No. 4484. $\times ca. 2.5$.
44. Two pinnules from the above magnified, showing the venation. $\times ca. 10$.
45. *Gleichenites* sp. No. 31092. $\times 1$.





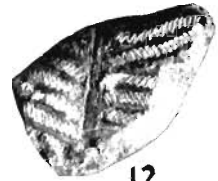
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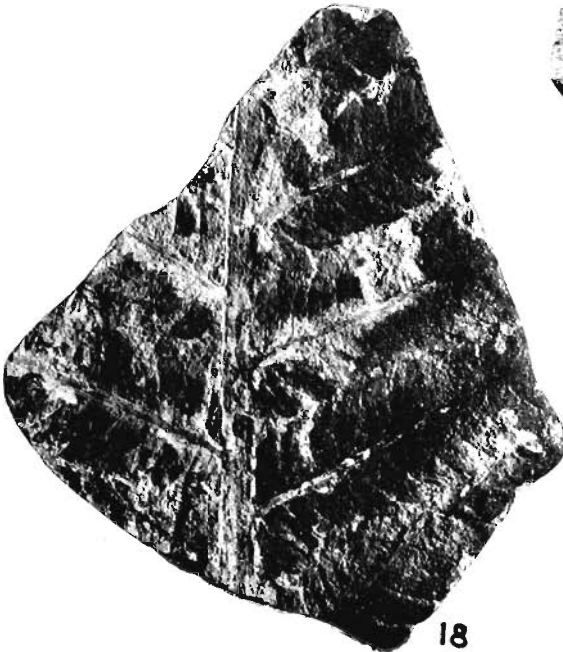
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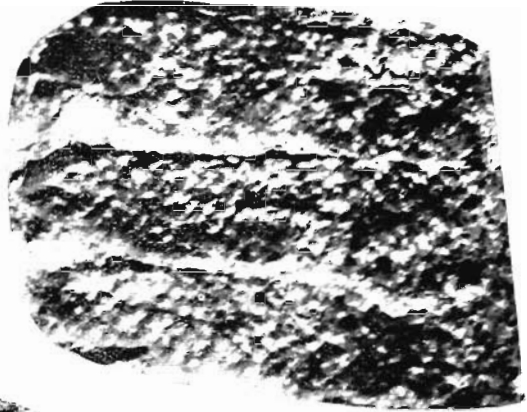
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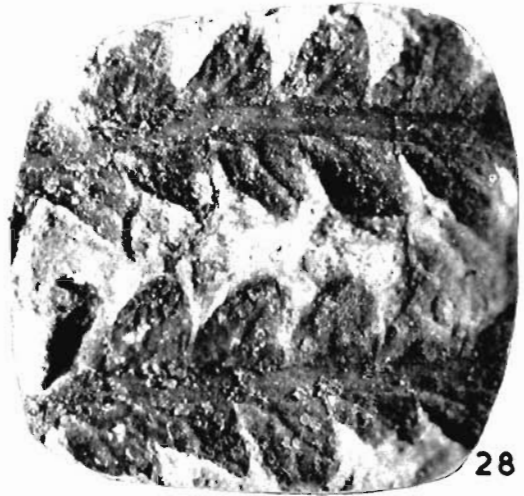
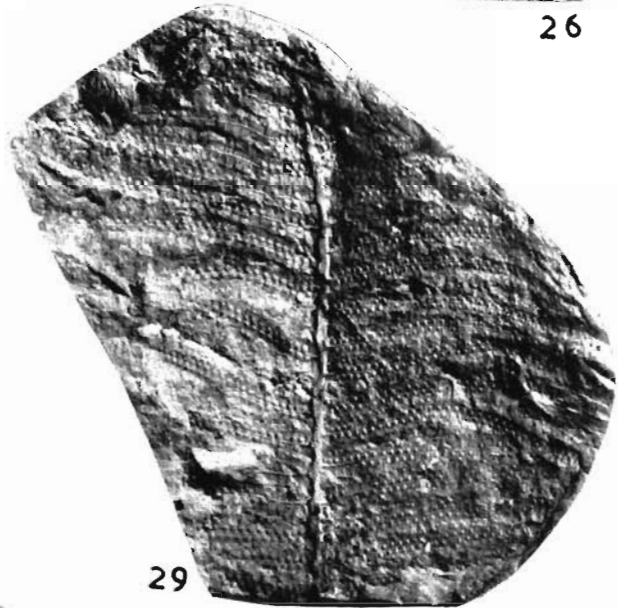
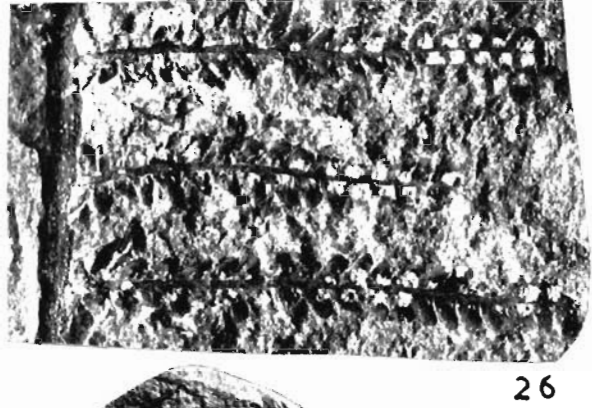
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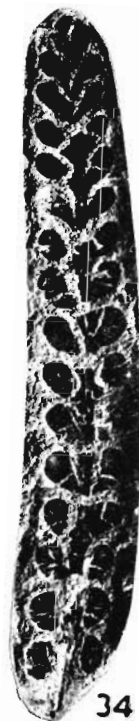
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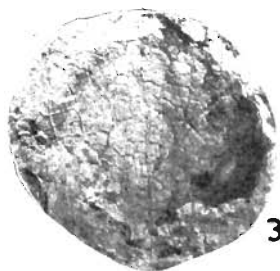
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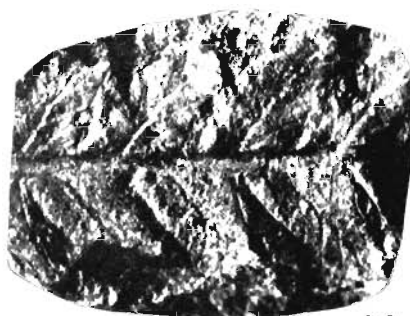
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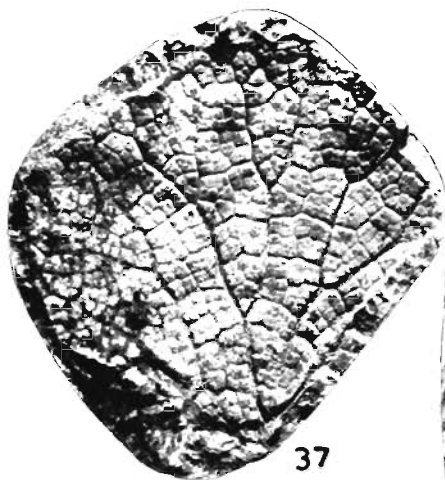
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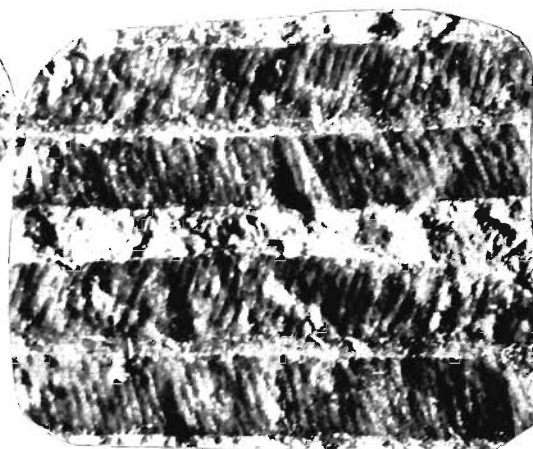
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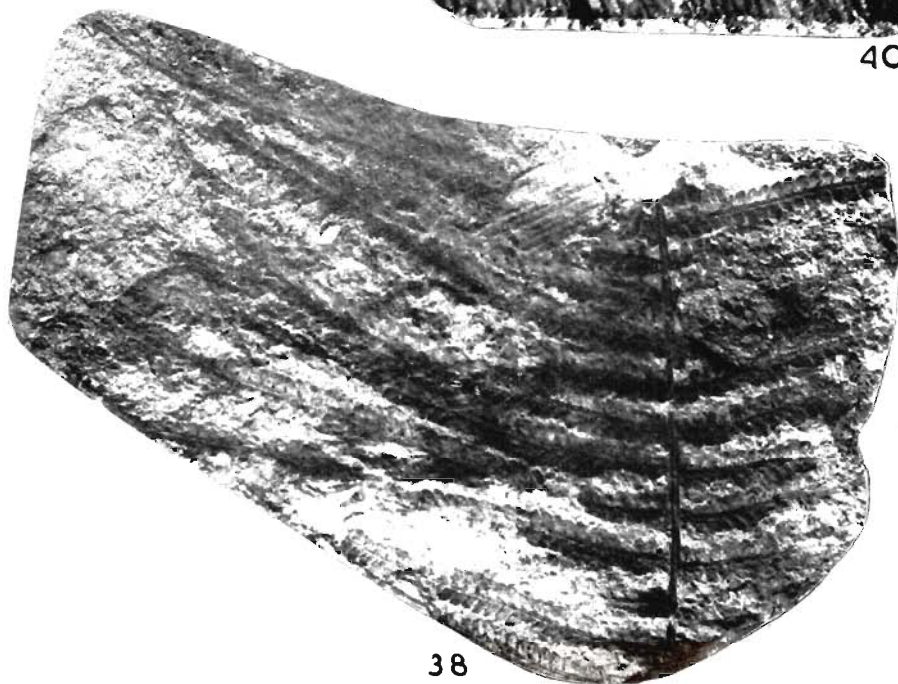
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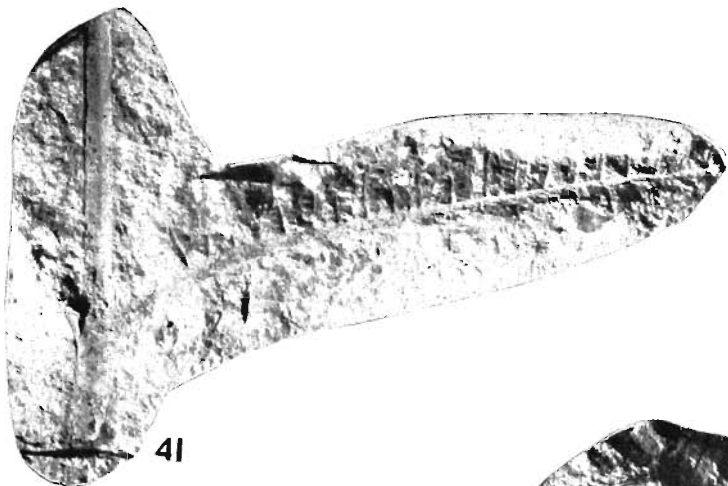
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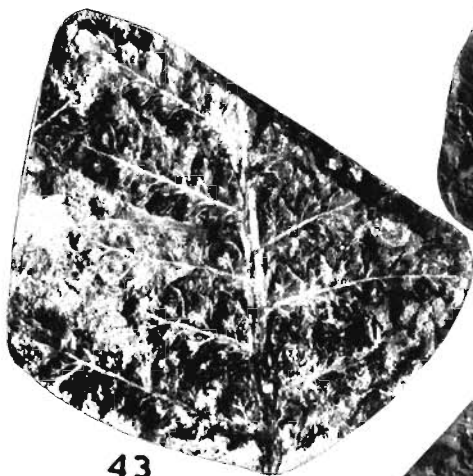
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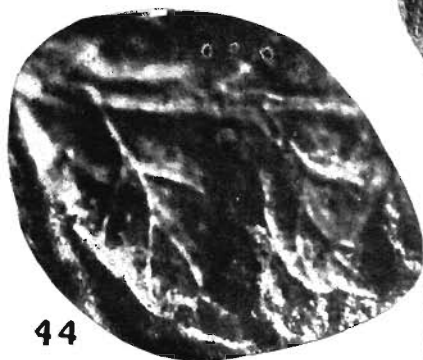
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