PALYNOLOGY OF THE GANGAPUR BEDS, PRANHITA-GODAVARI BASIN, ANDHRA PRADESH

P. V. RAJESHWAR RAO*, C. G. K. RAMANUJAM** AND Y. N. R. VARMA***

**Department of Botany, New Science College, Hyderabad*

***Department of Botany, Post Graduate College of Science (O. U.), Saifabad, Hyderabad*

****Department of Botany, Sardar Patel College, Secunderabad*

ABSTRACT

The Gangapur palyno-assemblage comprises 69 genera and 109 species referable to Bryophytes, Pteridophytes and Gymnosperms. Of these, nine are newly proposed, viz. *Undulatisporites venkatachalai*, *Neoraistrickia rallapetensis*, *Impardecispora adilabadensis*, *Foveosporitess sahii*, *Cicatricosisporites gangapurensis*, *Cicatricosisporites verrumuratus*, *Ischyosporites pusillus*, *Callialasporites crassimarginatus* and *Platysaccus bharadwajii*, and the diagnosis of *Psilospora lata* Venkatachala & Kar, 1968 has been emended. The gymnosperms are represented mostly by saccate and nonsaccate pollen of coniferae. A quantitative analysis of the microflora has revealed the abundance of *Microcachryidites*, followed by *Callialasporites*, *Araucariacites*, *Podocarpidites* and *Classopollis*. The microflora of the Gangapur beds shows similarity with the Lower Cretaceous (Neocomian-Aptian) palyno-assemblages of the Bhuj beds of Kutch, Bansa beds of Madhya Pradesh, Godavari-Krishna Basin of Andhra Pradesh and Palar and Cauvery basins of Tamil Nadu. The climate of the area as indicated by the spore and pollen complex seems to be of the subtropical type with good precipitation.

INTRODUCTION

The Upper Gondwana outcrops (as per the two-fold system of Gondwana classification) in the Pranhita-Godavari valley are represented by the Maleri, Kota and Chikiala formations. The type locality of Maleri Formation is in the Adilabad district of Andhra Pradesh, while that of Kota is situated near Sironcha in the Chandrapur district of the neighbouring Maharashtra State. An assemblage of essentially vertebrate fauna is known from the red clays of the Maleri Formation. The Kota Formation consisting of limestones, sandstones and clays has yielded fairly rich faunal and floral assemblages. The fauna recorded from the limestones, said to be of fresh water origin, consists of crustaceans and fishes; in addition to these, a number of reptiles including dinosaurs are known from the Kota clays and sandstones. The fishes and the reptilean remains indicate a Liassic (L. Jurassic) age to the Kota Formation. The flora associated with limestones accordingly constitutes a Liassic flora. A rich flora is known from the Gangapur beds near Naogaon, viz. Kattarala, Rallapeta (topo sheet spelling Ralapet), Ankisapur, etc. This flora is considered to be of a mixed nature as it shows both the Rajmahal and Jabalpur elements, and presumably is of Upper Jurassic age. The Gangapur beds have been said, according to KING (1881), to underlie the Kota limestones; this has created a ticklish problem and a confusing situation with regard to our understanding of the age of the Gangapur beds as indicated by the flora and that of the Kota limestones as indicated by the fauna. The faunal and floral evidences appear to be mutually contradictory and the fauna of the older age appears to overlie the flora of an younger age. The recent field work of KUTTY (1969) seems to have set right this anomaly. KUTTY (*l. c.*) has shown clearly that the Gangapur beds infact overlie uncon-

Geophytology. **13**(1): 22-45, 1983.

formably the Kota limestones in contradiction to the previous interpretation of their stratigraphic position.

In the absence of any faunal evidence one has to depend upon only the mega-flora preserved in Gangapur beds for their dating. The megafloral evidence, unfortunately, does not appear to be unequivocal as the flora is an admixture of the Rajmahal and Jabalpur elements. In view of this situation it was felt desirable to gather palynological evidence from these beds.

GEOLOGICAL SET UP OF THE AREA

The Pranhita-Godavari Gondwana Basin extends from Asifabad and Balharsha on the north-west to as far as Eluru in the south-east, stretching over a distance of about 400 km with an average width of 50 km. The various formations of the Gondwana System represented in the main basin, as described by KING (1881), are as follows :

Chikiala Formation
Kota Formation
Maleri Formation
Kamthi Formation
Barakar Formation
Talchir Formation

The Kota Formation, named after the village Kota, situated on the east bank of the river Pranhita, consists of sandstones, clays, limestones, and shales. The sandstones are of varied types of which the rubly calcareous sandstones (salt-and-pepper stones) containing inclusions of red shales and clay galls are the most important ones. The limestones typical of this formation, have yielded interesting fossils of invertebrates, vertebrates and plants. The faunal list given by KING (1881) consists of crustaceans (*Cyzicus, Estheria* and *Candona*) and the fishes (*Lepidotes, Tetragonolepis, Dapedium*, etc.). In addition, a crocodilian fossil (OWEN, 1852), some insects belonging to *Blattoidea, Coleoptera* and *Hemiptera* (RAO & SHAH, 1959), a possible pterosaur (RAO & SHAH, 1963) and some dinosaurs including a definite sauropod (JAIN *et al.*, 1962) have also been reported. The plant fossils recorded from the beds in between the limestone bands at Annaram include *Elatocladus* and *Cheirolepis* (KING, 1881). From a limestone bed (locality not given) of the Kota Formation, RAO AND SHAH (1963) recorded the following plant fossils, viz. *Equisetites, Cladophlebis, Otozamites, Sphenopteris, Hausmannia* and *Pagiophyllum*. The nearest limestone outcrop exposed in the area is in Bokivagu section near Sitharampally or Paikagigudem about 10 km east of Rebna. The Kota clays are of red and white types. The white clay is predominant in Anksapur, Kattarala (Kotharapelly), Rallapeta and Pachigaon area (Text-fig. 1). The plant fossils recorded from the white clays of Kattarala are *Taeniopteris spatulata, Cladophlebis indica, Gleichenites gleichenoides, G. rewahensis, Gleichenites* sp., *Otozamites* sp., *Ptilophyllum* sp., *Nilssonia* sp., *Elatocladus plana, E. conferta, E. jabalpurensis, Torreyites* sp., *Pagiophyllum peregrinum, Brachyphyllum* sp., and *Araucarites cutchensis* (FEISTMANTEL, 1879; unpublished progress reports of RAO & DUTTA, 1956; RAO & SHAH, 1957-1960; 1959; also see SHAH *et al.*, 1973). The white clays of Rallapeta yielded *Taeniopteris spatulata, Gleichenites* sp., and *Elatocladus* sp.; *Ptilophyllum acutifolium* and *Pagiophyllum* sp., were recorded from the Anksapur shales (RAO & DUTTA, 1956; RAO & SHAH, 1959).

Recent work on the geology of the area

In view of the stratigraphic importance of the Kota and Maleri formations, the geological studies unit of the Indian Statistical Institute, Calcutta, recently undertook stratigraphical and palaeontological investigations of some selected localities in Asifabad-Chennur area (JAIN *et al.*, 1964; ROY CHOWDHURY, 1965; CHATTERJEE, 1967; KUTTY, 1969). KUTTY (*l. c.*) redefined the base of the Kota Formation on the basis of faunal and lithological evidence. A new late Upper Triassic fauna, which is quite different from the typical early Upper Triassic Maleri fauna and also from the Lower Jurassic Kota fauna, has been discovered below the Kota limestones. This has prompted the designation of a new formation, viz. Dharmaram Formation (KUTTY, *l. c.*).

Gangapur Formation

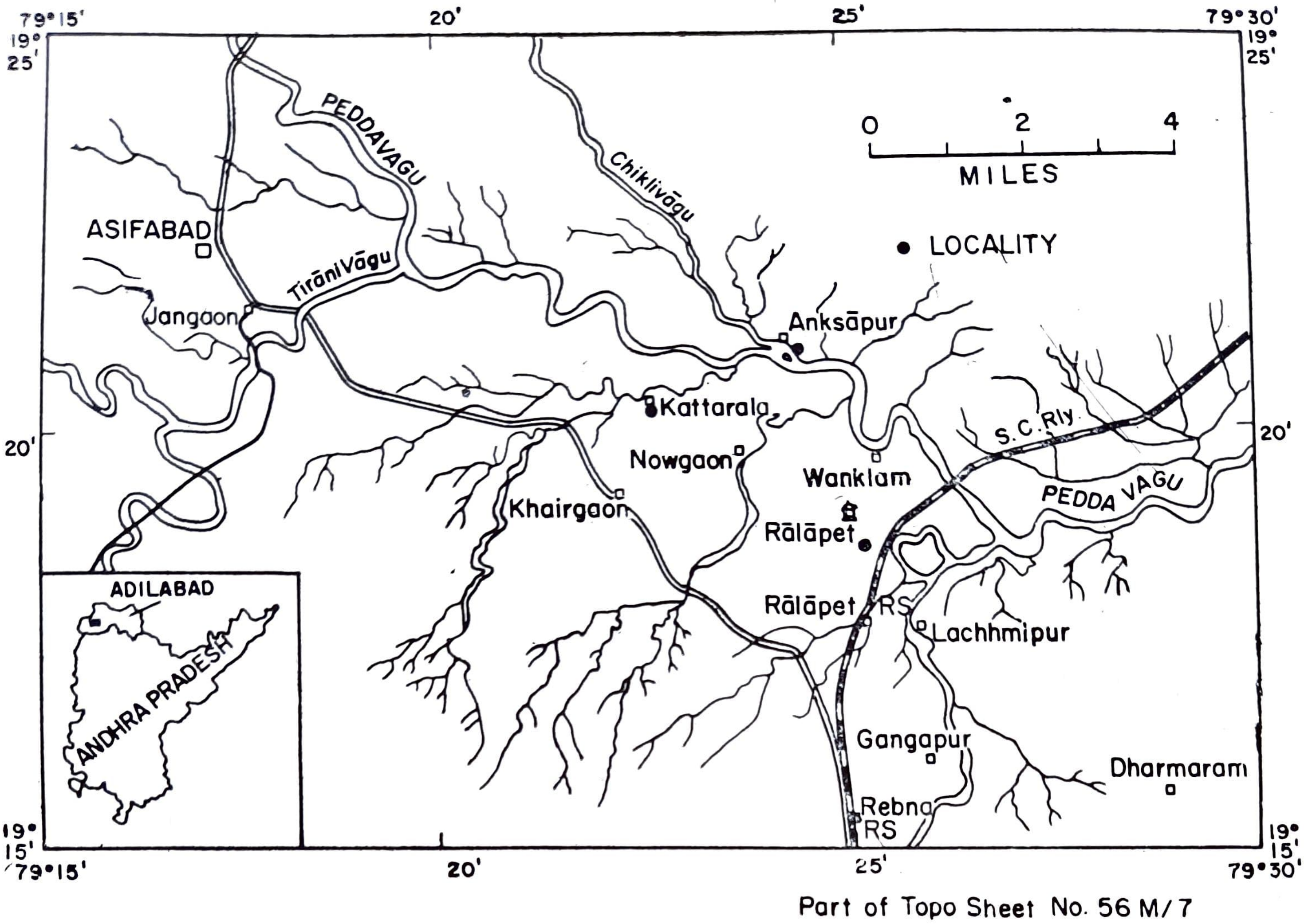
KING (1881) originally considered the Gangapur beds to form the basal member of the Kota Formation and the limestones appear in the upper part of the same formation. The Gangapur beds, however, yielded a flora which was considered to be younger in age than the typical Kota fauna. But KUTTY (*l. c.*) by remapping the area around Gangapur has shown that the Gangapur beds overlie unconformably the beds (including a limestone band) which have yielded the typical Kota fauna. Therefore, the Gangapur beds were removed from the Kota Formation and elevated to the level of a separate formation, viz. Gangapur Formation, at par with Kota Formation. The sandstones exposed in the cliffs near the village Gangapur and on which the cave temple stands (the Gangapur sandstones of KING, 1881) form the basal beds of this formation. These sandstones are pale grey but sometimes ferruginous and red in colour, coarse and locally pebbly. The plant fossil localities around Naogaon, viz. Kattarala, Rallapeta and Anksapur, etc. are all within the Gangapur Formation (Text-fig. 1).

The actual contact of the Gangapur Formation with the underlying beds was found by KUTTY (1969) exposed at two places; one is in a stream section about a quarter of a mile to the north-east of Paikagigudem and the other is in the Gangapur cliffs. In the former, the basal beds of the Gangapur Formation overlie the Kota limestone. The basal beds are here marked by a conglomerate. About half a mile to the west from here, pebbly sandstones overlie the Kota limestone, though the actual contact could not be exposed. In the Gangapur cliffs, they are seen to rest on Maleri clays. The exact relationship between the Gangapur and Chikiala formations as of today is not known.

From the Gangapur Formation at Rallapeta, Kattarala and Anksapur, the authors have collected the following plant fossils: *Gleichenites*, *Cladophlebis*, *Equisetites*, *Taeniopteris*, *Ptilophyllum acutifolium*, *Pagiophyllum*, *Brachyphyllum*, *Elatocladus* (*E. plana*, *E. conferta*, *E. jabalpurensis*), and *Araucarites*. An advance information regarding the palyno-assemblage of the Gangapur beds and its bearing on the geological horizon of the Gangapur Formation was earlier provided by RAMANUJAM AND RAJESHWAR RAO (1979, 1980). BOSE, KUTTY AND MAHESHWARI (1982) recently furnished an account of some plant megafossils and spores and pollen grains of the Gangapur beds.

MATERIAL AND METHODS

The material investigated consists of carbonaceous shales, black to grey-coloured clays and white to slightly yellow or pinkish clays, belonging to the Gangapur plant bearing beds at Rallapeta, Kattarala and Anksapur, all situated within a few kilometer radius around Naogaon (19° 20′N; 79° 24′E) in the Asifabad Taluk of the Adilabad district, Andhra Pradesh.



Text-fig. 1. Part of Pranhita-Godavari Basin showing localities of samples.

Rallapeta area—Rallapeta (19° 19′; 79° 25′) is about 3 km east of Naogaon. The Gangapur beds are extensively quarried around Rallapeta for the white clays, and the material investigated comes from these quarries. The quarries are situated in between the Kagaznagar-Rebna road and the Rallapeta railway station. Quarry No. I is adjacent to the Kagaznagar-Rebna road, whereas Quarry No. II is situated about seven hundred metres from Quarry No. I towards the Rallapeta railway station. In Quarry No. I, two bands of greyish black clays are seen exposed, whereas in Quarry No. II only one such band of clay is seen, particularly towards its base. The entire clay horizon is overlain by sandstones on top of which is the recent alluvium. Numerous samples were collected from the whitish and blackish clay bands both vertically and horizontally. The blackish clays yielded rich palynoflora. The samples have been numbered as RA I, RA II, RA III, etc.

Kattarala area—Kattarala (19° 20′N; 79° 23′E) is about 2 km north of Naogaon. The Upper Gondwana beds are exposed in a small tract at three places along a stream called Vattivagu (Kotharapally vagu). The beds consist of white clays and sandstones overlain by recent alluvium. A number of samples from these clays were collected. Palynologically these white clays are either poor or almost barren.

Anksapur area—Anksapur (19° 21′N : 79° 25′E) is situated about 3 km north-east of Naogaon on the left bank of the stream Peddavagu. The fossiliferous bed from which the samples were collected is exposed along the left bank of the stream approximately one km south-east of Anksapur. It is only during the summer months when the water level in the Peddavagu is very low that this bed could be seen clearly. During the rest of the year, the bed is more or less covered by water. Various samples of white and grey clays were collected along with the carbonaceous shales, the latter yielded a rich assemblage of excellently preserved spores and pollen grains. The white and grey clays of Anksapur are, however, poor in their microfloral contents. The samples have been numbered as A I, A II, A III, etc.

Usual technique of maceration was employed to recover and concentrate the palynoflora. Most of the slides were prepared with polyvinyl alcohol and canada balsam. All the permanent slides and unused samples have been stored in the palaeobotanical collection of Dr. C. G. K. Ramanujam, at the Department of Botany, Post Graduate College of Science (O. U.), Saifabad, Hyderabad.

SYSTEMATIC DESCRIPTION

The following is the list of palynofossils recorded by us from the Gangapur Formation; of these, the more prominent and characteristic taxa have been illustrated in Plates 1 to 6. The species of *Contignisporites*, an account of which was already published earlier by two of us (RAJESHWAR RAO & RAMANUJAM, 1979) are not illustrated in this work.

Cyathidites australis Coup., 1953; *C. minor* Coup., 1953; *C. concavus* (Bol.) Dettm., 1963; *C. asper* (Bol.) Dettm., 1963; *C. ghuneriensis* Singh, Sriv. & Roy, 1964; *Deltoidospora juncta* (Kara Murza) Singh, 1964; *D. diaphana* Wils. & Webst., 1946; *Alsophilidites* sp., *Todisporites* sp.; *Osmundacidites wellmanni* Coup, 1953; *O. singhii* Ramanu. & Srisail., 1974; *Haradisporites* sp. cf. *H. mineri* Singh & Kumar, 1972; *Baculatisporites rotundus* Kumar, 1973; *Concavisporites* sp.; *Verrucosisporites* sp.; *Converrucosisporites* sp.; *Biretisporites spectabilis* Dettm., 1963; *Coniatisporites* sp.; *Frangospora fracta* Venkatach. & Kar, 1968; *Dictyophyllidites* sp.; *Biformaesporites* sp. *Ceratosporites equalis* Cooks. & Dettm., 1958; *C. couliensis* Sriv., 1972; *Concavissimisporites punctatus* (Delcourt & Sprum.) Singh, 1964; *C. variverrucatus* (Coup.) Singh, 1964; *Leptolepidites major* Coup. 1953; *Impardecispora apiverrucata* (Coup) Venkatach.,Kar & Raza, 1969; *Lycopodiumsporites austroclavatidites* (Cooks.) Pot., 1956; *L. reticulumsporites* (Rouse) Dettm., 1963; *Klukisporites aerolatus* Singh, 1971; *K. foveolatus* Pocock, 1964; *K. scaberis* (Cooks. & Dettm.) Dettm., 1963; *Kuylisporites lunaris* Cooks. & Dettm. 1958; *Staplinisporites caminus* (Balme) Pocock, 1962; *Cicatricosisporites australiensis* (Cookson) Pot., 1956; *C. hughesii* Dettm., 1963; *C. ludbrooki* Dettm., 1963; *C. hallei* Delc. & Sprum., 1955; *C. imbricatus* (Markova) Singh, 1971; *C. mohrioides* Delc. & Sprum., 1955; *C. minor* (Bol.) Pocock, 1961; *C. angustus* Singh, 1971; *Callispora potoniei* Dev. 1961; *Trilites tuberculiformis* Cooks., 1947; *Matonisporites phlebopteroides* Coup., 1958; *M. discoidalis* Kumar, 1973; *Lametatriletes mesozoicus* Kumar, 1973; *Boseisporites insignatus* Venkatach., 1969; *B. jabalpurensis* Kumar, 1973; *Ischyosporites crateris* Balme, 1957; *Gleicheniidites senonicus* Ross, 1949; *Ornamentifera echinata* Bolkhovit., 1966; *Plicifera* sp.; *Sestrosporites pseudoalveolatus* (Coup.) Dettm., 1963; *Foraminisporis assymetricus* (Cooks. & Dettm.) Dettm., 1963; *F. wonthaggiensis* Dettm., 1963; *Lakhnavitriletes bansaensis* Maheshw., 1974; *L. mach-rarensis* Maheshw., 1974; *Polycingulatisporites reduncus* (Bol.) Playf. & Dettm., 1965; *Contignisporites glebulentus* Dettm., 1963; *C. cooksonii* Dettm., 1963; *C. dorsostriatus* Dettm., 1963; *C. multimuratus* Dettm., 1963; *C. fornicatus* Dettm., 1963; *C. crassicingulatus* Rao & Ramanu., 1979; *Crybelosporites* cf. *punctatus* Dettm., 1963; *Densoisporites* sp.; *Monolites indicus* Kumar, 1973; *Crassimonoletes surangei* Singh, Sriv. & Roy, 1964; *Metamonoletes haradensis* Singh & Kumar, 1972; *M. crassilabrum* Maheshw., 1973; *Polypodiisporites multiverrucosus* Nagy, 1963; *Coptospora cutchensis* Venkatach., 1969; *Aequitriradites verrucosus* Cooks. & Dettm., 1961; *A. spinulosus* Cooks. & Dettm., 1969; *Cooksonites minor* Venkatach., 1969; *Callialasporites trilobatus* (Balme) Dev, 1961; *C. segmentatus* (Balme) Dev, 1961; *C. dampieri* (Balme) Dev, 1961; *C. discoidalis* (Doering) Bharad. & Kumar, 1972; *C. triletes* Singh, Sriv. & Roy, 1964; *C. doeringii* Kumar, 1973; *C. reticulatus* Ramanu. & Srisail., 1974; *C. enigmatus* (Singh & Kumar) Kumar, 1973; *C. lametaensis* Kumar, 1973; *C. rudisaccus* Maheshw., 1974; *Alisporites rotundus* Rouse, 1959; *A. grandis* (Cookson) Dettm., 1963; *A. ovalis* Kumar, 1973; *Podocarpidites major* Coup., 1953; *P. ellipticus* Cooks., 1947; *P. multisimus* (Bol.) Pocock, 1962; *Vitreisporites pallidus* (Reiss.) Nils., 1958; *Platysaccus densus* (Venkatach.) Kumar, 1973; *P. indicus* Sah & Jain, 1965; *Cedripites nudis* Kar & Sah, 1970; *Abiespollenites triangularis* Kumar, 1973; *Laricoidites* sp.; *Araucariacites australis* Cooks., 1947; *A. ghuneriensis* Singh, Sriv. & Roy, 1964; *Spheripollenites scabratus* Coup., 1958; *Microcachryidites antarcticus* Cooks., 1947; *Dacrycarpites australiensis* Cookson & Pike, 1953; *Cycadopites* *fragilis* Singh, 1964; *C. gracilis* Sah & Jain, 1965; *Monosulcites ellipticus* (Dev) Kumar, 1973; *Classopollis classoides* (Pflug) Pocock & Jans., 1961; *Granuloperculatipollis mundus* Venkatach. & Sharma, 1974; *Schizosporis rugulatus* Cookson & Dettm., 1959

The new and emended taxa and the palynomorphs hitherto unrecorded from India are described below.

Genus **Undulatisporites** Pflug, 1953

Type species—U. microcutis Pflug, 1953

Undulatisporites venkatachalai sp. nov.

Pl. 1, Figs. 3 & 4

Holotype—Pl. 1, Fig. 3 ; A II, S. No. 7-41.4×105.9 (25 μm)
Type locality—Anksapur
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Spores trilete, 23-28 μm, amb triangular, inter-apical regions straight to slightly concave, apices broadly rounded. Y-mark distinct, rays almost reaching equator, commisures raised, strongly undulated with thickened lips, proximal exine smooth, distal exine with 1.5-2.2 μm thickening perpendicular to each laesura near distal apices.

Comments—This species is distinguishable from the other known species of the genus by having distal exinal thickenings perpendicular to each laesura and in possessing prominently sinuous laesurae with thickened lips. *Undulatisporites* is confined to the Lower Cretaceous (Neocomian to Albian) strata (see Brenner, 1963; Singh, 1971).

The species is named in honour of Dr. B. S. Venkatachala of the Oil and Natural Gas Commission, Dehra Dun.

Genus **Neoraistrickia** Potonié, 1956

Type species—N. truncatus (Cookson 1953) Potonié, 1956

Neoraistrickia rallapetensis sp. nov.

Pl. 1, Figs. 17 & 18

Holotype—Pl. 1, Figs. 17 & 18; RA III, S. No. 1-45.6×94.1 (40 μm)
Type locality—Rallapeta
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Spores trilete, 30-40 μm; amb triangular, angles acutely rounded, sides straight to convex; Y-mark distinct; laesurae straight, extending upto equator, raised with elevated lips; exine upto 2 μm thick baculate, bacules both on proximal and distal faces, but more numerous distally, rather sparse proximally, 2-4 μm high, with truncated tips. A tendency for bacules to get concentrated at certain regions of distal and proximal faces seen in some specimens.

Comments—In the possession of truncate processes *Neoraistrickia rallapetensis* sp. nov. resembles *N. truncatus* described from the Lower Cretaceous of Australia (Dettmann, 1963). The processes of the Australian species, however, are robust and broader at their bases.

Genus **Impardecispora** Venkatachala, Kar & Raza, 1969

Type species— I. apiverrucata (Couper, 1958) Venkatachala, Kar & Raza, 1969

Impardecispora adilabadensis sp. nov.

Pl. 1, Figs. 25 & 26

Holotype—Pl. 1, Fig. 25 ; AI, S. No. 9-38. 4×102.2 (36 μm)
Type locality—Anksapur
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis —Spores trilete, 35-38 μm; amb triangular with straight to slightly concave sides, apices acutely rounded; Y-mark prominent, laesurae extending upto equatorial margin, lips fairly prominent. Exine upto 1.5 μm thick, verrucate, verrucae of different sizes concentrated at contact area and in a narrow zone at radial apices but widely spaced on distal side. Surface, away from contact area on proximal side and at equatorial margin, psilate.

Comments—The specific name is after the Adilabad district in which the fossiliferous sites are situated.

Genus **Foveosporites** Balme, 1957

Type species—*F. canalis* Balme, 1957

Foveosporites sahii sp. nov.

Pl. 1, Figs. 20 & 21

Holotype—Pl. 1, Fig. 21; RA III, S. No. 1-43.3×102.9 (32 μm)
Type locality—Rallapeta
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Spores trilete, 30-35 μm, amb somewhat circular to rounded triangular with broad apices and convex sides; Y-mark indistinct, laesurae faint, straight, reaching upto equatorial margin; exine upto 1.5 μm thick, distinctly foveolate, foveolae circular to locally elliptical in outline, simple and not coalescing. *Extrema lineamenta* indented because of closely spaced foveolae.

Comments—Similar specimens were recorded as *Foveosporites* sp. by Sah and Jain (1965) from the Rajmahal Hills. The faint laesurae and the simple foveolae without showing any local fusion are the diagnostic features of this species. *Foveosporites canalis* Balme (1957) shows coalition of foveolae to form short, irregular canals. The authors consider *Foveosporites sahii* to be lycopodiaceous in its affinities.

The specific name has been given in honour of Dr. S. C. D. Sah of the Wadia Institute of Himalayan Geology, Dehra Dun.

Genus **Cicatricosisporites** Potonié & Gelletich, 1933

Type species—*C. dorogensis* Potonié & Gelletich, 1933

Cicatricosisporites gangapurensis sp. nov.

Pl. 2, Figs. 35 & 36

Holotype—Pl. 2, Figs. 35 & 36; RA I, S. No. 8-39.5×107.7 (42 μm)
Type locality—Rallapeta
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Spores trilete, 40-45 μm, amb triangular, apices acutely rounded, sides almost straight; Y-mark fairly prominent, rays reaching 3/4 distance to equatorial margin, straight, commissures with thin labra; exine upto 1.5 μm thick, canaliculate, muri conspicuously thick, (upto 4 μm), intervening lumina narrow, canal-like, upto 1.5 μm broad, distal side with 2 or 3 prominent often sinuous inter-radial ribs almost parallel to each other and converging at radial apices where inner rows of ribs fuse, ribs leave a distinct triangular area at distal pole; two conspicuous teeth-like processes (3-5 μm long) on distal ribs at one radial apex, the other two radial apices devoid of these processes. Proximal side with two parallel ribs in each interradial area; contact area smooth.

Comments—*C. gangapurensis* shows some similarities with *C. hughesi* Dettmann (1963), but easily distinguishable from the latter in the possession of the dentate processes at one radial apex.

The specific name is given after the village Gangapur in the vicinity of the fossiliferous locality.

Cicatricosisporites verrumuratus sp. nov.

Pl. 2, Figs. 38 & 39

Holotype—Pl. 2, Fig. 39; RA I, S. No. 12-37.3×103.3 (30 μm)
Type locality—Rallapeta
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Spores trilete, 30-35 μm, amb triangular, apices acutely rounded, sides convex; Y-mark undulating, laesurae reaching 3/4 distance to equatorial margin, commissures slightly raised; exine upto 1.5 μm thick, canaliculate, muri thick (upto 3.5 μm), intervening lumina narrow canal-like (upto 1.5 μm broad), distal side with 2 or 3 prominent, locally sinuous, inter-radial ribs almost parallel to each other and sides, converging short irregular muri even at distal pole, muri studded with low verrucae or tubercles; proximal side with one or two inter-radial muri, contact area also sculptured with short, discontinuous muri.

Comments—*Cicatricosisporites ornatus* described from the Upper Cretaceous Edmoton Formation of Canada (Srivastava, 1972) although possessing verrucae on muri crests is easily distinguishable from the Indian species in the anastomosing nature of the muri to form a reticulum. The specific name is after the characteristic verrucate muri.

Genus **Ischyosporites** Balme, 1957

Type species—*I. crateris* Balme, 1957

Ischyosporites pusillus sp. nov.

Pl. 3, Figs. 45 & 46

Holotype—Pl. 3, Figs. 45 & 46; RA I, S. No. 12-42. 6×98.1 (22 μm)
Type locality—Rallapeta
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Trilete; 22-28 μm, amb triangular, sides slightly convex; Y-mark distinct, laesurae straight, almost approximating equatorial margin; exine 1.5 μm thick, thicker at radial apices, valvate; distal surface coarsely foveoreticulate, muri with crenate margin, beaded, 3 μm thick, anastomising, lumina 4-6 μm wide, discontinuous, at radial apices muri protruding out (3 μm), proximal surface smooth except at radial apices.

Comments—The distinguishable features of this species are its small size, discontinuous meshes and beaded muri.

Genus **Callialasporites** Dev emend. Maheshwari, 1974

Type species—*C. trilobatus* (Balme) Dev, 1961

Callialasporites crassimarginatus sp. nov.

Pl. 4, Figs. 75 & 76

Holotype—Pl. 4, Fig. 75; AI, S. No. 5-42.8×100.7 (45 μm)

Type locality—Anksapur
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Alete or with faint triradiate mark; rounded to oval, 50-65 μm; central body rounded to roundly triangular with conspicuously thickened (upto 8 μm) rigid, margin surface; smooth or finely granular near equator; triradiate mark faint when seen; prosaccus subequatorial proximo-distally, 12-20 μm broad, rigid, smooth with a few radial folds locally, folds often tending to be confined to certain regions only.

Comments—In the possession of a conspicuously thickened margin of the central body, *Callialasporites crassimarginatus* differs from the other species of this genus. *C. monoalasporus* Dev (1961) which apparently resembles the present species, shows a conspicuous fold separating the central body from the prosaccus. The specific name is after the thick margin of the central body of the pollen.

Genus **Platysaccus** Naumova *ex* Potonié & Klaus, 1954

Type species—*P. papilionis* Potonié & Klaus, 1954

Platysaccus bharadwajii sp. nov.
Pl. 5, Figs. 86 & 87

Holotype—Pl. 5, Figs. 86 & 87; RA II, S. No. 4-4.5 $\times$ 105.6 (75 $\times$ 42 μm).
Type locality—Rallapeta
Horizon—Lower Cretaceous (Neocomian-Aptian)

Diagnosis—Pollen grains bisaccate, diploxylonoid, 75 $\times$ 42 μm; central body dark, 22 $\times$ 30 μm, subcircular with a fairly thick (upto 3 μm) margin; proximal cap prominently thickened, upto 5 μm, structureless, finely granular to psilate; sacci larger than central body, 40 $\times$ 36 μm, distally attached, locally joined equatorially by conspicuous strips or band of thickened sexine, finely reticulate; meshes more or less radiating from central body, fine, sinuous. Central body towards distal side with longitudinal folds near attachment of sacci and a conspicuous slit extending almost all along its length.

Comments—This is an occasional palynomorph of the Gangapur beds. The prominently thickened proximal cap, conspicuous sexinous strips connecting the bladder with the equatorial margin of the central body and the fine sinuous meshes, more or less radiating from the central body distinguish the present species from the other species of this genus.

The species is named in honour of Dr. D. C. Bharadwaj, formerly Deputy Director of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Genus **Dictyoderma** Phillips & Felix, 1971

Type species—*D.* (al. *Reticulatasporites*) *densa* (Leschik) Phillips & Felix, 1971

Dictyoderma sp.
Pl. 6, Fig. 95

Description—Pollen grains alete, spheroidal, 42 μ in diametre, exine two layered, inner layer smooth, finely granular, outer layer loosely or closely enveloping the central body and all over ornamented with reticulum; meshes often discontinuous, irregular, angles thickened, muri flat, prominent, lumina irregular.

Comments—Only few specimens were encountered.

Genus **Psilospora** Venkatachala & Kar, 1968, emend.

Emended Diagnosis—Oval to elliptical spore-like bodies, exine two layered, laevigate, splitting equatorially into two equal halves by furrow-like dehiscence sutures.

Comments—In their description of the genus VENKATACHALA AND KAR (1968) mentioned that they have not encountered any equatorial splitting of the specimens examined by them. Spore-like bodies strikingly resembling *Psilospora* but exhibiting distinct equatorial splitting have been encountered in the present study. Hence it was felt desirable to suitably emend the diagnosis of *Psilospora* to incorporate this particular feature. *Schizosporis parvus* described by COOKSON AND DETTMANN (1959) from the Cretaceous of Australia is also elliptical and laevigate. The authors feel that *Schizosporis* should include only those species which are circular and sculptured (reticulate, rugate, etc.) and the elliptical and laevigate species, such as *S. parvus* should be incorporated under *Psilospora*. Hence, *Schizosporis parvus* should be treated under *Psilospora*. The affinities of *Psilospora* are not known so far.

Psilospora lata Venkatachala & Kar, 1968, emend.
Pl. 6, Figs. 104-106

Emended Diagnosis—Spore-like bodies oval to elliptical, 47-67 × 65-90 μm; exine upto 1.5 μm thick, 2-layered, laevigate, occasionally with longitudinal folds; splitting along longer axis into two, more or less equal halves, which either getting completely separated or seen more often attached together at a locus on one end.

Comments—*Psilospora lata* is an occasional to frequent member of some of the Anksapur samples.

DISCUSSION

ANALYSIS OF THE MICROFLORA

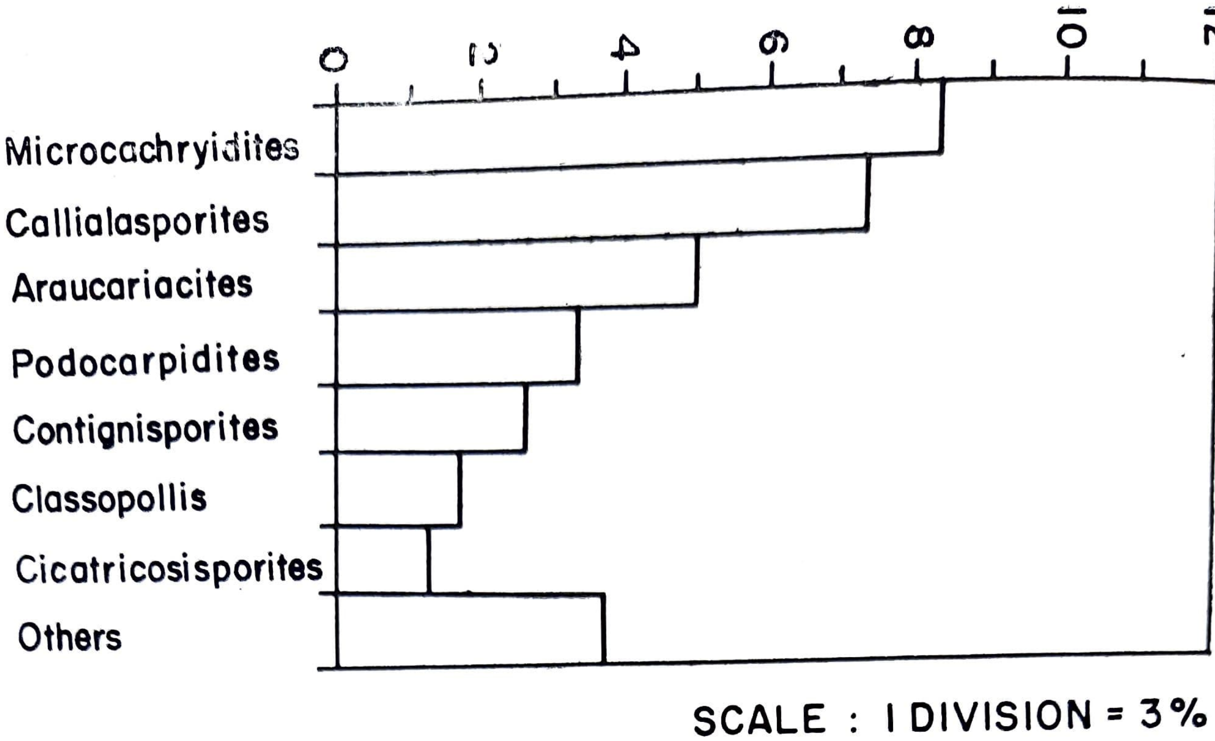
The Gangapur beds have yielded a rich palynological assemblage which includes spores referable to bryophytes and pteridophytes and pollen referable to the Conifers and Cycadophytes of the gymnosperms. The assemblage comprises 69 genera and 109 species, of which 9 species are new. In the assemblage, 40 genera constitute trilete spores and 9 genera represent saccate pollen; the rest include monolete and hilate spores, and inaperturate, monosulcate, and nonsaccate pollen grains.

The quantitative analysis of the sporomorphs of the Anksapur samples has brought to light the following percentages of the various taxa.

Microcachryidites—25; *Callialasporites*—22; *Araucariacites*—15; *Podocarpidites*—10; *Contignisporites*—8; *Classopollis*—5; *Cicatricosisporites*—4; Others—11.

The genera represented by 20 per cent or more were designated as abundant members of the assemblage and those represented by 10-19 per cent as common forms. The genera showing a frequency range between 5 and 9 per cent were considered to be fairly represented, and those between 2 and 4 per cent, as of poor occurrence. Forms of 1 or less than 1 per cent in the assemblage constituted rare elements. Text-fig. 2 represents the histogram of the Anksapur palyno-assemblage depicting the relative frequency of the various taxa.

The above data reveal that the gymnospermous pollen are the dominant members and the pteridophytes occupy a secondary position in the Gangapur microflora. Among the gymnosperms, *Microcachryidites*, *Callialasporites*, *Araucariacites* and *Podocarpidites*



Text-fig. 2. Histogram of the important palynofossils of Anksapur area.

constitute numerically the important members. The pollen of *Classopollis*, however, enjoys consistently fair representation. *Cycaaopites* is poorly represented. The triletes are well represented in the overall microflora. Among the triletes, *Contignisporites* and *Cicatricosisporites* are better represented; the other frequently encountered triletes are: *Cyathidites*, *Osmundacidites*, *Baculatisporites*, *Gleicheniidites*, *Matonisporites*, *Lycopodiumsporites*, *Klukisporites* and *Impardecispora*. Monoletes are poorly represented.

Palynological Comparison

The spore and pollen complex of the Gangapur beds shows significant similarities with the following Upper Jurassic-Lower Cretaceous palyno-assemblages of India.

The palynofossils of the Jabalpur Stage were studied by Dev (1961), Singh (1966) and Kumar (1973). Singh (1966, 1974) dated the Jabalpur sediments as early Cretaceous on palynological evidence. It may be noted significantly that most of the taxa recorded from the Jabalpur beds are also present in the Gangapur beds. Bharadwaj, Kumar and Singh (1972) quantitatively analysed the Jabalpur microflora and observed the dominance of *Araucariacites* (32%), followed by *Cycadopites* and *Callialasporites*. In the Gangapur assemblage the dominant element is *Microcachryidites* followed by *Callialasporites* and *Araucariacites* while *Cycadopites* is poorly represented.

The palyno-assemblage of the Katrol and Umia series of Kutch in Western India were studied by Singh, Srivastava and Roy (1964), Venkatachala, Kar and Raza (1969), and Venkatachala (1967, 1969a, 1969b). Venkatachala and Kar (1970) described three discrete palynozones from the Katrol and Bhuj sediments. According to them, Zone 1 represents the typical Katrol assemblage (U. Jurassic), zone 3, the Bhuj assemblage (L. Cretaceous), and zone 2, a transitional one. The Bhuj assemblage is closely comparable to the Gangapur assemblage. The following taxa are common to both: *Deltoidospora*, *Todisporites*, *Biretisporites*, *Frangospora*, *Leptolepidites*, *Alsophilidites*, *Concavisporites*, *Gleicheniidites*, *Foveosporites*, *Dictyophyllidites*, *Concavissimisporites*, *Baculatisporites*, *Osmundacidites*, *Neoraistrickia*, *Matonisporites*, *Ceratosporites*, *Lycopodiumsporites*, *Ischyosporites*, *Boseisporites, Polycingulatisporites, Sestrosporites, Cicatricosisporites, Coptospora, Aequitriradites, Cooksonites, Impardecispora, Staplinisporites, Contignisporites, Foraminisporis, Callialasporites, Platysaccus, Alisporites, Vitreisporites, Podocarpidites, Araucariacites, Laricoidites, Microcachryidites, Cycadopites, Classopollis, Schizosporis* and *Psilospora* (=psilate *Schizosporis*). The striking palynological similarity between the Bhuj and Gangapur beds is of stratigraphical significance.

Maheshwari (1974) studied the microflora of the Bansa Formation (L. Cretaceous) of the South Rewa Gondwana Basin. Excepting *Pilosisporites, Properinopollenites, Chordasporites,* all the rest of the taxa known from Bansa beds are also known from the Gangapur beds. *Polycingulatisporites, Coptospora, Cooksonites, Ornamentifera, Frangospora, Schizosporis, Plicifera* and *Sestrosporites* of the Gangapur beds have not been recorded from the Bansa beds. However, the Bansa microflora is dominated by *Araucariacites* and *Callialasporites,* whereas the Gangapur microflora is dominated by *Microcachryidites* and *Callialasporites.*

From the subsurface of the Godavari-Krishna Basin of Andhra Pradesh, Rao and Venkatachala (1971), and Sharma, Jain and Venkatachala (1977) have recorded a rich and well preserved palyno-assemblage. From Vemavaram in this region, Ramanujam (1957) and Kar and Sah (1970) recorded a number of cryptogamic spores and gymnospermous pollen. The Gangapur palynoassemblage shows remarkable similarities with the spore and pollen complex of the Godavari-Krishna basin. The following genera are common to both: *Cyathidites, Deltoidospora, Biretisporites, Concavisporites, Trilites, Osmundacidites, Baculatisporites, Neoraistrickia, Ceratosporites, Lycopodiumsporites, Klukisporites, Staplinisporites, Cicatricosisporites, Matonisporites, Boseisporites, Ischyosporites, Gleicheniidites, Plicifera, Sestrosporites, Ornamentifera, Contignisporites, Polypodiisporites,* (=*Thymospora*), *Polycingulatisporites, Crybelosporites, Cooksonites, Aequitriradites, Callialasporites, Alisporites, Podocarpidites, Vitreisporites, Microcachryidites, Araucariacites, Spheripollenites* and *Classopollis.* Most of the species of these genera are also common to the Godavari-Krishna and Gangapur assemblages.

Venkatachala, Sharma and Jain (1972) recognized three palynozones in the subsurface Jurassic-Lower Cretaceous sediments of the Cauvery Basin, viz. 1. *Callialasporites segmentatus*—Zone representing the late Jurassic (Portlandian) age, 2. *Microcachryidites antarcticus*—Zone of the early Cretaceous (Neocomian) age, and 3. *Coptospora cauveriana*—Zone marking the Aptian-Lower Albian of the early Cretaceous. The Gangapur palyno-assemblage shows striking resemblances with the Neocomian *Microcachryidites antarcticus*—Zone of the Cauvery Basin. This zone is dominated by *Callialasporites* and *Microcachryidites;* similar is the case with the Gangapur palynoflora. The other characteristic taxa of this zone are: *Trilites, Cooksonites, Leptolepidites, Staplinisporites, Aequitriradites, Sestrosporites, Neoraistrickia, Spheripollenites, Klukisporites* and *Polycingulatisporites.* All these taxa are also found in the Gangapur assemblage.

The Upper Gondwana deposits (Sriperumbudur beds) of the Palar Basin, Tamil Nadu were studied by Ramanujam and Srisailam (1974), and Ramanujam and Varma (1977) for their spore and pollen contents. More recently, Varma (1980) made an elaborate study of the palyno-assemblage of these beds and according to him the dominant elements of the Sriperumbudur assemblage are *Araucariacites* (60%), followed by *Callialasporites* (11%) and *Podocarpidites* (7%). The Gangapur assemblage, however, shows of dominance of *Microcachryidites* (25%) and *Callialasporites* (22%). *Araucariacites* occupies the third position in the latter assemblage. Almost all the Lower Cretaceous taxa recorded in the Sriperumbudur assemblage are also encountered in the Gangapur microflora. However, the mioflora of Sriperumbudur beds differ quantitatively in view of the dominance of *Araucariacites*.

The microflora of the Gangapur Formation compares to a number of Lower Cretaceous microfloras recorded from Australia (BALME, 1957; COOKSON & DETTMANN, 1958; DETTMANN, 1963), Argentina (ARCHANGELSKY & GAMERO, 1965, 1966a-c) and South Africa (SCOTT, 1976; HERNGREEN & CHLONOVA, 1981). BALME (1957) recognized 3 palynological assemblages in western Australia, viz. Microflora-I of Lower Jurassic, Microflora-IIa of Oxfordian-Kimmeridgian and Microflora-IIb of Neocomian-Aptian age. The Gangapur assemblage is comparable to the Microflora-IIb of western Australia in view of the abundance of *Microcachryidites* and *Podocarpidites* followed by the common occurrence of *Cycadopites* and *Classopollis*. In the Anksapur samples of the Gangapur Formation *Microcachryidites* and *Callialasporites* are the dominant genera followed by *Araucariacites* and *Podocarpidites*. *Cycadopites*, however, is poorly represented in the Gangapur assemblage.

DETTMANN (1963) provided a comprehensive account of the Upper Mesozoic (Neocomian-Aptian) microfloras of the south-eastern Australia classifying them into three palyno-assemblages, viz. *Stylosus*-, *Speciosus*- and *Paradoxa*-assemblage based upon the restricted occurrence of *Crybelosporites stylosus*, *Dictyosporites speciosus* and *Coptospora paradoxa*, respectively. The Gangapur palynoflora is closely comparable to the *Speciosus*-assemblage, considered to be Valanginian to Aptian in age. With few exceptions, most of the taxa of the *Speciosus*-assemblage of the south-eastern Australia are also encountered in the Gangapur assemblage.

AGE OF THE GANGAPUR FORMATION

In the introductory part, attention was drawn to the recent field observation regarding the stratigraphic position of the Gangapur deposits *vis a vis* the Kota limestones, which indicates that the Gangapur deposits overlie unconformably the Kota limestones. In the absence of any faunal evidence and the equivocal evidence of the plant megafossils, one has to rely upon the palynology for dating the Gangapur Formation.

It may be noted significantly that the Gangapur and the other Indian Palynoassemblages of the early Cretaceous age are characterized by the consistent occurrence of *Aequitriradites* (*A. verrucosus*, *A. spinulosus*), *Cooksonites*, *Coptospora*, *Crybelosporites*, *Ornamentifera*, *Contignisporites* (*C. glebulentus*, *C. multimuratus*, etc.), *Cicatricosisporites* (*C. australiensis*, *C. hughesi*, *C. ludbrooki*), *Impardecispora* and *Microcachryidites antarcticus*. Further, associated with these taxa are *Biretisporites*, *Polycingulatisporites*, *Sestrosporites*, *Staplinisporites* and *Trilites* (*T. tuberculiformis*). All these taxa are characteristic of the Lower Cretaceous strata of the various other parts of the Gondwanaland. Since no angiospermous pollen grains whatsoever were encountered in any of the large number of samples studied, the question of extending the age of the Gangapur Formation upto the Albian is ruled out. In view of this, it is concluded that the palynological evidence unequivocally point towards an early Cretaceous (Neocomian-Aptian) age for the Gangapur Formation. It may be noted pertinently that the Gangapur microflora is in conformity with the Neocomian-Aptian palynofloral-complex of the Gondwana province as designated recently by HERNGREEN AND CHLONOVA (1981). The overall palynoflora of the Gondwana province is characterized by the trisaccate genera—as *Microcachryidites* and *Podosporites*, and the general dominance of bisaccate, inaperturate and *Callialasporites* types of gymnospermous pollen.

As the Gangapur beds overlie unconformably the Liassic Kota beds, it can be conlcuded that the Middle to Upper Jurassic strata are missing in the Upper Gondwana sequence of the Pranhita-Godavari basin.

PALAEOECOLOGY

In the Gangapur palyno-assemblage, the gymnosperms, though represented by fewer taxa than the pteridophytes, quantitatively dominate the palynological spectrum. The preservation of the spores and pollen grains is uniformly good, which incidentally proves that these were derived from a flora growing around the depositional basin and that there was not much of a long distance transport. While the spores of the bryophytes and pteridophytes constituted local lowland vegetation, i. e. vegetation indigenous to the depositional basin, the majority of the saccate gymnospermous pollen grains were probably derived from a nearby upland vegetation. The numerical preponderance of the gymnospermous pollen grains is attributable to the stupendous pollen production of these plants.

The fair representation of *Classopollis* in the microflora points the prevalence of a brackish water environment in or around the depositional basin. The overall climate of the area as indicated by the spore and pollen complex appears to be subtropical with reasonably good precipitation.

ACKNOWLEDGEMENTS

The authors are highly thankful to Dr. M. V. N. Murthy, the former Dy. Director General of the Geological Survey of India, Southern Region for permission to use the library facilities of the G. S. I. The authors express their gratitude to Mr. C. Nageswara Rao, presently Director, Central Circle (M. P.), G. S. I., for providing useful data on the geology of the area and the location of the fossiliferous sites. The authors have very much benefitted from the discussions held with Mr. B. R. J. Rao, Director and Dr. P. Yadagiri, Geologist, of the Palaeontology Section of the G. S. I., Southern Region, on various aspects of the Upper Gondwana stratigraphy of the Pranhita-Godavari Basin.

REFERENCES

Archangelsky, S. & Gamerro, J. C. (1965-1966 a-c). Estudio palinologico de la Formacicn Baquero (Cretacico) provincia de Santa cruz I.—IV *Ameghiniana*, **4:** 159-167; 201-209; 229-236; 363-370.

Balme, B. E. (1957). Spores and pollen grains from the Mesozoic of western Australia. *C. S. I. R. O. Aust. Coal Res., Sect.* T. C. **25:** 1-48.

Bharadwaj, D. C., Kumar, P. & Singh, H. P. (1972). Palynostratigraphy of coal deposits in Jabalpur Stage, Upper Gondwana, India. *Palaeobotanist*, **19:** 225-247.

Bose, M. N., Kutty, T. S. & Maheshwari, H. K. (1982). Plant fossils from the Gangapur Formation. *Palaeobotanist*, **30:** 121-142.

Brenner, G. J. (1963). The spores and pollen of Potomac Group of Maryland. *Dept. Geol. Mines Water Resour. Bull.*, **77** : 215.

Chatterjee, S. (1967). New discoveries contributing to the stratigraphy of the continental Triassic sediments of the Pranhita-Godavari Valley. *Bull. geol. Soc. India*, **4** : 37-41.

Cookson, I. C. & Dettmann, M. E. (1958). Some trilete spores from Upper Mesozoic deposits in the eastern Australian region. *Proc. R. Soc. Vict.*, **70** : 95-128.

Cookson, I. C. & Dettmann, M. E. (1959). On *Schizosporis* a new form genus from Australian Cretaceous deposits. *Micropalaeontology*, **5** : 213-216.

Cookson, I. C. & Pike, K. M. (1953). The Tertiary occurrence and distribution of *Podocarpus* (Section *Dacrycarpus*) in Australia and Tasmania. *Aust. J. Bot.*, **1** : 71-82.

Dettmann, M. E. (1963). Upper Mesozoic microfloras from south-eastern Australia. *Proc. R. Soc. Vict.*, **77** : 1-148.

DEV, S. (1961). The fossil flora of the Jabalpur series. 3. Spores and pollen grains. *Palaeobotanist*, **8** : 43-56.

FEISTMANTEL, O. (1879). Upper Gondwana flora of the outliers of the Madras coast. *Mem. geol. Surv. India, Palaeont. Indica Ser.* 11, **1** (4) : 191-224.

HERNGREEN, G. F. W. & CHLONOVA, A. F. (1981). Cretaceous microfloral provinces. *Pollen Spores*, **73** : 441-556.

JAIN, S. L., ROBINSON, P. L. & ROY CHOWDHURY, T. K. (1962). A new vertebrate fauna from the early Jurassic of Deccan, India. *Nature* (*Lond.*) **194** : 755-757.

JAIN, S. L., ROBINSON, P. L. & ROY CHOWDHURY, T. K. (1964). A new vertebrate fauna from the Triassic of the Deccan, India. *Q. Jl. geol. Soc. Lond.*, **120** : 115-124.

KAR, R. K. & SAH, S. C. D. (1970). Palynological investigations of the Gondwana outcrop from Vemavaram with remarks on the age of the beds. *Palaeobotanist*, **18** : 103-117.

KING, W. (1981). The geology of the Pranhita-Godavari Valley. *Mem. geol. Surv. India*, **18** : 1-151.

KUMAR, P. (1973). The *sporae dispersae* of Jabalpur Stage, Upper Gondwana, India. *Palaeobotanist*, **20** : 91-126.

KUTTY, T. S. (1969). Some contributions to the stratigraphy of the Upper Gondwana Formations of the Pranhita-Godavari Valley, Central India. *J. geol. Soc. India*, **10** : 33-48.

MAHESHWARI, H. K. (1974). Lower Cretaceous palynomorphs from the Bansa Formation, South Rewa Gondwana Basin, India. *Palaeontographica*, **146 B** : 21-55.

OWEN, R. (1852). Note on the Crocodilian remains accompanying Dr. T. C. Bell's paper on Kotah. *Q. Jl. geol. Soc. Lond.*, **8** : 233.

RAJESHWAR RAO, P. V. & RAMANUJAM, C. G. K. (1979). The genus *Contignisporites* from the Lower Cretaceous, Gangapur beds of Adilabad district, A. P. *Geophytology*, **9** : 139-143.

RAMANUJAM, C. G. K. (1957). Microfossils from a carbonaceous shale near Vemavaram (Jurassic) in the east coast of India. *J. Indian bot. Soc.*, **36** : 181-197.

RAMANUJAM, C. G. K., & SRISAILAM, K. (1974). Palynology of the carbonaceous shales from a bore hole at Kattavakkam near Conjeevaram, Tamil Nadu, India. *Pollen Spores*, **16** : 57-102.

RAMANUJAM, C. G. K. & RAJESHWAR RAO, P. V. (1979). Palynological approach to the study of some Upper Gondwana clays at Ralapet near Asifabad in Adilabad district of Andhra Pradesh. *Geol. Surv. India, Misc. Publ.* No. **45** : 45-50.

RAMANUJAM, C. G. K. & RAJESHWAR RAO, P. V. (1980). Palynological evidence for the age of some upper Gondwana deposits in Adilabad District of Andhra Pradesh. *Proc. IV. Int. palynol. Conf., Lucknow* (1976-77), **2** : 386-391.

RAMANUJAM, C. G. K. & VARMA, Y. N. R. (1977). Palynological evidence for the age of Sriperumbudur beds encountered in a bore hole at Orikkai near Conjeevaram, Tamil Nadu. *J. geol. Soc. India*, **18**, 429-435.

RAO, C. N. & DUTTA, D. K. (1956). Progress Report for 1955-56. *Geol. Surv. India* (unpublished).

RAO, C. N. & SHAH, S. C. (1957-60). Progress report for 1957-60. *Geol. Surv. India* (unpublished).

RAO, C. N. & SHAH, S. C. (1959). Plant fossils from the Kota-Maleri beds, Adilabad district, Andhra Pradesh. *Indian Sci. Congr.* (*Abstracts*) **3** : 279.

RAO, C. N. & SHAH, S. C. (1963). On the occurrence of pterosaur from the Kota-Maleri beds of Chanda district, Maharashtra. *Rec. geol. Surv. India*, **92** : 315-318.

RAO, V. R. & VENKATACHALA, B. S. (1971). Upper Gondwana marine intercalations in Peninsular India. International Gondwana Symposium Aligarh, Jan. 1970. *Annl. Geol. Dept. A.M.U.*, **5** : 353-389.

ROY CHOWDHURY, T. K. (1965). A new metapsaurid amphibian from the Upper Triassic, Maleri Formation of Central India. *Phil. Trans. Roy. Soc. Lond.* (*Ser. B.*) **250** : 1-52.

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

SCOTT, L. (1976). Palynology of Lower Cretaceous deposits from the Algoa Basin (Republic of South Africa). *Pollen Spores*, **18** : 563-569.

SHAH, S. C., GOPAL SINGH, & GURURAJA, M. N. (1973). Observations on the Post-Triassic Gondwana sequence of India. *Palaeobotanist*, **20** : 221-237.

SHARMA, K. D., JAIN, A. K. & VENKATACHALA, B. S. (1977). Palynology of the early Cretaceous sediments from the subsurface of the Godavari-Krishna Basin, Andhra Pardesh, South India. *VIth Colloq. Indian Micropalaeont. Stratigr.* : 109-121.

SINGH, C. (1971). Lower Cretaceous microfloras of the Peace River area, North Western Alberta. *Res. Counc. Alberta, Bull.*, **28** : 1-295.

SINGH, H. P. (1966). Reappraisal of the microflora from the Jabalpur Series of India with remarks on the age of the beds. *Palaeobotanist*, **15** : 87-92.

SINGH, H. P. (1974). Jurassic-Lower Cretaceous microflora. In Surange *et al.* (Eds.), *Aspects and Appraisal of Indian Palaeobotany, Birbal Sahani Institute of Palaeobotany*, Lucknow : 199-205.

SINGH, H. P., SRIVASTAVA, S. K. & ROY, S. K. (1964). Studies on the Upper Gondwana of Kutch 1. Mio- and Macrospores. *Palaeobotanist*, **12** : 282-306.

SRIVASTAVA, S. K. (1972). Systematic description of some spores from the Edmonton Formation (Maestrichtian), Alberta, Canada. *Paloeontographica* **139 B** : 1-46.

VARMA, Y. N. R. (1980). Palynology of Upper Gondwana deposits of Palar basin. Tamil Nadu. *Ph.D. Thesis, Osmania Univ.* (unpublished).

VENKATACHALA, B. S. (1967). Palynology of the Umia plant beds of Kutch, West India 1. Stratigraphic palynology of the Bhuj exposures near Walkamata (Kutch district, Gujarat State). *Rev. Palaeobot. Palynol.*, **5** : 169-177.

VENKATACHALA, B. S. (1969a). Palynology of Umia plant beds of Kutch, West India 2. Bhuj exposures near Walkamata, Gujarat State—Systematic palynology. *Palaeobotanist*, **17** : 1-8.

VENKATACHALA, B. S. (1969b). Palynology of the Mesozoic sediments of Kutch 4. Spores and pollen from the Bhuj exposures near Bhuj. Gujarat State—Systematic palynology. *Palaeobotanist*, **17** : 208-219.

VENKATACHALA, B. S. & KAR, R. K. (1968). *Psilospora* gen. nov., a new fossil pollen genus from the Mesozoic rocks of Kutch, W. India. *Curr. Sci.*, **37** : 442-443.

VENKATACHALA, B. S. & KAR R. K. (1970). Palynology of the Mesozoic sediments of Kutch, W. India 10, Palynological zonation of Katrol (Upper Jurassic) and Bhuj (Lower Createaceous) sediments, Kutch, Gujarat. *Palaeobotanist*, **18** : 75-86.

VENKATACHALA, B. S., KAR, R. K. & RAZA, S. (1969). Palynology of the Mesozoic sediments of Kutch, W. India 5. Fossil spores and pollen from Katrol sediments around Bhuj. *Palaeobotanist*, **17** : 124-207.

VENKATACHALA, B. S., SHARMA, K. D. & JAIN, A. K. (1972). Palynological zonation of Jurassic-Lower Cretaceous sediments in the subsurface of Cauvery Basin ; *in* A. K. Ghosh *et al.*, (Eds.)—*Proceedings of the Seminar on Palaeopalynology and Indian Stratigraphy*, 1971, Bot. Dept., Calcutta Univ. : 172-188.

EXPLANATION OF PLATES

(Unless otherwise specified, all figures are ×500).

PLATE 1

1. *Cyathidites australis*
2. *Deltoidospora juncta*
3, 4. *Undulatisporites venkatachalai* sp. nov., Holotype
5. *Alsophilidites* sp.
6. *Haradisporites* cf. *H. mineri*
7. *Concavisporites* sp.
8. *Biretisporites spectabilis*
9. *Frangospora fracta*
10. *Dictyophyllidites* sp.
11. *Biformaesporites* sp.
12. *Ceratosporites equalis*
13. *C. couliensis*
14. *Kuylisporites lunaris*
15. *Concavissimisporites punctatus*
16. *C. variverrucatus* (×750)
17, 18. *Neoraistrickia rallapetensis* sp. nov., Holotype
19. *Leptolepidites major*
20,21. *Foveosporites sahii* sp. nov., Holotype (×1000)
22. *Lycopodiumsporites austroclavatidites* (× 1000)

23. *L. reticulumsporites* (×1000)
24. *Impardecispora apiverrucata* (×1000)
25. 26. *Impardecispora adilabadensis* sp. nov. (Fig. 25-Holotype)
27. *Klukisporites areolatus*
28. *K. areolatus* (×1000)

PLATE 2

29. *Klukisporites foveolatus* (×1000)
30. *K. scaberis* (×1000)
31. *Staplinisporites caminus* (×1000)
32. *Cicatricosisporites australiensis* (×1000)
33. *C. hughesi* (×1000)
34. *C. hallei* (×1000)
35. 36. *Cicatricosisporites gangapurensis* sp. nov., Holotype (×1000)
37. *C. imbricatus* (×1000)
38. 39. *Cicatricosisporites verrumuratus* sp. nov., Holotype (×1000)
40. *Callispora potoniei*
41. *Trilites tuberculiformis*
42. *Matonisporites phlebopteroides* (×1000)
43. *Lametatriletes mesozoicus* (×750)

PLATE 3

44. *Ischyosporites crateris*
45. 46. *Ischyosporites pusillus* sp. nov., Holotype (×1000)
47. 48. *Gleicheniidites senonicus* (×1000)
49. *Ornamentifera echinata* (×1000)
50. *Plicifera* sp. (×1000)
51. *Sestrosporites pseudoalveolatus* (×1000)
52. *Foraminisporis assymetricus* (×1000)
53. *F. wonthaggiensis* (×100)
54. *Lakhnavitriletes bansaensis* (×1000)
55. *Polycingulatisporites reduncus* (×1000)
56. 57. *Crybelosporites* cf. *punctatus*
58. *Densoisporites* sp. (×750)
59. *Monolites indicus*
60. *Crassimonoletes surangei*
61. *Metamonoletes haradensis* (×750)
62. *Polypodiisporites multiverrucosus*

PLATE 4

63. 64. *Aequitriradites verrucosus* (Fig. 63×1000)
65. *A. spinulosus*
66. *Cooksonites minor*
67. *Coptospora cutchensis*
68. *Callialasporites trilobatus*
69. *C. segmentatus*
70. *C. discoidalis* (×1000)
71. *C. triletes*
72. *C. doeringii*
73. *C. reticulatus*
74. *C. enigmaticus*
75. 76. *C. crassimarginatus* sp. nov., Holotype (×1000)

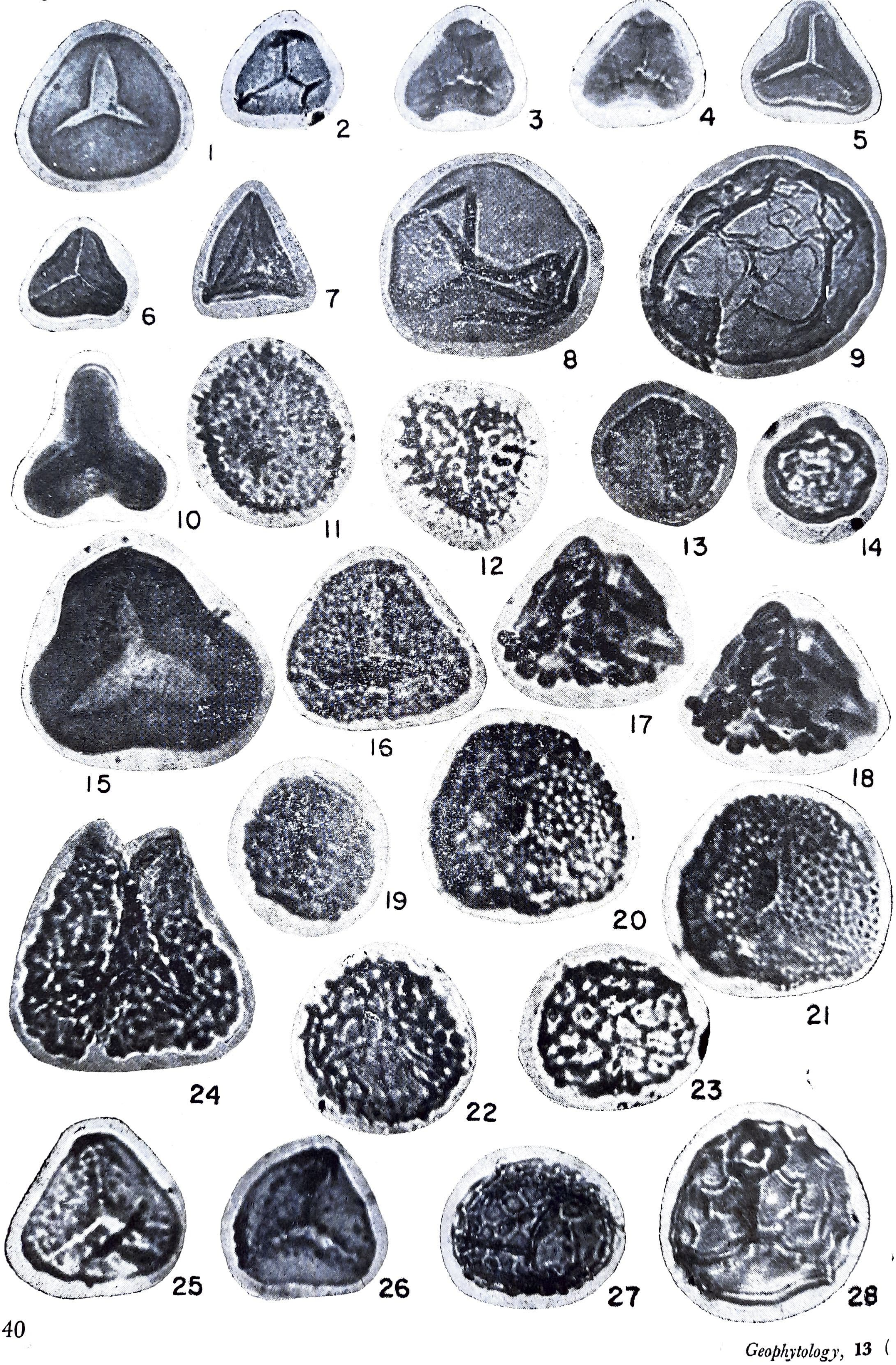
PLATE 5

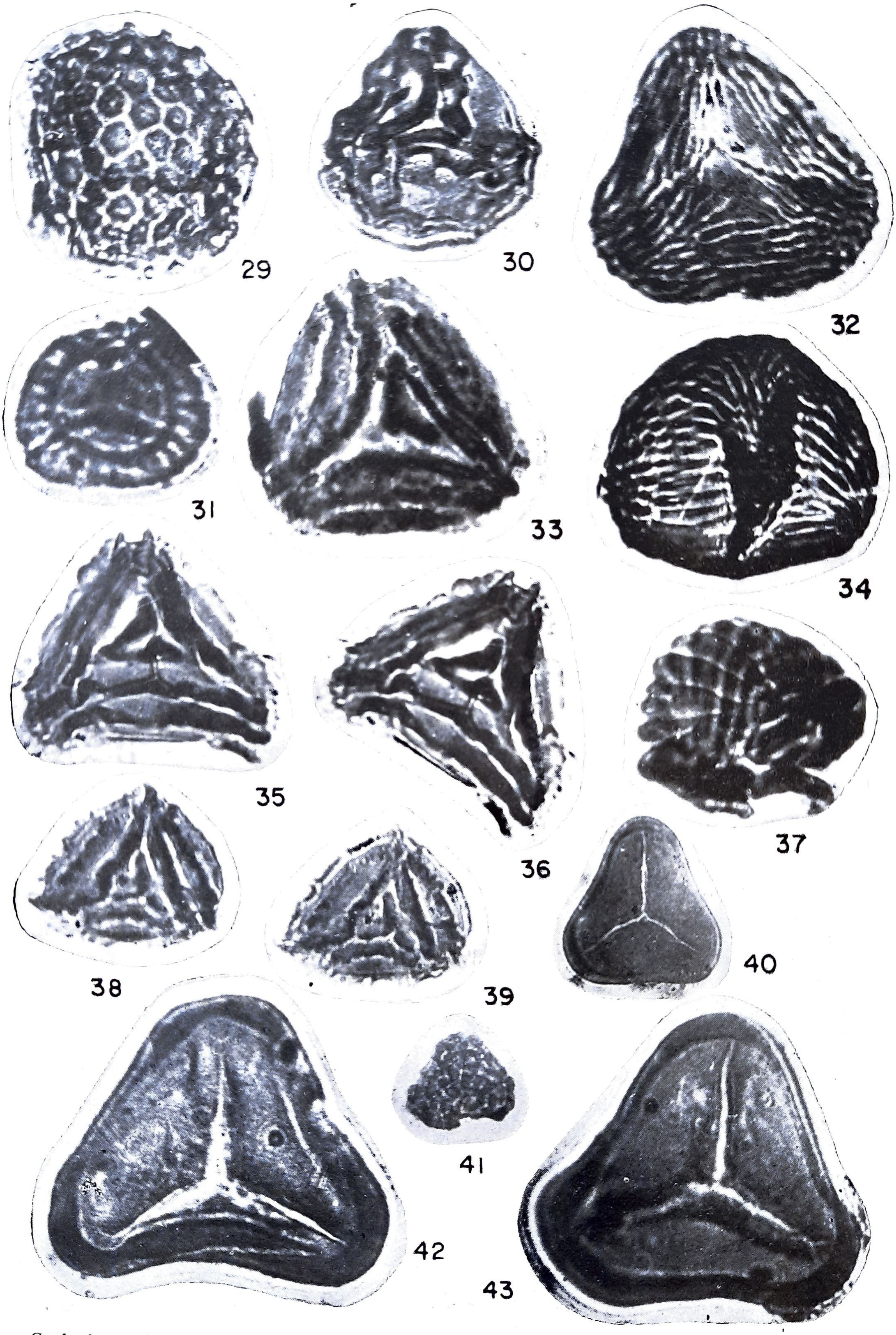
77. *Callialasporites doeringii* (×1000)
78. *C. rudisaccus*
79. *Alisporites rotundus* (×1000)

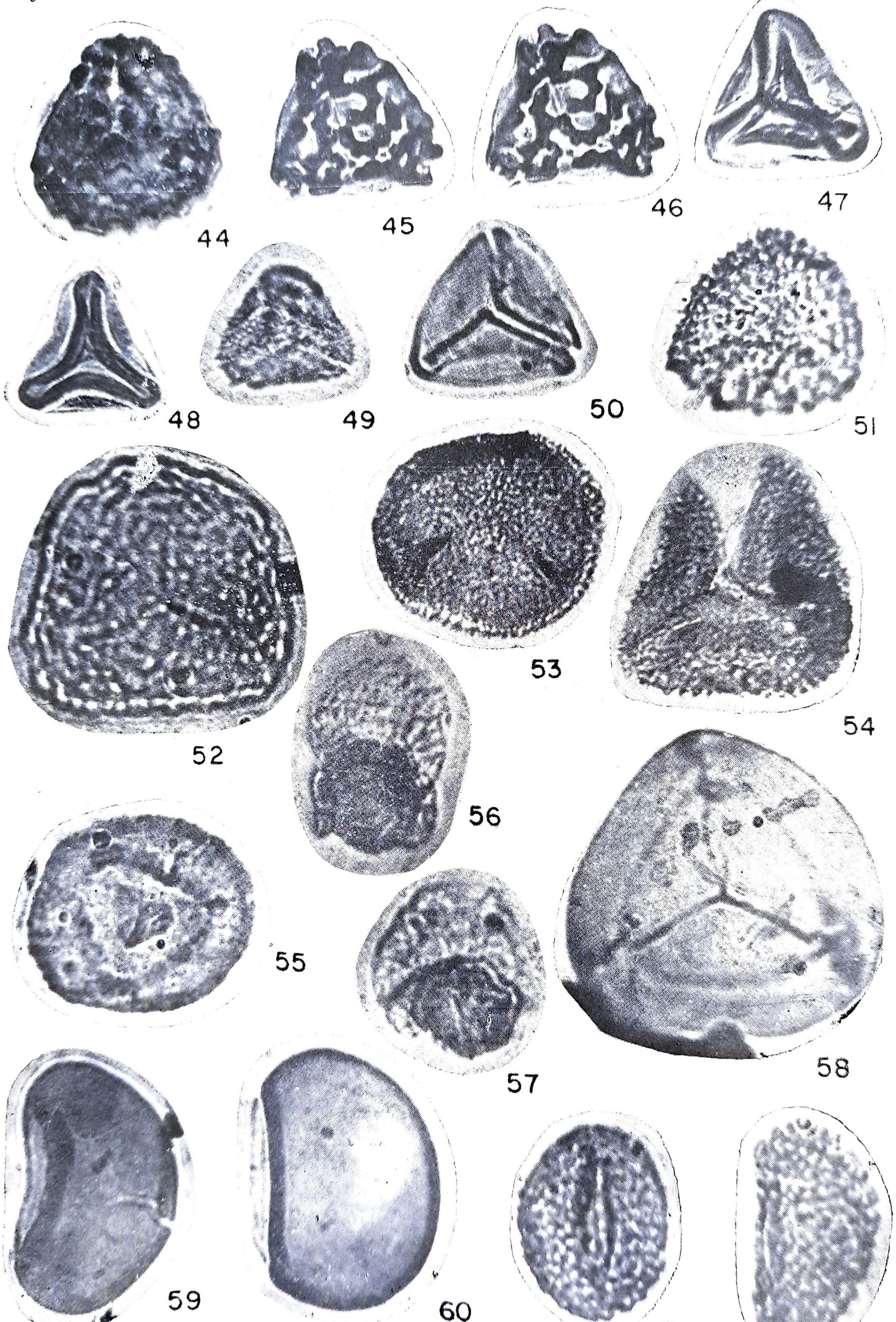
80. *A. grandis* (×1000)
81. *A. ovalis* (×1000)
82. *Podocarpidites major*
83. *Vitreisporites pallidus* (×1000)
84. *Podocarpidites ellipticus* (×1000)
85. *Platysaccus indicus*
86, 87 *Platysaccus bhardwajii* sp. nov., Holotype
88. *Cearipites nudis* (×750)
89, 90. *Microcachryidites antarcticus* (×1000)

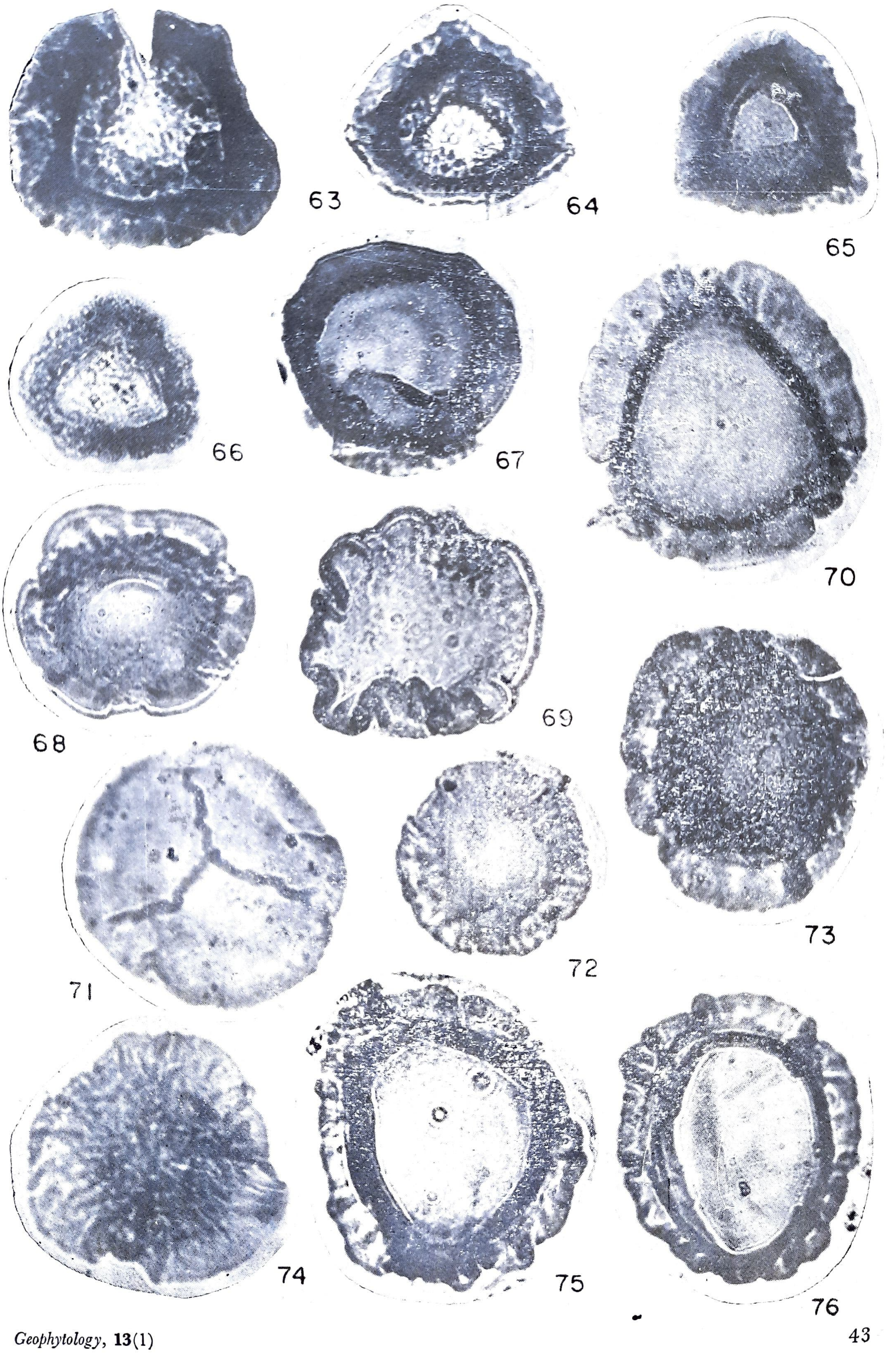
PLATE 6

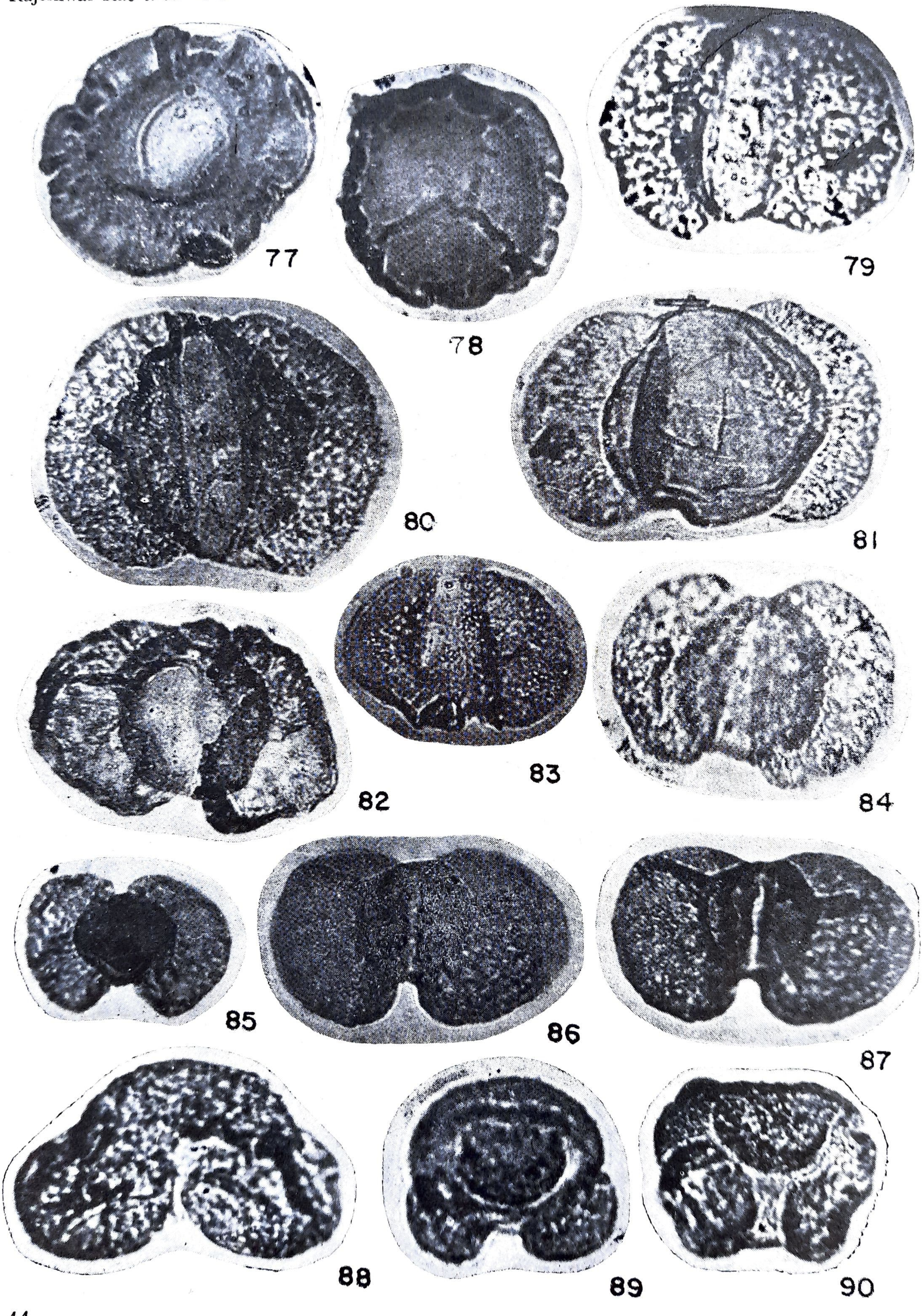
91. *Dacrycarpites australiensis* (750)
92. *Laricoidites* sp. (×1000)
93. *Araucariacites australis* (×1000)
94. *A. ghuneriensis* (×1000)
95. *Dictyoderma* sp.
96. *Cycadopites fragilis* (×750)
97. *C. gracilis* (×750)
98, 99. *Granuloperculatipollis mundus* (×1000)
100. *Classopollis classoides* (single grain×1000)
101, 102. *C. classoides* (Tetrads, Fig. 102×1000)
103. *Schizosporis rugulatus* (×1000)
104-106. *Psilospora lata* (×750)

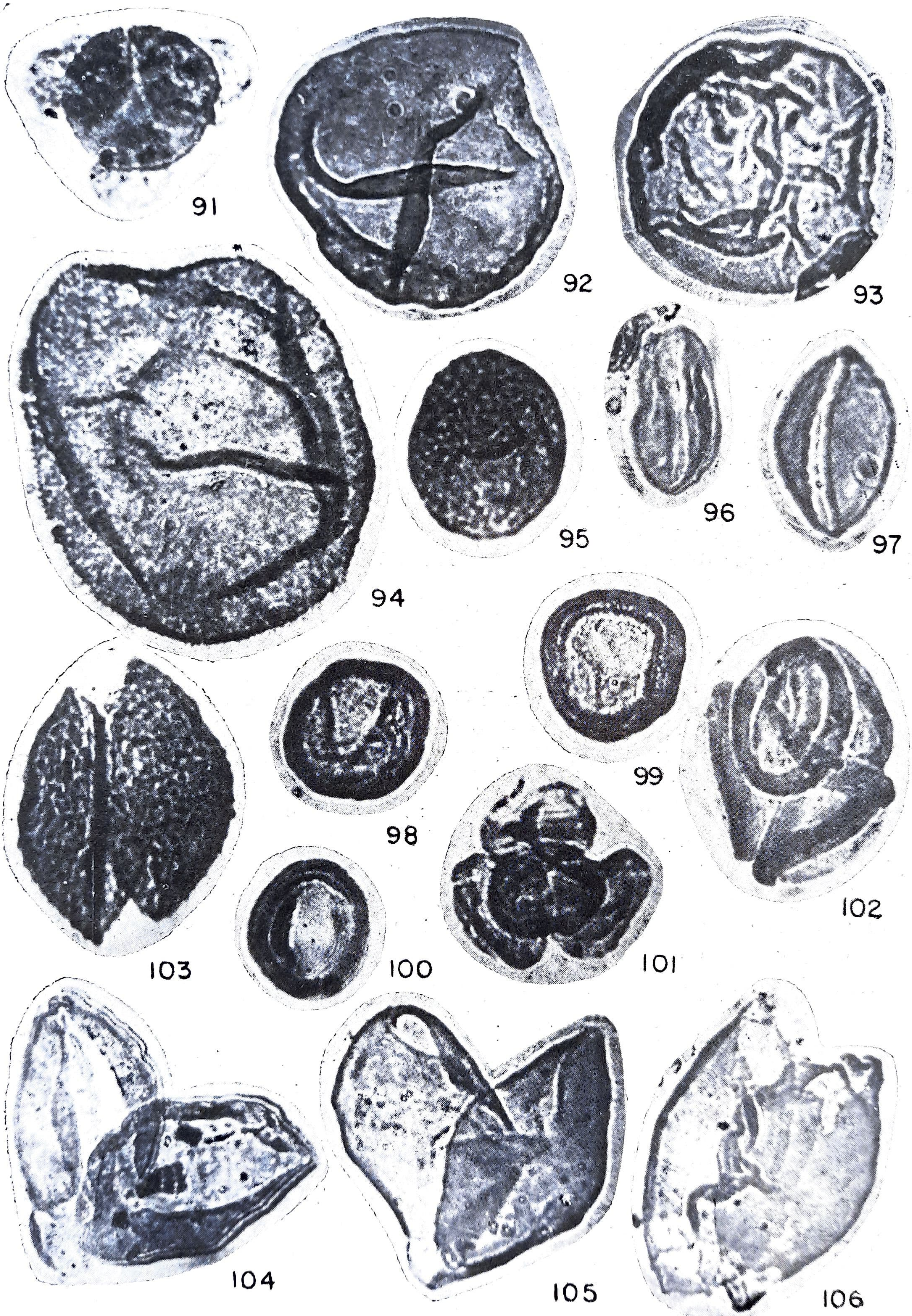

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
24
22
23
25
26
27
28


29
30
32
31
33
34
35
36
37
38
39
40
41
42
43


44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62


63
64
65
66
67
70
68
69
73
71
72
74
75
76


77
78
79
80
81
82
83
84
85
86
87
88
89
90


91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106