MIOFLORAL INVESTIGATION ON THE NEOGENE FORMATIONS OF MORAN AND NAHORKATIYA WELLS, UPPER ASSAM, INDIA*

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ABSTRACT

A search for palynomorphs in the Neogene sediments of Moran and Nahorkatiya wells, situated in Upper Assam, yielded a well preserved miofloral assemblage. The recovered polospores have been assigned to 48 genera and 62 species including one new genus *Ghoshiadites* and 6 new species. The statistical analyses of the palynomorphs reveal that the Girujan Clay Formation is microfloristically rich than those of the Namsang and Dhekiajuli Formations. Within the indigenous floral assemblage of Girujan Clay Formation some recycled Oligocene marker forms have been noticed. The distribution of the palynomorphs within these three sedimentary formations indicate two miofloral assemblage zones ; on the basis of their floral composition, the palaeoclimatic conditions during the deposition of these three sedimentary units has been emphasized.

INTRODUCTION

The Neogene sediments of Upper Assam are lithostratigraphically subdivided into Tipam, Dupi Tila and Dihing Group of rocks. The stratigraphic status of these three sedimentary units and their finer lithostratigraphic subdivisions (Table 1) are well established after the work of Mathur and Evans (1964).

The palynological evidence of the Neogene sedimentary sequences in Upper Assam are rather insignificant as compared to those of Central and Lower Assam. After the pioneering contribution of Sahni *et al.* (1947) successive investigators (Meyer, 1958; Sah & Dutta, 1968 ; Banerjee *et al.*, 1971 ; Banerjee, 1974 ; Singh & Saxena, 1979) added comprehensive data towards the understanding of palynology and bio-stratigraphy of these sedimentary units. The present study is to further the palynological information of the Neogene sediments of two important well sections in Upper Assam with an evaluation the history of palaeovegetation in the depositional area.

MATERIAL AND METHODS

The drill-cutting samples from Nahorkatiya and Moran Wells were kindly supplied by the Oil India Ltd. for palynological investigations. These two wells are situated in the shelf sediments of Upper Assam.

The samples supplied for the present study were collected from the Girujan Clay, Namsang and Dhekiajuli Formations. The samples are sandstones, clay, and sandy clay mixed with fragments of coal. The stratigraphical position of the samples and their depth in the respective well sections are shown in Tables 2-4.

The polliniferous parts were extracted by the usual techniques of maceration, using 10% HCl, HF, HNO_3 and 5% KOH, respectively and finally by specific gravity floatation technique KI-CdI mixture of 2.3 specific gravity. The slides were prepared by using glycerine jelly.

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Table 1—The Neogene sedimentary sequences in Assam (after Mathur & Evans, 1964**)

AGE (approximate)	GROUP	FORMATION AND LOCAL FACIES: Geosynclinal Sediments: Surma Valley (thickness in metres)	Geosynclinal Sediments: Upper Assam & Naga Hills	Shelf Sediments	LITHOLOGY
Recent and Pleistocene		Alluvium and high level terraces		Alluvium and high level terraces	
Unconformity					
Pliocene	Dihing	Not sub-divided (400)	Not sub-divided (900)	Dhekiajuli Beds (1800)	Conglomerates, grits, sandstones & clays.
Unconformity					
Mio-Pliocene	Dupi Tila	Upper Dupi Tila (2800) Lower Dupi Tila (500)	Namsang Beds (800)	Namsang Beds (600)	Clays, mottled sandstones, ferruginous sands, many bands of conglomerates, grits, coal conglomerate, some lenticular seams of lignite.
Unconformity					
	Tipam	Girujan Clay (1500)	Girujan Clay (1800)	Girujan Clay (600)	Argillaceous sandstones, mottled clays, sometimes blue grey or brightly coloured clay, sandy bands contain small fragments of coal.
Miocene		Tipam sandstone (1600)	Tipam sandstone (2300)	Tipam Sandstone (900)	Coarse, massive, ferruginous sandstones with subordinate beds of shales, in the oil fields sandstones are separated by mottled clays.
	Surma	Boka Bil (1500) Bhuban (4000)	Not subdivided (900)	Not sub-divided (1200)	Alternation of shales and sandstones with occasional thin conglomerates.

**The rank terms (series, stages, etc.) are modified by Chakraborty & Baksi (1972) after the American Code of Stratigraphic Nomenclature (1961).

Table 2—Samples collected from the Moran Well No. 2, Upper Assam

Sample No.	Depth (ft)	Stratigraphic horizon
92440	5400	Namsang
92441	5450	,,
92445	5650	,,
92449	5850	,,
92450	5900	,,

Table 2 (Contd.)

92463	6550	Girujan
92464	6600	,,
92466	6700	,,
92468	6800	,,
92470	6900	,,
92472	7000	,,
92474	7100	,,
92476	7200	,,
92478	7300	,,
92480	7400	,,

Table 3—Samples collected from Nahorkatiya Well No. 4, Upper Assam

Sample No.	Depth (ft.)	Stratigraphic horizon
89228	4550	Girujan
89235	4830	,,
89248	5500	,,
89256	5900	,,
89258	6000	,,
89260	6100	,,

Table 4—Samples collected from Nahorkatiya, Well. Upper Assam

Depth (ft)	Stratigraphic horizon
4708	Dhekiajuli
4757	,,
4806	,,
4856	,,
4921	,,
4970	,,
5020	,,
5069	,,
5118	,,
5167	,,

SYSTEMATIC PALYNOLOGY

The recovered biota are systematically arranged according to the system of classification of *Sporae dispersae* as proposed by Potonié and Kremp (1954, 1955, 1956) and subsequently elaborated by Potonié (1956, 1958, 1960, 1966, 1970).

Check-list of the spore-pollen genera encountered in the different stratigraphic units of Moran and Nahorkatiya Well Sections.

Cyathidites australis Couper (Pl. 1, Fig. 1), *C. minor* Couper (Pl. 1, Fig. 2), *Alsophilidites* sp. (Pl. 1, Fig. 3), *Dictyophyllidites* sp. (Pl. 1, Fig. 4), *Gleicheniidites cercinidites* Dettmann (Pl. 1, Fig. 5), *Triplanosporites sinuosus* Thomson & Pflug (Pl. 1, Fig. 6), *Todisporites major* Couper (Pl. 1, Fig. 7), *Stereisporites assamensis* Sah & Dutta (Pl. 1, Fig. 8), *Lygodiumsporites adriensis* Potonié *et al.* (Pl. 1, Fig. 9), *Leptolepidites rariverrucatus* sp. nov. (Pl. 1, Fig. 10), *Corrugatisporites terminalis* Sah & Dutta (Pl. 1, Fig. 11), *Lycopodiumsporites agathoecus* Theirgart

(Pl. 1, Fig. 12), *L. pervireticulatus* Sah & Dutta (Pl. 1, Fig. 13), *Cicatricosisporites knoxi* (Baksi) n. comb. (Pl. 1, Fig. 14), *C. macrocostatus* (Baksi) Sah & Dutta (Pl. 1, Fig. 15), *C. baconicus* Deak (Pl. 1, Fig. 16), *Polypodiaceoisporites* sp. (Pl. 1, Fig. 17), *Laevigatosporites ovatus* Wilson & Webster (Pl. 1, Fig. 18), *L. discordatus* Potonié (Pl. 1, Fig. 19), *Polypodiaceaesporites haardti* Thiergart (Pl. 1, Fig. 20), *P. tertiarus* Sah & Dutta (Pl. 1, Fig. 21), *Polypodiidites speciosus* (Sah) n. comb. (Pl. 1, Fig. 22), *P. oligocenicus* (Sah & Dutta) n. comb. (Pl. 1, Fig. 23), *Sporites circulus* (Pl. 1, Fig. 24), *Cannanoropollis* sp. (Pl. 1, Fig. 25), *Pinuspollenites labdacus* Potonié & Venitz (Pl. 2, Fig. 26), *Podocarpidites ellipticus* (Pl. 2, Fig. 27), *Platysaccus* sp. (Pl. 2, Fig. 28), *Retipilonapites cenozoicus* Sah (Pl. 2, Fig. 29), *Couperipollis brevispinosus* Venk. & Kar (Pl. 2, Fig. 30), *Palmaepollenites eocenicus* Sah & Dutta (Pl. 2, Fig. 31), *P. communis* Sah & Dutta (Pl. 2, Fig. 32), *Proxapertites scabratus* Jain *et al.* (Pl. 2, Fig. 33), *Dicolpopollis* sp. (Pl. 2, Fig. 34), *Cupuliferoidaepollenites liblarensis* Pot. *et al.* (Pl. 2, Fig. 35), *Quercoidites fusus* Sah (Pl. 2, Fig. 36), *Tricolpites reticulatus* Cookson (Pl. 2, Fig. 37), *T. foxi* Ramanujam (Pl. 2, Fig. 38), *Stephanocolpites* sp. (Pl. 2, Fig. 39), *Polycolpites cooksonii* Sah & Dutta (Pl. 2, Fig. 40), *Rhoipites nitidus* Sah & Dutta (Pl. 2, Fig. 42), *Bombacacidites microreticulatus* sp. nov. (Pl. 2, Fig. 43), *Nyssapollenites barooahii* Sah & Dutta (Pl. 2, Fig. 44), *Foveotricolporites foveolatus* sp. nov. (Pl. 2, Fig. 45), *Talisiipites* cf. *mundus* Sah & Dutta (Pl. 2, Fig. 46), *Ghoshiadites reticulatus* gen. *et* sp. nov. (Pl. 2, Fig. 47), *Meyeripollis naharkotenis* Baksi & Venk. (Pl. 2, Fig. 48), *Caprifoliipites* sp. (Pl. 2, Fig. 49), *Margocolporites* sp. (Pl. 2, Fig. 50), *Symplocoipollenites vestibulum* Potonié (Pl. 2, Fig. 51), *Sapotaceoidaepollenites* sp. (Pl. 2, Fig. 52), *S. miocenicus* sp. nov. (Pl. 2, Fig. 53), *Graminidites assamicus* Sah & Dutta (Pl. 2, Fig. 54), *Caryapollenites simplex* Raatz (Pl. 2, Fig. 55), *Engelhardtioipollenites* sp. (Pl. 2, Fig. 56), *Triatriopollenites granulatus* sp. nov. (Pl. 2, Fig. 57), *Alnipollenites verus* Potonié (Pl. 2, Fig. 58), *Tetradomonoporites psilatus* sp. nov. (Pl. 2, Fig. 59), *Polyadopollenites* sp. (Pl. 2, Fig. 60.).

Systematic position and diagnosis for the proposed new genera, species and newly combined taxa are detailed as under :

Genus—**Leptolepidites** Couper, 1953
Type species—Leptolepidites verrucatus Couper, 1953

Leptolepidites rariverrucatus sp. nov.
Pl. 1, Fig. 10

Holotype—Pl. 1, Fig. 10, size 28 μm, Sl. No. A2/1.

Type locality—Girujan Clay State of Moran Well, Assam.

Diagnosis—Spore small, subtriangular, trilete rays long, lips thickened, exine thick, with verrucate projections, verrucae scarce, globular.

Description—Spore small, amb subtriangular, sides of amb convex, apices broadly rounded. Trilete mark distinct, rays long, extending upto the equator, lips thickened, suture thin. Exine ± 2.5 μm thick with verrucate projections, verrucae scarce in number, globular, 2-4 μm in diameter and ± 2.5 μm high, irregularly dispersed.

Comparison—*Leptolepidites rariverrucatus* sp. nov. is distinguished from *L. verrucatus* Couper by its smaller size and the exine having fewer and smaller verrucae. *L. tenuis* Stanley is triangular in shape and the verrucae are polygonal and closely placed. The major distinguishing character of the presently described specimen from the other known species is the presence of scarce number of verrucae on the exine surface.

Affinity—Dennstaeditiaceae.

Genus—**Cicatricosisporites** Potonié & Gelletich, 1933
Types species—Cicatricosisporites dorogensis Potonié & Gelletich, 1933

Cicatricosisporites knoxi (Baksi, 1962) n. comb.
Pl. 1, Fig. 14

Synonym—Schizaeaceaesporites knoxi Baksi, 1962

Holotype—Baksi, 1962; Pl. 3, Fig. 4

Description—Spore trilete, amb subtriangular, sides of amb convex, apices broadly rounded, 60 μm—80 μm in size. Trilete mark long reaching the equator, suture thin, lips thickened by distinct margo. Exine ± 4.5 μm thick, cicatricose, with two sets of intersecting ridges, ridges and furrows almost equal in width, ridges 6 μm-8 μm wide, running parallel to one another, furrows 4 μm-8 μm wide, smooth.

Remark—The spore described by Baksi (1962) is smaller than the presently described spore but other morphological details are closely similar within the two specimens.

Affinity—Baksi (1962) has noted the resemblance of these spores to those of Perkeriaceae or probably related to the genus *Aneimia* (Schizaeaceae).

Genus—**Polypodiidites** Potonié, 1966

Type species—Polypodiidites senonicus Potonié, 1966

Remarks—Ross (1949) established the genus *Polypodiidites* that shares its morphological characters to the spores of the living fern *Polypodium pellucidum* Kaulf ; but he has not given any generic diagnosis. Couper (1953) enumerated the diagnostic characters of the genus *Polypodiidites* to included those spores having sub- to per-verrucate exine. Later, Potonié (1956) retained the generic name *Polypodiidites* Ross for monolete spores having the exine with more or less conical verrucae forming negatively reticulate pattern at their base. He also described the other two closely related genus *Polypodiisporites* Potonié and *Verrucatosporites* Pflug. and clearly distinguished them from *Polypodiidites*. In 1966 Potonié emended the genus *Polypodiidites* (Ross, 1949) and treated the genus *Verrucatosporites* (Thoms. & Pflug,); *Polypodiisporites* (Potonié); *Verrumonoletes* (V. D. Hammen,); *Gemmatosporites* (Krutzsch,) *Gemmamonoletes* (Pierce,) as the junior synonym of *Polypodiidites*. He referred that there is no valid difference in the morphological characters of the above mentioned genera. Dutta and Sah (1970) treated all the spores having exine with flat to perverrucate sculpture into the genus *Polypodiisporites* (Potonié,) but Potonié's (1966) emendation of the genus *Polypodiisporites* and retention of the name *Polypodiidites* gets the nomenclatural priority over Dutta and Sah (1970). Hence, in the present study, all the spores having the exine with flat to slightly elevated, rounded to polygonal or cone-shaped verrucae which may or may not form negative reticulum are treated as *Polypodiidites* Potonié (1966).

Polypodiidites speciosus (Sah, 1967) n. comb.
Pl. 2, Fig. 22

Synonym—Polypodiisporites speciosus Sah, 1967

Description—Spores bilateral, bean shaped, extremities plano-convex, size ranges from 36 μm × 50 μm—42 μm × 52 μm. Monolete mark long, thin, extending more than 3/4th of the longer axis, lips thin, ends pointed. Exine ± 2.5 μm thick, sculptured with verrucate projections, verrucae rounded to polygonal, 3 μm-5 μm broad and 3.5 μm high, apex more or less rounded, closely placed but evenly distributed.

Affinity—Polypodiaceae.

Polypodiidites oligocenicus (Sah & Dutta, 1968) n. comb.
Pl. 1, Fig. 23

Synonym—Polypodiisporites oligocenicus Sah & Dutta, 1968

Description—Spore bilateral, monolete, subspherical, 38 μm×42 μm—48 μm×72 μm in size, extremities convex. Monolete mark short, 1/2 to 3/4th of the axis, laesura thin. Exine ± 1.5 μm thick densely verrucate, verrucae very low with flat tops, circular to subcircular, 2.5 μm-4 μm in size, closely placed and uniformly distributed.

Affinity—Polypodiaceae, showing closer affinity with the spores of *Gomiophlebium amoenum* (Sah & Dutta, 1968).

Genus—**Rhoipites** Wodehouse, 1933

Type species—*Rhoipites bradleyi* Wodehouse, 1933

Rhoipites reticuloides sp. nov.

Pl. 2, Fig. 42

Holotype—Pl. 2, Fig. 48, size 32 μm, Sl. No. A2/27

Type locality—Girujan Clay Stage, Moran Well No. 2, Assam.

Diagnosis—Grain tricolporate, 22 μm-56 μm in size, colpi 1/2 the longer distance of the pole, margin thick, pores large, exine thin, reticulate.

Description—Grain tricolporate, amb prolate-spheroidal, sides of amb roundly convex, poles rounded to somewhat pointed, size ranges from 32 μm×28 μm—36 μm×56 μm. Colpi short, more or less 1/2 of the longer axis, margin thickened, ends pointed, broadly open. Pores large rounded to slightly lalongate, 4 μm—6 μm in diameter, margin slightly thickened. Exine thin, not differentiated into sexine and nexine, reticulate, lumen small, less than 1 μm in diameter, muri thick, uniform in size.

Comparison—*R. bradleyi* differs from the present species by having longer colpi without marginal thickenings and infra-reticulate exine. *R. pseudocingulum* Potonié, 1960, *R. dolium* Potonié, 1960 differ by smaller size and having longer colpi. *R. nitidus* Sah & Dutta, 1967 differs in smaller size and finely sculptured exine. *R. communis*, *R. striatoreticulatus*, *R. psilatus*, and *R. dubius* reported by Sah (1967) from the Neogene profile of Rusizi Valley (Burundi) differ from the present species by their size and nature of exine ornamentation.

Affinity—Anacardiaceae.

Genus—**Bombacacidites** Couper, 1960

Type species—*Bombacacidites bombaxoides* Couper, 1960

Bombacacidites microreticulatus sp. nov.

Pl. 2, Fig. 43

Holotype—Pl. 2, Fig. 49, Size 28 μm×32 μm, Sl. No. A1/41.

Type locality—Girujan Clay Stage, Moran Well No. 2, Assam.

Diagnosis—Grain tricolporate, plano-aperturate, amb oblate- spheroidal, colpi short, without marginal thickening, ora small, indistinct. Exine thick, reticulate.

Description—Grain tricolporate, amb oblate-spheroidal, 28 μm×32 μm in size, plano-aperturate, colpi short, 1/2 of the distance of the pole, slightly open, margin thickened, ends blunt, pores small, indistinct, without marginal thickenings. Exine thick, ± 4 μm in thickness, sexine thicker than nexine, columellae distinct, finely reticulate, homobrochate.

Comparison—The presently described species shows closer affinity with *Bombacacidites assamicus* Sah & Dutta, 1967 by its shape, size and nature of exine ornamentation but differ by having thickening around the colpi and smaller indistinct pores. *B. bombaxoides* Couper, differ in shape and having longer colpi. *B. africanus*, *B. clarus* reported by Sah (1967) from Neogene of Burundi differ from the present specimen by having smaller colpi and coarser exine ornamentation.

Affinity—Bombacaceae.

Genus—**Foveotricolporites** Pierce, 1961

Type species—Foveotricolporites rhombohedralis Pierce, 1961

Foveotricolporites foveolatus sp. nov.

Pl. 2, Fig. 45

Holotype—Pl. 2, Fig. 94.

Type locality—Girujan Clay Stage, Moran Well No. 2, Assam.

Diagnosis—Grain tricolporate, roundly triangular, 56 μm—60 μm in size, angulo-aperturate, colpi long, pores large, both colpi and pore with marginal thickening, exine thick, foveolate.

Description—Amb of the grain roundly triangular to spheroidal, sides of amb convex to slightly flattened, size ranges from 56 μm—60 μm, tricolporate, angulo-aperturate. Colpi long, broadly open at the equator and gradually pointed towards the pole, apex pointed, margin thickened, thickening more pronounced at the equator. Pore large rounded to slightly lalongate, margin thickened. Exine ± 3 μm thick, sexine and nexine similar in thickness, foveolate, tectate, foveolae rounded to slightly elongated, small.

Comparison—Foveotricolporites foveolatus sp. nov. is comparable to other known species of *Foveotricolporites* by its nature of the exine ornamentation and thickening around the aperture.

Affinity—?Nyssaceae. The grain resembles closely with that of *Nyssa* sp.

Genus—**Talisiipitis** Wodehouse, 1933

Type species—Talisiipitis fischeri Wodehouse, 1933

Talisiipitis cf. **T. mundus** Sah & Dutta, 1967

Pl. 2, Fig. 46

Remarks—The presently described specimen shows the characteristic features as that of *T. mundus* but is distinguishable from the later by its larger size (44 μm to 52 μm) and having shorter colpi.

Genus—**Ghoshiadites** gen. nov.

Type species—Ghoshiadites reticulatus gen. *et* sp. nov.

Generic diagnosis—Grain oblate-spheroidal, isopolar, tricolporate, sexine thicker than nexine, mesexinous layer thick being more pronounced at the two sides of the colpi and absent at the apical region ; pore large, lalongate, crassi-marginate ; sexine tegillate with undulating surface and densely crowded, flattened bacula ; exine reticulate.

Comparison—Ghoshiadites gen. nov. is closely comparable to *Favitricolporites* Sah, 1967 in shape and size but differs by having shorter colpi. In *Favitricolporites* the colpi are not surrounded by mesexinous thickening which is found in the present genus. *Ghoshiadites* gen. nov. also could be distinguished from *Favitricolporites* in having thicker and coarsely reticulate exine. The genus *Nyssapollenites* is angulo-aperturte and with longer colpi and thinner exine.

Derivation of name—The genus is named in the honour of Prof. A. K. Ghosh, Department of Botany, Calcutta University, an eminent palynologist of India.

Ghoshiadites reticulatus sp. nov.

Pl. 2, Fig. 47

Holotype—Pl. 2, Fig. 53

Type locality—Girujan Clay Stage, Moran Well No. 2, Assam.

Diagnosis—Grain isopolar, amb oblate-spheroidal, 56 μm—64 μm in size, brevicolpate ; pore large, rounded to lalongate, crassi-marginate ; exine thick, sexine thicker than nexine, tectate columellate, distinctly reticulate, reticulum more or less uniform, simpli-baculate.

Description—Grain oblate-spheroidal, size range 56 μm—64 μm, tricolporate, brevicolpate, colpi wide at the equator and gradually tapering towards the pole, ends blunt, surrounded by mesexinous thickening except at the apex ; pore large, rounded to lalongate, crassimarginate. Exine ± 3 μm thick, sexine thicker than nexine, appearing to be undulated due to densely crowded bacula, reticulate, reticulum uniform, muri thinner than lumen, simpli-baculate.

Affinity—Tiliaceae.

Genus—**Sapotaceoidaepollenites** Potonié, Thomson & Thiergart, 1950
Type species—*Sapotaceoidaepollenites manifestus* Potonié, Thomson & Thiergart, 1950

Sapotaceoidaepollenites miocenicus sp. nov.
Pl. 2, Fig. 52

Holotype—Pl. 2, Fig. 61, Size 32 μm, Sl. No. A1/40.

Type locality—Girujan Clay Stage, Moran Well No. 2, Assam.

Diagnosis—Grain spheroidal, 5-7 colporate, colpi long with thickened margin, ora lalongate, without thickening ; sexine thicker than nexine ; ornamentation reticulate.

Description—Grain prolate-spheroidal to spheroidal, 5-7 colporate, colpi long, extending from pole to pole, narrow, margin thickened, apex pointed, ora large, rounded to lalongate, without marginal thickening. Exine ± 3.5 μm thick, sexine thicker than nexine, simpli-baculate, ornamentation finely and uniformly reticulate.

Comparison—*Sapotaceoidaepollenites miocenicus* sp. nov. could be comparable to other known species of *Sapotaceoidaepollenites* by its 5-7 colporate condition and nature of exine ornamentation.

Affinity—Sapotaceae.

Genus—**Triatriopollenites** Thomson & Pflug, 1953
Type species—*Triatriopollenites rurensis* Thomson & Pflug, 1953

Triatriopollenites granulatus sp. nov.
Pl. 2, Fig. 57.

Holotype—Pl. 2, Fig. 66, Size 30 μm, Sl. No. A2/24.

Type locality—Girujan Clay Stage, Moran Well No. 2, Assam.

Diagnosis—Grain suboblate, 30 μm—42 μm in size, triporate, angulo-aperturate, pores rounded to slightly lalongate, sexine thickened near the pore, exine granulate.

Description—Grain triporate, amb suboblate to subtriangular, sides of the amb slightly convex to straight, 30 μm—42 μm in size, angulo-aperturate. Pores rounded to slightly lalongate, 8 μm in diameter, thickening around the pore. Exine ± 2.5 μm thick, sexine slightly thicker than nexine, ornamentation granulate.

Comparison—The presently described grain closely resemble *Triatriopollenites rurensis* Thom. & Pfl., 1953 in shape, nature of the pore but could be distinguished by larger size and granulate exine.

Affinity—Myricaceae.

DISCUSSION

The palynoflora recovered from the Girujan Clay, Namsang and Dhakiajuli Formations of Moran and Nahorkatiya wells consist of 48 genera and 65 species. The overall floral assemblage is dominantly represented by the following taxa : *Cyathidites* *australis* Couper, *C. minor* Couper, *Alsophilidites* sp., *Dictyophyllidites* sp., *Gleicheniidites cercinidites* Dettmann, *Triplanosporites sinuosus* Thom. & Pfl., *Lycopodiumsporites pervireticulatus* Sah & Dutta, *Cicatricosisporites knoxi* (Baksi) n. comb., *C. macrocostatus* Sah & Dutta, *C. baconcus* Deak, *Laevigatosporites ovatus* Wils. & Webs., *Polypodiaceaesporites haardti* Thiergart, *Polypodiidites speciosus* (Sah) n. comb., *P. oligocenicus* (Sah & Dutta) n. comb., *Tricolpites reticulatus* Cookson, *T. foxii* Ramanujam, *Rhoipites nitidus* Sah & Dutta, *R. reticuloides* sp. nov., *Nyssapollenites barooahii* Sah & Dutta, *Symplocoipollenites vestibulum* Potonié, etc.

The other less significant taxa are : *Leptolepidites rariverrucatus* sp. nov., *Corrugatisporites terminalis* Sah & Dutta, *Pinuspollenites labdacus* Pot. & Venitz., *Podocarpidites ellipticus* Cookson, *Palmaepollenites eocenicus* Sah & Dutta, *Palmaepollenites communis* Sah & Dutta, *Retipilonapites cenozoicus* Sah, *Cupuliferoidaepollenites liblarensis* Pot. *et al.*, *Quercoidites fusus* Sah, *Ghoshiadites reticulatus* gen. *et* sp. nov., *Sapotaceoidaepollenites* sp., *Caryapollenites simplex* Raatz, *Engelhardtioipollenites* sp., *Triatriopollenites* sp., *Alnipollenites verus* Pot., *Sporites circulus* Wolff, etc.

A critical statistical survey on the distribution of the palynomorphs within these three sedimentary formations reveal that the Girujan Clay Formation is floristically conspicuous than its younger deposits. In this floral assemblage predominance of the following taxa are noticed : *Cyathidites australis* Couper, *C. minor* Couper, *Dictyophyllidites* sp., *Gleicheniidites cercinidites* Dettm., *Triplanosporites sinuosus* Thom. & Pfl., *Lycopodiumsporites pervireticulatus* Sah & Dutta, *Cicatricosisporites knoxi*, *C. macrocostatus* Sah & Dutta, *Laevigatosporites ovatus* Wils. & Webs., *Polypodiidites haardti* Thierg., *Rhoipites nitidus* Sah & Dutta, *Tricolpites reticulatus* Cookson, *Symplocoipollenites vestibulum* Pot., *Nyssapollenites barooahii* Sah & Dutta.

The comparatively less significant taxa recorded in this assemblage are : *Stereisporites assamensis* Sah & Dutta, *Leptolepidites rariverrucatus* sp. nov., *Corrugatisporites terminalis* Sah & Dutta, *Cupuliferoidaepollenites liblerensis* Pot. *et al.*, *Palmaepollenites eocenicus* Sah & Dutta, *Pinuspollenites labdacus* Pot. & Vent., *Podocarpidites ellipticus* Cookson, *Sapotaceoidaepollenites* sp., *S. miocenicus* sp. nov., *Caryapollenites simplex* Raatz, *Quercoidites fusus* Sah, *Engelhardtioipollenites* sp., *Alnipollentis verus* Pot., *Polycolpites cooksonii* Sah & Dutta, *Meyeripollis naharkotensis* Baksi & Venkatachala, etc.

Within this indigenous floral assemblage of the Girujan Clay Formation particularly in the upper part, few Palaeocene spore-pollen taxa are noticed. These are *Couperipollis brevispinosus* Venk. & Kar, *C. wodehousei* Venk. & Kar, *Proxapertites operculatus* V. D. Hammen, *Dicolpopollis* sp., *Dandotiaspora* sp., etc. which might have been deposited after being recycled from the older rocks. In addition, few reworked Permian biota such as, *Cannanoropollis* sp., *Platysaccus* sp., etc. has been recovered from the Girujan Clay Formation. The source rock of these Permian palynotaxa might be the Lower Gondwana sediments of Eastern Himalaya. Banerjee (1974) also reported similar type of recycled palynotaxa in the floral assemblage of Girujan Clay Formation.

The floral assemblage of Namsang and Dhekiajuli formations do not show rather significant floristic difference apart from the percentage of occurrence of the sporomorphs and appearance and disappearance of few taxa. These two sedimentary units are microfloristically less productive than the Girujan Formation and devoid of *Cicatricosisporites*, *Palmaepollenites*, *Pinuspollenites*, *Podocarpidites*, *Rhoipites*, *Bombacacidites* whereas presence of *Sporites circulus* Wolff, *Graminidites assamicus* Sah & Dutta, *Retipilonapites cenozoicus* Sah, *Cupuliferoidaepollenites liblerensis* Pot. *et al.* are significant.

On the evidence of the distribution of the palynomorphs within the three studied sedimentary units Ghosh and Nandi (1976) proposed the following two biostratigraphic zones (Fig. 1).

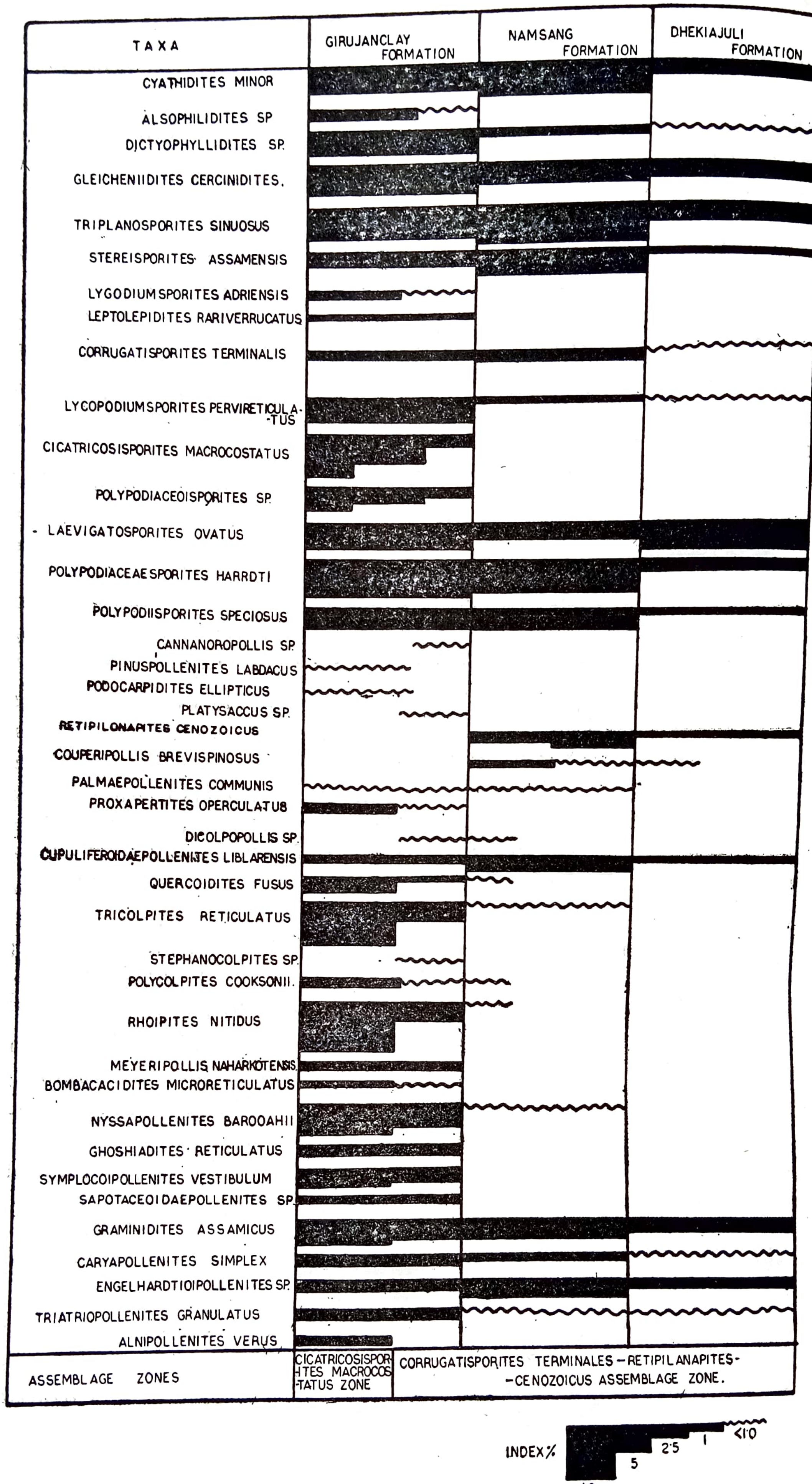

Fig. 1.—Palyno-stratigraphy of Moran and Nahorkatiya Wells, Upper Assam.

Zone I—*Cicatricosisporites macrocostatus Assemblage Zone*

This Assemblage zone has been assessed in the lower part of the Girujan Clay Formation and best exposed at the Moran Well Section. The significant presence of *Cicatricosisporites macrocostatus*, *C. knoxi*, *Rhoipites nitidus*, *R. reticuloides*, *Tricolpites reticulatus*, *Polypodiaceaesporites speciosus*, *P. haardti*, *Cyathidites minor*, etc. in association with *Pinuspollenites*, *Podocarpidites*, *Alnipollenites verus*, *Quercoidites fusus*, *Palmaepollenites communis*, *Polycolpites cooksonii*, etc. has been noticed within this assemblage Zone.

Zone II—*Corrugatisporites-Retipilonapites Assemblage Zone*

The Upper part of the Girujan Clay Formation with Namsang and Dhekiajuli Formations are included within this zone. *Cicatricosisporites*, *Rhoipites*, *Tricolpites* gradually disappear in this zone. Appearance of *Retipilonapites cenozoicus*, *Sporites circulus* with higher percentage of *Corrugatisporites terminalis*, *Cupuliferoidaepollenites liblerensis*, *Engelhardtioidites* sp., *Graminidites assamicus* has been noticed. This assemblage zone is best known from the Moran Well Section. The Namsang Bed and Dhekiajuli Formation of Nahorkatiya Well Section are floristically poor.

PALAEOECOLOGY

The assemblage pattern of the palynotaxa within the presently studied three sedimentary sequences assist to evaluate the palaeoecological condition of the depositional basin. The general microfloral constitution of the Girujan Clay, Namsang and Dhekiajuli Formations exhibit a remarkable dominance of pteridophytic spores over the angiosperm pollen. Gymnospermous representatives are scanty.

The prevalence of *Cicatricosisporites* (aff. Schizaeaceae, Parkeriaceae), *Cyathidites* (aff. Cyatheaceae), *Polypodiaceaesporites*, *Polypodiidites* (aff. Polypodiaceae) in the floral assemblage of the Girujan Clay Formation in association with lower frequency of *Palmaepollenites* (aff. Palmae), *Tricolpites reticulatus* (aff. Halorrhagaceae), *Polycolpites cooksonii* (aff. Rubiaceae), *Rhoipites nitidus* (Anacardiaceae), etc. indicates that the vegetation was tropical to subtropical type inhabited in warm humid, swampy climatic condition. From the infrequent occurrence of temperate elements such as, *Alnipollenites*, *Quercoidites*, *Pinuspollenites* it may be deduced that topographically elevated areas were far away from the basin of deposition. Similar type of flora has been reported from the Girujan Clay Formation of Upper Assam by Sah and Dutta (1968) and Banerjee (1974).

In the floral assemblage of Namsang and Dhekiajuli Formations the rare presence of the taxa representing the family Schizeaeaceae, Parkeriaceae, etc. and prevalence of *Retipilonapites* (Potamogetonaceae), *Corrugatisporites* (Lycopodiaceae), *Graminidites* (Gramineae) in association with the other forms suggests that the vegetation might be of more inland type which was inhabited in tropical to subtropical, warm and drier climatic condition. The paucity of microflora in the Dhakiajuli Formation might be due to the geological disturbances that took place during the Plio-Pleistocene Himalayan Orogeny.

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REFERENCES

BAKSI, S. K. (1962). Palynological investigation of Simsang river Tertiaries, South Shillong Front, Assam. *Bull. geol. Min. metall. Soc. India.*, **26** : 1-22.

BANERJEE, D. (1974). Palynological studies on the Tertiary formations of Assam. *Unpublished D. Phil. Thesis*, University of Calcutta.

BANERJEE, D., MISRA, C. M. & KOSHAL, V. N. (1971). Palynology of the Tertiary subcrops of Upper Assam. *Palaeobotanist*, **20** (1) : 1-6.

CHAKRABORTY, A. & BAKSI, S. K. (1972). Stratigraphy of the Cretaceous—Tertiary sedimentary sequence, southwest of Shillong Plateau. *Q. J. geol. Min. metall. Soc. India*, **44** (3) : 109—127.

COUPER, R. A. (1953). Upper Mesozoic and Cainozoic pollen grains from New Zealand. *Palaeont. Bull. N. Z.*, **22** : 5—77.

DUTTA, S. K. & SAH, S.C. D. (1970). Palyno-stratigraphy of the Tertiary sedimentary Formations of Assam: 5. Stratigraphy and palynology of South-Shillong Plateau. *Palaeontographica*, **131** : 1-72.

GHOSH, A. K. & NANDI, B. (1976). Biostratigraphic zonation of the Upper Tertiary sediments of Upper Assam (Abstract). *6th Colloq. Micropalaeontol. Indian Strat. Benaras* : 4.

MATHUR, L. P. & EVANS, P. (1964). Oil in India. *Intern. Geol. Congr. 22nd Sess. India* : 1-87.

MEYER, B. L. (1958). Palynological investigation of some samples from Naharkotiya, Assam. *J. palaeont. Soc. India.*, **3** : 156-157.

PIERCE, R. L. (1961). Lower Upper Cretaceous plant microfossils from Minnesota. *Bull. geol. Surv. Univ. Minn.*, **42** : 1—81.

POTONIÉ, R. (1934). Zur Mikrobotanik des eocanen Humodils des Geiseltals (in Zur Mikrobotanik der Kohlen und ihrer Verwandten). *Preuss. Geol. Land.*, **4** : 25-125.

POTONIÉ R. (1956). Synopsis der Gattungen der Sporae Dispersae, Teil. I. *Beih. Geol. Jb.*, **23** : 1-103.

POTONIÉ R. (1958). Synopsis der Gattungen der Sporae Dispersae. Teil. II. *Beih. Geol. Jb.*, **31** : 1-114.

POTONIÉ R. (1960). Synopsis der Gattungen der Sporae Dispersae, Teil. III. *Beih. Geol. Jb.*, **39.**

POTONIÉ R. (1966). Synopsis der Gattungen der Sporae Dispersae, Teil. IV. *Beih. Geol. Jb.*, **72.**

POTONIÉ R. (1970). Synopsis der Gattungen der Sporae Dispersae, Teil V. *Beih. Geol. Jh.*, **87.**

POTONIÉ R. & GELLETICH, J. (1933). Uber pteridophyten—Sporen einer eozanen Braunkohle aus Dorog in Ungarn. *S. B. Gesch. naturf. Fr. Berl.* , **33** : 517-526.

POTONIÉ R. & KREMP, G. O. W. (1954). Die Gattungen der palaeozoischen Sporae Dispersae und ihre Stratigraphie. *Geol. Jb.*, **69** : 111-194.

POTONIÉ, R. & KREMP, G. O. W. (1955) Die Sporae Dispersae des Ruhrkarbons. Teil I. *Palaeontographica*, **98B** : 1-136.

POTONI'É, R. & KREMP, G. O. W. (1956). Die Sporae Dispersae des Ruhrkarbons. Teil II & III. *Palaeontographica*, **99B** : 895-191; **100B** : 65-121.

POTONIE, R., THOMSON, P. W. & THIERGART, FR. (1950) Zur Nomenklatur und klassifikation der neogenen Sporomorphae (Pollen und Sporen). *Geol. Jb.* **65** : 35—70.

ROSS, N. E. (1949). On a Cretaceous pollen and spore bearing clay deposits of Scania. *Bull. geol. Inst. Uppsala*, **34** : 25-43.

SAH, S. C. D. (1967). Palynology of an Upper Neogene profile from Rusizi (Burundi). *Mus. Roy. de. L. Afrique Centrale Tervuren, Belgique, Annales Ser. in 8°. Sci. Geol.*, **57** : 1-173.

SAH, S. C. D. & DUTTA, S. K. (1967). Palynostratigraphy of the sedimentary formations of Assam. I. Stratigraphical position of the Cherra Formation. *Palaeobotanist*, **15** (1-2) : 72-86.

SAH, S. C. D. & DUTTA, S. K. (1968). Palynostratigraphy of the sedimentary formations of Assam. I. Stratigraphic significance of spores and pollen in the Tertiary succession of Assam. *Palaeobotanist*, **16** (2) : 177-194.

SAHNI, B., SITHOLEY, R. V. & PURI, G. S. (1947). Correlation of Tertiary succession in Assam by means of microfossils. *J. Indian bot. Soc.*, **26** (4) : 262-263.

SINGH, H. P. & SAXENA, R. K. (1979). Palynology of the neogene sediments of Jorajan Well-3, Upper Assam (Abstr.). *Symposium on Evolutionary Botany and Biostratigraphy*, Calcutta University, 1976 : 26.

THOMSON, P. W. & PFLUG, H. (1953). Pollen und Sporen des mitteleuropäischen Tertiärs. *Palaeontographica* B **94** : 1—138.
WODEHOUSE, R. P. (1933). Tertiary pollen—II. The oil shales of the Green River Formation. *Bull. Torrey bot. Cl.* **60** : 479—524.

EXPLANATION OF PLATE 1

(All figures are *ca* ×700)

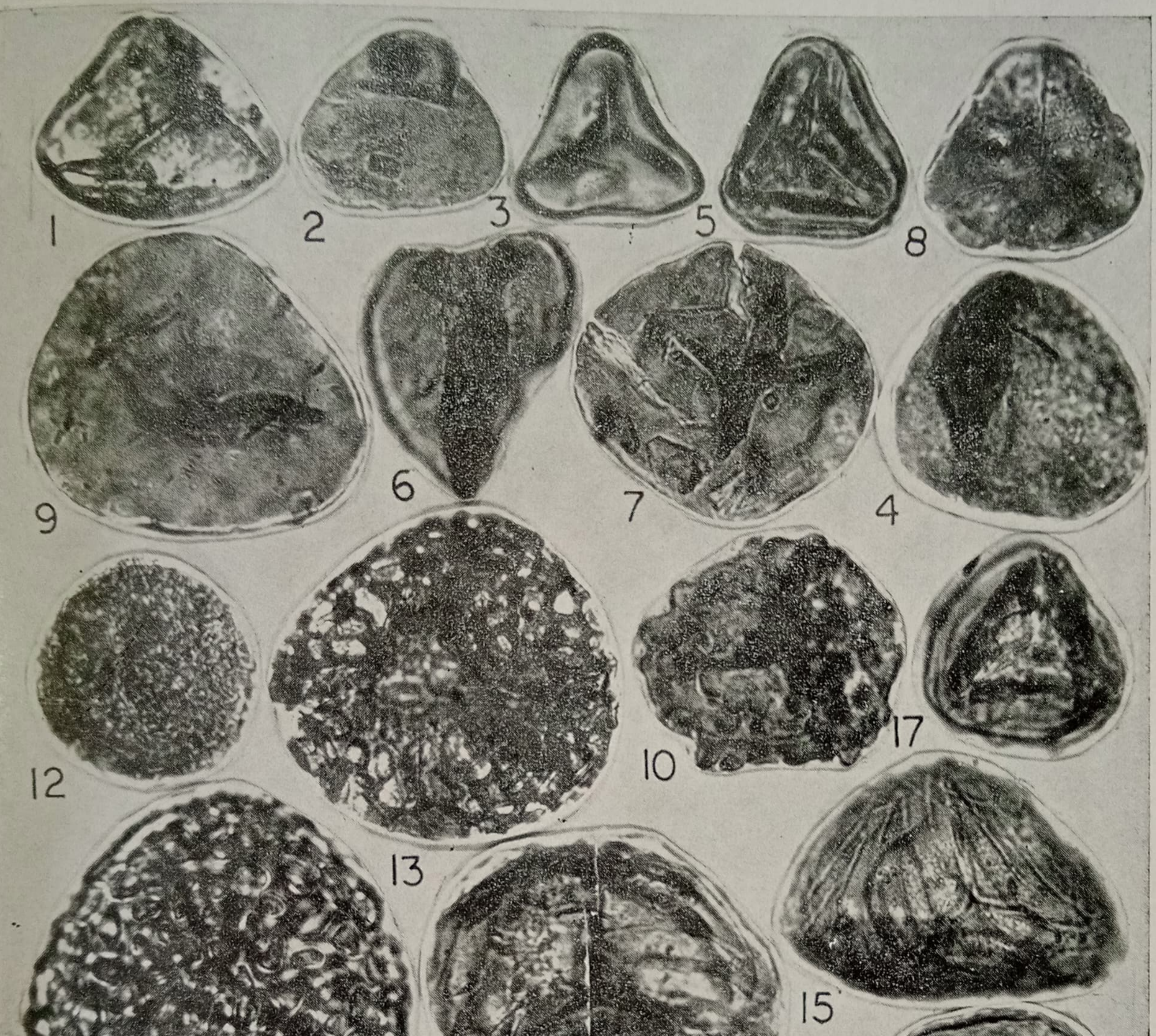
1. *Cyathidites australis* Couper—Sl. No. A1/13.
2. *C. minor* Couper—Sl. No. A1/35
3. *Alsophilidites* sp. —Sl. No. A1/22
4. *Dictyophyllidites* sp.—Sl. No. A2/27
5. *Gleicheniidites cercinidites* Dettmann—Sl. No. A1/9
6. *Triplanosporites sinuosus* Pflug.—Sl. No. A1/76
7. *Todisporites major* Couper—Sl. No. 1A2/62
8. *Stereisporites assamensis* Sah & Dutta—Sl. No. A1/33
9. *Lygodiumsporites adriensis* Pot. et al. —Sl. No. A1/89
10. *Leptolepidites rariverrucatus* sp. nov.—Sl. No. A1/2, X1000
11. *Corrugatisporites terminalis* Sah & Dutta—Sl. No. A1/7
12. *Lycopodiumsporites agathoecus* Thiergart—Sl. No. A1/39
13. *L. pervireticulatus* Sah & Dutta—Sl. No. A1/96
14. *Cicatricosisporites knoxi* (Baksi, 1962) n. comb. Sl. No. A2/3
15. *C. macrocostatus* Sah & Dutta—Sl. No. A1/95
16. *C. baconicus* Deak.—Sl. No. A2/11
17. *Polypodiaceoisporites* sp.—Sl. No. A1/47
18. *Laevigatosporites ovatus* Wils. & Webst.—Sl. Nos. A1/35, A1/83
19. *L. discordatus* Potonie—Sl. No. A2/45
20. *Polypodiaceaesporites haardti* Thiergart—Sl. No. A2/5
21. *P. tertiarus* Sah & Dutta—Sl. No. A1/6
22. *Polypodiidites speciosus* (Sah.) n. comb.—Sl. No. A1/91
23. *P. oligocenicus* (Sah & Dutta) n. comb.—Sl. No. A2/47
24. *Sporites circulus* Wolff.—Sl. No. A2/40
25. *Cannanoropollis* sp.—Sl. No. A1/17

EXPLANATION OF PLATE 2

(All figures are *ca* ×700, unless otherwise mentioned)

26. *Pinuspollenites labdacus* Potonié & Venitz.—Sl. No. A1/25, approx. ×500
27. *Podocarpidites microreticulatus* Cookson—Sl. No. A2/50, approx. ×500
28. *Platysaccus* sp. Sl. No. A2/43, approx. ×500
29. *Retipilonapites cenozoicus* Sah.—Sl. No. A1/35
30. *Couperipollis brevispinosus* Venk. & Kar 1969—Sl. No. A1/23
31. *Palmaepollenites eocenicus* Sah & Dutta—Sl. Nos. A1/51 ×1000, A2/12
32. *P. communis* Sah & Dutta——Sl. No. A2/45
33. *Proxapertites scabratus* Jain, Kar & Sah—Sl. Nos. A2/8, A2/12, A2/13
34. *Dicolpopollis* sp. 1.—fil. Nos. A2/15, A/9
35. *Cupuliferoidaepollenites liblarensis* Pot., Thom. & Thierg.—Sl. Nos. A2/21
36. *Quercoidites fusus* Sah—Sl. Nos. A1/2, A2/41
37. *Tricolpites reticulatus* Cookson—Sl. No. A2/32
38. *T. foxi* Ramanujam.—Sl. No. A2/13
39. *Stephanocolpites* sp.—Sl. No. A1/13
40. *Polycolpites cooksonii* Sah & Dutta——Sl. No. A2/9
41. *Rhoipites nitidus* Sah & Dutta—Sl. No. A2/19
42. *Rhoipites reticuloides* sp. nov.—Sl. No. A2/27
43. *Bombacacidites microreticulatus* sp. nov.—Sl. No. A1/41
44. *Nyssapollenites barooahii* Sah & Dutta—Sl. No. A2/42

45. *Foveotricolporites foveolatus* sp. nov.—Sl. No. A1/19
46. *Talisiipitis* cf. *mundus* Sah & Dutta—Sl. No. A1/36
47. *Ghoshiadites reticulatus* gen. *et* sp. nov.—Sl. Nos. A1/83, A2/36
48. *Meyeripollis naharkotensis* Baksi ;& Venkatachala—Sl. No. A2/29
49. *Caprifoliipites* sp.—Sl. No. A3/99
50. *Margocolporites* sp.—Sl. No. A2/35
51. *Symplocoipollenites vestibulum* Potonié —Sl. No. A2/13
52. *Sapotaceoidaepollenites* sp.—Sl. Nos. A1/85, A3/99, A2/40
53. *S. miocenicus* sp. nov.—Sl. Nos. A1/40, A2/23, A2/5
54. *Graminidites assamicus* Sah & Dutta—Sl. No. A1/85
55. *Caryapollenites simplex* Raatz.—Sl. No. A1/85
56. *Engelhardtioipollenites* sp.—Sl. No. A2/18
57. *Triatriopollenites granulatus* sp. nov.—Sl. No. A2/24
58. *Alnipollenites verus* Potonie—Sl. Nos. A1/78, A1/30
59. *Ttetradomonoporites psilatus* sp. nov.—Sl. No. A2/99
60. *Polyadopollenites* sp.—Sl. No. A1/40, A2/15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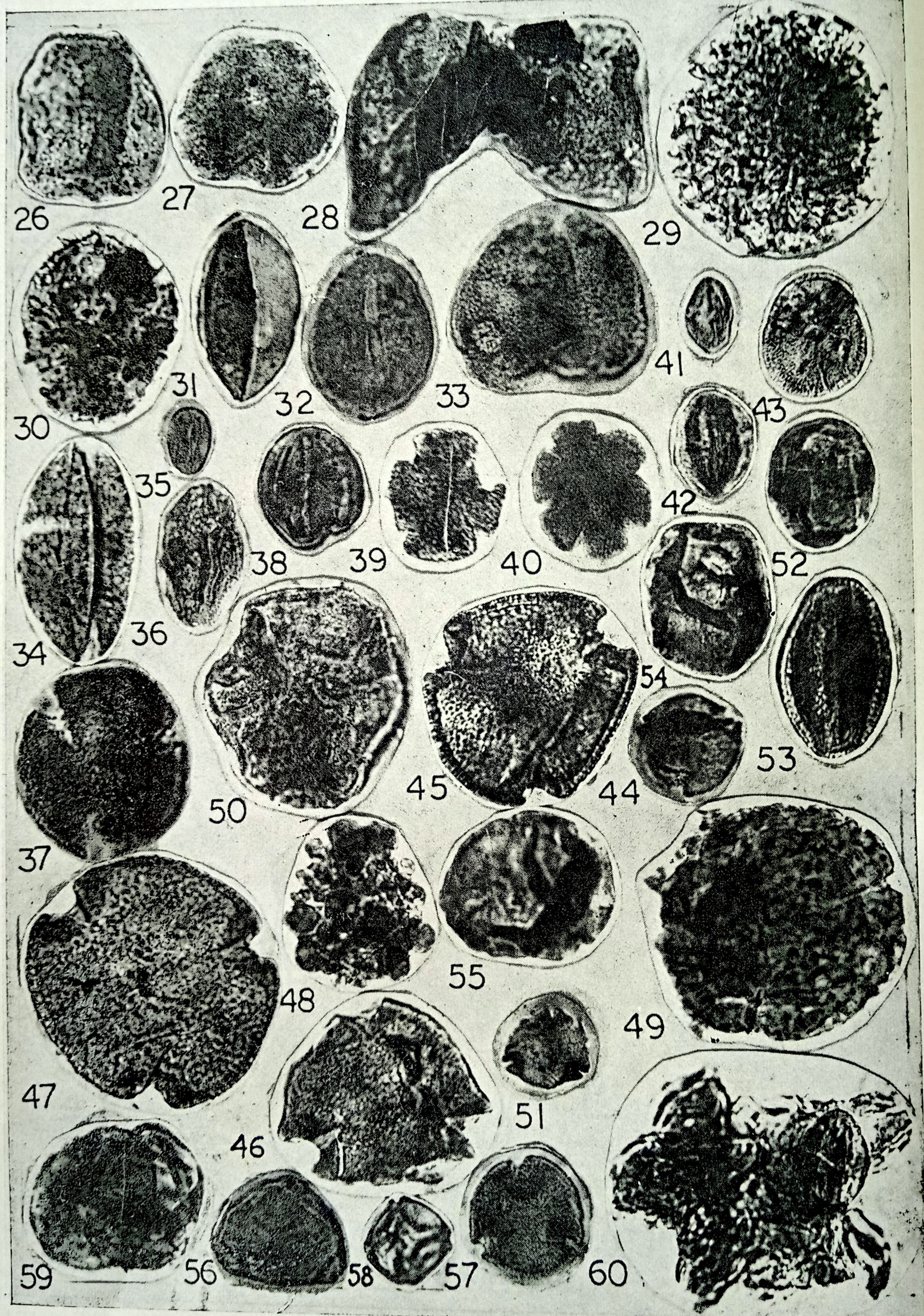
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