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THE MICROPALAEONTOLOGY, PALYNOLOGY AND STRATIGRAPHY OF THE PANARCTIC TENNECO ET AL. POLLUX G-60 WELL

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I

INTRODUCTION

This report comprises a summary of the micropalaeontological, palynological and stratigraphical analyses carried out under Project No. RRNA/767/333, on material recovered from the interval 70' - 11,249' (T.D.) of the Panarctic Pollux G-60 Well.

This well was drilled on the western side of the Isachsen Peninsula, Ellef Ringnes Island, in the Canadian Arctic Islands at 79° 09' 23.51" N., 104° 57' 23.35" W..

The stratigraphical interval studied for this report commences in Neogene - Recent sediments of the Beaufort Formation, which pass down with possible disconformity into the Eureka Sound Formation of Palaeocene age. These Tertiary sediments are underlain with great unconformity by Upper, Middle and Lower Triassic rocks of the Heiberg, Schei Point and Blind Fiord Formations in which the Rhaetian, Norian, Karnian, Ladinian, Anisian, Spathian, Smithian and Scythian (undifferentiated) stages are recognised.

The Triassic sequence is, in turn, unconformably underlain by Pennsylvanian - Lower Permian sediments of the Nansen and Hare Fiord Formations with the Sakmarian stage being recognised at the top of the sequence. The oldest rocks encountered in Pollux G-60, are sediments and meta-sediments, questionably correlated with the Cape Phillips Formation, which unconformably underlie the Nansen Formation and dated as being of undifferentiated Silurian - Devonian age.

III

MATERIALS AND METHODS

Under Project No. RRNA/767/333, cuttings samples were examined from the interval 70' - 11,249' (T.D.), together with samples from cores No. 1 (2584' - 2604'), No. 2 (4500' - 4530'), No. 3 (7542' - 7592'), No. 4 (9184' - 9188'), No. 5 (11,050' - 11,067') and No. 6 (11,233' - 11,249'). The examination comprised both detailed palynological and micropalaeontological studies. For specific information reference should be made to the biostratigraphical analysis charts, enclosures 1 and 2.

A tentative interpretation of the environments of deposition is indicated on the biostratigraphical analysis chart and discussed in the stratigraphical remarks. The interpretation of a probable environment is based on the use of a combination of factors including the faunal and floral diversity and dominance, stratigraphical distribution, the comparison of species, genera and assemblages with analogous components in the Recent and fossil record, and the lithological characteristics of the intervals studied.

It should be realized that as the information is mainly derived from cutting samples, only a generalized interpretation of the environment is feasible throughout the well section.

The prepared samples and recorded information are now curated in the confidential files of the Calgary laboratory of Robertson Research (North America) Limited.

II

SUCCESSION

TABLE I

DEPTH	THICKNESS	AGE	
70' - 190'	120'	Neogene-Recent	Tertiary-Quaternary
190' - 2120'	1930'	Palaeocene	Tertiary
2120' - 2390'	270'	Rhaetian	Upper Triassic
2390' - 3030'	640'	Norian	
3030' - 3690'	660'	Karnian	
3690' - 3990'	300'	Ladinian	Middle Triassic
3990' - 4790'	800'	Anisian	
4790' - 5690'	900'	Spathian	Lower Triassic
5690' - 6090'	400'	Smithian	
6090' - 7400'	1310'	Scythian (undifferentiated)	
7400' - 7592'	192'	Sakmarian	Lower Permian
7592' - 10,600'	3008'	Pennsylvanian-Lower Permian	
10,600' - 11,249' (T.D.)	649'	Silurian-Devonian	

N.B. The above figures are mainly based on results derived from cuttings samples and are therefore approximations only.

calcareous shales that are silty in part, predominate with generally subordinate grey siltstone beds throughout and minor, essentially non-calcareous, very fine to fine-grained sandstones towards the base. Core No. 2 (4500' - 4530'), recovered dark grey, silty, finely micaceous, hard shales with numerous grey siltstone laminae.

Micropalaeontology

The top of the interval, down to the casing shoe set at 4500', yielded a microfauna similar to that from the overlying interval, although its absence below the casing shoe suggests that the fauna is largely caved. Core No. 2 (4500' - 4530') yielded a poorly preserved agglutinating foraminiferal assemblage consisting only of indeterminate species of Bathysiphon and Saccammina in abundance. The cuttings samples below the core yielded only Saccammina spp. and two questionable occurrences of Eoguttulina bulgella.

Palynology

This interval is characterised by an abundance of the Striatoabictites aytugii/balmei complex and Dictyotidium sp. with the continuing dominance of Micrhystridium spp. Other important species to make their highest appearance in this interval include Equisetosporites spp., Triadispora crassa, T. obscura, T. verrucata, Ovalipollis sp., Infernopollenites cf. parvus and Nevesisporites limatulus. The latter species ranges from the Late Permian to the early Anisian.

INTERVAL 4790' - 7400': Lower Triassic, Scythian

(4790' - 5690': Spathian)

(5690' - 6090': Smithian)

(6090' - 7400': Scythian, undifferentiated)

General Lithology

This entire interval consists essentially of dark grey shale that is slightly calcareous and silty in part, with generally subordinate, usually non-calcareous, grey siltstone interbeds and partings. Two intervals,4790' - 4930' and 5740' - 5810', have predominate siltstone with minor shale partings, while thin, light to medium grey, finely crystalline limestones occur at 5520' and 5620'.

Micropalaeontology

Agglutinating foraminifera occur persistently, although in low numbers, throughout the interval. Species recorded include Gaudryina aff. adoxa, Reophax sp. 5, Trochammina sp. 12, Bathysiphon spp., Ammobaculites sp. 12 and 14, Ammodiscus sp. 4 and Haplophragmoides sp. 16. Towards the base of the interval, below 7150', there is an increase in the specific variety of the assemblages with the highest occurrences of Ammobaculites? sp. 19 along with indeterminate species of Hippocrepina, Saccammina, Hyperammina and ?Glomospirella. It is possible that this fauna is derived, at least in part, from Permian strata.

Conodonts of the genus Neogondolella were recorded at 5100', 5500' and 6000'.

Palynology

The upper boundary of this interval is marked by the appearance

of Protohaploxypinus jacobii coupled with the disappearance of Dictyotidium sp. and the Striatoabietites aytugii/balmei complex. Taeniaesporites novimundi, which makes a brief appearance in the 4200' - 4290' sample,becomes a consistent component of assemblages below this boundary as does Protohaploxypinus samoilovichii and the whole interval is dominated by Micrhystridium species. This assemblage suggests a Scythian, probably Spathian age for the interval 4790' - 5690'.

From 5090' to 5690', and especially between 5090' and 5290', the assemblages contain significant proportions of reworked Palaeozoic palynomorphs, dominantly Carboniferous in composition but with some Devonian and Permian forms.

Below 5690', the Spathian palynoflora is joined by abundant specimens of Veryhachium sp. A, a distinctive acritarch species which is elsewhere characteristic of the Smithian. On this basis, the boundaries of the stage are tentatively drawn at 5690' and 6090'.

The assemblages recovered from the remainder of the interval (6090' - 7390'),are essentially the same as those from the Spathian. The preservation of the organic material deteriorates as the base of the Triassic sequence is approached but this is masked to a certain extent by contamination due to caving.

Towards the base of this sequence, between 7290' and 7390', Cycadopites, a relatively unimportant genus throughout the Triassic section, increases in abundance, an event which often signifies that Permian strata have been encountered. In the 7300' - 7390' sample, a single specimen referrable to the Thuringian genus Crucisaccites would assign this section to the Late Permian; however, because of the

high incidence of probable reworked forms together with the abundance of Triassic taxa (which could be caved, at least in part), this interval is considered to be of Lower Triassic age. Upper Permian taxa found lower down in the well have probably caved from here.

PENNSYLVANIAN - PERMIAN

INTERVAL 7400' - 10,600': Pennsylvanian - Lower Permian

(7400' - 7592': Lower Permian, Sakmarian)

(7592' - 10,600': Pennsylvanian - Lower Permian, undifferentiated)

General Lithology

The lithologies of this interval fall into three distinct units. The highest unit extends from 7400' to 8565' and consists almost exclusively of buff to grey, very fine to finely crystalline limestones, that are siliceous or cherty in the highest 80' and which become increasingly chalky and bioclastic with depth. Thin, dark grey to black shales occur between 8010' and 8100'. Core No. 3 (7542' - 7592') consists of light to medium grey, very finely crystalline, slightly dolomitic limestone and a dark grey, slightly calcareous shale.

The middle unit extends from 8565' to 9280' and is topped by a 60' thick, dark grey, calcareous, very finely micaceous, soft, blocky shale which passes down into dark grey to grey-black, siliceous, argillaceous and, in part, calcareous siltstone with occasional shale partings. Below 8980', the siltstones grade into light to medium grey, very fine-grained quartz sandstones which in turn pass below 9060' into dark grey and grey-brown silty shales. The lowest part of the unit, 9190' - 9280', is marked by a medium grey, very fine-grained, subangular to sub-rounded, calcareous sandstone. Core No. 4 (9184' - 9188') recovered a dark grey, non-calcareous shale and a light grey, very fine-grained, silty, calcareous sandstone.

The lowest unit, 9280' - 10,600', again consists of essentially carbonate sediments with buff to light grey, chalky, dolomitic limestones predominating down to 9770', below which they are replaced by grey and buff dolomites with occasional chert laminae and black shale partings. The base of the interval is marked by a thin, reddish-brown sandstone with fine-grained, angular, poorly sorted quartz grains set in a dolomitic and sideritic matrix.

Micropalaeontology

The recovery of microfauna from this interval is unusual in that both cores yielded abundant and diverse foraminiferal assemblages, whereas the cuttings samples produced only impoverished assemblages, or proved to be barren. The top two cuttings samples from the interval yielded only Hyperammina sp. 4, Ammobaculites sp. and single occurrences of 'productid' brachiopod spines. By contrast, core No. 3 (7542' - 7592') yielded abundant Hyperammina sp. 3, Hyperammina spp., Ammodiscus sp. 14, Glomospirella sp. 11 and Thuramminoides sp.; common Lunucammina spp., Ammodiscus sp. 15, Hemigordius sp. 1, Thuramminoides sphaeroidalis, and Glomospirella sp. 16 along with Cribrogenerina sp., Lunucammina aff. texana, Nodosinella cf. nodosariformis and Rhabdammina sp. 1. Bryozoa are also present in abundance. This assemblage indicates Lower Permian strata, as does the questionable occurrence of the ostracod species Roundyella dorsopapillosa.

The cuttings samples between 7600' and 9150' are again generally poor with only sporadic occurrences of Ammodiscus spp., Hyperammina spp.

and Lunucammina aff. texana, although 'productid' brachiopod spines occur persistently.

Core No. 4 (9184' - 9188'), yielded an assemblage similar to that from core No. 3, although of considerably less specific variety. Species of Nodosinella and Lunucammina, a conspicuous element of the core No. 3 microfauna, are absent, probably because of the facies difference between the cores. The cuttings samples from the remainder of the interval are poor, although the presence of the condonont genus Neogondolella at 9650', if in situ, would indicate strata no older than Permian at this level.

Palynology

Cavings contamination from the Triassic dominate all the assemblages obtained from cuttings in this interval and an accurate age assignation is impossible on the basis of cuttings alone.

Five samples were processed from core No. 3 (7542' - 7592') and the assemblages obtained are extremely poor in diversity, preservation and richness and bear no resemblance to the cuttings assemblages over the same section. Specimens referable to Vittatina indicate a probable Permian age and the lack of striate-bisaccate pollen suggests Lower rather than Upper. Specimens of Diatomozonotriletes sp. A and D. sp. aff. townrowii, both of which are typical of the Sakmarian of Australia, were also found in this core. Portions of this assemblage show Mississippian and Devonian affinities respectively and are considered reworked but it is impossible to discern whether the specimens of ?Proprisporites sp., Triquitrites sp., Schultzospora sp.,

Verrucosisporites spp. and some cingulizonate forms belong with these groups or not. The presence of only one, poorly-preserved, specimen of Micrhystridium contrasts markedly with the equivalent cuttings sample and highlights the cavings contamination in the cuttings.

Core No. 4, 9184' - 9188', yielded an extremely poorly preserved assemblage. Apart from questionable specimens of Vittatina and Protohaploxypinus the assemblage is dominated by indeterminate species of Verrucosisporites, Cyclogranisporites, Lophotriletes, Convolutispora, Retusotriletes, Densosporites and Auroraspora which could be derived in part.

The presence of occasional specimens of Protohaploxypinus limpidus and Hamiapollenites sp. in the cuttings below core No. 3 are considered to be the result of caving contamination.

The portions of the assemblages derived from cuttings in this interval which are obviously cavings contamination are largely made up of indeterminate, poorly preserved spores. Recognisable forms such as Knoxisporites cf. stephanophorus and Grandispora cf. echinata suggest a late Mississippian - early Pennsylvanian age for part of the section below core 4 but it is impossible to suggest limits.

SILURIAN - DEVONIAN

INTERVAL 10,600' - 11,249' (T.D.): Silurian - Devonian (undifferentiated)

General Lithology

The top of the interval, 10,600' - 10,670', is marked by a quartz diorite sill, intruded into interbedded red, green, grey and brown shales. The shales pass down below 10,750' into grey, brown, green and reddish-brown, argillaceous quartzites that persist to 10,970', intruded at 10,910' by a thin quartz diorite sill. The remainder of the well section, 10,970' - 11,249' (T.D.), consists if grey and red, very siliceous siltstones with minor black, brown and red shale partings.

Core No. 5 (11,050' - 11,067'), produced black, partially metamorphosed shale and medium grey, very siliceous, pyritic siltstone. Core No. 6 (11,233' - 11,249') consists of interbedded medium grey siltstones and dark grey shales.

Micropalaeontology

This interval proved to be barren of in situ microfauna.

Palynology

The assemblages obtained from cuttings samples are again dominated by cavings contamination from the Triassic. The cuttings samples from 10,700' - 10,790', 11,000' - 11,090' and 11,100' - 11,190' together with core No. 5, 11,055' - 11,060' yielded poorly preserved specimens of chitinozoa which appear to be completely carbonised. Rare spores

in cores No. 5 and No. 6 are also unidentifiably black.

The chitinozoa together with the spores suggest a Silurian - Devonian age for this interval.

STRATIGRAPHICAL REMARKS

From 11,249' (T.D.) to 10,600', the Panarctic Tenneco et al. Pollux G-60 well was in multicoloured siltstones, shales and quartzites, tentatively correlated with the Cape Phillips Formation and dated on the presence of chitinozoa and spores as being of undifferentiated Silurian - Devonian age. The ?Cape Phillips Formation was probably deposited in a deep, open marine environment.

The Cape Phillips Formation is unconformably overlain by dolomites and limestones (10,600' - 9280'), calcareous sandstones, shales and siltstones (9280' - 8565'), and limestones (8565' - 7400'), dated as being of undifferentiated Pennsylvanian - Lower Permian age (10,600' - 7592') and of Lower Permian, Sakmarian age (7592' - 7400'). With the exception of cores No. 3 and 4, microfaunal recovery throughout the section was poor, and similarly, the impoverished in situ palynoflora was largely masked by caving from the overlying Triassic section. The carbonate intervals are equated with the Nansen Formation which is a shallow water, marginal facies, while the middle clastic unit is correlated with the basinal facies equivalent, Hare Fiord Formation.

The Nansen Formation carbonates are unconformably overlain at 7400' by a thick series of dark grey shales and subordinate grey siltstones correlated with the Blind Fiord Formation (7400' - 4430') and dated palynologically as undifferentiated Scythian (7400' - 6090'), Smithian (6090' - 5690'), Spathian (5690' - 4790') and the lower part of the Anisian (4790' - 4430'). Deposition of the Blind Fiord Formation was

largely under deep to shallow, open marine conditions, with probable shallowing in the lowest hundred feet of the section, where the presence of rare Permian microfossils is interpreted as reworking from Upper Palaeozoic rocks.

The argillaceous sediments of the Blind Fiord Formation are overlain with apparent conformity by light coloured, very fine to fine-grained calcareous sandstones with occasional shale partings correlated with the Schei Point Formation (4430' - 2830'). Within this formation, the upper part of the Anisian (4430' - 3990'), Ladinian (3990' - 3690') and Karnian (3690' - 3030') stages, and the lower part of the Norian stage (3030' - 2820') are recognised. The Karnian and Norian stages yielded a fairly diverse, shallow marine, calcareous foraminiferal assemblage ascribable to the Nodosaria shublikensis/mitis Assemblage Zone of Upper Triassic age.

The Schei Point Formation is conformably overlain by grey and grey-green shales and grey siltstones believed to be equivalent to the Heiberg Formation (2820' - 2120') in which the upper part of the Norian stage (2820' - 2390') and the Rhaetian stage (2390' - 2120') are recognised. The shale beds yielded shallow marine foraminifera of the N. shublikensis/mitis Assemblage Zone, ostracoda of Ostracod Zone C (2800' - 2400') and dinoflagellates of the NO and RHNO complexes. These marine elements are all absent from the regressive siltstones and sandstones at the top of the section which were probably deposited under transitional conditions.

The Upper Triassic sediments are overlain with great unconformity at 2120', by a thick series of sands and gravels, here correlated with the Eureka Sound Formation. Microfaunal and microplankton remains

are virtually absent from this essentially non-marine deposit, but rich spore and pollen assemblages date the interval (2090' - 190') as being of Lower Tertiary, Palaeocene age. The remainder of the interval (190' - 70'), again consists of non-marine sands and gravels, but these yielded a far younger palynomorph assemblage of Neogene to Recent age. This section is correlated with the Beaufort Formation and probably overlies the Eureka Sound Formation disconformably.

IX

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PANARCTIC ET AL. POLLUX G-60

3000' - 11,249'

All magnifications X500 unless otherwise stated

PLATE 1

1.	*Riciisporites* sp.	3000' - 3030'
2,6.	*Camerosporites* spp.	3000' - 3030', 3800' - 3890'
3.	*Dictyophyllidites mortoni*	3200' - 3290'
4.	Dinoflagellate gen. et sp. nov.	3900' - 3990' phase contrast
5.	*Sulcatisporites ovatus*	3700' - 3790'
7.	*Rhaetogonyaulax* sp.	3200' - 3290' phase contrast
8.	*Corisaccites* sp.	4200' - 4290'
9.	*Dapcodinium* sp. cf. *priscum*	4200' - 4290' phase contrast
10.	*Veryhachium europaeum*	4300' - 4390'
11,12.	*Striatoabietites aytugii*	4300' - 4390'

PLATE 2

1.	*Triadispora obscura*	4300' - 4390'	
2.	*Alisporites* sp.	4300' - 4390'	
3.	*Dictyotidium* sp.	4300' - 4390'	
4.	*Taeniaesporites* cf. *novimundi*	4800' - 4890'	
5.	*Protohaploxypinus samoilovichii*	4900' - 4990'	
6.	*Veryhachium* sp. A	5600' - 5690'	
7.	*Micrhystridium* sp.	6500' - 6590'	phase contrast
8.	*Micrhystridium* sp.	6800' - 6890'	
9.	*Cycadopites* sp.	6800' - 6890'	
10.	*Nevesisporites limatulus*	6900' - 6990'	
11.	*Aratrisporites parvispinosus*	7000' - 7090'	
12.	*Equisetosporites steevesii*	7300' - 7390'	

PLATE 3

1,2. *Vittatina* spp.	Core 3, 7572' - 7577', 7542' - 7547'
3. *Schultzospora* sp.	Core 3, 7572' - 7577'
4. *Proprisporites* sp.	Core 3, 7552' - 7557'
5. Saccate pollen grain	Core 3, 7587' - 7592'
6-9. *Murospora* spp.	Core 3, 7542' - 7547', 7572' - 7577', 7587' - 7592'
10. *Diatomozonotriletes* sp. A	Core 3, 7542' - 7547'
11,12. *Diatomozonotriletes* sp. aff. *townrowii*	Core 3, 7587' - 7592'. 9500' - 9590' (cuttings)

PLATE 4

1.	*Vittatina* sp. cf. *saccifer*	Core 3, 7552' - 7557'
2.	Devonian spore reworked	Core 3, 7552' - 7557', X250
3.	*Cingulizonates* sp.	Core 3, 7572' - 7577'
4.	*Lycospora* sp.	Core 4, 9184' - 9188'
5.	Scolecodont	Core 4, 9184' - 9188'
6.	?*Protohaploxypinus* sp.	Core 4, 9184' - 9188'
7.	*Cymatiosphaera* sp.	9500' - 9590'
8.	*Knoxisporites* sp. aff. *stephanophorus*	9500' - 9590'
9,10.	*Knoxisporites* sp. cf. *stephanophorus*	10,000' - 10,090'
11.	*Desmochitina* sp.	Core 5, 11,055 - 11,060' X250
12.	*Conochitina* sp.	11,000' - 11,090'

PLATE 1

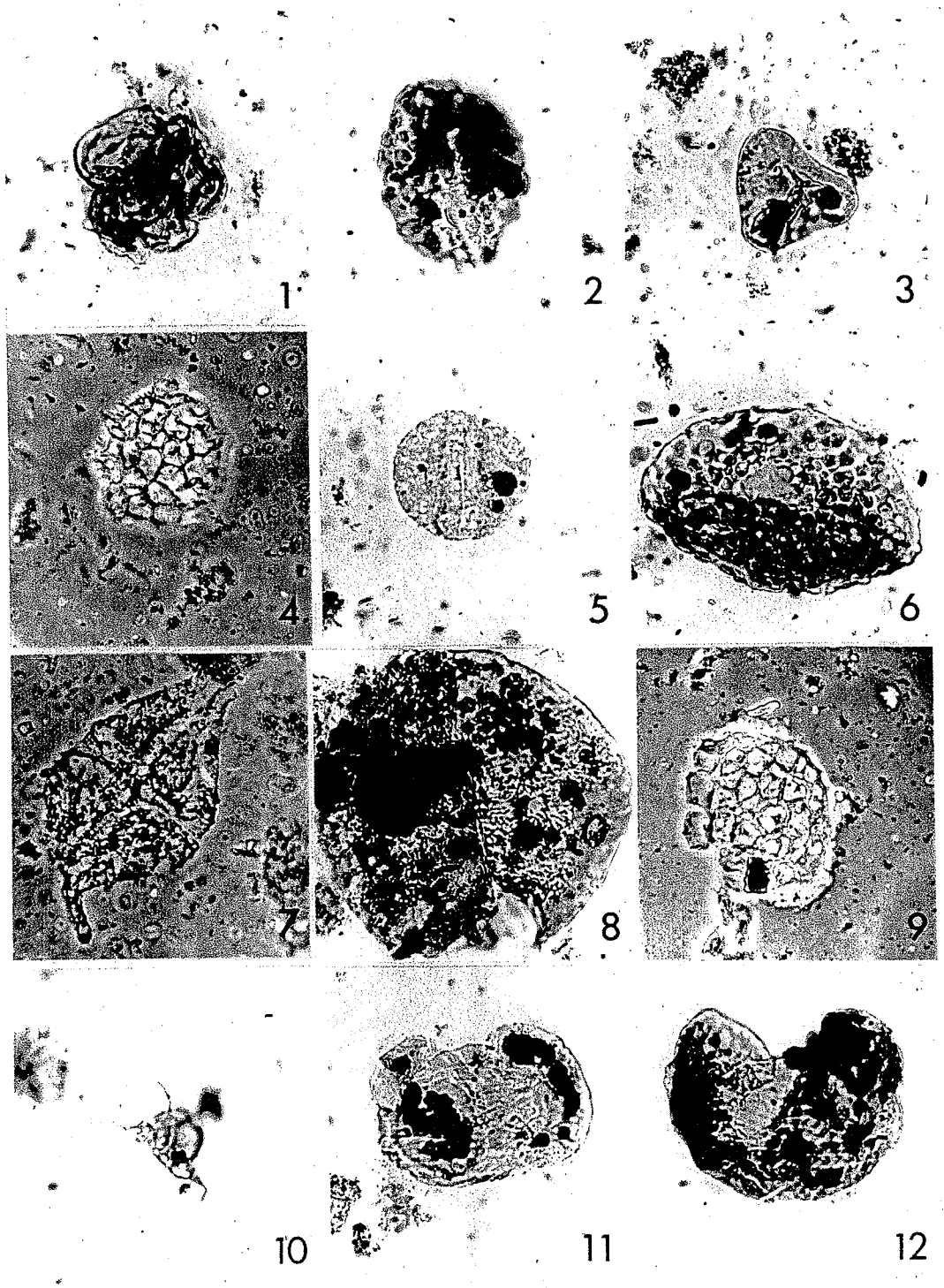

PLATE 2

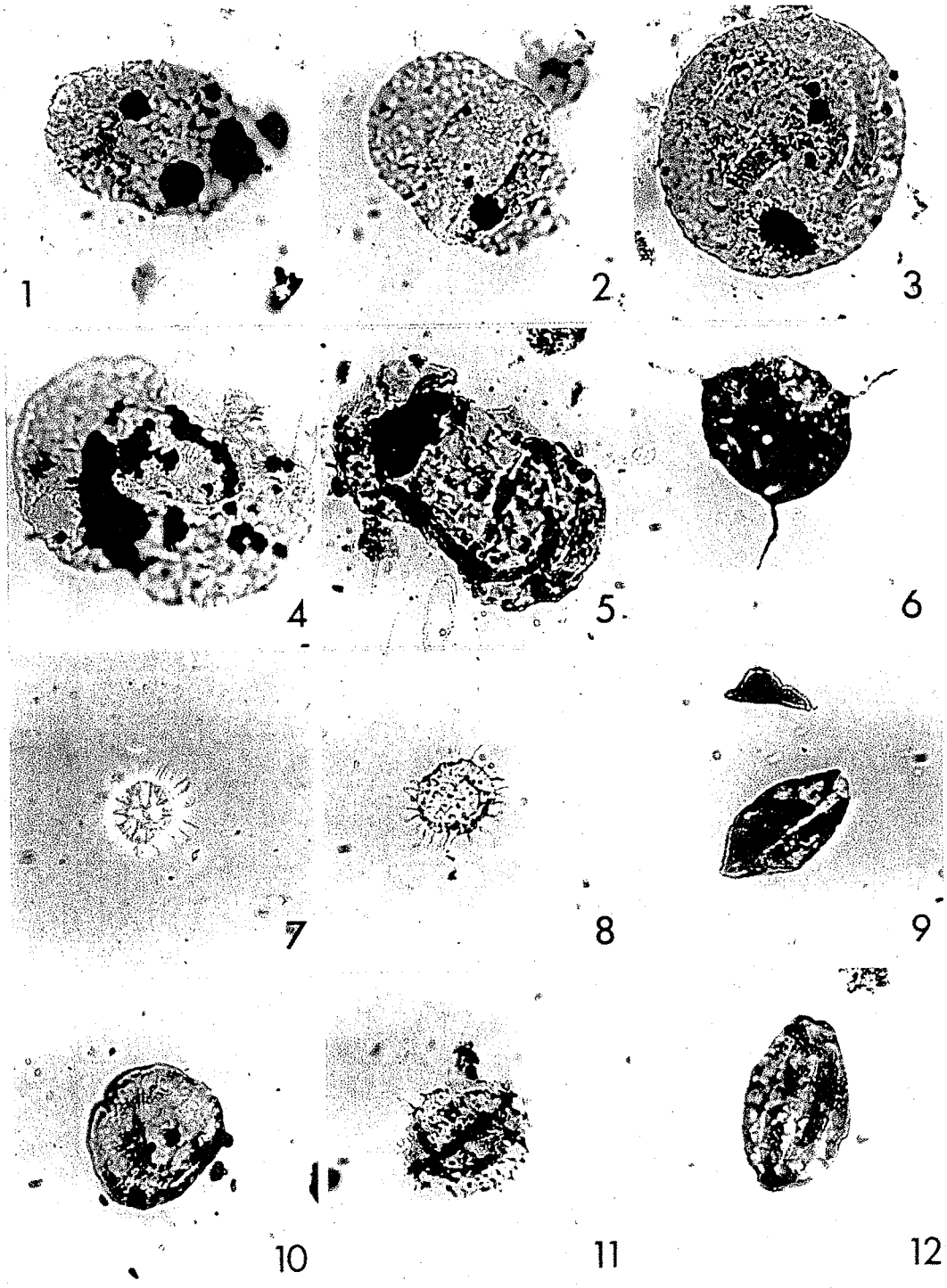

PLATE 3

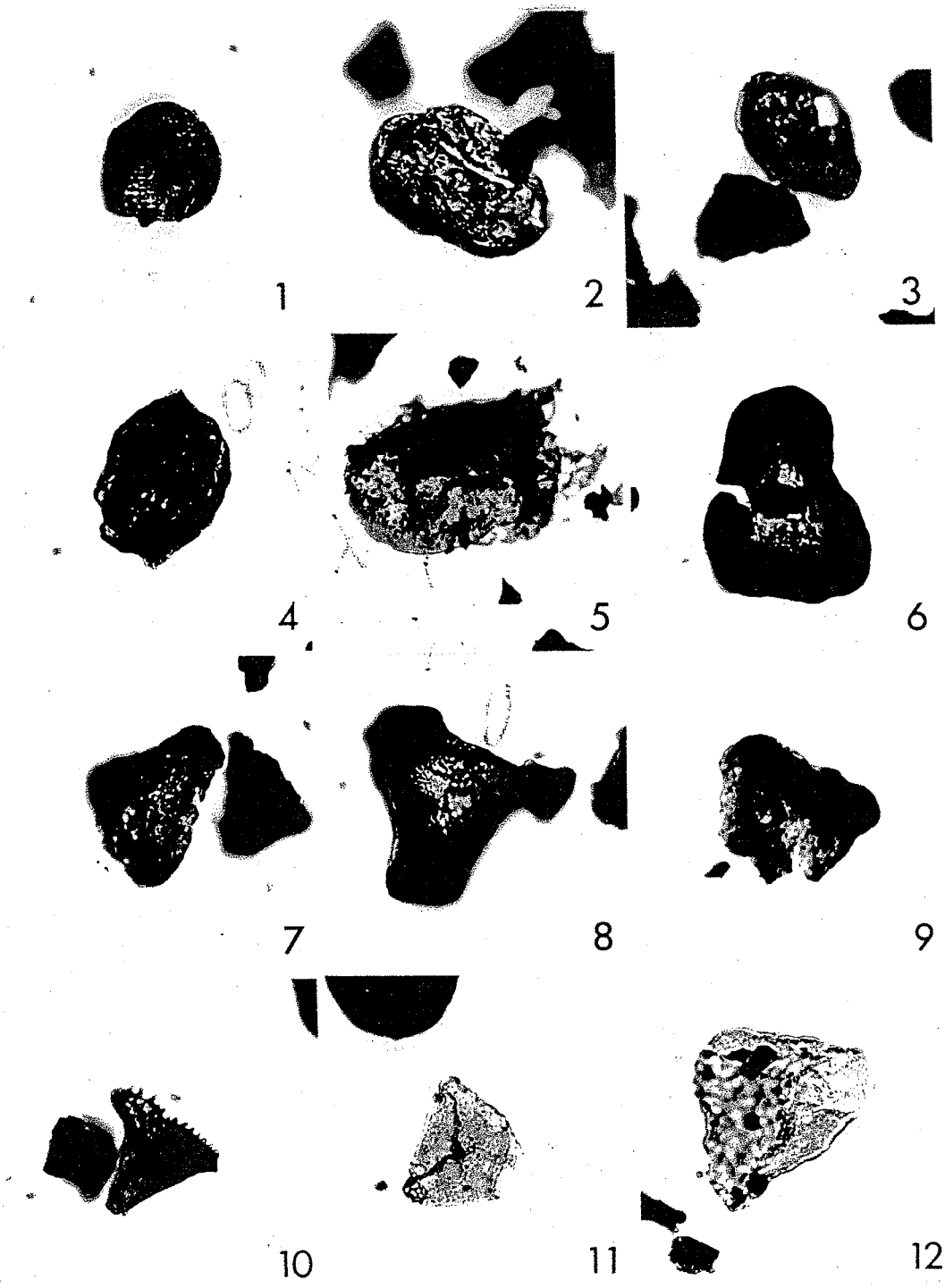

PLATE 4