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THE BIOSTRATIGRAPHY OF THE ELF JAMESON BAY C-31 BOREHOLE, DISTRICT OF FRANKLIN

by

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C O N T E N T S

		Page No
I	INTRODUCTION	1
II	METHODS	3
III	PALYNOLOGY	4
IV	MICROPALAEONTOLOGY	11
V	BIOSTRATIGRAPHY	17
VI	CONCLUSIONS	25
VII	BIBLIOGRAPHY	26

ENCLOSURES: Micropalaeontological Charts Nos. 1 and 2.

I

INTRODUCTION

Elf Jameson Bay C-31 wildcat well, sited in eastern Prince Patrick Island, Northwest Territories at 76° 40' 12" N. and 116° 43' 45" W. at a ground elevation of 191' spudded on March 11, 1971 and completed drilling on May 12, 1971 at a total depth of 8,327'. Casing was set at 84' (20" conductor pipe), 965' (13 3/8" casing) and 4,535' (9 5/8" casing). The well status is abandoned.

A total of 54 sidewall samples were taken of which 48 were recovered; two cores were cut between 4,148' and 4,183' and between 7,887' and 7,917'. Cuttings samples were collected from the interval 80' - 8,327'.

This study was based on an examination of cuttings samples and core material made available by the Geological Survey of Canada; the sidewall samples were not available for examination.

II

METHODS

i. Palynology

Approximately 25 grams of sediment are treated with hydrochloric and hydrofluoric acids to dissolve the carbonate and silicate minerals respectively and the insoluble organic residue concentrated by heavy liquid separation ($Zn\ Br_2$/HCl aqueous solution, S.G. 2.0).

After washing in distilled water the organic concentrate is sieved through 20μ mesh "Nytral" gauze and both fractions suspended in glycerine jelly from which the assemblage slides for optical examination are prepared. When necessary the residues are oxidized to reduce colour density using nitric acid or Schulz solution.

ii. Micropalaeontology

Approximately 200 grams of sediment are heated, placed in a beaker with 'Quaternary O' and boiled for 30 minutes, the residues being washed through sieves with water to remove the fine fraction. With satisfactory breakdown, the dried residues are dry-sieved, into B.S. sieve sizes +30 (500 microns), +80 (177 microns) and -80, and the microfauna is picked from the sediment using a fine camel-haired brush. As most microfaunal remains are found in the +80 mesh-size, more emphasis is placed on the picking of this fraction than on the other two fractions. In general, two trays of +30 sieve sediment, three trays of +80 sieve sediment and two trays of -80 sieve sediment are sufficient to yield a representative microfauna from any one sample.

Although single (10') samples are occasionally utilized, more commonly composite samples over 50' intervals for micropalaeontology and 100' intervals for palynology are examined initially. Smaller composited intervals and single samples are used where required to more accurately define biostratigraphical boundaries.

III

PALYNOLOGY

by

M. J. Fisher, R. E. Dunay and J. P. Bujak

The section 110' - 300' yielded assemblages dominated by cryptogam spores and gymnosperm pollen. Angiosperm pollens were not recorded in the well and, in this upper section, microplankton are extremely rare. Although many of the species recorded are relatively long ranging, spanning the Jurassic - Cretaceous boundary, a number are more commonly associated with palynofloras of early Cretaceous, Neocomian, age; these include Cicatricosisporites major and Trilobosporites canadensis. Species indicative of a younger Neocomian, Hauterivian - Barremian, age are absent and the assemblages in toto are consistent with an older Neocomian, Berriasian - Valanginian, age determination.

Early Cretaceous cryptogam spores persist below 300' with Pilosisporites trichopapillosus, Trilobosporites apiverrucatus, Retitriletes parvimurus and Maculatisporites microverrucatus being conspicuous in the samples 300' - 310' and Trilobosporites obsitus, Foraminisporis wonthaggiensis, Cicatricosisporites abacus and Retitriletes parvimurus in the sample from 350'. Associated with this cryptogam assemblage are a number of microplankton species including Ellipsoidictyum sp., Horologinella sp. 1, Pareodinia ceratophora and Canningia adnata. This last species, encountered in the sample from 350', has been previously recorded only from the lower to middle Berriasian of California (Warren, unpubl. thesis). In the immediately underlying sample (360') an

early Cretaceous cryptogam assemblage, including Schizosporis reticulatus, Trilobosporites apiverrucatus, T. tenuiparietalis, Tuberosisporites montuosus, Maculatisporites microverrucatus, Cicatricosisporites australiensis and Varirugosisporites mutabilis, was recorded together with the microplankton species Horologinella sp. 1, "pareodiniod" TAB 1,"p." SPIN 2, Psaligonyaulax sp. Gitmez 1970, Gonyaulacysta granuligera, G. perforans, Endoscrinium luridum and Chytroeisphaeridia pococki. This association is considered to represent the Tithonian - Berriasian transition and this is corroborated by the record in the samples 400' - 420', of Ellipsohystrichidium cornutum which has been previously recorded only from the "upper Tithonian" of California (Warren, unpubl. thesis).

The delineation of the Jurassic - Cretaceous boundary on published palynological evidence has been hampered by both the uncertainty of the precise location of the boundary in the type sections and by the fact that a number of species which constitute conspicuous elements of early Cretaceous palynofloras make their first appearance in the uppermost Jurassic. An added complication when examining well sections in the form of cuttings samples is that there appear to be no well defined extinctions at, or near, the Jurassic - Cretaceous boundary. The palynofloral succession is marked by a steady diversification of assemblages across the boundary and where caving occurs, as is frequently the case, the accurate definition of a Jurassic "top" is virtually precluded.

Examination of Arctic Island well sections which spudded close to the Jurassic - Cretaceous boundary, thereby reducing the risk of caving contamination, coupled with studies of well documented surface sections, have

enabled Arctic Tithonian palynofloral associations to be relatively well circumscribed. The succession of the spore/pollen assemblages is consistent with those described from the equivalent intervals in Northwest Europe by Burger (1966), Döring (1965, 1966) and Norris (1969, 1970). The microplankton, however, include a number of previously undescribed morphotypes together with species whose association together indicates an extension of their recorded ranges. There are broad consistencies with the results obtained by Millioud (1967, 1969) from the type localities of the Neocomian stages in Europe and by Warren (unpubl. thesis) from the Sacramento Valley, California; in the absence of other applicable data, correlation has of necessity relied heavily on these works. In the present study the Tithonian stage is used in an informal sense with the upper and lower limits defined by the bases of the Buchia okensis and the Gravesia gigas zone equivalents respectively.

The occurrences of selected palynomorph species in the interval 300' - 650' together with their previously recorded ranges is given in Table 1. Between 380' and 680' the microplankton assemblages are dominated by pareodinoid cysts including forms with marked tabulation, "pareodiniod" TAB 1, and with gonal spines "p" SPIN 1 and "p" SPIN 2, and forms with pronounced antapical structures tentatively assigned to the genus Netrelytron. In addition Scriniodinium dictyotum var. osmingtonensis is locally common.

Cicatricosisporites spp. and Trilobosporites spp. persist to ±560' which is coincident with the highest occurrences of Gonyaulacysta longicornis (520' - 540'), and Pareodinia nuda (550' - 560'). Between 560' and 950'

the palynofloras are distinctly late Jurassic in aspect and the record of Gonyaulacysta jurassica at 640' - 660' is correlative with the upper limits of the Kimmeridgian (s.s) stage. The Kimmeridgian and younger microplankton Psaligonyaulax apatela and "pareodiniod" TAB 1 persist to 670' - 690', together with Gonyaulacysta granuligera. In the underlying sample, 700' - 710', the occurrence of Acanthaulax venusta is suggestive of an Upper Oxfordian - Lower Kimmeridgian age, whilst the record of Gonyaulacysta cladophora with Meiourogonyaulax cf. deflandrei at 890' - 920' is more indicative of an Oxfordian age.

Below 950' the palynofloras are composed predominantly of long-ranging non-marine, spore/pollen complexes. In the composite sample 1000'-1090', however, the association of Pareodinia prolongata with Podocarpidites arcticus and Endosporites jurassicus suggests a Callovian age and this is corroborated by the occurrences of Nannoceratopsis pellucida at 1310' - 1370' and of Meiourogonyaulax deflandrei and aff. Paragonyaulacysta sp. at 1300' - 1390'.

The highest occurrence of Nannoceratopsis gracilis, noted in the composite sample 1610' - 1670', marks the upper limits of the Upper Pliensbachian - Bajocian palynoflora. Within this palynofloral unit the assemblage at 2100', which includes Granodiscus granulatus, Crassosphaera hexagonalis, Cerebropollenites thiergartii, Tasmanites suevicus and Convolutispora klukiforma in addition to N. gracilis, is correlative with Lower Toarcian palynfloras, and the occurrence of Mancodinium semitabulatum in the composite sample 2300' - 2390' probably marks the upper limits of the Upper Pliensbachian. Although this palynofloral complex persists below 3000', the assemblages recorded between 2810' and 3110'

include Taurocusporites verrucatus, Pityosporites vancampoi, Lycopodiacidites keupperi, Circularesporites cerebroides, Polycingulatisporites liassicus, Stereisporites perforatus, S. cicatricosus and common Stereisporites spp. associated with the microplankton Dinoflagellate gen. et sp. indet. 7, Micrhystridium inconspicuum, M. lymensis vars., M. recurvatum, Concentricystes cf. rubinus and Sphaeromorpha gen. et sp. indet., together suggestive of a Lower Liassic age.

In situ Rhaetian palynofloras are first encountered in the sample 3110' - 3140'; the record of Ricciisporites tuberculatus at 2720' - 2780' is attributable to derivation. Although restricted Triassic species are rare between 3110' and 3200', in the immediately underlying interval 3200' - 3500', typical Rhaeto-Norian spore/pollen associations were recorded together with rich assemblages of the Norian "RHNO" dinoflagellate complex.

The highest occurrence of the Camerosporites- Fossapollenites plexus at 3500' - 3590' indicates the proximity of the Karnian - Norian transition and the interval ±3500' - 3800' includes representatives of Karnian and perhaps Ladinian assemblages. Caved material predominates in the Triassic section and this, coupled with the relatively unpalyniferous nature of many of the lithotypes represented, has made identification of the in situ palynofloras uncertain. Below 3800', however, some components of the assemblages are suggestive of a Mesotriassic and older age; the occurrences of Protodiploxypinus cf. sittleri at 3800' - 3890', Schizosporis sp. CA.AN 1 at 3920' - 3980', Protodiploxypinus sp. WS 1, Striatoabieites balmei and Leuckisporites palynodeme at 3900' - 3990', Triadispora crassa, T. epigona, Striatoabieites aytugii and P. cf. sittleri at 4010' - 4040', Striatisaccus "rugosus", Triadispora staplini,

Triadispora plicata, Nevesisporites fossulatus, Falcisporites stabilis and aff. Protohaploxypinus pellucidus at 4100' - 4140' being of especial correlative value.

The core samples examined from the interval 4148' - 4183' yielded rare non-diagnostic palynomorphs and small amounts of indeterminable carbonaceous debris. This would again suggest that the often rich assemblages obtained from cuttings samples, especially those immediately above and below this cored interval, have resulted primarily from caving. Of the species first recorded below 4183', however, some, including Sulcatisporites institatus at 4200' - 4290', Corisaccites sp. and Lunatisporites albertae at 4310' - 4370', Striatisaccus goswicensis at 4400' - 4480', aff. Striatopodocarpites hannonicus, aff. Protohaploxypinus bharadwajii and Lundbladispora sp. JB1 at 4500' - 4590', are consistent with a pre-Anisian Triassic age and are therefore unlikely to have caved from the interval above the core. The highest occurrence of aff. Protohaploxypinus pellucidus at 4100' - 4140' is tentatively taken as marking the upper limit of the Lower Triassic palynofloras. The assemblages recorded between 4100' and 4590' are dominated by caved material, although the presumed in situ palynofloras are of Smithian - Spathian aspect. In the absence of sidewall samples it has not been possible to define the lower limits of the palyniferous Triassic strata in this well section and, although the samples below 4590' are barren, or contain only obviously caved specimens, an undifferentiated Lower Triassic age has been assigned to this interval.

The highest occurrence of Permian palynofloras is at 5420' where Weylandites lucifer and Vittatina spp. were recorded. These forms persist in the underlying samples and their association with Weylandites cincinnata, Vittatina subsaccata, V. saccata and V. vittifer indicate affinities with the Lower Pechora palynofloral suite of Kazanian age recorded from the Pechora Basin, U.S.S.R.

(Chaliskev & Varyukina, 1960). Trilete spores, including representatives of the genera Apiculatisporites, Cirratriradites, Deltoidospora, Granulatisporites Kraeuselisporites, Raistrickia etc., are often commonly encountered and this is also consistent with Kazanian assemblages from the Pechora Basin. Elements of this equivalent of the Lower Pechora palynofloral suite persist to the base of the well although the highest occurrence of Hamiapollenites bullaeformis at 6600' - 6690' suggests that the equivalent of the Bolshepatokian palynofloral suite of Kungurian age has been encountered. This is corroborated by the occurrences of Vittatina saccifer at 7020' and V. minima at 7110', both of which are considered to be restricted to the Kungurian by Hart (1965); although they are now known to range into the Artinskian Sabine Bay Formation of Melville Island. Below this, at 7320', the highest record of Vittatina costabilis sensu stricto may be correlative with the Wolfcampian - Leonardian or Sakmarian - Artinskian transition.

Permian palynofloras were recorded throughout the interval 7770' - 8327' T.D. although the core at 7887' - 7917' was completely barren of palynomorphs. A few, highly carbonized spores of Carboniferous aspect are also present in this interval and it is possible that these may be either reworked or represent the in situ assemblages.

IV

MICROPALAEONTOLOGY

by

P. F. Sherrington and D. R. Clowser

A restricted, almost entirely agglutinating, foraminiferal assemblage was recorded from the interval 90' - 410'. The fauna is dominated by common to abundant occurrences of Haplophragmoides topagorukensis and indeterminate species of Haplophragmoides, along with Ammobaculites aff. fragmentarius and rare calcareous forms, while the highest occurrence of Haplophragmoides canui is recorded from the base of the interval at 410'. The assemblage is poorly age-indicative, suggesting an undifferentiated Neocomian age for the interval.

A considerable diversification of the microfauna occurs below 410', coincident with the top of the lower Mould Bay shales, and while agglutinating forms still dominate, the number of calcareous species increases, although the number of individuals ascribed to these species remains low. The most common forms found in the interval down to 1000' are Haplophragmoides kingakensis/barrowensis. Haplophragmoides canui, Ammobaculites alaskensis/barrowensis and Haplophragmoides spp., whilst the lower part of this interval sees the highest occurrences of 'Involutina' aspera/silicea, Rectoglandulina brandi, Trochammina aff. topagorukensis T. topagorukensis, T. canningensis, and Astacolus sp. 12. Haplophragmoides topagorukensis is common only at the very top of the interval, below which it is only rarely recorded down to 750'. Other forms recorded from this interval, either as individuals, or in low numbers, include Glomospira pattoni/corona, a variety of Lenticulina audax, Globulina topagorukensis, Reophax suevica/densa and Ammobaculites aff. vetusta. This fauna can be ascribed to the Gaudryina milleri/leffingwelli Assemblage Zone, although the index species itself is not

recorded. The Assemblage Zone is known to range in the Sverdrup Basin, from the Kimmeridgian stage of the Upper Jurassic, to the Valanginian/Hauterivian stages of the Lower Cretaceous, although the fauna recorded in this interval is indicative of the lower (Upper Jurassic) part of the zone. The restricted fauna of the overlying interval may possibly represent the upper (Lower Cretaceous) portion of the zone, although the division between the two faunas is essentially facies controlled.

The interval from 1,000' to 1,500' is virtually barren of foraminifera, although occasional megaspores are recorded, corresponding with the non-marine sediments of the upper Wilkie Point Formation.

Below 1,500', the microfauna gradually diversifies with the development of marine facies within the Wilkie Point Formation. Down to 2,350', the fauna is almost entirely restricted to agglutinating forms, with Haplophragmoides spp., H. canui, (down to 1750'), H. kingakensis/barrowensis and 'Involutina' aspera/silicea being the most commonly recorded speices of foraminifera, along with single or rare occurrences of Gaudryina cf. tailleuri, Trochammina sp., Bathysiphon sp., Lituotuba sp., Saccammina sp., Ammobaculites sp. and Ammodiscus sp. This assemblage gives an undifferentiated Jurassic age, although it should be noted that the long-ranging 'Involutina' aspera/silicea group is commonly recorded in greater abundance in the Toarcian/Bajocian interval relative to older and younger Jurassic samples. Such an interpretation is consistent with the occurrences of the ostracoda Camptocythere sp. 1 and 'Procytheridea' sp. 6 from 1850' and 1900' respectively.

Below 2,350', the foraminiferal fauna becomes richer, and although agglutinating forms still predominate, calcareous forms are not uncommon. Haplophragmoides kingakensis/barrowensis becomes rare, although a number of poorly preserved forms recorded as Haplophragmoides spp. may possibly be ascribed to this group. Ammobaculites alaskensis/barrowensis becomes common and Reophax suevica/densa along with species of Trochammina, Bathysiphon, Ammobaculites, Saccammina and Gaudryina are persistent elements in the fauna. A number of species are indicative of a Lower Jurassic age, including Saccammina sp. 7, Vaginulinopsis sp. 3, Citharina fallax?, Trochammina sablei, Haplophragmoides sp. 10 and Marginulina aff. bergquisti. The ostracod species 'Procytheridea' aff. magnycourtensis, recorded at 2350' and 2650, is a commonly encountered form in the Sverdrup Basin from strata of Lower Toarcian and Upper Pliensbachian age.

Below 2750', in the glauconitic sandstones of the Borden Island Formation, occasional Triassic species are encountered, including, Nodosaria shublikensis/mitis, Trochamminoides cf. vertens, marginulina prisca, Astacolus aff. connudatus and Ammodiscus sp. 5. Such forms are recorded only as rare individuals, are poorly preserved and are considered to have been derived from older strata.

Below 3200', the samples are characterized by the appearance of a rich Upper Triassic foraminiferal assemblage dominated by calcareous forms of the super-family Nodosariacea. Agglutinating foraminifera persist into this interval, probably as the result of caving, and only a few new agglutinating forms appear. This fauna has been designated the Nodosaria shublikensis/mitis Assemblage Zone, and is commonly encountered in rocks of Upper Triassic age in the Sverdrup Basin.

In this section, the zone is characterized by the association of the following species, recorded in order of appearance: Astacolus connudatus group, Nodosaria shublikensis/mitis, Nodosaria nordvikensis, Marginulina prisca, Marginulinopsis daedala, Marginulina aff. arctica, Ammodiscus sp. 4, Pseudoglandulina simpsonensis, Lingulina borealis, Lingulina alaskensis, Lingulina tenera var. maxima, Vaginulinopsis acrulus, and Marginulina aff. prima. The N. shublikensis/mitis Assemblage Zone persists downwards to around 3,800', below which point, the irregular occurrence of species of the assemblage are probably the result of caving.

Below 3,450', rich ostracode assemblages are found, dominated by the metacopid genera, Hungarella and Healdia. Two distinct ostracode assemblages can be distinguished in this section. The highest, ranging from 3,450' down to around 3,700', can be ascribed to the Hungarella II Assemblage Zone, characterized by the association of Hungarella sp. 1 and H.? sp. 2. This zone is known to range from the Upper Karnian to the Norian. Below 3,700', an ostracode assemblage dominated by Hungarella sp. 6, Healdia sp. 6, Paracypris spp. 1 and 6, and Triebelina (Ptychobairdia) sp. 1, occurs, that has been designated the Hungarella I Assemblage Zone. This zone is thought to range from the Middle Triassic (Ladinian) to the Karnian. The lower limit of the Hungarella I zone in this section is uncertain as extensive caving of forms occurs down to the casing shoe, set at 4537'.

Below the casing shoe, samples are entirely barren of microfauna until below 5,450' where the Permian foraminifera Ammodiscus sp. 7 occurs in association with calcareous spine debris which is presumed to have been derived from

'Productid' brachiopoda. This association, along with rare occurrences of Ammodiscus sp. 4, ranges down to 6,200', where there is a distinct diversification of the microfauna associated with marine limestones and shales. Here Ammodiscus spp. 6 and 7 are associated with indeterminate species of Sorosphaera, Haplophragmoides, Bathysiphon, Saccamina and Globivalvulina along with nodosariid species such as Frondicularia aff. hemiinflata, Frondicularia sp., Rectoglandulina sp. 10 and Dentalina? sp. Ostracoda include Bairdia sp. 9, Healdia sp. 8 and Healdia spp., and bryozoans are common and diverse. This microfaunal association persists to approximately 6,500', and gives an undifferentiated Upper Permian age for the interval.

From 6,500' to 7,200', the samples are almost entirely barren of foraminifera, although species of Healdia occur sporadically.

Between 7,200' and 7,950', a relatively rich microfauna is recorded, associated with the development of marine limestones. Members of the Fusulinacea and Endothyracea are common, associated with rarer agglutinating foraminifera and a fairly diverse ostracod assemblage. The fusulinid assemblages proved to be age-diagnostic, yielding a Lower Permian, Wolfcampian (Asselian/Sakmarian) age for the interval. An anomolous occurrence of the early Leonardian (early Artinskia species, Schwagentina cf. moffiti at 7,350', possibly results from caving as it occurs below the first occurrences of the Wolfcampian species. "Schwagerina cf. emaciata", Okataella? aff. waldripensis, Schwagerina cf. krotowi and S. aff. emaciata occur in the interval from 7,290' to 7,590' and are indicative of a mid-Wolfcampian age. An early Wolfcampian (Asselian) age is suggested by the presence of Pseudofusulina aff. grinnelli and cf. Pseudofusulinella sp. at 7,710',

and of Pseudofusulinella cf. utahensis at 7950'. Associated with the fusulines in this interval are indeterminate species of Ammodiscus, Endothyranopsis, Glyphostomella? and Nodosinella?. Ostracoda occurring in this interval include Healdia spp., Healdia spp., 8 and 9, Bairdia spp. 3, 7 and 10, Bairdiacypris? spp. 3 and 10, Cavellina? sp. 3, Paraparchites? sp.1 and Quasillitidea? indet. gen./sp. 1, indicating an undifferentiated Lower Permian age.

Below 7950', much of the microfauna is considered to have resulted from caving, and the few species of foraminifera and ostracoda appearing in this interval are non age-diagnostic.

V

BIOSTRATIGRAPHY

The basal section, 7770' - 8327' T.D., is composed predominantly of purple, red, brown and grey, fine to medium grained, angular, calcareous sandstones. Although the greater part of the microfauna and palynoflora recorded from this interval may have resulted from caving, the occurrences of Pseudofusulinella cf. utahensis at 7950' and of Linoproductus cf. shrenki (Stuckenberg) in the core sample at 7913' are indicative of an earliest Wolfcampian age. The boundary between undifferentiated Permo-Pennsylvanian and Permian strata has consequently been arbitrarily drawn at 7950', coincident with the earliest occurrence of presumed in situ Permian assemblages. This section is correlative with the Canyon Fiord on lithological evidence. These sediments were probably deposited under non-marine, transitional and near-shore marine conditions and are overlain abruptly, with possible non-sequence, by a section comprising partially recrystallized white to grey limestones, correlative with the Belcher Channel Formation. This carbonate sequence, which is developed to a thickness of 600' (7170' - 7770'), is characterized by relatively rich and diverse foraminiferal and ostracod assemblages including fusulinids indicative of an early to mid-Wolfcampian age. The ages suggested by the associated palynofloras range from Sakmarian to early Artinskian with the Sakmarian-Artinskian boundary suggested at 7320', and are therefore broadly consistent with the microfaunal determinations. The immediately overlying section, ±6500' - 7170', is composed of white, yellow and brown calcareous sandstones grading into cherty gravels with argillaceous sandstones, silts and ironstones in the upper part. This interval is virtually

barren of foraminifera and ostracods although the palynofloral assemblages suggest that the Kungurian - Kazanian boundary may be located at ±6600'. This predominantly arenaceous sequence has been equated with the undifferentiated Sabine Bay and Assistance Formations (sensu Nassichuk, 1965). Although the Canyon Fiord Formation was at least partially deposited under marine conditions, as evidenced by the brachiopod assemblage noted at 7913', the carbonates of the Belcher Channel Formation indicate a major marine transgression. The abundance of fusulinids in this section suggests that deposition occurred in shallow off-shore, open marine conditions. An abrupt increase in terrigenous material marks the contact of the Belcher Channel and Sabine Bay/Assistance Formations, with calcareous sandstones forming the dominant lithotype in the lower part, grading into cherty gravels and ironstone-rich horizons consistent with progressively shallowing, regressive conditions, in the upper part.

The overlying grey limestones and calcareous shales mark a return to shallow off-shore, open marine conditions and grade upwards into grey, locally glauconitic sandstones with minor shales, siltstones and limestones, again possibly representing a second transgressive-regressive phase. The predominantly carbonate interval, 6180' - ±6500', is considered to be equivalent to the Degerbols Formation, whilst the predominantly arenaceous interval 5300' - 6180' is thought to be correlative with the Trold Fiord Formation. Microfaunal assemblages, which are restricted to the carbonate lithologies, are indicative of an undifferentiated Upper Permian age. The associated palynofloras, which are also present in the arenaceous interval, are suggestive of a Kazanian age, indicating that Tartarian strata are absent from this section.

The base of the interval 3950' - 5300' is marked by cherty gravels and conglomerates and coarse, angular sandstones grading upwards into medium to coarse buff and greenish-grey sandstones with a distinctive red shale at 4130' - 4180'. Microfaunas and palynofloras are recorded in the upper part of this interval above 4590' although their almost total absence below the casing shoe set at 4535', and from the core at 4148' - 4183', strongly suggests that most of these forms have resulted from caving. Immediately overlying this interval is a predominantly red shale (3820' - 3950') which grades into a buff and grey dolomite (3750' - 3820'). It is thought that the unfossiliferous arenaceous formation 3950' - 5300' was deposited in predominantly non-marine environments, and that the shales in the upper part and the immediately overlying shales and dolomites mark a return to more stable marine depositional environments. The lithotypes below 3950' are correlative with the Bjorne Formation, whilst those above 3950' (to 3610') are equated with the Schei Point Formation. It appears that there is a transition zone between these two Formation equivalents and it should be stressed that the formational boundary at 3950' has been informally selected.

Because of the predominance of caved material, delineation of biostratigraphical boundaries has been somewhat tentative. Uppermost Lower Triassic (Spathian) palynofloras are present in the sample at 4100' - 4140', although the Spathian-Anisian boundary could not be drawn with certainty. The palynofloral assemblages from the interval 3800' - 4100' are predominantly of Anisian aspect, caving from the overlying intervals, however, precludes accurate determination of the Anisian-Ladinian boundary.

Between 3610' and 3750' a white, shelly limestone yielded a rich microfaunal assemblage, designated the "Hungarella I" zone, which persisted in the cuttings samples as cavings to ±4535'. This assemblage is commonly restricted to sediments of Ladinian - early Karnian age, and its appearance at ±3700' is consistent with the palynological evidence which suggests that this limestone is of ?Ladinian - Karnian age with the Karnian - Norian boundary located at 3580'.

A sharp sedimentological break at 3610' separated the white limestone Schei Point Formation equivalent from a succession of grey brown shales (3250' - 3610'), grey, glauconitic sandstone (3200' - 3250') and red shale (3100' - 3200'), and possibly marks the commencement of a regressive sedimentary phase. It is not certain that there is a non-sequence between the limestone and the shales as neither the palynological nor microfaunal evidence indicates a major break. The sediments which comprise this interval 3100' - 3610', although lithologically atypical, are age-equivalents of the Upper Triassic Heiberg Formation. Palynological data suggests that the extinction of the Camerosporites - Fossapollenites plexus at 3580' marks the Karnian - Norian boundary, and that the extinction of the "RHNO" dinoflagellate complex at 3200' - 3290' marks the Norian - Rhaetian boundary. This last boundary is coincident with both the extinction of the Upper Triassic Nodosaria shublikensis/mitis Assemblage Zone and with the glauconitic sandstone/red shale boundary; the inference being that this is a facies controlled boundary. The red shale which is developed between 3100' and 3200' is poorly fossiliferous. The occurrence of the Rhaeto-Norian marker species Perinosporites thuringiacus and Ricciisporites tuberculatus within this unit, however, coupled

with its stratigraphical position suggest that it is of Rhaetian age and probably correlative with a Rhaetian red shale known from outcrop samples in eastern Prince Patrick Island.

The interval 2800' - 3100' is composed predominantly of light grey, fine grained glauconitic sandstone, occasionally calcareous or ferruginous, and with shaly interbeds. Its lithological characters suggest correlation with the Borden Island Formation. Caving from the overlying interval is prevalent and effectively obscures the nature of the in situ palynofloras and microfaunas. The absence of distinctive Triassic palynofloral marker species together with the occurrence of species indicative of an early rather than late Liassic age, suggest that this interval is of undifferentiated Lower Liassic age. The microfaunal content is somewhat anomalous in that rare, derived Triassic species are found in association with restricted Lower Jurassic assemblages. Derived Triassic palynomorphs and foraminifera are also present at the base of the overlying interval (1500' - 2800') which is comprised of grey silty shales grading into shales, siltstones and very fine grained sandstones with dark pyritic shales predominating in the interval 1820' - 2000'. The palynofloral and microfaunal assemblages are indicative of an Upper Pliensbachian - ?Callovian age, with the Upper Pliensbachian - Toarcian boundary located at 2300' - 2390', determined on the extinction of the microplankton Mancodinium semitabulatum, the Lower Toarcian - Upper Toarcian boundary located at 2100', coincident with the extinction of the microplankton Granodiscus granulatus and Crassosphaera hexagonalis, and the Bajocian - ?Bathonian boundary marked by the extinction of the dinoflagellate Nannoceratopsis gracilis at 1610' - 1670'. This equivalent of the Lower Wilkie Point Formation marks the maximum development of the marine transgression initiated during deposition of the underlying

glauconitic sandstones. Commencement of a regressive phase is indicated by progressive coarsening of the sediments above 1820', culminating in the deposition of the coals and non-marine, coarse, white sands of the overlying interval 930' - 1500', which has been equated with the Upper member of the Wilkie Point Formation. The depositional environments in which the Borden Island and Wilkie Point Formation equivalents accumulated, range from shallow marine at the base, through open marine and then restricted marine during deposition of the poorly fossiliferous pyritic shales. Progressive shallowing is reflected in the increasingly arenaceous nature of the sediments above 1820' although marine microplankton and foraminifera persist at ±1500'. Within the Upper Wilkie Point Formation equivalent, marine microplankton, representing minor marine incursions, are recorded at 1300' - 1390' and 1000' - 1090'. The coals present in this section must, however, have accumulated under continental conditions. The paucity of diagnostic microfaunas or palynofloras precludes any possibility of biostratigraphical subdivision: the interval between 1300' - 1390' and 1610' - 1670' has therefore been assigned an undifferentiated Bajocian - Callovian age, although it is not certain that sediments of Bathonian age are represented in this well. Above the sample at 1300' - 1390', the palynofloras are of Callovian aspect, whilst the Callovian - Oxfordian boundary has been located at 1000' - 1090', immediately above the last occurrence of undoubted Callovian palynofloras.

The Wilkie Point Formation equivalents are succeeded by a sequence of black shales, grading into grey-brown shales above 700' finally passing into an alternating succession of sandstones, shales and siltstones above 400'. This interval,

90' - 980', has been correlated with the Mould Bay Formation; the interval below 400' with the Lower member, and that above with the Middle member. The Lower Mould Bay Formation equivalent yielded a rich foraminiferal assemblage of Upper Jurassic age assigned to the Gaudryina milleri/leffingwelli Assemblage Zone. The Middle Mould Bay Formation equivalent yielded a restricted assemblage of G. milleri/leffingwelli Zone aspect, although lacking the typical components of the Jurassic assemblage. The associated palynofloras are also of Upper Jurassic - Lower Cretaceous aspect and, below 300', include varied assemblages of marine microplankton. The extinction of Gonyaulacysta cladophora at 890' - 920' marks the highest occurrence of undoubted Oxfordian assemblages, although the occurrence of Acanthaulax venusta at 700' - 710', followed by the first appearance of the Kimmeridgian and younger species Psaligonyaulax apatela, Gonyaulacysta granuligera and "pareodiniod" TAB 1 at 670' - 690' may mark the Oxfordian - Kimmeridgian boundary at ±700'. The Kimmeridgian floras persist to ±650' marked by the extinction of Gonyaulacysta jurassica. The first appearance of a rich spore assemblage, including Trilobosporites spp. and Cicatricosisporites spp at 560', which is coincident with the extinction of the dinoflagellates Gonyaulacysta longicornis and Pareodinia nuda, marks the boundary between the early and late Tithonian. The Jurassic-Cretaceous boundary problem has been discussed in Chapter III and the ranges of palynofloras across the boundary summarized in Table 1. The boundary selected, at 360' is marked by the extinction of the major part of the Tithonian microplankton assemblage, and the appearance of a Berriasian spore/pollen complex. The palynofloras recorded above 200' are composed of relatively long ranging species and a Valanginian age for the upper part of the section cannot be entirely excluded.

The sediments at the base of the Mould Bay Formation equivalents mark a return to open marine depositional environments. The preponderance of coarser clastics in the upper sections, however, indicate regressive, shallowing conditions with probably restricted marine or transitional environments prevailing above 200'.

VI

CONCLUSIONS

The sequence penetrated in Jameson Bay C-31 Well is consistent, in the post-Triassic intervals, with the surface exposures on Prince Patrick Island, especially those between Intrepid Inlet and Jameson Bay. The red, ferruginous shale marker noted at 3100' - 3200' has been identified in surface sections and may prove to be a useful marker horizon for the uppermost Triassic in this area. Although the only published records of Triassic sediments from surface exposures on Prince Patrick Island have been referred to the Schei Point Formation, the sequence 3100' - 3610', immediately above the Schei Point Limestone equivalent, is represented by a similar sedimentary succession in unpublished surface sections. This is undoubtedly equivalent to the Heiberg Formation although the facies development is somewhat atypical. The ?Pennsylvanian/ Permian - Lower Triassic succession has not been recognized in surface outcrops in Prince Patrick Island, although the succession recorded in this well is similar, in many respects, to equivalent sections described from Melville Island (Nassichuk, 1965; Tozer & Thorsteinsson, 1964).

The generally marginal marine or transitional marine to non-marine facies exhibited in the succession of transgressive and regressive pulses recorded in this section reflect its marginal location within the Sverdrup Basin.

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PLATE I

Selected palynomorphs from the Elf Jamieson Bay C-31 well;
all figures x600±

Figure 1. Pilosisporites trichopapillosus (Thiergart), from depth 300 - 310 ft., Berriasian.

Figure 2. Horologinella sp. 1, from depth 300 - 310 ft., Berriasian.

Figure 3. Canningia "adnata" Warren, from depth 350 ft., Berriasian.

Figure 4. Trilobosporites apiverrucatus Couper, from depth 360 ft., Berriasian.

Figures 5 and 6. "pareodinioid" SPIN 2, from depth 360 ft., Berriasian; respectively high and low focus.

Figure 7. "pareodinioid" TAB 1, from depth 430 - 450 ft., Late Tithonian.

Figure 8. "pareodinioid" SPIN 1, from depth 490 - 510 ft., Late Tithonian.

Figure 9. Nannoceratopsis gracilis Alberti, from depth 1,610 - 1,670 ft., Bajocian.

Figure 10. dinoflagellate indet. JB3, from depth 670 - 690 ft., Kimmeridgian.

Figure 11. Acanthaulax sp., from depth 700 - 710 ft., Oxfordian.

Figure 12. Mancodinium semitabulatum Morgenroth, from depth 2,780 ft., Pliensbachian.

Figure 13. Rhaetipollis germanicus Schulz, from depth 3,320 - 3,380 ft., Norian.

Figure 14. Lunatisporites sp., from depth 3,320 - 3,380 ft., Norian.

Figure 15. dinoflagellate RHNO 6, from depth 3,410 - 3,470 ft., Norian.

Figure 16. dinoflagellate RHNO 7, from depth 3,500 - 3,590 ft., Norian.

Figure 17. dinoflagellate RHNO 2, from depth 3,500 - 3,590 ft., Norian.

Figure 18. Ricciisporites tuberculatus Lundblad, from depth 3,500 - 3,590 ft., Norian.

Figure 19. gen. et sp. indet., from depth 3,610 - 3,690 ft., ?Ladinian to Karnian.

Figure 20. Zebrasporites laevigatus (Schulz), from depth 3,610 - 3,690 ft., ?Ladinian to Karnian.

Figure 21. Brachysaccus sp., from depth 3,610 - 3,690 ft., ?Ladinian to Karnian.

PLATE 2

Selected palynomorphs from the Elf Jamieson Bay C-31 well;
all figures x600±

Figure 1. Camerosporites verrucosus Madler, from depth 3,610 - 3,710 ft., ?Ladinian to Karnian.

Figure 2. Spiritisporites spirabilis Scheuring, from depth 3,610 - 3,710 ft., ?Ladinian to Karnian.

Figure 3. Dapcodinium sp., from depth 3,610 - 3,710 ft., ?Ladinian to Karnian.

Figure 4. Camerosporites pseudoverrucatus Scheuring, from depth 3,610 - 3,710 ft., ?Ladinian to Karnian.

Figure 5. Fossapollenites moderatus Scheuring, from depth 3,610 - 3,710 ft., ?Ladinian to Karnian.

Figure 6. Eucommiidites major (author?) from depth 3,900 - 3,980 ft., Anisian to ?Ladinian.

Figure 7. Protodiploxypinus sp. WS 1, from depth 3,900 - 3,980 ft., Anisian to ?Ladinian.

Figure 8. Triadispora sp., from depth 4,010 - 4,040 ft., Anisian to ?Ladinian.

Figure 9. Triadispora modesta Scheuring, from depth 4,100 - 4,140 ft., Smithian to Spathian.

Figure 10. Triadispora staplini (Jansonius), from depth 4,100 - 4,140 ft., Smithian to Spathian.

Figure 11. Aratrisporites cf. A. paraspinosus Klaus, 40594 from depth 4,100 - 4,140 ft., Smithian to Spathian.

Figure 12. Nevesisporites fossulatus Balme, from depth 4,100 - 4,140 ft., Smithian to Spathian.

Figure 13. dinoflagellate RHNO 10, from depth 4,100 - 4,140 ft., Smithian to Spathian.

Figure 14. Rhaetogonyaulax sp., from depth 4,200 - 4,290 ft., Smithian to Spathian.

Figure 15. Infernopollenites sp., from depth 4,200 - 4,290 ft., Smithian to Spathian.

Figure 16. Conbaculatisporites mesozoicus Klaus, from depth 4,200 - 4,290 ft., Smithian to Spathian.

Figure 17. Pityosporites neomundanus (author?) from depth 4,220 - 4,280 ft., Smithian to Spathian.

Figure 18. Protohaploxypinus sp. CR1, from depth 4,220 - 4,280 ft., Smithian to Spathian.

Figure 19. Corisaccites sp., from depth 4,310 - 4,370 ft., Smithian to Spathian.

Figure 20. Lunatisporites sp., from depth 4,310 - 4,370 ft., Smithian to Spathian.

Figure 21. Kraeuselisporites sp., from depth 4,310 - 4,370 ft., Smithian to Spathian.

Figure 22. Aratrisporites sp., from depth 4,310 - 4,370 ft., Smithian to Spathian.

Figure 23. Corallina sp., from depth 4,310 - 4,370 ft., Smithian to Spathian.

Figure 24. Protodiploxypinus sp., from depth 4,400 - 4,480 ft., Smithian to Spathian.

PLATE 3

Selected palynomorphs from the Elf Jamieson Bay C-31 well;
all figures x600±

Figure 1 Cyclotriletes granulatus Madler, from depth
4,400 - 4,480 ft., Smithian to Spathian.

Figure 2. Kraeuselisporites sp., Madler, from depth
4,400 - 4,480 ft., Smithian to Spathian.

Figure 3. Carnisporites hercynicus (author?) from depth
4,400 - 4,480 ft., Smithian to Spathian.

Figure 4. Protodiploxypinus gracilis (author?) from depth
4,400 - 4,480 ft., Smithian to Spathian.

Figure 5. dinoflagellate RHNO 9, from depth
4,400 - 4,480 ft., Smithian to Spathian.

Figure 6. Densoisporites sp., from depth
4,520 - 4,580 ft., Smithian to Spathian.

Figure 7. Carnisporites sp., from depth
4,520 - 4,580 ft., Smithian to Spathian.

Figure 8. Lundbladispora sp. JB1, from depth
4,500 - 4,590 ft., Smithian to Spathian.

Figure 9. Striatoabieites balmei (author?) from depth
4,500 - 4,590 ft., Smithian to Spathian.

Figure 10. Chordasporites sp., from depth
4,500 - 4,590 ft., Smithian to Spathian.

Figure 11. Lunatisporites novimundi (Jansonius), from depth
4,500 - 4,590 ft., Smithian to Spathian.

Figure 12. Weylandites sp., from depth
5,420 - 5,480 ft., Kazanian.

Figure 13. Acanthotriletes cf. A. tereteangulatus Balme,
from depth 5,420 - 6,000 ft., Kazanian.

Figure 14. Kraeuselisporites sp., from depth
5,420 - 6,000 ft., Kazanian.

Figure 15. Osmundacidites senectus Balme, from depth
5,420 - 6,000 ft., Kazanian.

Figure 16. Protohaploxypinus sp., from depth 6,300 - 6,390 ft., Kazanian.

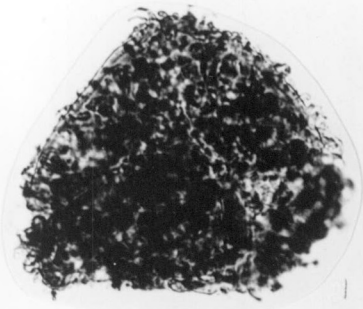
Figure 17. Punctatisporites cf. P. fungosus (author?) from depth 6,000 - 6,600 ft., Kazanian.

Figure 18. Protohaploxypinus sp., from depth 6,000 - 6,600 ft., Kazanian.

Figure 19. aff. Facisporites nuthallensis (author?) from depth 6,000 - 6,600 ft., Kazanian.

Figure 20. Neoraistrickia sp., from depth 6,000 - 6,600 ft., Kazanian.

Figure 21. Weylandites sp., from depth 6,000 - 6,600 ft., Kazanian.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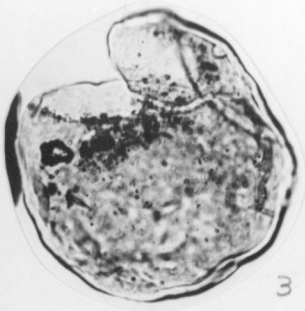
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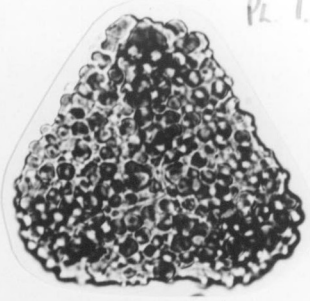
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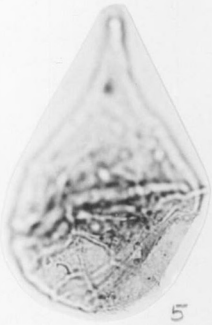
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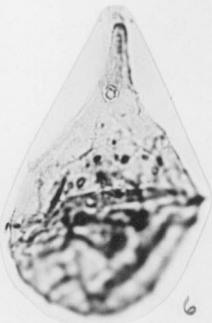
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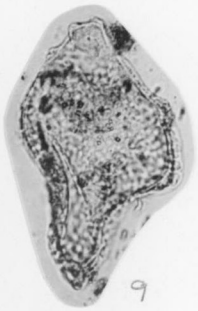
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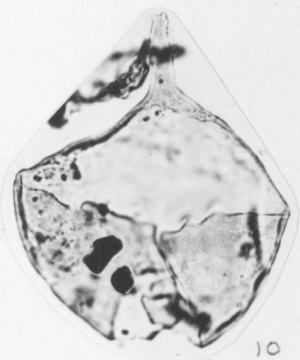
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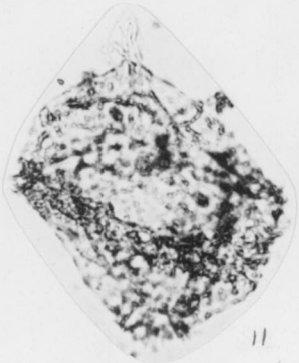
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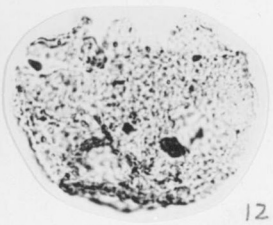
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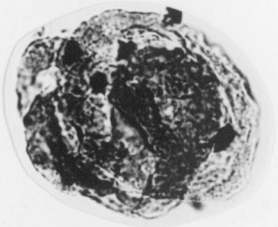
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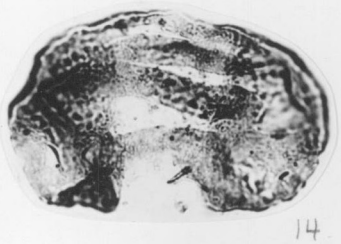
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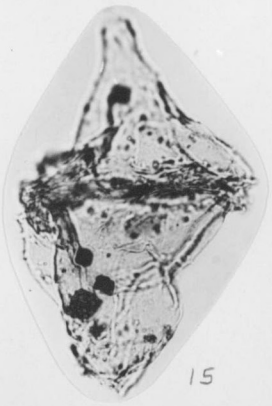
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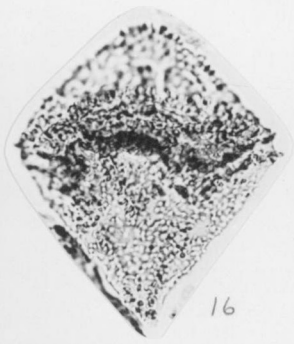
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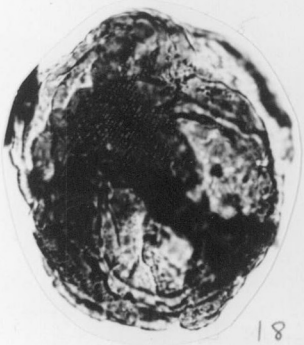
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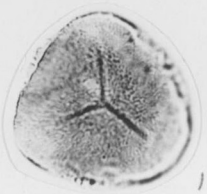
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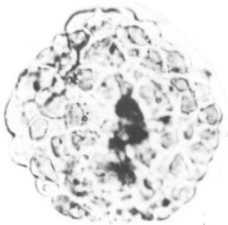
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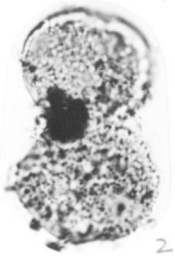
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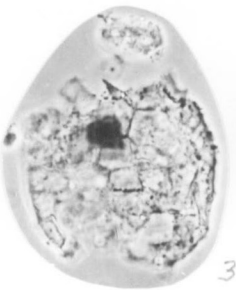
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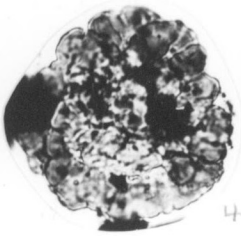
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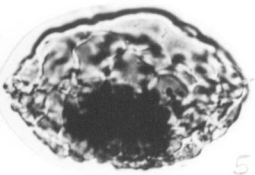
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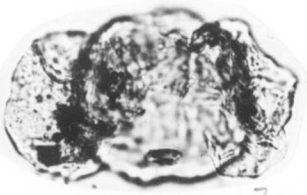
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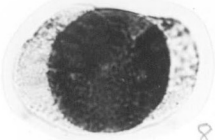
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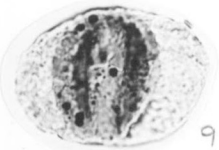
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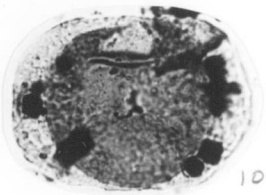
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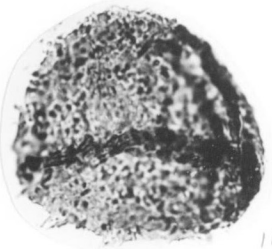
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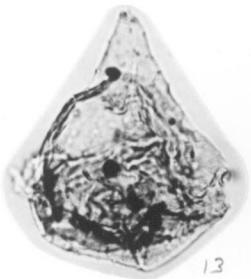
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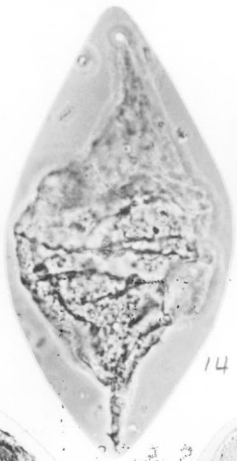
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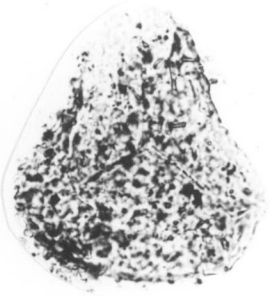
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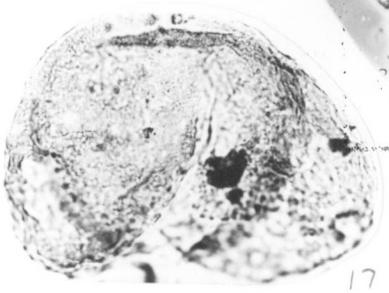
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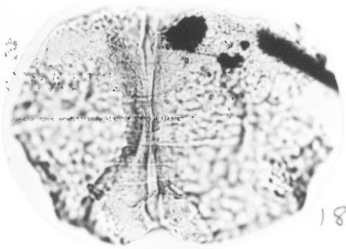
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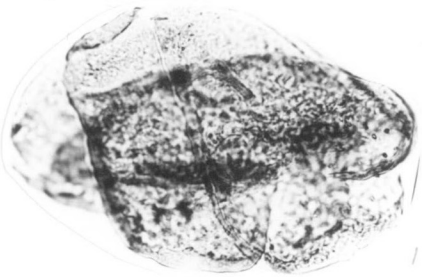
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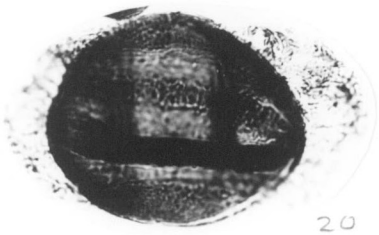
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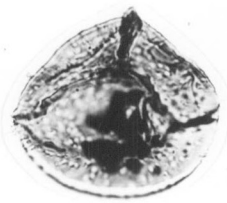
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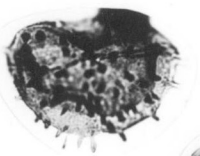
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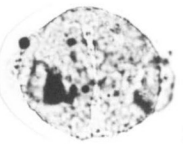
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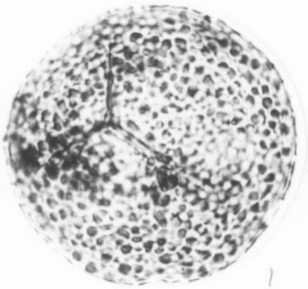
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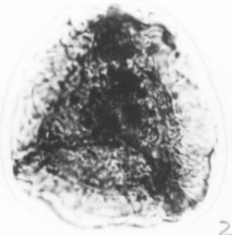
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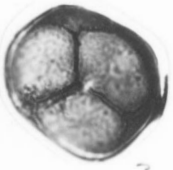
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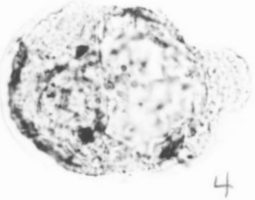
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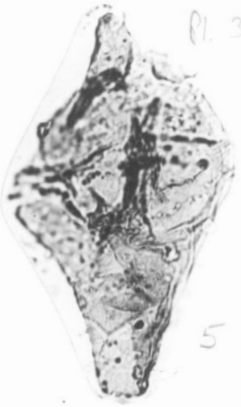
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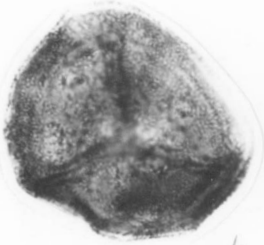
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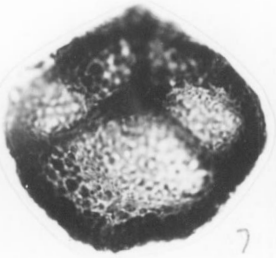
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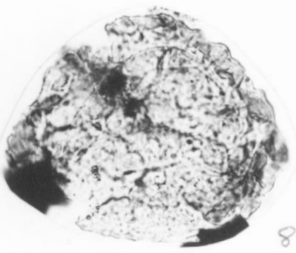
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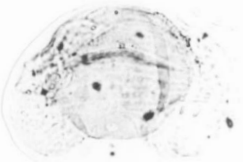
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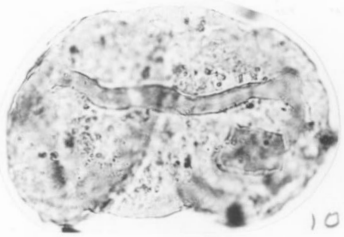
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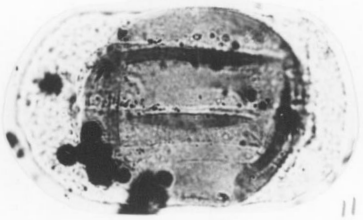
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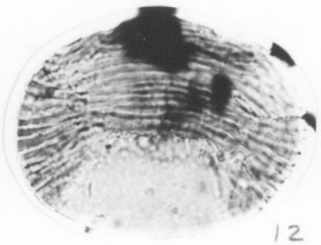
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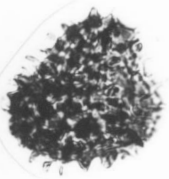
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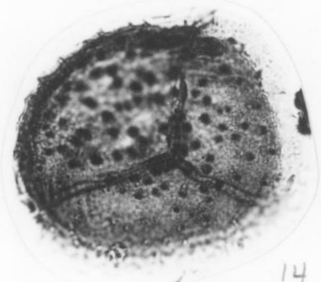
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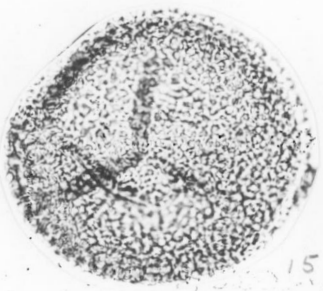
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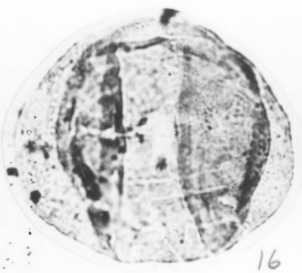
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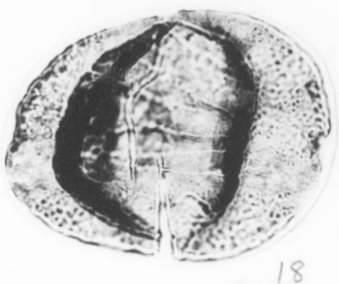
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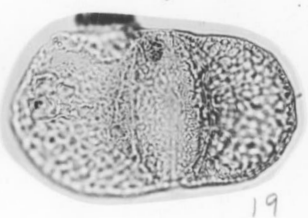
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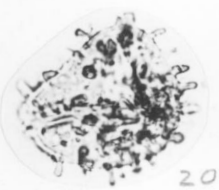
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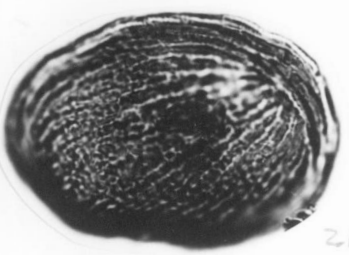
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