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EXPLORATION REPORT NO. 76

THE BIOSTRATIGRAPHY OF THE DOME ARCTIC VENTURES SUTHERLAND O-23 WELL

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MAY, 1976, REVISED JANUARY, 1977

OF 570

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I

INTRODUCTION

This report comprises a summary of the results obtained from the micropalaeontological, palynological and stratigraphical analyses of material received from the interval 705' - 14,623' of the Dome Arctic Ventures Sutherland O-23 Well. This work was carried out under Project No. RRNA/734/071.

The well is located on the southwestern coast of King Christian Island, one of the Canadian Arctic Islands. The actual location of Dome Arctic Ventures Sutherland O-23 is 77° 42' 53.07" N., 102° 08' 28.78" W.

The stratigraphical interval covered by this report ranges from Middle Jurassic to Lower Triassic. The available samples commence with a succession of Middle to Lower Jurassic sediments representing the ?Savik, Jaeger, Borden Island and topmost Heiberg Formations, ranging in age from Callovian to Hettangian. These are underlain by a thick and apparently conformable sequence of Triassic sediments comprising the Heiberg, Blaa Mountain and Blind Fiord Formations, the well reaching total depth in rocks of Lower Triassic, Griesbachian/Dienerian age.

Similar sequences are penetrated in both the Sutherland O-23 and Louise O-25 wells. Correlation of the different foraminiferid assemblages recognised in both wells is illustrated on the enclosures accompanying the Louise O-25 report.

within this interval are probably derived from higher intervals by caving.

Palynology

The combined appearance at 1100' - 1190' of the dinoflagellates Nannoceratopsis gracilis and Mancodinium semitabulatum strongly suggests a Toarcian age for this interval. Again, palynomorphs of generalized Jurassic aspect comprise the remainder of the palynoflora. Occasionally, species common in Lias horizons, such as Contignisporites problematicus are present.

It is most probable that the bottom horizons of this interval are Upper Pliensbachian. It is not possible, however, to measure the extent of caving from the Toarcian.

INTERVAL 1600' - 1900'; Lower Jurassic - Sinemurian

General Lithology

Fine quartz siltstones or very fine sandstones persist throughout this interval, although coarse to medium, subangular to subrounded quartz and chert sands become important in the lower third.

Micropalaeontology

This interval is considered to be barren of in situ microfauna.

Palynology

The presence of Stereisporites apolaris at 1600' - 1690' suggests

that Sinemurian strata have been penetrated. This is associated with a typical Jurassic palynoflora, comprised of such species as Classopollis torosus, Mathesisporites turmulosus and Tsugaepollenites mesozoicus.

INTERVAL 1900' - 2000'; Lower Jurassic, Hettangian - Lower Sinemurian

General Lithology

Some medium to coarse sands were recorded at the top of the interval, but this section is essentially composed again of angular quartz siltstones or very fine sandstones.

Micropalaeontology

This interval is considered to be barren of in situ microfauna.

Palynology

At 1900' - 1990', Tsugaepollenites cf. thiergartii and Stereisporites stictus woelfersheimensis are encountered, thereby suggesting that lowest Lias horizons have been penetrated. Carnisporites cf. granulatus, Densoisporites velatus, and other species common in Lias palynofloras also occur.

V

TRIASSIC

INTERVAL 2000' - 2950'; Upper Triassic, Rhaetian

General Lithology

Light coloured angular quartz siltstones and very fine sandstones persist down to around 2560', interrupted between 2300' and 2400' by a development of very dark grey to black siltstones. Below 2560', silty shales and hard, brown siliceous shales appear, while grey pyritic shale appears at 2660' and becomes increasingly important towards the base of the interval. Core No. 1 (2809'-2831') was composed entirely of light grey, pyritic shale.

Micropalaeontology

The microfauna recovered from the interval down to 2600' is considered to have caved. The first Triassic species, Ammodiscus sp. 4, is encountered at 2600', and the interval below this appearance is considered to be a regressive development of the Nodosaria shublikensis/mitis Assemblage Zone which is normally confined to the Upper Triassic in the Sverdrup Basin.

Palynology

The appearance of Ricciisporites tuberculatus at 2000', a Rhaetian/Norian palynomorph species, indicates that Upper Triassic strata have been encountered at this depth. Some other Upper Triassic forms encountered at successive levels within this interval are Camarozonosporites laevigatus, Anulatizonites

cf. rotundus, Perinosporites thuringiacus, Zebrasporites interscriptus, Limbosporites lundbladii, cingulizonates rhaeticus, Kyrtomisporites speciocus, Aratrisporites granulatus and Ballosporites hians.

Core No. 1 (2808' - 2833') contains a palynoflora indicative of a Norian, perhaps Lower Rhaetian age, with such forms as Anulatizonates rotundus, Lunatisporites cf. rhaeticus, Limbosporites lundbladii, and Dinoflagellate RHNO-2 being present.

INTERVAL 2950' - 3810'; Upper Triassic, Norian

General Lithology

Argillaceous sediments predominate throughout this interval, including grey pyritic shales, siliceous shales, and silty shales. Siltstones occur rarely, and a small amount of grey limestone was recorded from the interval 3160' - 3200'.

Micropalaeontology

There is a gradual diversification of the N. shublikensis/mitis Assemblage Zone microfauna in the uppermost 250' of this interval, and below 3200' a rich and diverse development of the zone occurs. Species recorded include, in order of highest occurrence, Ammodiscus sp. 4, Nodosaria shublikensis/mitis, Lingulina alaskensis, Astacolus connudatus, Nodosaria nordvikensis, Vaginulinopsis acrulus, Marginulina prisca, Lingulina tenera var. maxima, Pseudoglandulina simpsonensis, Frondicularia aff. acmaea, Lingulina borealis, Frondicularia carinocostata, Nodosaria aff. larina, Trochamminoides aff. vertens and Dentalina tenuistriata.

Metacopid ostracoda are fairly common within this interval, and may be

ascribed to Ostracod Zone C of upper Karnian and Norian age. Ostracod Zone C is here characterised by the species, Pseudohealdia? sp. 2, Ogmoconchella sp. 1, 'Healdia' sp. 5 and Healdia aff. sp. 1. As metacopid ostracoda are not known to range above the Norian in the Sverdrup Basin, the Norian-Rhaetian boundary is drawn on the first occurrence of the group, a postulate that is substantiated by palynological evidence.

Palynology

Zebrasporites interscriptus, Ricciisporites tuberculatus, Ballosporites hians, Lunatisporites rhaeticus, etc., persist into this interval and are joined by other Upper Triassic taxa such as Granuloperculatipollis cf. gracilis. Commencing at 3000', dinoflagellate species of the RHNO plexus become common, with dinoflagellates RHNO 7, 6, 4, and 2 occurring throughout this interval. This dinoflagellate suite first appears in the Norian/ Lower Rhaetian elsewhere in the Canadian Arctic, but does not become varied and abundant until the Norian.

INTERVAL 3810' - 6100'; Upper Triassic, Karnian

General Lithology

Grey pyritic shales persist down to about 4650' below which point there appears a complex series of 'vein rocks', consisting mainly of quartz, associated with minor amounts of a dark mafic mineral and pyrite. Vein calcite also occurs, and becomes more common below 5000'. Many of the shales associated with this rock are spotted, and appear to have been thermally or

hydrothermally altered. Below 4950', many of the shales become siliceous, while from 5460' down to the casing shoe set at 5605', siliceous and soft, grey shales are associated with brown ferruginous shales. Below the casing shoe, an association of very fine, white, calcareous sandstone, and pale grey cherts, is replaced below 5800' by siliceous shales, grey shales and chert, along with lesser amounts of fine calcareous sandstone. Vein calcite also occurs in this lower interval.

Micropalaeontology

The N. shublikensis/mitis fauna persists into this interval with a number of new species occurring, including Lenticulina sp. 21, Trochammina sp. 12, Frondicularia lepida, and Ammobaculites sp. 14. Between 4600' and and 4800', coincident with the maximum development of 'vein rock', the samples are barren of microfauna, but below 4800', the N. shublikensis/mitis fauna reappears, with a number of additional species including 'Globulina' spp. and Reophax sp. 8, along with other species in open nomenclature. The microfauna virtually disappears below the casing shoe at 5605', suggesting that the N. shublikensis/mitis zone fauna may be caved in its lower part.

Metacopid ostracoda are present from the top of the interval down to 4450', representing the lower part of Ostracod Zone C described in the previous section, and again between 5000' and the casing shoe (5605'), where a distinct association occurs ascribable to Ostracod Zone B. This zone characterizes strata of Karnian age, (although occasionally it may range down to the

top of the Ladinian), and is here defined by the association of Ogmoconchella sp. E3, and Healdia? sp. E2 along with other metacopids and a species of ?Bythocypris.

Microgastropoda, and pyritised juvenile lamellibranchs become common between 4850' and the casing shoe.

Palynology

The Norian palynomorphs described above persist into this interval. This may be indicative of caving, although elsewhere in the Arctic Rhaeto-Norian palynofloras persist well into the Karnian. The Karno-Norian boundary is arbitrarily placed at 3810' - 3890', where Protodiploxypinus ornatus appears. It is recognized, however, that this boundary may occur at some deeper level. More certain Karnian elements, such as Aratrisporites cf. saturni, A. cf. fimbratus, Duplicisporites sp., and forms attributable to Patinasporites densus begin to appear after 4600'.

INTERVAL 6100' - 7200'; Middle Triassic, Anisian - ?Ladinian

General Lithology

Slightly calcareous, hard, very dark grey, shales at the top of the interval pass down below 6250' into dirty calcareous siltstones and grey and buff-coloured cherts, which in turn pass down below 6600' into a monotonous series of non-calcareous siltstones with occasional silty shales, and cherts which have probably caved from above 6600'.

Micropalaeontology

A poorly developed foraminiferal assemblage consisting entirely of arenaceous species was recorded in this interval. The assemblage is not age-diagnostic, and is composed of the long-ranging Ammodiscus sp. 4, along with species of Ammobaculites, Haplophragmoides?, Bathysiphon?, Reophax, Saccammina and Trochammina?. Single occurrences of calcareous forms have probably resulted from caving from the N. shublikensis/mitis Assemblage Zone.

The ostracod, Cavellina sp. 1, recorded from 6100' and 6700', is one of the species that defines, and appears to be confined to Ostracod Zone A, a zone that is commonly encountered in the axial part of the basin in strata of Anisian, and possibly of Ladinian age.

Palynology

With the exception of probable caved specimens, this interval is, for the most part, barren. However, Polycingulatisporites cf. ANI-1 is present at 6400' - 6490', and Stereisporites ANI-1 occurs at 6700' - 6790'. Both these taxa occur in the Ladinian/Anisian elsewhere in the Canadian Arctic, and thus may indicate a Middle Triassic age for this interval.

Acritarchs, in particular Micrhystridium, occur in some numbers within this interval.

INTERVAL 7200' - 10,800'; Lower Triassic, Scythian (undifferentiated)

General Lithology

Non-calcareous siltstones, with subordinate shales, silty shales,

calcareous siltstones and cherts persist down to 8650', below which silty shales and grey shales dominate the lithology down to 9900', interrupted between 9550' and 9700' by light-coloured, non-calcareous, siltstones. Below 9900' the shales again pass into siltstones, which are associated below 10,350' with black, slightly ferruginous mudstones that are typically structureless, but occasionally show fine laminations. Considerable amounts of cement were found in the samples for 250' below the casing shoe set at 10,165'.

Micropalaeontology

A poor, agglutinating foraminiferal assemblage was recovered from this section above 8800' consisting of Ammodiscus sp. 4, Trochamminoides? sp. and Saccammina sp. Again, the assemblage is not age-diagnostic, and again the calcareous forms are regarded as having caved from Upper Triassic, and younger, strata. With the exception of a single Ammodiscus sp. 4 at 9500', the section is barren of microfauna below 8800'.

Palynology

The pollen assemblage becomes more diverse at 7200', with such typical Lower Triassic species as Lunatisporites noviaulensis and L. hexagonalis first occurring here. These and other striate bisaccate species, including Lunatisporites albertae, L. pellucida, L. transversundatus, and Protohaploxypinus samoilovichii dominate the spore and pollen fraction of this interval. Nevesisporites fossulatus, and Densoisporites nejburgii, both Lower Triassic cryptogam spores, also occur in this interval. All of these

species are frequently observed components of Scythian palynofloras throughout Canada.

Micrhystridium spp., as well as other acritarchs, are abundant throughout this interval. Upper Triassic species, presumably caved, also are found throughout this interval.

The palynoflora recovered from the in situ sample at 8300' is also of Scythian aspect, with Lunatisporites hexagonalis and Nevesisporites fossulatus being present. The occurrence here of Aratrisporites cf. saturni further suggests an age at this depth of no older than Upper Scythian (Smithian - Spathian).

The Permian palynomorph Vittatina simplex was found at 9000', associated with typical Scythian taxa. However, as Scythian taxa occur in Core No. 3 (11,636'), as described below, this Palaeozoic species is considered to be reworked.

INTERVAL 10,800' - 14,623' (T.D.); Lower Triassic, Griesbachian - Dienerian

General Lithology

Black mudstones and siltstones, as described in the previous section, pass down at 11,050', into light grey calcareous siltstones with occasional shales, silty shales, mudstones, cherts and limestones, which are all replaced below 11,650' by a thick series of grey, micromicaceous shales and silty shales that persist to T.D. These are interrupted between 13,300' and 13,600' by black mudstones, and are associated at T.D. with subordinate calcareous siltstones. Core No. 2, (11,636' - 11,658') produced grey micromicaceous shale.

Micropalaeontology

This interval proved to be completely barren of microfauna.

Palynology

The appearance of Endosporites papillatus at 10,800' - 10,890', a species quite indicative of the Lower Scythian, suggests that Griesbachian/Dienerian sediments have been penetrated by this depth. Striatoabieites cf. richteri, another palynomorph common in the Lower Scythian is also present as are the Scythian pollen, spores, and acritarchs mentioned above. Striate taxa, Densoisporites nejburgii, and Endosporites papillatus persist to T.D. No taxa diagnostic of the Permian were encountered in this interval.

Core No. 3 (11,636') was dominated by the acritarch genera Micrhystridium and Veryhachium. Due to the presence of Lunatisporites sp. U of Jansonius, Gnetaceaepollenites steevesii, and Densoisporites nejburgii, this core is also considered to be Scythian.

Because of the sparse and corroded nature of the pollen assemblages, no definite repetition of sequence could be ascertained. There appears to be small intervals throughout the Lower Scythian which are characterised by bursts of spores and pollen. These intervals occur at 10,800' - 11,210', 12,200' - 12,500', 12,900' - 12,910', 14,000' - 14,290'. Interspersed between these are longer sequences which are dominated by microplankton, such as Micrhystridium and Veryhachium.

However, because of the probability of caving, and because of the overall scarcity of palynomorphs, no repetitive pattern of palynofloras could be ascertained with confidence.

VI

STRATIGRAPHICAL REMARKS

The Dome Arctic Ventures Sutherland 0-23 well reached T.D. at 14,626' in grey shales and silty shales of Lower Triassic, Griesbachian - Dienerian age. The lowest 8000' of the section (6600' to 14,623' T.D.) has been correlated with the Blind Fiord Formation, consisting essentially of a thick series of shales, silty shales and siltstones, interrupted by calcareous siltstones, black ferruginous mudstones, and rare chert and limestone beds. With the exception of the highest 2200', where a thick siltstone unit contains a sparse, agglutinating foraminiferal assemblage, this section is completely barren of microfauna, and its breakdown into Griesbachian - Dienerian, undifferentiated Scythian, and Anisian - ?Ladinian stages is accomplished palynologically. The lithological characteristics of this section, together with the lack of microfauna and the high ratio of microplankton to pollen and spores suggests rapid sedimentation contemporaneous with rapid subsidence under sublittoral conditions of deposition. The appearance of a poor microfauna above 8800' could indicate a shallowing trend. The black, ferruginous mudstones recorded at 13,600' - 13,300' and 11,650' - 10,250' may indicate the existence of euxinic sea-floor conditions, this being a function of lack of water circulation rather than of depth.

The Blind Fiord Formation is succeeded by a variable series of sediments including cherts, siliceous, calcareous, ferruginous and silty shales, grey shales, and calcareous sandstones and siltstones. These pass up above 5000' into a more homogeneous succession of pyritic shales, passing back into siliceous shales above 3850', and finally into non-calcareous siltstones

at the top of the section. The sedimentary succession is interrupted between 4800' and 4600' by a series of 'vein rocks', that have thermally or hydrothermally altered the adjacent shales. This sequence (6600' - 2650') has been correlated with the Blaa Mountain Formation, and contains a fairly diverse microfauna and palynoflora. An Anisian - ?Ladinian age is postulated between 6600' and 6100', based on the presence of Stereisporites ANI-1, Polycingulatites ANI-1 and rare ostracoda of the Anisian Ostracod Zone A. Above 6100' a Karnian age is indicated by the presence of Aratrisporites cf. saturni, A. cf. fimbriatus and Protodiploxypinus ornatus and above 5600' by the appearance of species of Ostracod Zone B, (5600' - 5050') and foraminifera of the N. shublikensis/mitis Assemblage Zone. The Karnian-Norian boundary is arbitrarily drawn at 3810' on the last occurrence of P. ornatus, although it is recognized that the boundary could be placed below this depth. The N. shublikensis/mitis Assemblage Zone fauna persists throughout the Norian, where it reaches its greatest diversity, and ranges in a modified form, into the lower part of the overlying Rhaetian. A distinctive suite of ostracods was recorded between 4450' and 2950', ascribable to Ostracod Zone C of uppermost Karnian to Norian age. The Norian - Rhaetian boundary is drawn at 2950' on the last appearance of metacopid ostracods, although the presence in Core No. 1 (2833' - 2808') of the Dinoflagellate RHNO plexus may indicate that Norian strata is already present at this depth. Inner to outer sublittoral environments of deposition are suggested to have prevailed throughout the Blaa Mountain interval, with the exception of 5050' - 4300', and above 3200', where impoverishment of the microfaunas may suggest shallowing to littoral (?) environments, although in the former case this may be a function of intrusive activity subsequently destroying the microfossils.

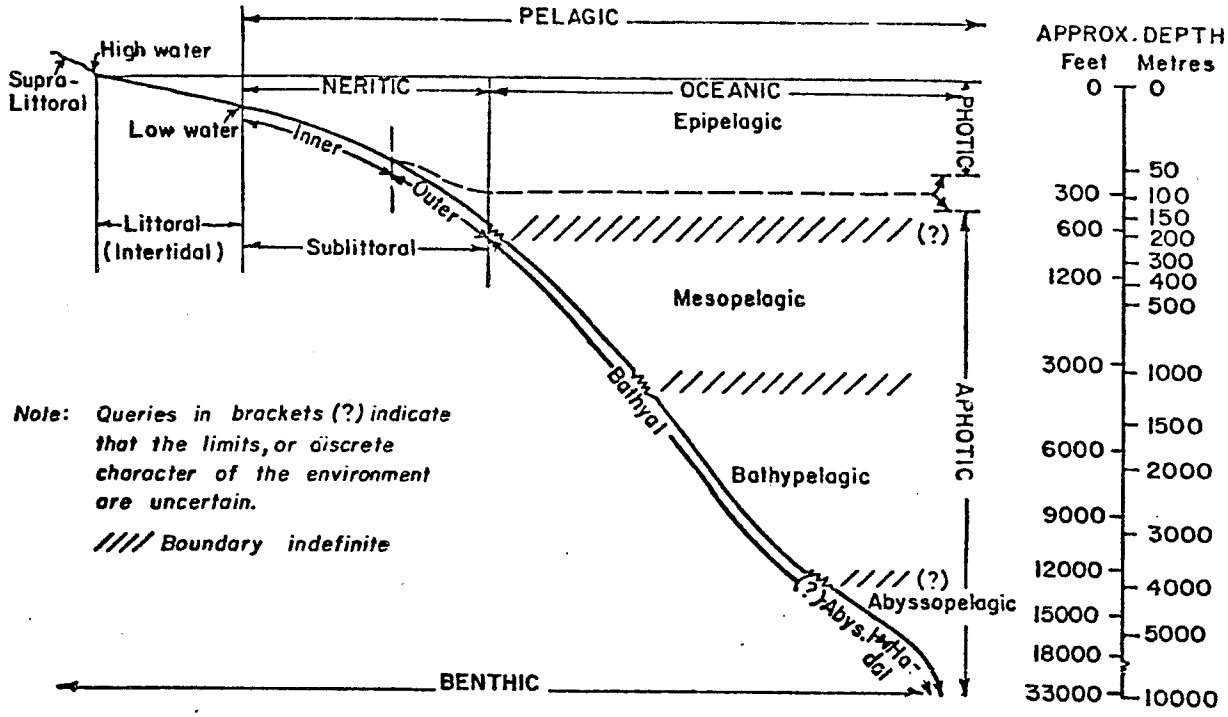
The Blaa Mountain sediments are succeeded by dark siltstones, quartz siltstones, fine sandstones, medium to coarse sands and brown coals which have been ascribed to the Heiberg (2650' - ±1950'), Borden Island (±1950' - 1550') and Jaeger (1600' - 1270') Formations; the Heiberg - Borden Island boundary can be drawn somewhat arbitrarily at the base of a sand at ±1950' within an essentially homogenous siltstone succession or positioned at approximately 2110'. This entire interval is virtually barren of in situ microfauna, and supralittoral to littoral conditions are postulated for its environments of deposition.

Typical Rhaetian palynomorphs are present between 2950' and 2000'. The presence at 1900' of Stereisporites stictus woelfersheimensis suggests a Hettangian to Lower Sinemurian age at this depth, whereas the presence of S. polaris at 1600' is indicative of a Sinemurian age. The occurrence of Nannoceratopsis gracilis and Mancodinium semitabulatum between 1600' and 1100' demonstrates the presence of Toarcian strata. It is, however, recognized that the lower portion of this interval may be of Pliensbachian age.

The essentially non-marine sediments of the Jaeger Formation are overlain by calcareous siltstones and siliceous shales, questionably correlated with the Savik Formation, and containing a fairly diverse microfauna. The foraminifera belonging to the M. phragmites Assemblage Zone of Toarcian to Lower Kimmeridgian age, while the ostracoda permit a further delimitation of the Toarcian, Bajocian and Callovian stages. No Bajocian or Bathonian palynofloras were recognized, although the presence of Pareodinia prolongata at 710' - 790' and Meiourongonyaulax deflanderi at 800' - 890' supports a Callovian age at these levels. The absence of both microfaunal and floral evidence for the presence of the Bathonian stage is probably a result of

a tentative unconformity at approximately 900'. Littoral to inner sublittoral environments probably prevailed during the deposition of the ?Savik Formation sediments. No material was available for study above 705'.

CLASSIFICATION OF MARINE ENVIRONMENTS



Note: Queries in brackets (?) indicate that the limits, or discrete character of the environment are uncertain.

//// Boundary indefinite

The classification of marine environments used in this report is presented in diagrammatic form above. Pelagic (water) and Benthic (bottom) environments are recognised.

PELAGIC

- Neritic
- Oceanic
  - Epipelagic
  - Mesopelagic
  - Bathypelagic
  - Abyssopelagic

BENTHIC

- Supralittoral
- Littoral (Intertidal)
- Sublittoral
  - Inner
  - Outer
- Bathyal
- Abyssal
- Hadal

The classification is after Hedgpeth (1957) and results from several years discussion by a Committee of the Division of Earth Sciences, National Research Council, National Academy of Sciences, Washington D.C.

IX

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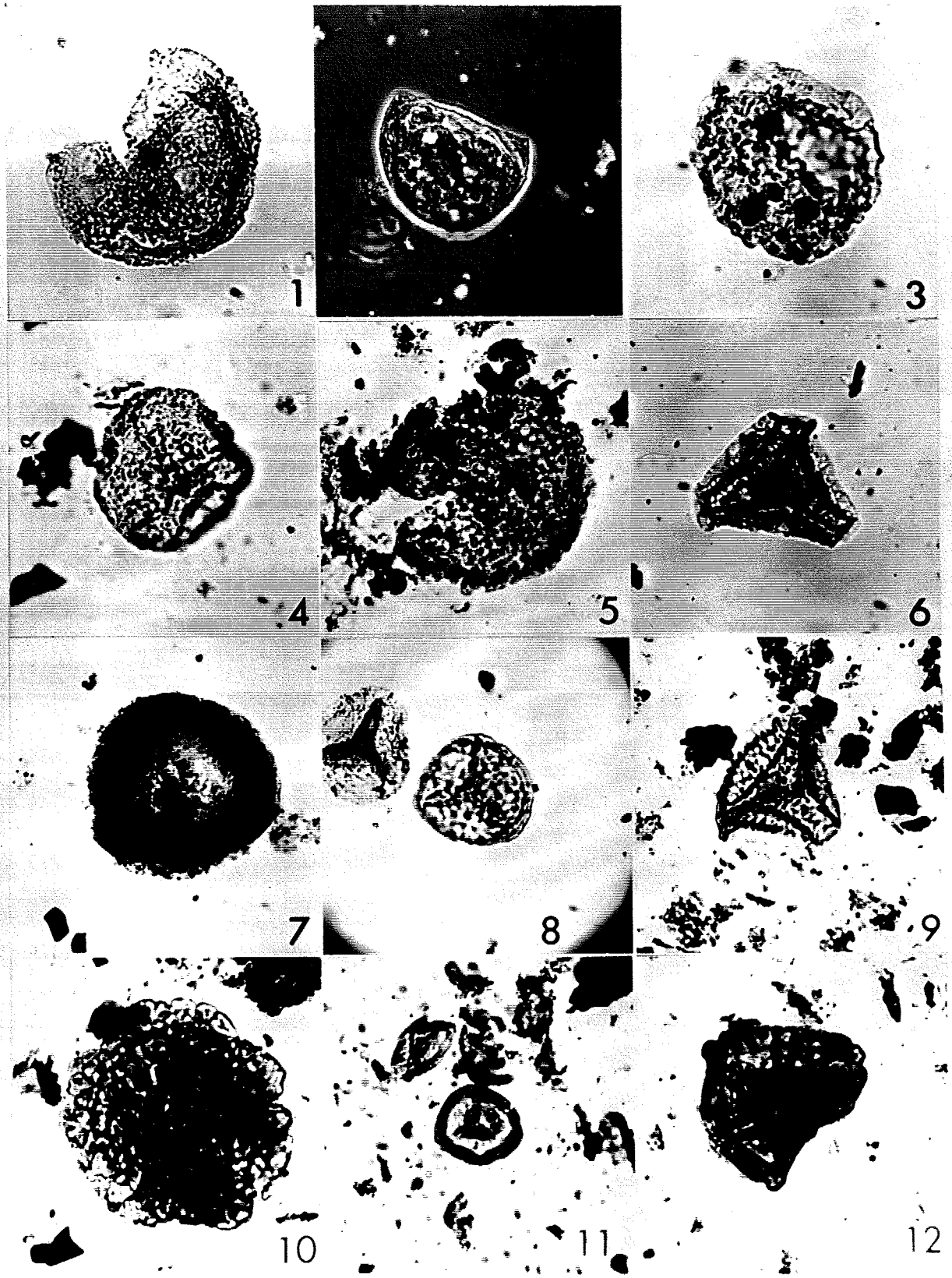
PLATE 2

1.	Rhaetipollis germanicus	2400' - 2490'
2.	Granuloperculatipollis sp.	3200' - 3290'
3.	Semiretisporis gothae	3810' - 3890'
4.	Polycingulatisporites sp.	6400' - 6490'
5.	Ricciisporites sp.	6400' - 6490'
6.	RHNO-2 (Sverdrupiella usitata)	2300' - 2390'
7.	RHNO-6 (S. septentrionalis)	3200' - 3290'
8.	RHNO-8,9 (S. mutabilis)	3200' - 3290'
9.	RHNO-2 (S. usitata)	3400' - 3490'
10.	Sverdrupiella downiei	3400' - 3490'
11.	RHNO-3 (S. cristata)	3400' - 3490'

PLATE 3

1.	*Sverdrupiella spinosa*	3500' - 3590'
2.	*Sverdrupiella spinosa*	3500' - 3590'
3.	*Sverdrupiella sabinensis*	3500' - 3590'
4.	RHNO-5 (*S. baccata*)	6400' - 6490'
5.	*Micrhystridium* sp.	6700' - 6790'
6.	*Micrhystridium* sp.	6700' - 6790'
7.	cf. *Micrhystridium* sp.	6700' - 6790'
8.	*Stereisporites* sp.	6700' - 6790'
9.	*Nevesisporites fossulatus*	8300' - 8390'
10.	*Protohaploxypinus* sp.	8300' - 8390'
11.	*Veryhachium* sp.	8300' - 8390'
12.	*Protohaploxypinus* sp.	8300' - 8390'

PLATE 1



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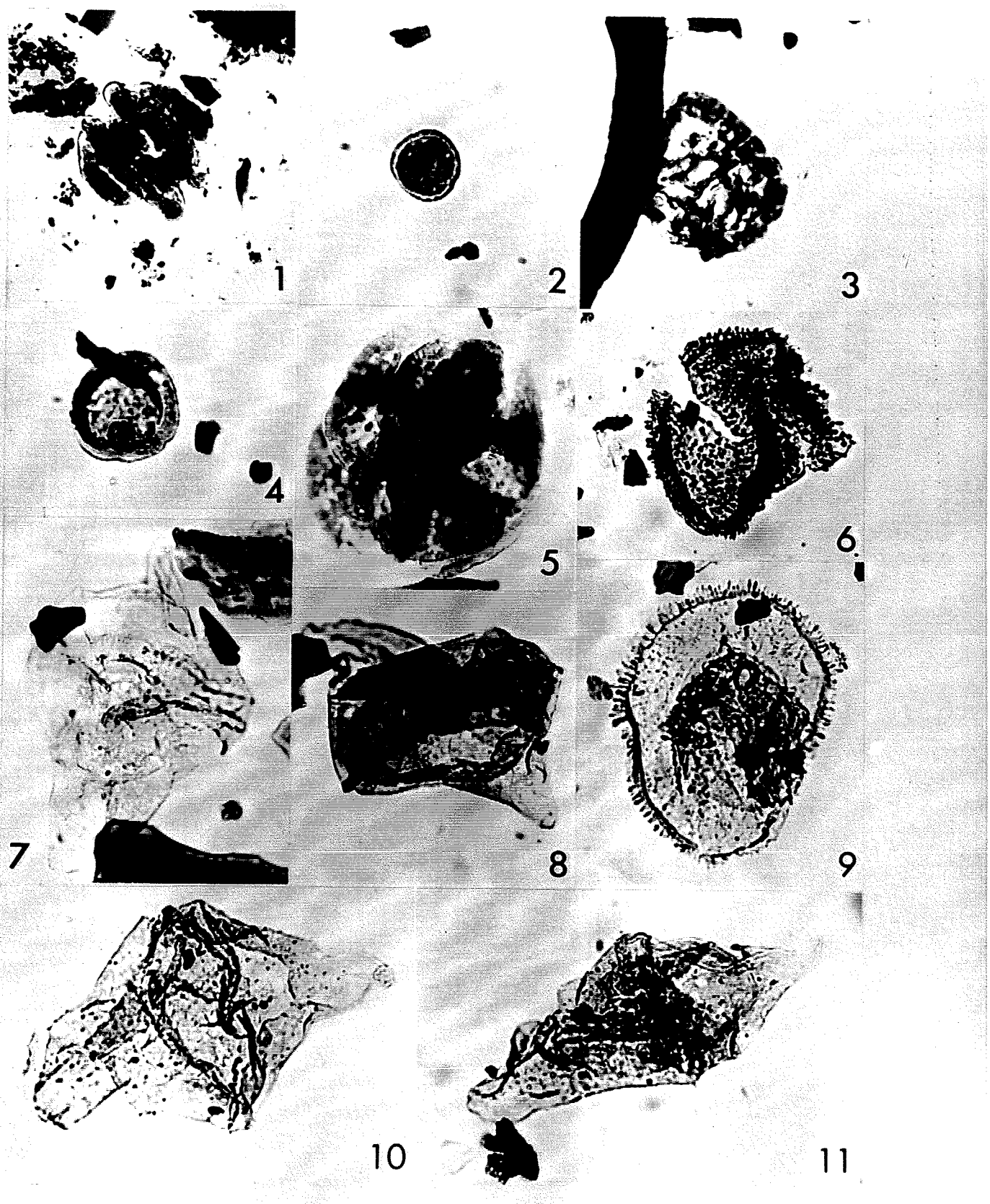
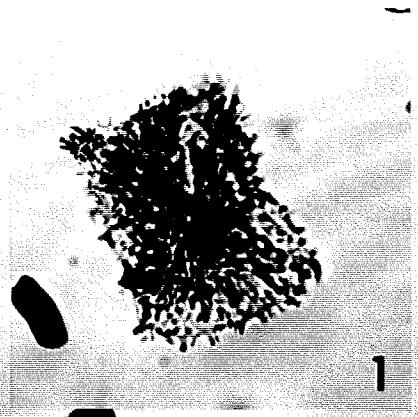


PLATE 3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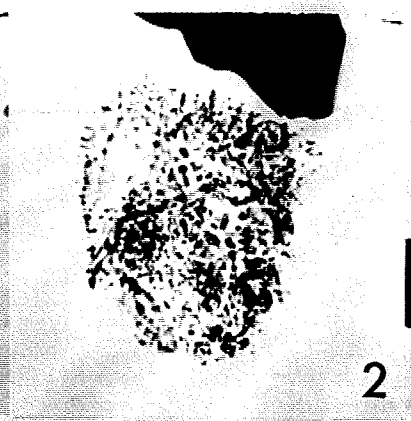
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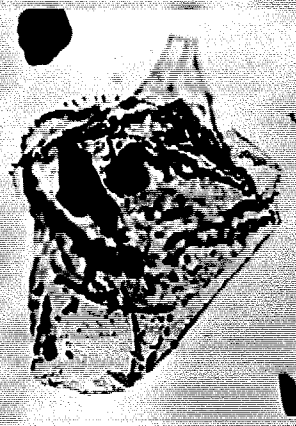
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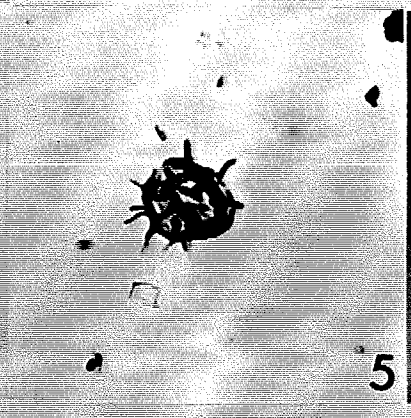
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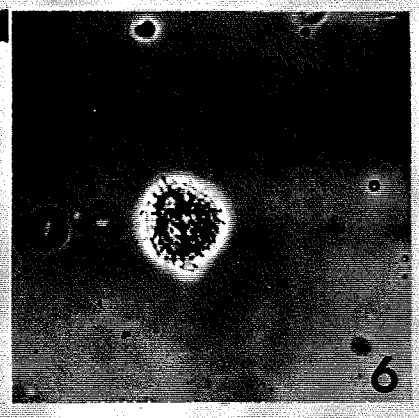
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