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PRELIMINARY PALEOPALYNOLOGY OF THE KANGUK FORMATION (UPPER CRETACEOUS), REMUS CREEK, CANADIAN ARCTIC ARCHIPELAGO: I. MARINE PALYNOMORPHS

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ABSTRACT

A 39 m section of the Kanguk Formation (Upper Turonian to Lower Campanian) on Remus Creek, Ellesmere Island, was sampled at about one metre intervals to provide stratigraphic control on palynomorph taxa present. These samples yield well-preserved marine and terrestrial palynofloras represented by a total of 181 taxa, of which 103 are dinocysts and acritarchs and represent 51 % of the population. Based on the abundance and type of taxa present the section can be divided into a lower, dinocyst dominated interval, and an upper interval, where dinocysts are present in lower numbers and terrestrial palynomorphs dominate. In the lower part dinocysts are abundant, diverse and well-preserved. Chorate cysts are the most abundant in terms of species diversity and numbers of specimens, however, cavate dinocysts are common also. In turn, in the upper part of the section, marine palynomorphs are much less common, poorly preserved and sporadic in occurrence. Acritarchs account for a small but significant proportion of the marine assemblages. Small numbers of taxa of Albian-Cenomanian age are considered to be reworked from the underlying Hassel Formation. This indicates an unconformity between the Hassel and Kanguk formations.

Keywords: Upper Cretaceous, Marine palynomorphs, Kanguk Formation, Remus Creek, Ellesmere Island, Canadian Arctic Archipelago.

RESUMEN

El análisis palinológico de una sección de 39 metros de la Formación Kanguk (Turoniense sup. al Campaniense inf.) en Remus Creek, Isla de Ellesmere, mediante muestras recolectadas a intervalos de un metro con el fin de obtener un control estratigráfico de la presencia de taxones en la sección, ha permitido recuperar en un buen estado de conservación, un total de 181 taxones marinos y terrestres, incluyendo 103 dinoquistes y acritarcos. Los marinos presentan una diversidad específica más alta que los terrestres, pero sólo un 51 % del total es marino. Basándose en la abundancia y distribución de los taxones a lo largo de la sección ésta puede ser dividida en dos partes, una inferior dominada por dinoquistes y una superior donde los dinoquistes aparecen en pequeñas cantidades y dominada por palinomorfos terrestres. En la parte inferior los dinoquistes son abundantes, diversos y en buen estado de conservación. Los dinoquistes corados son los más numerosos tanto en términos de diversidad específica como en cantidad absoluta de especímenes, seguidos por los dinoquistes cavados. Sin embargo, en la parte superior los palinomorfos marinos son mucho menos abundantes, están peor conservados y aparecen esporádicamente. Los acritarcos se encuentran en pequeñas pero significativas cantidades en las asociaciones marinas. Taxones de edad Albiense-Cenomaniense y que aparecen en pequeñas cantidades son considerados como reciclados de la infrayacente Formación Hassel. Estos taxones documentan la presencia de una disconformidad entre las formaciones Hassel y Kanguk.

Palabras clave: Palinomorfos marinos, Cretácico Superior, Formación Kanguk, Remus Creek, Archipiélago Ártico Canadiense.

INTRODUCTION

The present study provides detailed information on marine palynomorph content of the Kanguk Formation from Remus Creek, Ellesmere Island, Canadian Arctic Archipelago. The fact that this formation is present in remote areas of the Arctic, and has neither any outstanding lithological features nor any known economic prospects constitute the reasons it has been so poorly studied. It is, however, important because of the potential for palynomorphs to provide a northern link between Western and Eastern North American seaways during the Late Cretaceous, and to test latitudinal variation in dinocyst taxa.

Although marine and terrestrial palynomorphs are abundant, diverse and well preserved in the Kanguk Formation (Doerenkamp *et al.*, 1976; Felix and Burbridge, 1973, 1976; Ioannides, 1986; Manum, 1963; Manum and Cookson, 1964; Núñez-Betelu, 1991) detailed stratigraphic studies have not been undertaken.

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GEOLOGICAL FRAMEWORK

The Kanguk Formation is widespread in the Arctic Islands and occurs in the Sverdrup Basin, Franklinian Geosyncline and Arctic Platform (Fig. 1) indicating that it once covered large parts of the Canadian Arctic Archipelago (Stewart, 1987). It is the youngest major marine Mesozoic formation in the Canadian Arctic Archipelago and was defined by Souther (1963) from western Axel Heiberg Island where it consists predominantly of dark grey shale, siltstone and smaller amounts of interbedded fine- to medium-grained sandstone. Tuffaceous and bentonitic beds occur at the base. On Banks Island the predominant lithology is carbonaceous shale, but porous, deltaic, fluvial sandstone beds are interdigitated (McWhae, 1981). The Kanguk Formation is generally conformably to disconformably overlain by the Eureka Sound Group. Except on Western Axel Heiberg Island where it is underlain by the Strand Fiord or the Bastion Ridge formations, the Kanguk Formation is unconformably to conformably underlain by the Hassel Formation (Ricketts, 1991; Souther, 1963; *pers. obs.*). It ranges from about 70 m on Ellesmere Island to about 1000 m thick on Bylot Island (Miall *et al.,* 1980).

A prominent unit of black, bituminous shale is present at the base of the formation in most of the sections in the Arctic (Miall, 1979). This bituminous shale was deposited in an euxinic environment of very wide areal extent. The high bituminous content and the tuff and bentonite beds and manganese spherulites indicate that the environment was unusual and associated with volcanic activity. Preservation of the very thin tuffaceous clay beds implies low-energy conditions of accumulation that may be related to a postulated lack of direct free circulation between the Atlantic and Arctic oceans (Gradstein and Srivastava, 1980; Lentin and Williams, 1981). These bentonite beds imparted an extreme acidity to the Kanguk shale with pH values ranging from 2.65 to 5.1 with an average of 3.4 (Balkwill, 1983). This extreme acidity may have caused significant leaching, and, thus, explain the paucity of calcareous foraminifers (Wall, 1983).

Figure 1. Geological elements of the Canadian Arctic Islands and study area (Modified from Balkwill, 1983 and Wall, 1983).

The remainder of the Kanguk Formation records an open-marine environment with the accumulation of a thick succession of silty shale derived from adjacent, lowlying land areas and interbedded sandstone, likely from shoreface and foreshore facies with shallow subtidal to intertidal sand bars localized over shoals in the Kanguk sea. Planar crossbed sets may represent point bar deposits in tidal channels (Miall, 1979). Jeletzky (1978) emphasized that these rocks probably accumulated in an arcuate, northward-facing seaway that connected the Canadian Western Interior Basin with ancestral Baffin Bay and eastern Greenland. Foraminifera and radiolaria permitted Wall (1983) to correlate the Kanguk Formation with the Patoo beds of Disco Bay, west Greenland. The Patoo fauna shows affinities with assemblages from the western interior of continental North America and indicates a direct marine link between the Canadian Arctic Islands and west Greenland.

Originally, a Santonian to Campanian age was assigned to the formation (Souther, 1963) in the type area, but subsequent studies (Balkwill, 1983; Miall, 1979) questioned this age assignment. Jeletzky (1978) and Miall (1979) considered the oldest age for the formation to be Eearly Turonian. In turn, Wall (1983) proposed a Turonian to Late Campanian age for the Foraminifera recovered from this formation on Ellesmere Island. Based on the presence of the dinocyst ? *Isabelidinium globosum* at the base and *Wodehouseia-Azonia* type pollen in the upper part, the Remus Creek section of the Kanguk Formation is considered to be Late Turonian to Late Campanian in age. (McIntyre, 1990; Núñez-Betelu, 1991; Wiggins, 1976).

Moreover, the Kanguk shale yields a fauna in which the genus *Inoceramus* is particularly abundant (Greiner, 1963). Specimens belonging to the *Inoceramus lobatus* group (Santonian-Campanian) are common in the type section and in the upper Kanguk shales on Axel Heiberg and Ellef Ringnes islands (Fig. 1). Radiolaria typically are found only in the tuffaceous horizons in the Kanguk Formation probably resulting from the break down of these sediments and release of silica into marine waters (Wall, 1983).

Stratigraphy of the Kanguk Fm., Remus Creek, Ellesmere Island

This section was selected because of its relatively uniform shale lithology, known basal transgressive and upper regressive character and the suitable nature of the sediments for palynological analysis.

At Remus Creek the Kanguk Fm is disconformably underlain by the Hassel Fm and is conformably overlain by the Eureka Sound Group. The top of the deltaic Hassel sandstones is sharp and erosive indicating the presence of an unconformity between the Hassel and the overlying Kanguk dark mudstones. The upper part of the Kanguk Fm. becomes silty and sandy and is transitional with the overlying Eureka Sound Group.

The formation is about 70 m thick on Remus Creek (lat 79° 56', long. 85° 09') and partly exposed. The studied section (Fig. 2) comprises organic-rich mudstones with two thin siltstones interbedded in the upper part. A thick fine-grained sandstone constitutes the top of the section. A horizon rich in *Inoceramus* sp. is

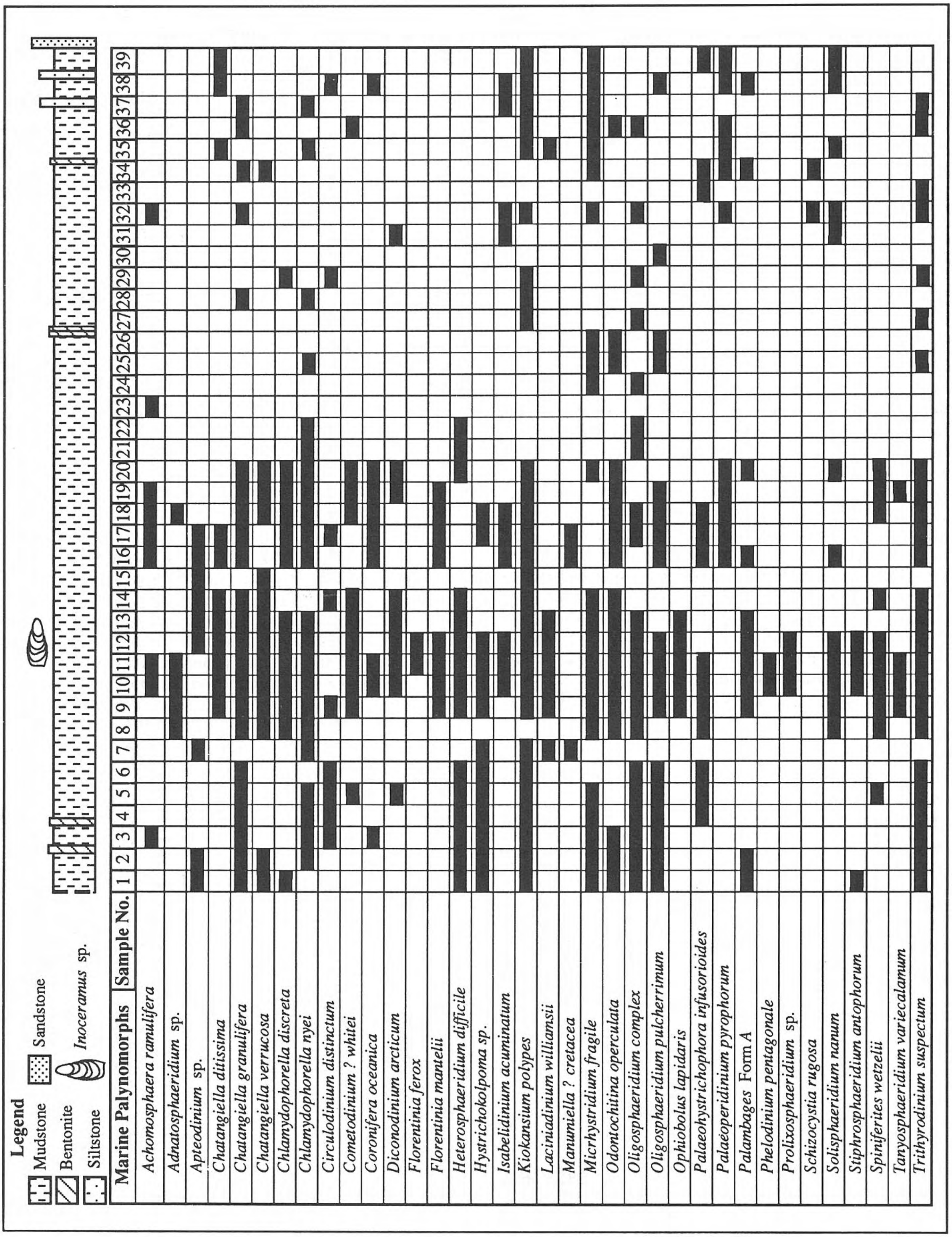


Figure 2. Kanguk Formation. Stratigraphic occurrences of principal marine palynomorph taxa from Remus Creek and columnar representation of the lithology of the section. Samples are spaced at one metre intervals and taxa arranged in alphabetical order.

present at about 12 m. above the base of the section. Bentonite beds are interbedded mainly in the lower part and ironstone concretionary beds are common about the middle of the section. These siderite nodules often contain very well-preserved *Inoceramus* sp. shells.

RELATED PALYNOLOGICAL STUDIES

Six previous publications deal with the palynology of the Kanguk Formation (Doerenkamp *et al.,* 1976; Felix and Burbridge, 1973, 1976; Ioannides, 1986; Manum, 1963; Manum and Cookson, 1964).

The pioneer studies on Late Cretaceous dinocysts in the Arctic Islands are those by Manum (1963), and Manum and Cookson (1964). Both publications deal with the same Graham Island sample, which was poorly located both stratigraphically and geographically. Felix and Burbridge (1976), in a study of organic-walled microplankton recovered from reliably identified Kanguk shales, show that Manum and Cookson's material was remarkably similar to their assemblages, and bore no resemblance to known assemblages from the Hassel Formation (Doerenkamp *et al.* 1976) as Manum and Cookson (1964) had previously proposed. All these studies provide some control on palynomorphs present but do not detail their distribution, paleoecologic significance and importance. Thus, a systematic collection of samples was carried out on Remus Creek, Ellesmere Island, to determine the biostratigraphy and paleoecological significance of palynomorphs present. Analysis of these samples yield both marine and terrestrial palynomorphs. The marine palynomorphs are more abundant (51 % of total) than the terrestrial ones and consist of fossil non-calcareous microplankton, mainly dinocysts and acritarchs. Terrestrial palynomorphs consist of miospores and gymnosperm and angiosperm pollen (Núñez-Betelu and Hills, 1992).

Studies providing additional information on late Cretaceous marine palynofloras of North America include the reports on Late Cretaceous assemblages from Alberta by Brideaux (1971); offshore southeastern Canada by Bujak and Williams (1978), Hyslop (1986) and Williams and Brideaux (1975); Drugg (1967) from California; Firth (1987) from Georgia, U.S.A.; Krause *et al.,* (*in press*) from Alberta; McIntyre (1974) form the District of Mackenzie; Singh (1983) from Alberta; Sweet and McIntyre (1988) from Alberta; and Zaitzeff and Croos (1970) from Texas.

SAMPLING AND LABORATORY TECHNIQUES

Thirty-nine samples were systematically collected from the Kanguk Formation at Remus Creek. Only part of the formation could be sampled due to partial exposure. The sampled section is 39 metres thick and comprises shale from the first to the 37th metre and then, two thin siltstones interbedded with shale up to the 39th metre where a thick fine-grained sandstone is present (Fig. 2).

Sampling was done at one metre intervals to determine introduction of taxa. Samples were processed at the laboratory of palynology (Department of Geology and Geophysics, The University of Calgary) following a standard palynological technique that includes breakdown of the rocks in hydrochloric and hydrofluoric acids, followed by heavy liquid separation, oxidation and staining and permanent mounting of the residues in polyvinyl alcohol sealed to glass slides with bioplastic (Barss and Williams, 1973). Samples were numbered in stratigraphic order from lowest (No. 1) to highest (No. 39). Generally three to five slides per sample were examined by traversing each slide at a magnification of x 200 lengthwise along lines 1 mm apart. The specimens of various taxa were identified, counted and recorded for later analysis.

After complete analysis of the samples, the six with highest diversity and best preservation, were selected for SEM photography. For this purpose, a 12 mm rounded cover slip was glued on a stub. The palynomorph residue, mixed with a drop of methanol, was placed on the coverslip. The mixing with methanol helps in bringing about an even distribution of the palynomorphs on the surface and is fast drying. Finally, samples were gold-coated twice following the standard technique for SEM analysis.

Palynological analysis

Within individual samples, various microfossil entities show considerable variation in preservation. Bisaccate pollen are perhaps the most susceptible to corrosion and damage from the impingement of mineral grains and thermal alteration (Núñez-Betelu and Hills, 1992), whereas dinocysts are generally very well-preserved.

Originally it was intended to count about 300 specimens per sample since this was considered to be a sufficient number of specimens to include with certainty all taxa present in the sample. A total of 15,625 specimens were counted and identified as far as the preservation allowed and, for example, in some taxa preservation permited identification only to the generic level as in *Hystrichokolpoma* sp. This total number of specimens makes a mean average of 400 specimens per sample. Also in a few samples, due to excellent preservation and abundance of specimens, all slides were studied reaching a total of 800 to 1000 specimens. These high counts were used because it is becoming increasingly evident that dinocysts can have high intraspecific variability (May, 1980), and because of the view expressed by Newell (1956) of the importance of dealing with sufficiently large populations in order to observe the inherent variability of the organism under consideration. Discontinuities in small populations may form conspicuous anomalies, but may be placed within gradational contemporaneous series as individual variants of large populations. For this reason a high number of specimens were studied in this project.

RESULTS

Altogether, 181 taxa, 103 species of dinocysts and acritarchs (Table 1 and 2), and 78 species of terrestrial palynomorphs (Núñez-Betelu and Hills, 1992) were recovered from the Remus Creek samples.

CLASS DINOPHYCEAE

Group APICAL ARCHEOPYLE

Subgroup Acavate, Proximate Cyst

Batioladinium sp.
D ® *Cassiculosphaeridia reticulata* Davey, 1969
Circulodinium distinctum (Deflandre & Cookson, 1955) Jansonius, 1986.
Dinogymnium cf. *D. acuminatum* Evitt, Clarke & Verdier, 1967
D *Fromea fragilis* (Cookson & Eisenack, 1962) Stover & Evitt, 1978.
Microdinium sp.
Palaeostomocystis reticulata Deflandre 1937
Palaeostomocystis sp. *A*

Subgroup Acavate, Proximochorate Cyst

D *Cyclonephelium* sp.
Prolixosphaeridium sp.
Sentusidinium sp.

Subgroup Acavate, Skolochorate Cyst

Adnatosphaeridium sp.
Areoligera senonensis Lejeune-Carpentier, 1938
Areosphaeridium sp.
Cleistosphaeridium ? aciculare Davey 1969
Cleistosphaeridium diversispinosum Davey *et al.*, 1966
® *Cleistosphaeridium ? multispinosum* (Singh, 1964) Brideaux, 1971
Heterosphaeridium difficile (Manum & Cookson, 1964) Ioannides, 1986
Hystrichiokolpoma sp.
Hystrichosphaeridium sp.
® *Oligosphaeridium albertense* (Pocock, 1962) Davey & Williams, 1969
D *Oligosphaeridium complex* (White, 1982) Davey & Williams, 1966b
D *Oligosphaeridium pulcherrimum* (Deflandre & Cookson, 1955) Davey & Williams, 1966
D *Stiphrosphaeridium anthophorum* (Cookson & Eisenack, 1958) Davey, 1982
Surculosphaeridium ? longifurcatum (Firtion, 1952) Davey, *et al.*, 1966
® *Tanyosphaeridium salpinx* Norvick, 1976.
Tanyosphaeridium variecalamum Davey & Williams, 1966

Subgroup Cavate, Proximate Cyst

Chlamydophorella discreta Clarke & Verdier, 1967
D *Chlamydophorella nyei* Cookson & Eisenack, 1958
Craspedodinium, sp.
Gardodinium, sp.
Leberidocysta chlamydata (Cookson & Eisenack, 1962) Stover & Evitt, 1978
Odontochitina costata Alberti, 1961; emend. Clarke & Verdier, 1967
D *Odontochitina operculata* (Wetzel, 1933) Deflandre & Cookson, 1955
Trigonopixidia ginella (Cookson & Eisenack, 1961) Downie & Sarjeant, 1965
D *Wallodinium anglicum* (Cookson & Hughes, 1964) Lentin & Williams, 1973

Group INTERCALARY ARCHEOPYLE

Subgroup Acavate, Proximate Cyst

Diconodinium arcticum Manum & Cookson, 1964
Diconodinium sp. *A*
Hexagonifera glabra Cookson & Eisenack, 1961
Paragonyaulacysta sp.
Pareodinia ceratophora Deflandre, 1947; emend. Gocht, 1970
Isabelidinium acuminatum (Cookson & Eisenack, 1958) Stover & Evitt, 1978
Isabelidinium ? globosum (Davey, 1970) Lentin & Williams, 1977
Manumiella ? cretacea (Cookson, 1956) Bujak & Davies, 1983
Nelsoniella sp.
Palaeocystodinium sp.
Phelodinium pentagonale (Corradini, 1973) Stover & Evitt, 1978
Spinidinium sverdrupianum (Manum, 1963) Lentin & Williams, 1973
Spinidinium sp. *A*
Trithyrodinium suspectum (Manum & Cookson, 1964) Davey, 1969

Subgroup Acavate, Skolochorate Cyst

Operculodinium sp.

Subgroup Cavate, Proximate Cyst

Alterbidinium minor (Alberti, 1959) Lentin & Williams, 1985
Chatangiella ditissima (McIntyre, 1975) Lentin & Williams, 1976
D *Chatangiella granulifera* (Manum, 1963) Lentin & Williams, 1976
Chatangiella verrucosa (Manum, 1963) Lentin & Williams, 1976
Deflandrea sp.

Group PRECINGULAR ARCHEOPYLE

Subgroup Acavate, Proximate Cyst

Apteodinium sp. *A*

Subgroup Acavate, Proximochorate Cyst

Pterodinium cingulatum (Wetzel, 1933) Below, 1981

Subgroup Acavate, Skolochorate Cyst

Achomosphaera ramulifera (Deflandre, 1937) Evitt, 1963
Callaiosphaeridium asymmetricum (Deflandre & Courteville, 1939) Davey & Williams, 1966
Cordosphaeridium sp.
D *Coronifera oceanica* Cookson & Eisenack, 1958; emend. May, 1980
Fibrocysta sp.
® *Florentinia cooksoniae* (Singh, 1971) Duxbury, 1980
Florentinia ferox (Deflandre, 1937) Duxbury, 1980
Florentinia mantellii (Davey & Williams, 1966) Davey & Verdier, 1973
® *Florentinia verdieri* Singh, 1983
Hystrichodinium sp.
Kiokansium polypes (Cookson & Eisenack, 1962) Below, 1982
D *Spiniferites ramosus* (Ehrenberg, 1838) Loeblich & Loeblich, 1966
Spiniferites scabrosus (Clarke & Verdier, 1967) Lentin & Williams, 1975
Spiniferites wetzelii (Deflandre, 1937) Sarjeant, 1970

Subgroup Cavate, Proximate Cyst

D ® *Gonyaulacysta cassidata* (Eisenack & Cookson, 1960) Sarjeant, 1966
® *Gonyaulacysta cretacea* (Neale & Sarjeant, 1962) Sarjeant, 1969
Scriniodinium sp.
Thalassiphora sp.

Group COMBINATION ARCHEOPYLES

Subgroup Acavate, Proximate Cyst

Laciniadinium williamsii Ioannides, 1986
Palaeoperidinium cretaceum Pocock, 1962; emend. Davey, 1970
D *Palaeoperidinium pyrophorum* (Ehrenberg, 1838) Sarjeant, 1967

Subgroup Acavate, Skolochorate Cyst

Lingulodinium sp.

Subgroup Cavate, Proximate Cyst

Ascodinium sp.
Luxadinium sp.

Subgroup Cavate, Proximochorate Cyst

Palaeohystrichophora infusorioides Deflandre, 1935

Group UNKNOWN ARCHEOPYLE

Subgroup Acavate, Skolochorate Cyst

Cometodinium ? whitei (Deflandre & Courteville, 1939) Stover & Evitt, 1978

Subgroup Acavate, Proximochorate Cyst

Raphidodinium sp. *A*

Subgroup Cavate, Proximate Cyst

Dingodinium sp.

Table 1. Dinocyst taxa from the Kanguk Formation at Remus Creek. These taxa have been allocated to suprageneric categories following the classifications proposed by Sarjeant and Downie (1966), Downie *et al.* (1963) and Singh (1983). These classifications are based on morphological characters and, thus, taxa are arranged on the basis of paratabulation, shape, overall similarity in appearance, etc. (®): reworked taxa; (D): dinocysts also described from the Hassel Fm. by Doerenkamp *et al.* (1976).

Following Singh (1983) and Stover and Evitt (1978) the Remus Creek microplankton taxa (Table 1 and 2) have been assigned to suprageneric categories outlined in the classifications proposed by Sarjeant and Downie (1966) and Downie *et al.* (1963) for fossil dinocysts and acritarchs. The classification is based on morphological characters at the suprageneric level.

Stratigraphic ranges of principal marine palynomorphs at Remus Creek are presented on Fig. 2. These taxa are photographically represented in Plates I-III.

The stratigraphic distribution of selected marine palynomorphs (dinocysts and acritarchs) indicates that the section can be subdivided into two units (Fig. 2). The lower unit (1-21 m) is characterized by abundant marine palynomorphs whereas in the upper unit the marine taxa are less common and sporadic in occurrence. This indicates that the lower part of the Kanguk Fm is more marine than the upper part.

Chorate dinocysts exhibit the highest species diversity and highest number of specimens, followed by cavate cysts and the relatively accessory presence of proximate cysts (Table 1). The following taxa (Fig. 2) are most abundant: *Chatangiella granulifera* (Pl. II, fig. 3), *C. verrucosa* (Pl. II, fig. 4), *Chlamydophorella discreta* (Pl. I, fig. 10), *C. nyei* (Pl. I, fig. 11), *Hystrichokolpoma* sp. (Pl. I, fig. 5), *Kiokansium polypes* (Pl. III, fig. 2), *Oligosphaeridium complex* (Pl. I, fig. 6), *O. pulcherrimum* Pl. I, fig. 7), *Palaeohystrichophora infusorioides* (Pl. III, fig. 6), *Palambages* Form *A* (Pl. III, fig. 11), *Spiniferites ramosus* (Pl. III, fig. 3), and *Trithyrodinium suspectum* (Pl. II, fig. 8). All are well-preserved except *Hystrichokolpoma* sp. which often has all processes broken or is otherwise poorly preserved.

The peak relative abundance of microplankton (90 %), best preservation and highest diversity (40 species) occur at approximately 12 m above the base coinciding with a level rich in *Inoceramus* sp. Higher in the section the relative percentage of marine palynomorphs decreases, and at about 30 m above the base only two poorly preserved species (Fig. 2), *Oligosphaeridium pulcherrimum* (Pl. I, fig. 7) and *Spiniferites ramosus* (Pl. III, fig. 3), are present and only in low numbers (3 %). Higher in the section, preservation and relative percentage improve slightly.

Acritarchs are present throughout the section and account for less that 10 % of the marine palynomorphs. They tend to be long ranging species. The most common acritarchs in these samples are *Micrhystridium fragile* and *Palambages* Form *A* (Pl. III, fig. 8 and. fig. 11, respectively).

Group ACRITARCHA Evitt, 1963
Subgroup Acanthomorphitae
- *Baltisphaeridium fimbriatum* (White, 1842) Sarjeant, 1959
- *Baltisphaeridium,* sp. *A*
- ® *Micrhystridium* cf. *M. breve* Jansonius, 1962
- *Micrhystridium fragile* Deflandre, 1947
- *Micrhystridium inconspicuum* (Deflandre, 1935) Deflandre 1937; emend. Downie & Sarjeant, 1963
- *Micrhystridium recurvatum* forma *brevispinosa* Valensi, 1953
- *Micrhystridium shinetonense* Downie, 1958.
- *Micrhystridium singulare* Firtion, 1952
- *Micrhystridium stellatum* Deflandre, 1945
- *Solisphaeridium nanum* (Deflandre, 1945) Turner, 1984

Subgroup Polygonomorphitae
- *Veryhachium reductum* (Deunff, 1958) Jekhowsky, 1961

Subgroup Herkomorphitae
- *Cymatiosphaera* sp.

Subgroup Pteromorphitae
- *Pterospermella* sp. *A*

Incertae Sedis
- *Ophibolus lapidaris* Wetzel, 1932
- D *Palambages* Form *A* Manum & Cookson, 1964
- *Palambages* Form *C* Manum & Cookson, 1964
- *Schizocystia rugosa* Cookson & Eisenack, 1962

Table 2. Acritarch taxa from the Kanguk Formation at Remus Creek, after the classification by Downie *et al.* (1963). They classified acritarchs as form-genera and proposed one group and 14 subgroups. (®): reworked taxa; (D): acritarchs also found in the Hassel Fm. by Doerenkamp *et al.* (1976).

REWORKED MARINE PALYNOMORPHS

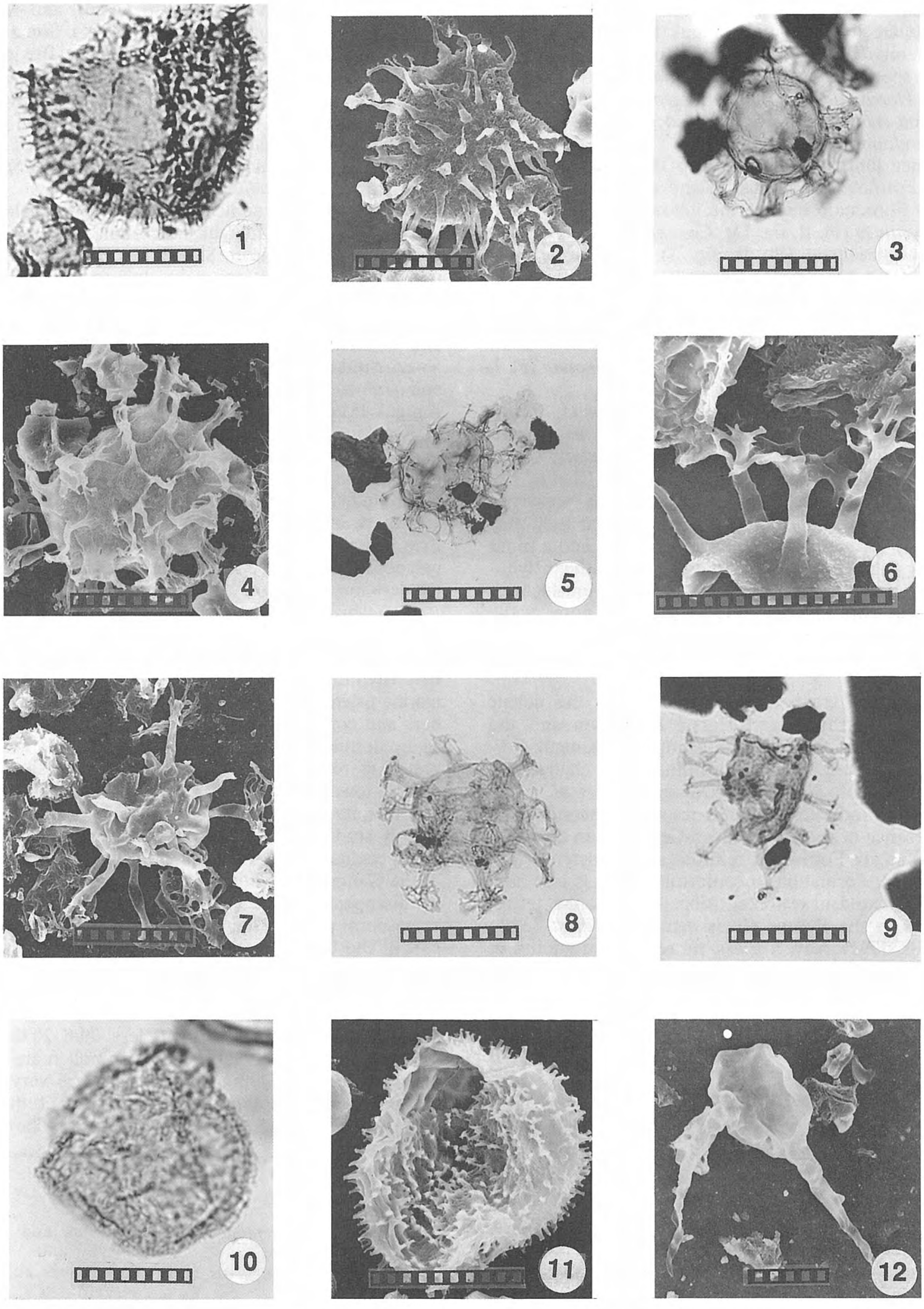
Reworked taxa are present in very small numbers (only 2 to 5 specimens were encountered for some of them). They often are poorly preserved and darker coloured than associated taxa. Some of these rare taxa have been reported from older rocks from several regions of North America (Brideaux, 1971; Brideaux and McIntyre, 1975; Doerenkamp *et al.,* 1976; Hyslop, 1986; Singh, 1964, 1971, 1983) and their known age ranges indicate that they have been reworked from Albian-Cenomanian sediments.

Reworked taxa include *Cassiculosphaeridia reticulata, Cleistosphaeridium ? multispinosum, Florentinia cooksoniae, F. verdieri, Gonyaulacysta cassidata, G. cretacea, Oligosphaeridium albertense,* and *Tanyosphaeridum salpinx.*

Doerenkamp *et al.* (1976) reported the presence of *Cassiculosphaeridia reticulata* and *Gonyaulacysta cassidata* in the Hassel Fm. on Banks Island but did not

Plate I
1. *Circulodinium distinctum* (Deflandre and Cookson) Jansonius, UCG029-38 1/5.
2. *Prolixosphaeridium* sp., UCG029-10a 1/5, SEM.
3. *Adnatosphaeridium* sp., UCG029-10a 1/5.
4. *Heterosphaeridium difficile* (Manum and Cookson) Ioannides, UCG029-9 1/5, SEM.
5. *Hystrichokolpoma* sp., UCG029-7 1/5.
6. *Oligosphaeridium complex* (White) Davey and Williams, UCG029-9 1/5, SEM.
7. *Oligosphaeridium pulcherrimum* (Deflandre and Cookson) Davey and Williams, UCG029-12 1/5, SEM.
8. *Stiphrosphaeridium anthophorum* (Cookson and Eisenack) Davey, UCG029-10a 1/5.
9. *Tanyosphaeridium variecalamum* Davey and Williams, UCG029-19a 1/5.
10. *Chlamydophorella discreta* Clarke and Verdier, UCG029-11a 2/5.
11. *Chlamydophorella nyei* Cookson and Eisenack, UCG029-12 1/5, SEM.
12. *Odontochitina operculata* (Wetzel) Deflandre and Cookson, UCG029-13 1/5, SEM.

Plate I



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Unless otherwise stated the pictures are from the light microscope. In the explanation of figures illustrated, the species name is followed by a slide number in which the first part refers to the University collection number and the second to the sample number. Scale bar representes 30 μm.

find them in the overlying Kanguk Fm. These reworked taxa are found in the Kanguk Formation samples from Remus Creek together with other Albian-Cenomanian species including *Cleistosphaeridium ? multispinosum, Florentinia cooksoniae, Florentinia verdieri, Gonyaulacysta cretacea, Oligosphaeridium albertense* and *Tanyosphaeridium salpinx.*

Other long ranging taxa also described from the Hassel Formation on Banks Island and present in the Kanguk Formation include the following (Fig. 2): *Coronifera oceanica* (Pl. II, fig. 11), *Cyclonephelium* sp., *Chatangiella granulifera* (Pl. II, fig. 3), *Chlamydophorella nyei* (Pl. I, fig. 11), *Fromea fragilis, Odontochitina operculata* (Pl. I, fig. 12), *Oligosphaeridium complex* (Pl. I, fig. 6), *Oligosphaeridium pulcherrimum* (Pl. I, fig. 7), *Palaeoperidinium pyrophorum* (Pl. III, fig. 5), *Spiniferites ramosus* (Pl. III, fig. 3), *Stiphrosphaeridium anthophorum* (Pl. I, fig. 8), and *Wallodinium anglicum.*

Many acritarchs, including *Micrhystridium* cf. *M. breve, Micrhystridium inconspicuum, Micrhystridium recurvatum* forma *brevispinosa, Micrhystridium singulare, Cymatiosphaera* sp. and *Schizocystia rugosa* (Pl. III, fig. 12), are very dark coloured, pyrite pitted, poorly preserved and very long ranging in age suggesting that they may have gone through several reworking cycles and a more complex thermal history than the rest of the palynomorphs. However, no acritarchs have previously been mentioned from the Hassel Formation and none of the taxa found in the Kanguk is known as exclusively Albian-Cenomanian in age. Therefore, their source cannot be established.

At Remus creek the contact between the deltaic sandstones of the Albian Hassel Formation and the marine shales of the Turonian-Campanian Kanguk Formation is marked by an abrupt lithological change and a major palynological break (Doerenkamp *et al.,* 1976) and strongly indicates the presence of an unconformity. The presence of reworked Albian-Cenomanian dinocysts in the Kanguk Formation reinforces the existence of a sub Kanguk Formation unconformity. This is also supported by abundant reworked Albian-Cenomanian terrestrial taxa in the Remus Creek samples (Núñez-Betelu and Hills, 1992). Nevertheless, more detailed studies of the Hassel Formation are necessary to fully understand the amount of reworking that has taken place.

DISCUSSION

The assemblages recovered from the Kanguk Formation on Remus Creek also present certain similarities with those described by Manum (1963), and Manum and Cookson (1964) and Ioannides (1986). Some of the taxa common to all these previous and the present study include *Chatangiella granulifera, Chatangiella verrucosa, Diconodinium arcticum* (Pl. II, fig. 1), *Heterosphaeridium difficile* (Pl. I, fig. 4), *Micrhystridium fragile, Odontochitina operculata, Oligosphaeridium complex, Oligosphaeridium pulcherrimum, Palambages* Form *A, Spiniferites ramosus, Trithyrodinium suspectum.*

Although close similarities between microplankton-assemblages of the Kanguk Formation and Upper Cretaceous formations from Siberia can be expected, comparisons are difficult to make due to the scarcity of readily available data from Siberia. The only works available are those by Lentin and Vozzhennikova (1990) and Vozzhennikova (1967) on dinocysts from the U.S.S.R. Vozzhennikova (1967) reported *Chatangiella granulifera* and *Trithyrodinium suspectum* which are common in the Kanguk Formation from the Santonian and Campanian of Kazakhstan.

Furthermore, a range chart (Fig. 2) illustrates that there are decreased numbers and disappearance of many marine palynomorphs at 7, 15 and 21 m. This suggests that these intervals were less favourable to marine taxa than intervening intervals. However, at 32 m marine palynomorphs reappear and increase in numbers for the last few metres of the section.

The high numbers of marine taxa substantiates the general conclusion that the lower part of the Kanguk Fm is more marine than the upper part but also shows that rhythms can be defined by an abrupt influx of marine palynomorphs that progressively decrease in numbers and coincide with a progressive increase in terrestrially derived palynomorphs. These rhythms are interpreted to reflect marine transgressive-regressive events for the lower interval.

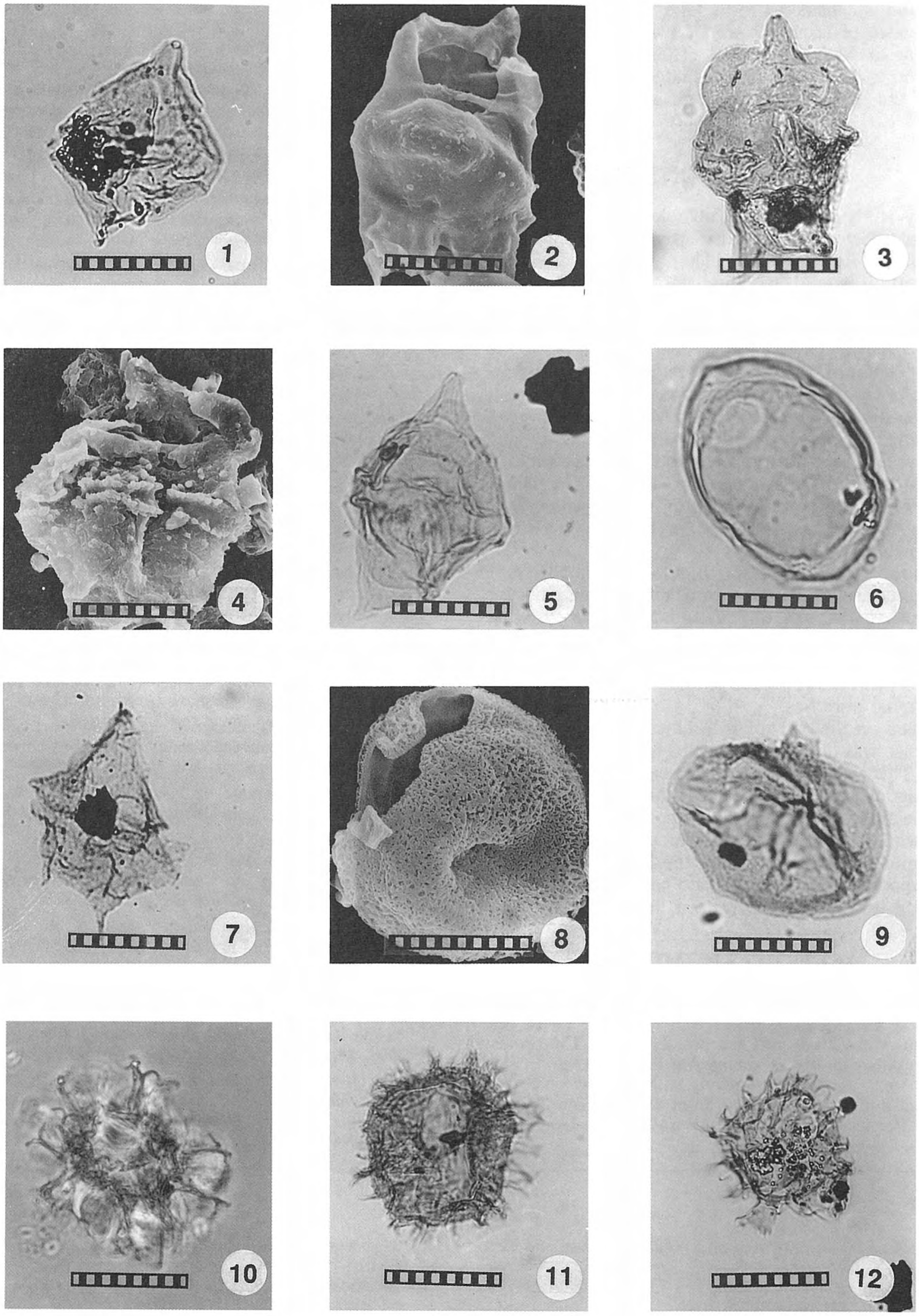
Despite the presence of similarities with other previously studied sections of this formation it also has its own peculiarities. For example, on Banks Island the top of the Kanguk Formation is characterized by a decrease or disappearance of characteristic Upper Cretaceous angiosperm pollen (Doerenkamp *et al.,* 1976). The major part of the terrestial microflora is made up of gymnosperm pollen. Marine microplankton reach 50 % of relative abundances with a great variety of species. In contrast, in the upper part of the section on Remus Creek marine palynomorphs represent less than 20 % of the total assemblage, whereas angiosperm pollen are consistently present and gymnosperm pollen are very rare.

Some individual diagnostic taxa permit the establishment of the age with relative certainty. The base of

Plate II

1 *Diconodinium arcticum* Manum and Cookson, UCG029-12 1/5.
2 *Chatangiella ditissima* (McIntyre) Lentin and Williams, UCG029-38a 2/5, SEM.
3 *Chatangiella granulifera* (Manum) Lentin and Williams, UCG029-1a 5/5.
4 *Chatangiella verrucosa* (Manum) Lentin and Williams, UCG029-12 1/5, SEM.
5 *Isabelidinium acuminatum* (Cookson and Eisenack) Stover and Evitt, UCG029-12 1/5.
6 *Manumiella ? cretacea* (Cookson) Bujak and Davies, UCG029-7 1/5.
7 *Phelodinium pentagonale* (Corradini) Stover and Evitt, UCG029-10a 1/5.
8 *Trithyrodinium suspectum* (Manum and Cookson) Davey, UCG029-12 1/5, SEM.
9 *Apteodinium* sp. *A,* UCG029-7 1/5.
10 *Achomosphaera ramulifera* (Deflandre) Evitt, UCG029-19a 1/5.
11 *Coronifera oceanica* Cookson and Eisenack, UCG029-10a 1/5.
12 *Florentinia ferox* (Deflandre) Duxbury, UCG029-12 1/5.

Plate II



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the section is considered to be Late Turonian based on the presence of taxa such as ? *Isabelidinium globosum* according to McIntyre (1990). The presence of *Wodehouseia-Azonia* types suggest that strata of the upper part of the section are Campanian in age (Wiggins 1976).

CONCLUSIONS

This study includes the Palynological analysis of 39 samples collected at one metre intervals from the Kanguk Fm, at Remus Creek. They yield an abundant palynomorph assemblage with a total of 15,625 specimens that include 181 well-preserved taxa, 103 species of dinocysts and acritarchs and 78 miospore and pollen species. Marine palynomorphs represent 51 % of the total palynomorph population, whereas terrestrial palynomorphs comprise the other 49 %.

The studied section is entirely marine, however, the change in dinocyst and acritarch abundance and diversity, and their distribution through the lower part of the section represent sea level oscilations. The increase in terrestrial palynomorphs in the upper interval indicate that it was deposited in a nearer to shore position than the lower part.

Chorate cysts show the highest specific diversity and highest relative abundances, whereas cavate dinocysts are common and less diverse and proximate cysts are rare. Acritarchs account for less than 10 % of the marine palynomorphs but range throughout the section. Some of them are reworked although not significant for stratigraphic purposes.

Based on the palynology a Late Turonian to Campanian age was determined for this formation at Remus Creek. This age appears to be in accordance with similar results obtained by Wall (1983) utilizing Foraminifera.

The Hassel Formation is proposed as a source for the reworked Albian-Cenomanian dinocysts found in the Remus Creek samples from the Kanguk Formation. This supports other lithologic and paleontologic evidence for an unconformity betweeen these formations.

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BIBLIOGRAPHY

Balkwill, H. P. 1983. Geology of Amund Ringnes, Cornwall, and Haig-Thomas islands, District of Franklin. *Geological Survey of Canada Memoir,* **390,** 1-76.

Barss, M. S. and Williams, G. L. 1973. Palynology and nannofossil processing techniques. *Geological Survey of Canada Paper,* **73-26,** 1-25.

Brideaux, W. W. 1971. Palynology of the Lower Colorado Group, central Alberta, Canada. I. Introductory remarks, geology, and microplankton studies. *Palaeontographica,* Abt. B, **135** (3-6), 53-114.

Brideaux, W. W. and McIntyre, D. J. 1975. Miospores and microplakton from Aptian-Albian rocks along Horton River, District of Mackenzie. *Geological Survey of Canada Bulletin,* **252,** 1-85.

Bujak, J. P. and Williams, G. L. 1978. Cretaceous palynostratigraphy of offshore southeastern Canada. *Geological Survey of Canada Bulletin,* **297,** 1-19.

Doerenkamp, A., Jardine, S. and Moreau, P. 1976. Cretaceous and Tertiary palynomorph assemblages from Banks Island and adjacent areas (N.W.T.). *Bulletin of Canadian Petroleum Geology,* **24** (3), 372-417.

Downie, C., Evitt, W. R. and Sarjeant, W.A.S. 1963. Dinocysts, hystrichospheres, and the classification of the acritarchs. *Stanford University publications, Geological Sciences,* **7,** 1-16.

Drugg, W. S. 1967. Palynology of the Upper Moreno Formation (Late Cretaceous-Paleocene) Escarpado Canyon, California. *Palaeontographica,* Abt. B, **120,** 1-71.

Felix, C. J. and Burbridge, P. P. 1973. A Maastrichtian age microflora from Arctic Canada. *Geoscience and Man,* **7,** 1-29.

Felix, C. J. and Burbridge, P. P. 1976. Age of microplankton studied by Manum and Cookson from Graham and Ellef Ringnes Islands. *Geoscience and Man,* **15,** 83-86.

Firth, J. V. 1987. Dinocyst biostratigraphy of the Maastrichtian to Danian interval in the U.S. Geological Survey Albany core, Georgia, U.S.A. *Palynology,* **11,** 199-216.

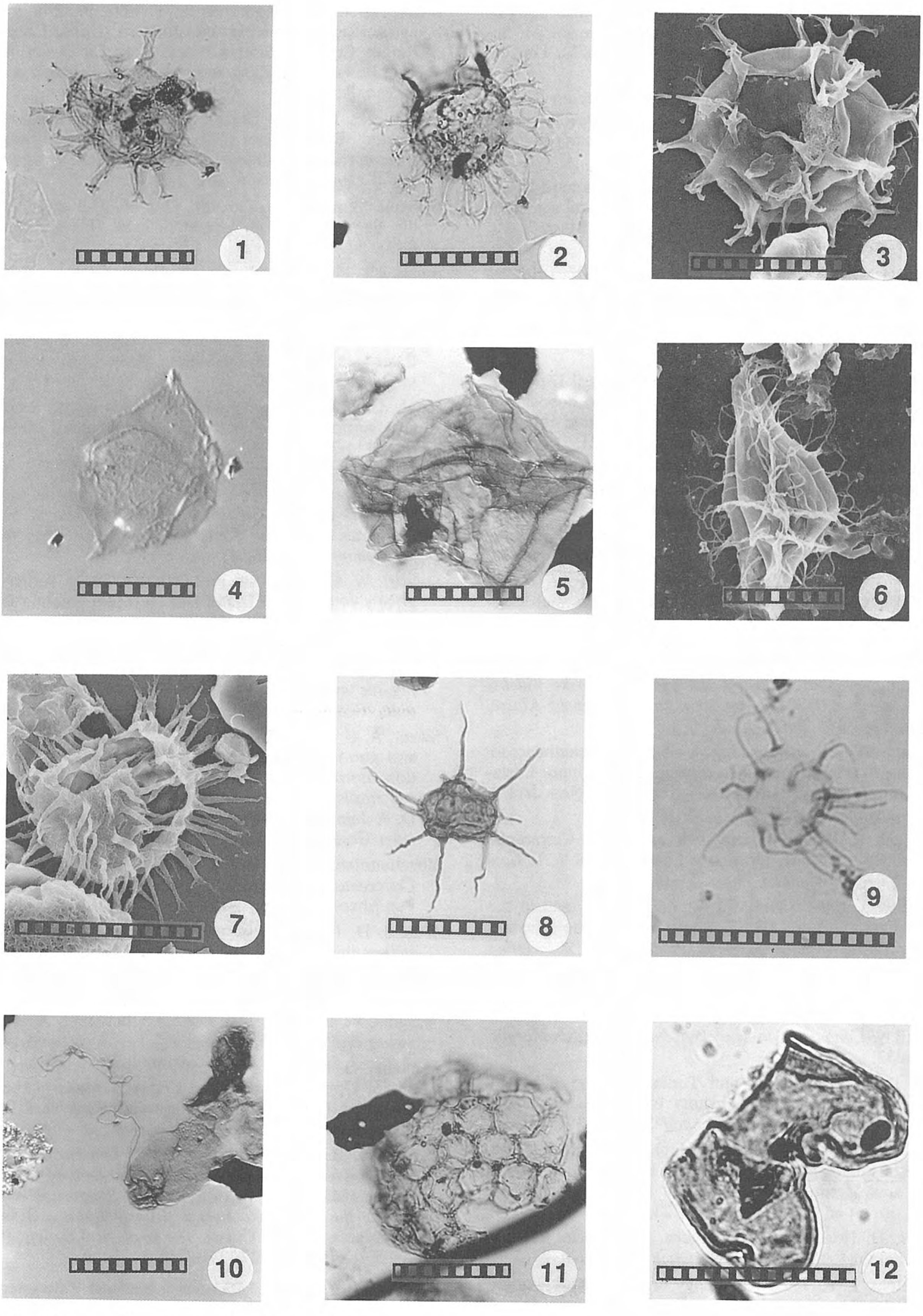
Gradstein, F. M. and Srivastava, S. P. 1980. Aspects of Cenozoic stratigraphy and paleooceanography of the Labrador Sea and Baffin Bay. *Paleogeography, Paleoclimatology, Paleoecology,* **30,** 261-295.

Greiner, H. R. 1963. Graham Island. In: *Geology of the north-central part of the Arctic Archipelago, Northwest Territories (Operation Franklin). Geological Survey of Canada Memoir,* **320,** 407-412.

Plate III

1 *Florentinia mantellii* (Davey and Williams) Davey and Verdier, UCG029-9 1/5.
2 *Kiokansium polypes* (Cookson and Eisenack) Below, UCG029-1b 4/5.
3 *Spiniferites ramosus* (Ehrenberg) Loeblich and Loeblich, UCG029-12 1/5, SEM.
4 *Laciniadinium williamsii* Ioannides, UCG029-12 2/5.
5 *Palaeoperidinium pyrophorum* (Ehrenberg) Sarjeant, UCG029-16a 1/5.
6 *Palaeohystrichophora infusorioides* Deflandre, UCG029-12 1/5, SEM.
7 *Cometodinium ? whitei* (Deflandre and Courteville) Stover and Evitt, UCG029-12 1/5, SEM.
8 *Micrhystridium fragile* Deflandre, UCG029-1b 4/5.
9 *Solisphaeridium nanum* (Deflandre) Turner, UCG029-12 2/5.
10 *Ophibolus lapidaris* Wetzel, UCG029-9 1/5.
11 *Palambages* Form *A* Manum and Cookson, UCG029-12 1/5.
12 *Schizocystia rugosa* Cookson and Eisenack, UCG029-34 1/5.

Plate III



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Unless otherwise stated the pictures are from the light microscope. In the explanation of figures illustrated, the species name is followed by a slide number in which the first part refers to the University collection number and the second to the sample number. Scale bar representes 30 μm.

Hyslop, K. D. 1986. Dinocyst biostratigraphy, Dawson Canyon Formation, Hibernia area, offshore eastern Canada. M. Sc. Thesis, Department of Geology and Geophysics, University of Calgary, Calgary, Alberta, 1-176.

Ioannides, N. S. 1986. Dinoflagellate cysts from Upper Cretaceous-Lower Tertiary sections, Bylot and Devon Islands, Arctic Archipelago. *Geological Survey of Canada, Bulletin,* **371,** 1-99.

Jeletzky, J. A. 1978. Causes of Cretaceous oscillations of sea level in western Arctic Canada and some general geotectonic implications. *Geological Survey of Canada Paper,* **77-18,** 1-44.

Krause, F. F., Hills, L. V., Joiner, S. D. and Núñez-Betelu, L. K. (*in press*). Conglomeratic tidalites: conglomerate and sandstone beds with mudstone couplets, Cardium Formation, Pembina and Carrot Creek fields, Alberta, Canada. *Bulletin of Canadian Petroleum Geology.*

Lentin, J. K. and Vozzhennikova, T.F. 1990. Fossil Dinocysts from the Jurassic, Cretaceous and Paleogene deposits of the USSR - A re-study. *American Association of Stratigraphic Palynologists Contribution Series,* **23,** 1-221.

Lentin, J. K. and Williams, G. L. 1981. Fossil Dinocysts - index to genera and species. *Bedford Institute of Oceanography, Report Series BI-R-81-12,* 1-345.

Manum, S. 1963. Some new species of *Deflandrea* and their probable affinity with Peridinium. *Norsk Polarinstitutt,* 1962, 55-67.

Manum, S. and Cookson, I. C. 1964. Cretaceous microplakton in a sample from Graham Island, Arctic Canada, collected during the second "Fram"-Expedition (1898-1902). With notes on microplankton from the Hassel Formation, Ellef Ringnes Island. *Skrifter utgett av Det Norske Videnskaps Akademi i Oslo, matematisk-naturvidenskapelig Klasse, Skrifter,* **17,** 1-35.

May, F. E. 1980. Dinoflagellate cysts of the Gymnodiniaceae, Peridiniaceae, and Gonyaulacaceae from the Upper Cretaceous Monmouth Group, Atlantic Highlands, New Jersey. *Palaeontographica, Abt. B,* **172,** 10-116.

McIntyre, D. J. 1974. Palynology of an Upper Cretaceous Section, Horton River, District of Mackenzie, N.W.T. *Geological Survey of Canada Paper,* **74-14,** 1-57.

McIntyre, D. J. 1990. Significant dinoflagellate events in the Upper Cretaceous of the Northern part of the Western Interior Basin. In *Proceedings of the American Association of Stratigraphic Palynologists,* 23rd Annual Meeting, Banff, 16.

McWhae, J. R. H. 1981. Structure and spreading history of the north-western Atlantic region from the Scotian shelf to Baffin Bay. *Canadian Society of Petroleum Geologists Memoir,* **7,** 299-332.

Miall, A. D. 1979. Mesozoic and Tertiary geology of Banks Island, Arctic Canada. The history of an unstable craton margin. *Geological Survey of Canada Memoir,* **387,** 1-235.

Miall, A. D., Balkwill, H. R. and Hopkins, W. S. Jr. 1980. Cretaceous and Tertiary sediments of Eclipse Trough, Bylot Island area, Arctic Canada, and their regional setting. *Geological Survey of Canada Paper,* **79-23,** 1-20.

Newell, N. D. 1956. Fossil populations. The species concept in paleontology. *Systematics Association Publication,* **2,** 63-82.

Núñez-Betelu, L. K. 1991. Palynology of the Kanguk Formation (Late Cretaceous), Remus Creek, Ellesmere Island, Canadian Arctic Archipelago. M. Sc Thesis, Department of Geology and Geophysics, The University of Calgary, 1-270.

Núñez-Betelu, L. K. and Hills, L. V. 1992. Preliminary paleopalynology of the Kanguk Formation (Upper Cretaceous), Remus Creek, Ellesmere Island, Canadian Arctic Archipelago: II. Terrestrial Palynomorphs. *Revista Española de Paleontología,* **7,** 197-206.

Ricketts, B. D. 1991. Delta evolution in the Eureka Sound Group, Western Axel Heiberg Island: the transition from wave-dominated to fluvial dominated deltas. *Geological Survey of Canada Bulletin,* **402,** 1-72.

Sarjeant, W. A. S. and Downie, C. 1966. The classification of dinoflagellate cysts above generic level. *Grana Palynologica,* **6** (3), 503-527.

Singh, Ch. 1964. Microflora of the Lower Cretaceous Manville Group, east-central Alberta. *Research Council of Alberta Bulletin,* **15,** 1-239.

Singh, Ch. 1971. Lower Cretaceous microfloras of the Peace River area, northwestern Alberta. *Research Council of Alberta Bulletin,* **28,** 1-542.

Singh, Ch. 1983. Cenomanian microfloras of the Peace River area, northwestern Alberta. *Alberta Research Council Bulletin,* **44,** 1-322.

Souther, J. G. 1963. Geological traverse across Axel Heiberg Island from Buchanan Lake to Strand Fiord. In: *Geology of the North-Central part of the Arctic Archipelago, Northwest Territories (Operation Franklin). Geological Survey of Canada Memoir,* **320,** 426-448.

Stewart, W. D. 1987. Late Proterozoic to Early Tertiary stratigraphy of Somerset Island and Northern Boothia Peninsula, District of Franklin, N.W.T. *Geological Survey of Canada Paper,* **83-26,** 35-36.

Stover, L. E. and Evitt, W. R. 1978. Analyses of pre-Pleistocene organic-walled dinoflagellates. *Stanford University Publications, Geological Sciences,* **15,** 1-300.

Sweet, A. R. and McIntyre, D. J. 1988. Late Turonian marine and non-marine palynomorphs from the Cardium Formation, north-central Alberta Foothills, Canada. In: *Sequences, stratigraphy, sedimentology: surface and subsurface.* (Eds. D. P. James and D. A. Leckie). *Canadian Society of Petroleum Geologists Memoir,* **15,** 499-516.

Vozzhennikova, T. F. 1967. *Fossil peridineae from Jurassic, Cretaceous and Paleogene deposits of the U.S.S.R.* Nauka Publishers, Moscow, 1-154.

Wall, J. H. 1983. Jurassic and Cretaceous foraminiferal biostratigraphy in the eastern Sverdrup Basin, Canadian Arctic Archipelago. *Bulletin of Canadian Petroleum Geology,* **31** (4), 246-281.

Wiggins, V. D. 1976. Fossil oculata pollen from Alaska. *Geoscience and Man,* **15,** 51-76.

Williams, G. L. and Brideaux, W. W. 1975. Palynologic analyses of Upper Mesozoic and Cenozoic rocks of the Grand Banks, Atlantic continental margin. *Geological Survey of Canada Bulletin,* **236,** 1-163.

Zaitzeff, J. B. and Cross, A. T. 1970. The use of Dinocysts and acritarchs for zonation and correlation of the Navarro Group (Maastrichtian) of Texas. In: *Symposium on palynology of the Late Cretaceous and Early Tertiary.* (Eds. R. M. Kosanke and A. T. Cross). *The Geological Society of America, Special Paper,* **127,** 341-377.

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