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STRATIGRAPHIC SECTIONS AND PALYNOLOGICAL REPORTS FOR MESOZOIC ROCKS AT LAKE HAZEN, ELLESMERE ISLAND

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Aerial view of the north shore of Lake Hazen in the vicinity of Mesa Creek. Cuesta Creek and Johns Island are visible in the distance. Tertiary beds are exposed in the foreground, and Mesozoic beds form light-coloured cuestas in the middle of the view. R.C.A.F. T401R-100

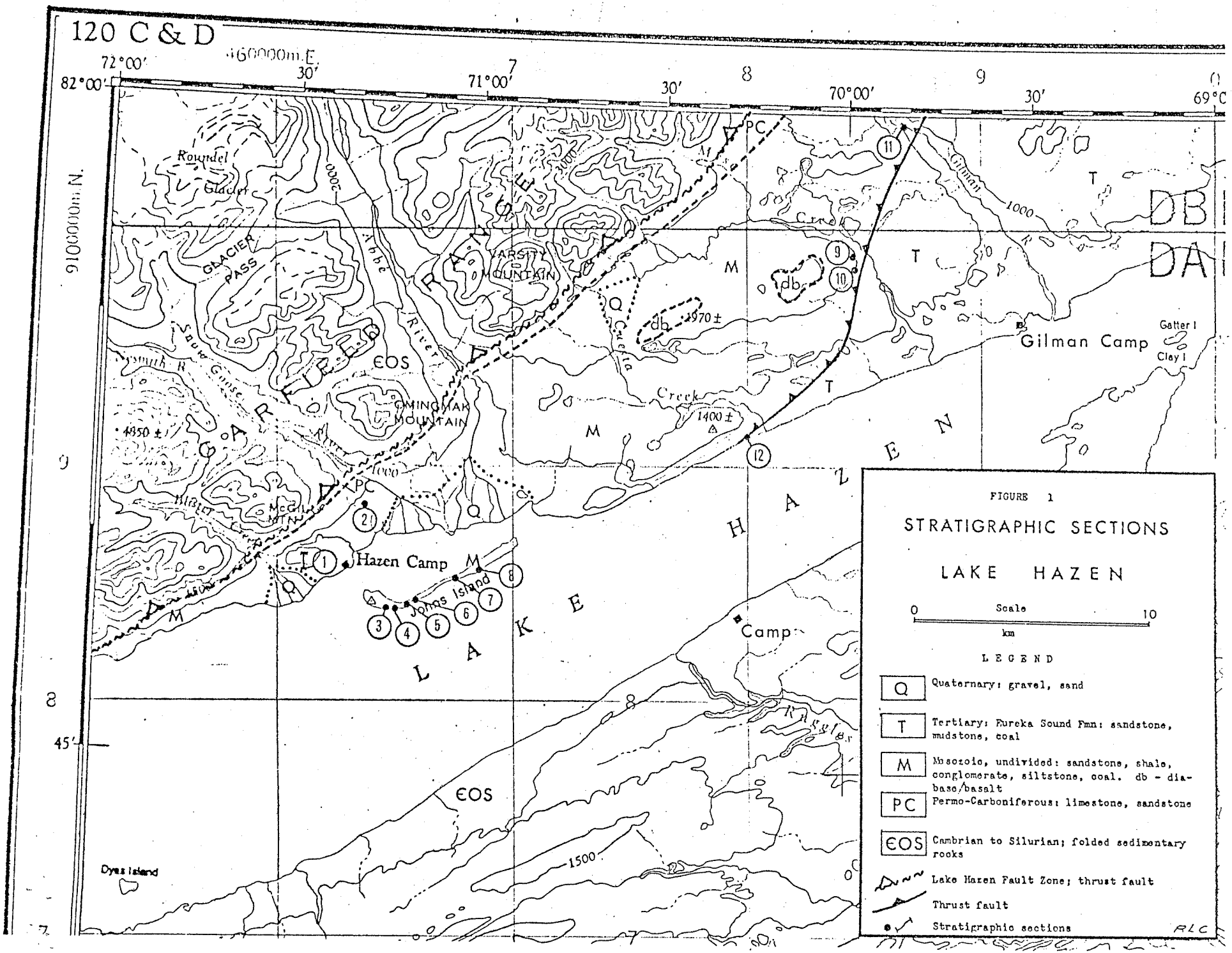

FIGURE 1

STRATIGRAPHIC SECTIONS

LAKE HAZEN

0 Scale 10

km

LEGEND

Q	Quaternary: gravel, sand
T	Tertiary: Eureka Sound Fmn: sandstone, mudstone, coal
M	Mesozoic, undivided: sandstone, shale, conglomerate, siltstone, coal. db - diabase/basalt
PC	Permo-Carboniferous: limestone, sandstone
EOS	Cambrian to Silurian; folded sedimentary rocks
	Lake Hazen Fault Zone; thrust fault
	Thrust fault
	Stratigraphic sections

RLC

ABSTRACT

Descriptions of certain stratigraphic sections in Mesozoic rocks, and palynological determinations on samples from the sections, are presented as a supplement to an earlier paper by A.A. Petryk (1969: Geological Survey of Canada, Paper 68-17). The data allow some refinements in interpretation of local structure; for example, Mesozoic beds, and perhaps some of late Paleozoic age, have been thrust over Tertiary coal measures.

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CONTENTS

INTRODUCTION

The results of stratigraphic studies in Mesozoic and Tertiary rocks of the Lake Hazen region of northern Ellesmere Island carried out by A.A. Petryk in 1965 were published in the Geological Survey of Canada Papers series (Petryk, 1969). Palynological determinations for Mesozoic rocks from this region have become available since publication of Petryk's paper; the purpose of the present paper is to make available the new data, which allow some refinements in the interpretation of the geology of the Lake Hazen region.

Earlier Discoveries and Recent Field Work

The presence of 'younger' coaly rocks in the Lake Hazen region was first noted by Lieut. A.W. Greely of the United States Army expedition to Fort Conger (1881-83). Members of Commander R.E. Peary's hunting parties travelled on and near Lake Hazen between 1898 and 1909, and the Inuit families evidently collected Tertiary amber nodules, as did the ancient visitors before them (*see* Maxwell, 1960, p. 63).

Outcropping Mesozoic beds of the Lake Hazen basin were examined in 1956 by D.F. Barnes. U.S. Air Force Cambridge Research Centre, and described briefly in an unpublished report.

The Permo-Carboniferous and younger rocks of the Lake Hazen region were described by R.L. Christie (1964) after reconnaissance field work carried out in 1957 and 1958 in cooperation with the Defence Research Board of Canada (Operation Hazen: *see* Hattersley-Smith, 1974). The same beds were again studied during 'Operation Grant Land', an airborne field project of the Geological Survey of Canada: by A.A. Petryk in 1965, W.W. Nassichuk in 1966, and R.L. Christie in 1966 and 1973, (*see* Petryk, 1969; Nassichuk, 1967; Christie, 1967 , 1974). Tertiary rocks were studied by A.D. Miall in 1977 (*see* Miall, 1979).

Access

Lake Hazen is accessible by air from the D.O.E. Arctic weather stations or from Resolute Airport. The nearest airstrips and weather stations are Alert, 160 km (100 miles) to the northeast, and Eureka, 320 km (200 miles) to the southwest. Landings in the Lake Hazen region may be made on short, slightly improved airstrips at one of three field camps near the lake shore when ground conditions, season, and aircraft performance characteristics are suitable. Landings on certain unprepared terrain in the region are practical for some STOL aircraft. Lake Hazen itself is well suited to aircraft landings during much of the year because of a uniform, moderately thick (about 1.5 m; 5 ft) ice cover, very light snowfall, and usually light or calm wind conditions.

Hazen and Gilman field camps on the north shore of Lake Hazen were established respectively by the Defence Research Board of Canada and the Geological Survey of Canada. The two camps now serve as cache sites and as landmarks for airstrips for STOL aircraft. A private camp and short landing field, built by W.W. Phipps, formerly of Atlas Aviation, Resolute, lies on the south shore of the lake about a mile east of the outlet, Ruggles River.

Stratigraphic Sections and Palynological Determinations

The Mesozoic stratigraphic sections of the Lake Hazen region contain abundant palynomorphs at many levels. Palynological data have been obtained from various measured sections, descriptions of many of which were published in Petryk's earlier paper (Petryk, 1969, Appendix). Other sections were not included in that paper and are appended to this paper in order to provide stratigraphic bases for the palynological determinations. The locations of stratigraphic sections, and of localities from which palynomorphs were obtained, are shown in Figure 1.

A few numbered localities of this paper are not new, but are sample localities reported earlier in Geological Survey of Canada Memoir 331 (Christie, 1964). These are included for completeness and to establish relative geographic or stratigraphic positions for the miospore-bearing beds.

Determinations of miospores herein were completed by D.C. McGregor, Geological Survey of Canada, in 1959 and 1968; W.W. Brideaux, Geological Survey of Canada, examined and reported on the dinoflagellates in certain collections. The report was compiled by R.L. Christie and A.A. Petryk.

It must be noted here that the miospore determinations are, at this time, 'dated' and are therefore preliminary or reconnaissance in nature. It has not been considered practical to review the species assignments, which presumably could change to some extent in the light of recent knowledge.

Acknowledgments

The compilors are grateful for advice and help given by many members of the Geological Survey of Canada, Calgary, by M.E. Dettmann of the University of Queensland, Brisbane, Australia, and by G.E. Rouse, University of British Columbia.

REGIONAL AND LOCAL GEOLOGY

Lake Hazen lies near the northeastern extremity of the large, post-orogenic[1] Sverdrup Basin of the Canadian Arctic Islands. The basin is in the form of a major synclinorium and overlies, with profound unconformity, the deeply eroded, folded terrain of the late Precambrian to mid-Paleozoic Franklinian Geosyncline. The Sverdrup Basin contains an essentially conformable sequence of beds ranging in age from Early Carboniferous (Viséan) to latest Cretaceous (Maastrichtian). The sequence may be virtually complete in the centre of the basin. Elsewhere, however,

[1]Post-mid-Paleozoic orogeny

regional breaks in sedimentation evidently occurred in latest Pennsylvanian, Late Permian, and Middle to Late Jurassic times. Other, more local breaks also are recognized near the basin margins. (Nassichuk, 1972 and pers. com.; Plauchut, 1971; Thorsteinsson and Tozer, 1970; Thorsteinsson, 1974).

The upper Paleozic, and probably also the Mesozoic rocks at Lake Hazen lie within a northeastern marginal clastic and carbonate facies belt of the Sverdrup Basin (*see* Thorsteinsson, 1974, Fig. 6). Formations in this belt are the relatively thin representatives of markedly thicker units nearer the basin axis; sedimentary sections in the marginal region are characterized by disconformities, pinch-outs of rock units, and overstepping relationships.

Subsidence and sedimentation in the Sverdrup Basin continued within relatively well-defined margins until early Cretaceous time, when a more general downsinking resulted in widespread transgressions beyond the margins, onto the adjacent sedimentary platform.[1]

The pattern of sedimentation in the Arctic Archipelago changed dramatically near the close of Mesozoic time, which saw the end of the more or less uniform subsidence and widespread marine conditions (terrigenous clastic sediments) of the Sverdrup Basin. The areal extent of marine environments became much restricted, and sedimentation was interrupted over wide areas. Tertiary clastic beds of the mainly nonmarine Eureka Sound Formation transgressed widely beyond the limits of the earlier Sverdrup Basin. Within the basin, at least some of these beds evidently were derived from local uplifts that represent early phases of the coming Eurekan Orogeny. Tectonic activity as early as latest Cretaceous (Maastrichtian ?) time is recorded by hiatuses and angular unconformities between Mesozoic and Tertiary beds at certain localities on eastern Axel Heiberg

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[1]Such Cretaceous transgressions to the southwest have long been recognized. Only recently discovered, however, east of the Sverdrup Basin, are Cretaceous shale units overlying lower Paleozoic rocks (H.R. Balkwill, pers. com.).

and northern Ellesmere Islands. The early tectonism was expressed as uplift along northwest-trending, possibly basement-cored arches on Axel Heiberg, Amund Ringnes, and Cornwall Islands (Thorsteinsson and Tozer, 1970; Balkwill et al., 1975).

The Tertiary beds at Lake Hazen appear to belong to a nonmarine facies and to overlie folded Mesozoic beds with angular unconformity. Coarse conglomerate beds at the top of the Lake Hazen Tertiary section, as yet undated, may be equivalents of the syn- and post-tectonic, late Tertiary, Beaufort Formation of the Arctic Coastal Plain and Axel Heiberg Island (*see* Thorsteinsson and Tozer, 1970; Balkwill and Bustin, 1975).

BIOCHRONOLOGY AND STRATIGRAPHY AT LAKE HAZEN

The stratigraphic sections and palynological identifications from material collected at Lake Hazen are described below and keyed to 12 localities (*see* Fig. 1). Eleven localities are in Mesozoic rocks of Blister Hill, Johns Island, and outcrops to the northeast and are grouped under the title, 'I. Mesozoic Rocks'. Locality 12 is titled: 'II. Permian(?), Triassic and Cenozoic; this section contains an important thrust fault.

I. Mesozoic Rocks

Introduction

Mesozoic rocks at Lake Hazen (and thin, underlying formations of late Paleozoic age considered incidentally in Section II of this report) form an isolated outlier on the northern edge of the gently north-sloping Hazen Plateau (*see* Christie, 1964). The outlier is surrounded by a terrain of tightly folded, lower Paleozoic, or Franklinian rocks. Upthrust belts of Franklinian rocks separate the late Paleozoic - Mesozoic terrain of Lake Hazen from the remaining,

and main northeastern extremity of the Sverdrup Basin; the Lake Hazen rocks thus lie, tectonically depressed, at the foot of a mountain-front zone of faulting (the Lake Hazen Fault zone)[1].

Several high-angle thrust faults of the Lake Hazen fault zone cut the outlier. Although the internal geometry has not yet been resolved, the beds appear to form a structural basin, the section thickening northward through fault repetition and perhaps through drag-folding. Gilman River crosses the eastern part of the outlier, or structural basin, and Lake Hazen occupies a glacially excavated trough along its southern margin.

The structural basin contains a conformable sequence of Permo-Carboniferous to Cretaceous beds, mainly sandstone, siltstone, and shale, with minor calcareous sandstone, granule conglomerate, limestone, and coal. Most Mesozoic formations of the Sverdrup Basin, between and including the Lower Triassic Bjorne Formation and the Upper Cretaceous Hassel Formation, are present at Lake Hazen in a section with a total thickness of about 1800 m (6,000 ft) or somewhat more. The uniformly sandy character and weak induration of the Mesozoic rocks, with the extensive solifluction characteristic of this periglacial region, render mapping of such formations a difficult project. The biochronological data from both macro- and microfossils are therefore of considerable aid toward this goal.

Samples from several of Petryk's (1969) published sections and from several measured sections that were not published in Paper 68-17 have yielded numerous palynomorphs, the palynomorph assemblages listed in Appendix A. Biochronological conclusions by McGregor and Brideaux allow modifications and refinements to be

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[1]For remarks on this major structural feature, *see* Petryk, 1969, p. 15-16; Trettin, 1971, p. 89, 101-104; Christie, 1964, p. 65-66; Miall, 1979.

made to the earlier map and published sections: viz, Heiberg Formation and younger beds evidently are exposed immediately north of Hazen Camp, and the section is overturned or is repeated by a hitherto unrecognized thrust fault, and a younger age assignment can be made for the sandstone-siltstone beds of Johns Island.

Biochronology

The following biochronological remarks are by McGregor (DCM), based on assemblages consisting mainly of miospores, and by Brideaux (WWB), from dinoflagellates. All palynological identifications, and the description of relevant measured stratigraphic sections (not previously published) are tabulated in appendices to this report.

(1)[1] Blister Hill, northwest of Lake Hazen. Section, Locality 1 (*see* Fig. 1); unit 6, at 780 feet. Section and palynomorphs tabulated in Appendices. (GSC Loc. 7374)[2].

Remarks (DCM): this is an excellent assemblage of Rhaetic-Liassic (Late Triassic to Early Jurassic) age. It contains many species described from Rhaeto-Liassic rocks of Germany and Austria. There is perhaps slightly more evidence for correlation with the European Rhaetic than with the Liassic, but either age could be correct. Several of these species occur in samples from the Heiberg Formation from Black Top Ridge near Eureka (*see* McGregor, 1965, p. 14-16, pl. II and III).

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[1]Numbers and letters in brackets adjacent to fossil localities refer to localities shown on the accompanying geological sketch map.

[2]Plant locality catalogue number, Geological Survey of Canada.

However, considering the fact that localities 7383 and 7386 contain recycled Triassic-Jurassic palynomorphs, it is reasonable to suspect that those at this locality may also be reworked, and the beds may be as young as Early Cretaceous.

(2) Northwest of Lake Hazen, about 1.5 miles north of Hazen Camp, from about middle of unit 3 (at 197 feet), of section A, Fig. 2, of Petryk, 1969; (GSC Loc. 7377). Palynomorphs tabulated in Appendix A.

Remarks (DCM): this assemblage is of approximately the same age as the one from locality 7374, i.e., Rhaeto-Liassic. No component indicating younger age was observed. A single dino-

flagellate was observed, but was not indentifiable (WWB); the presence of this form is noteworthy however, as undoubted dinoflagellates are rare before the Middle Jurassic.

(3) Southwest end of Johns Island, Lake Hazen. Reported by Christie, 1964, p. 50: 14 species of miospores, tentative assignment: uppermost Jurassic or Lower Cretaceous, (GSC Loc. 5237).

(4) South tip of Johns Island, Lake Hazen.

Assemblage from light-and-dark banded sandstone; section 4, (*see* Fig. 1); unit 1, 0 to 35 feet. Section tabulated in Appendix B. (GSC Loc. 7386) Miospores and dinoflagellates tabulated in Appendix A.

Remarks (DCM): components of this assemblage are latest Triassic or earliest Jurassic. (Rhaeto-Liassic), about the same age as those from localities 7374 and 7377. The acritarchs (*Leiosphaeridia* and *Pterospermopsis*) and dinoflagellates, however, indicate probable marine conditions and Early Cretaceous age. *Hystricosporites delectabilis* was reworked from a Late Devonian (late Givetian or Frasnian) source, possibly an equivalent of the Hecla Bay or Beverley Inlet Formations, which contain *H. delectabilis*.

Remarks (WWB): age is Late Jurassic (late Kimmeridgian) to as young as

Early Cretaceous (Valanginian). An early Cretaceous, possibly Berriasian age is favoured because of the absence of the typical late Jurassic species and the presence of many forms of *Tenua* and *Canningia* and of "Organism" sp. AE, reported hitherto only from the Berriasian Upper Member of the Husky Formation along Martin Creek, District of Mackenzie (Brideaux, 1976).

(5) Johns Island, at narrow neck.

Assemblage from sandstone with thin pebbly layers; section 5 (*see* Fig. 1); unit 1, 0 to 10 feet. Section tabulated in Appendix B. (GSC Loc. 7385) Miospores and dinoflagellates tabulated in Appendix A.

Remarks (DCM): this assemblage contains many species that range throughout the Jurassic and Early Cretaceous. A more definitive age determination cannot be made from the miospores.

Remarks (WWB): Early Cretaceous, Berriasian, possibly as young as early Valanginian. These species have been previously recorded only from Berriasian rocks of the Husky Formation, Upper Member, and the buff sandstone unit of the lower sandstone division along Martin Creek, District of Mackenzie (Brideaux, 1976).

(6) Johns Island, at narrow neck.

Assemblage from carbonaceous siltstone with wood fragments; section 6 (*see* Fig. 1); unit 1, 10 to 20 feet. Section tabulated in Appendix B. (GSC Loc. 7383). Palynomorphs tabulated in Appendix A.

Remarks (DCM): Like that at locality 7386, this assemblage appears to be mixed, containing elements of Early Jurassic and Early Cretaceous age. The sample is probably Early Cretaceous, with reworked Early Jurassic (Liassic) palynomorphs. *Hymenozonotriletes lepidophytus* was reworked from a latest Devonian source. The acritarchs indicate that the depositional environment was probably marine.

(7) Johns Island, about 1.8 miles from northeast end.

Assemblage from thin bedded carbonaceous sandstone; section 7 (*see* Fig. 1); unit 2, 30 to 40 feet. Section tabulated in Appendix B. (GSC Loc. 7382) Miospores and dinoflagellates tabulated in Appendix A.

Remarks (DCM): based on the miospores, no more precise age determination is possible than Jurassic or Early Cretaceous.

Remarks (WWB): Early Cretaceous, probably Aptian, but possibly as young as early Albian.

(8) Johns Island, about 1.3 miles from northeast end.

Assemblage from banded argillaceous sandstone; section 8 (*see* Fig. 1); unit 1, 0 to 100 feet. Section tabulated in Appendix B. (GSC Loc. 7384) Palynomorphs tabulated in Appendix A.

Remarks (DCM): Most of the forms identified in this assemblage are long-ranging in the Jurassic and Early Cretaceous. The sample cannot be dated more specifically on present evidence.

(9) Northwest of Lake Hazen and west of Mesa Creek, about 3.7 miles, bearing N34° W from mouth of Mesa Creek; section 9 (*see* Fig. 1). Section tabulated in Appendix B.

Unit 1; light yellow- to orange-weathering sandstone, at 42 feet. (GSC Loc. 7360). Palynomorphs tabulated in Appendix A.

Remarks (DCM): Most of the fossils in this list are long-ranging in the Jurassic and Early Cretaceous, and no more specific age determination is possible. *Lycopodiumsporites semimurus* and *Pseudopicea monstruosa* were first described from the Jurassic but similar forms also occur in Early Cretaceous rocks.

(10) Northwest of Lake Hazen and west of Mesa Creek, about 3.3 miles, bearing N35° W from mouth of Mesa Creek; near section 9 (*see* Fig. 1). probably from beds near the base of the section (GSC Loc. 5236). Reported by Christie, 1964, p. 50: 10 species of miospores, uppermost Jurassic or Lower Cretaceous.

(11) Gilman River, about 6 miles above its mouth. (GSC Loc. 5238). Reported by Christie, 1964, p. 51: 16 species of miospores, probably Jurassic.

Discussion

From the palynological and dinoflagellate determinations it now seems apparent that:

a) the palynological determinations for samples from the top of Blister Hill (locality 7374) appear at first glance to confirm the designation of these sandstone beds as Heiberg Formation. However, evidence from other localities (7383, 7386, on Johns Island) suggests that the upper beds of Blister Hill may be as young as Early Cretaceous, perhaps a sandy facies of the Deer Bay Formation. The Deer Bay Formation was defined on Ellef Ringnes Island by Heywood (1956) as a shale and silty shale unit of Neocomian age; an age range from Upper Volgian (latest Jurassic) to Valanginian (early Early Cretaceous) has since been determined from ammonoid faunas (Thorsteinsson and Tozer, 1970, p. 581). The sandstone beds of Lake Hazen probably represent a basin-marginal facies of the Deer Bay Formation, as does the age-equivalent Mould Bay Formation of the western Queen Elizabeth Islands (op. cit.).

The presence of Jurassic beds in the vicinity of Blister Hill is indicated by an Early Jurassic dating by P. Davies (1965)[1] of miospores and plants at a locality south of the hill, at the lakeshore.

b) the lowest beds of section 2 (locality 7377; *see* Fig. 1) are evidently Triassic or younger so that the section must be overturned, or a fault must be crossed at about unit 7 of the stratigraphic section. The latter relationship was suggested by Petryk (1969, p. 21). Moreover, the overlying, recessive interval of about 500 feet may contain other faults. Thrust faults bringing Bjorne Formation up against Heiberg or younger formations would be compatible with and part of, the Lake Hazen fault zone. As at the top of Blister Hill, the sandy beds may represent the Heiberg Formation, or younger units as young as the Deer Bay Formation.

c) the beds of Johns Island evidently are younger than Triassic and must be assigned to an undivided 'Jurassic and Cretaceous' unit, possibly equivalent to the Deer Bay Formation of the western islands, as for the locality at the top of Blister Hill. Heiberg beds of Blister Hill and those along the shore of Lake Hazen northeast of Johns Island appear to trend towards the island; undoubtedly, the island is isolated by undetected faults.

II. Permian (?), Triassic, and Cenozoic Rocks at Locality 12

Introduction

The vicinity of 12, which is locality G of Fig. 1 of Petryk (1969), is a critical area in the interpretation of the geology of the north shore of Lake Hazen. Coal-bearing shale and sandstone beds at this locality underlie fossiliferous Triassic sandstone beds with structural conformity, separated from them by a zone of shattering, shearing, and distortion. Faulting early was suspected and indeed some evidence was noted (*see* Christie, 1964, p. 46; Petryk, 1969,

[1]Some 31 and 27 forms (respectively) of plant fossils and miospores were identified in a collection from a shale outcrop "three quarters of a mile south of Camp Hazen".

p. 16, 27). Palynological reports, noted below, confirm the interpretation that late Paleozoic to Mesozoic beds have been thrust over the Tertiary coal measures. The fault or faults are nearly parallel to the north shore of Lake Hazen (*see* Fig. 1).

Biochronology

The stratigraphic units listed below are those of section G of Figure 2 of Petryk, (1969). Palynological and biochronological remarks on GSC Loc. 7357 are by D.C. McGregor (DCM), and assignment of Cenozoic ages to GSC Loc. 7349 and Loc. 7354 is by G.E. Rouse (GER), University of British Columbia. The palynological identifications for 7357 are tabulated in Appendix A.

(12) Northwest shore of Lake Hazen, about 1.2 miles southwest of mouth of Cuesta Creek; Section G of Figure 2, Petryk, 1969. Note correction to thickness of unit 1 of section G, Paper 68-17 (p. 27).

Unit 1, 0-20 feet; sandstone with coal stringers and ironstone pebbles. (GSC Loc. 7349). Palynomorphs present.

Remarks (GER): there are few palynomorphs in the assemblage, and their preservation is poor. A Paleocene-Eocene age is most likely.

Units 2 and 3; 20-35 feet; 10 feet of purplish clay overlain by 5 feet of interbedded coal and grey mudstone. (GSC Loc. 7354). Palynomorphs present.

Remarks (GER): Paleocene-Eocene.

Unit 4, 35-75 feet: interbedded sandstone, siltstone, mudstone, and coal; recessive. Assemblage is from interval 38 to 45 feet. (GSC Loc. 7357) Palynomorphs tabulated in Appendix A.

Remarks (DCM): This is a Permian assemblage, possibly mid- to Late Permian Age assignment within the Permian is tentative, because there is still very little palynological data for comparison from Permian rocks of the Arctic Islands. Closest comparisons are with Permian assemblages from Australia, Germany, and the western U.S.S.R.

Micrhystridium and other acritarchs were marine microplankton, and indicate a marine influence at the site of deposition.

There is no evidence of younger fossils in this sample, i.e., there is no evidence that this assemblage was reworked subsequent to Permian time. However, although I think reworking is unlikely in this instance, I cannot exclude the possibility that it occurred.

Discussion

It is now apparent that the Mesozoic-Tertiary contact west of Cuesta Creek is the trace of a thrust fault, and that at section 12 (Fig. 1), pre-Tertiary beds are tectonically emplaced over the Tertiary coal measures. The presence of a Permian palynological assemblage in sandstone and siltstone overlying the Tertiary beds is problematical because of the small apparent stratigraphic interval between the sandstone-siltstone and overlying coquinoid limestone characteristic of the Triassic Schei Point Formation. Three explanations are possible:

1. The sandstone, siltstone, and mudstone of unit 4 and possibly also the sandstone of units 5 and 6 may be separated by other faults from the structurally conformable, overlying calcareous sandstone and coquinoid limestone (units 7 and 8 of section G, Petryk, 1969).
2. The material from Loc. 7357 may be fault gouge of Permo-carboniferous rock that has been carried up the thrust plane.
3. The Permian palynomorphs were deposited in the Tertiary from reworked Permian rocks.

Alternatives 1 and 2, above, are structurally similar, and one of these explanations seems, to the authors, most likely to be correct.

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A P P E N D I C E S

A: PALYNOLOGICAL DETERMINATIONS

B: STRATIGRAPHIC SECTIONS OF MESOZOIC ROCKS

Lake Hazen Region

APPENDIX A

PALYNOLOGICAL DETERMINATIONS

I. Mesozoic Rocks

The following identifications were made by D.C. McGregor, unless otherwise noted.

(1)[1] Blister Hill, Northwest of Lake Hazen.

Assemblage from carbonaceous sandstone; section, locality 1 (*see* Fig. 1); unit 6, at 780 feet. Section tabulated in Appendix B. (GSC Loc. 7374)[2].

Alisporites spp.
A. cf. *A. parvus* deJersey
Camarozonotriletes sp.
C. rudis (Leschik) Klaus
Cingutriletes clavus (Balme) Dettmann
Cornutispora seebergensis Schulz
Densosporites sp.
Limbosporites lundbladii Nilsson
Lycopodiacidites rugulatus (Couper) Schulz
Perinosporites thuringiacus Schulz
Polycingulatisporites mooniensis deJersey and Paten
Polypodiisporites ipsviciensis (deJersey) Playford and Dettmann
Riccisporites tuberculatus Lundbald
Rogalskaisporites cicatricosus (Rogalska) Danzé-Corsin and Laveine
Taeniaesporites kraeuseli Leschik
Triancoraesporites reticulatus Schulz
Vitreisporites pallidus (Reissinger) Nilsson

(2) Northwest of Lake Hazen, about 1.5 miles north of Hazen Camp, from about middle of unit 3 (at 197 feet) of section A, Fig. 2, of Petryk (1969).

Assemblage is from dark grey to black, argillaceous sandstone; (GSC Loc. 7377).

?Alisporites grandis (Cookson) Dettmann
Camarozonosporites rudis (Leschik) Klaus
Chasmatosporites elegans Nilsson
cf. *Cingulatisporites floridus* Balme
Cyathidites sp.
Cycadopites fragilis C. Singh
Lycopodiumsporites austroclavatidites Cookson
Polypodiisporites ipsviciensis (deJersey) Playford and Dettmann
cf. *Rogalskaisporites multicicatricosus* Danzé-Corsin and Laveine
Tripartina variabilis Malyavkina

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[1]Numbers and letters in brackets adjacent to fossil localities refer to localities shown on the accompanying geological sketch map.

[2]Locality catalogue number, Geological Survey of Canada.

Tsugaepollenites mesozoicus Couper
Undulatisporites concavus Kedves
Unidentified dinoflagellates

(3) Southwest end of Johns Island; reported by Christie, 1964, p. 50 (GSC Loc. 5237).

(4) South tip of Johns Island, Lake Hazen.

Assemblage from light-and-dark banded sandstone; section 4 (*see* Fig. 1); unit 1, 0 to 35 feet. Section tabulated in Appendix B. (GSC Loc. 7386).

?Concavissimisporites penolaensis Dettmann
Cycadopites sp.
cf. *Cyclosaccus podocarpoides* Mädler
Densoisporites velutus Weyland and Krieger
cf. *Densosporites foveocingulatus* Schulz
Distalanulisporites sp.
Lycopodiacidites varigranulatus Levet-Carette
Lycopodiumsporites cerniidites Ross
L. semimurus Danzé-Corsin and Laveine
Papillotriletes grandis Mädler
cf. *Parvisaccites radiatus* Couper
Podocarpidites cf. *P. ellipticus* Cookson
Pteruchipollenites microsaccus Couper
Rogalskaisporites cicatricosus (Rogalska) Danzé-Corsin and Laveine
cf. *R. multicicatricosus* Danzé-Corsin and Laveine
Tsugaepollenites mesozoicus Couper
Vitreisporites pallidus (Reissinger) Nilsson
Zebrasporites interscriptus (Thiergart) Klaus
Leiosphaeridia sp.
Pterospermopsis sp.
Unidentified dinoflagellates
Hystricosporites delectabilis McGregor (Devonian spore)

Dinoflagellate cysts (W.W. Brideaux):

Psaligonyaulax apatela (Cookson and Eisenack) Sarjeant
Caligodinium aceras (Manum and Cookson) Lentin and Williams
Sirmiodinium grossii Alberti emend. Warren
Tubotuberella sp. cf. *T. rhombiformis* Vozzhennikova
Pareodinia ceratophora Deflandre emend. Gocht
Lunatadinium dissolutum Brideaux and McIntyre
"Organism" sp. AE of Brideaux, 1976
Canningia spp.
Tenua spp.
Lecaniella sp.

(5) Johns Island, at narrow neck.

Assemblage from sandstone with thin pebbly layers; section 5 (*see* Fig. 1); unit 1, 0 to 10 feet. Section tabulated in Appendix B. (GSC Loc. 7385).

Alisporites bilateralis Rouse
Baculatisporites sp.
Lycopodiumsporites austroclavatidites Cookson
Marratisporites scabratus Couper

Perinopollenites elatoides Couper
Podocarpidites cf. *P. ellipticus* Cookson
cf. *Podocarpus tricocca* (Malyavkina) Bolkhovitina
Rogalskaisporites cicatricosus (Rogalska) Danzé-Corsin and Laveine
cf. *R. multicicatricosus* Danzé-Corsin and Laveine
Abundant unidentified dinoflagellates

Dinoflagellate cysts (W.W. Brideaux):

"Organism" sp. AE of Brideaux, 1976
Cleistosphaeridium sp. JE of Brideaux, 1976
Tubotuberella sp.

(6) Johns Island, at narrow neck.

Assemblage from carbonaceous siltstone with woody fragments; section 6 (*see* Fig. 1); unit 1, 10 to 20 feet. Section tabulated in Appendix B. (GSC Loc. 7383).

Baculatisporites comaumensis (Cookson) Potonié
Cicatricosisporites sp.
Classopollis classoides Pflug emend. Pocock and Jansonius
cf. *Corollina meyeriana* (Klaus) Venkatachala and Goczan
cf. *Converrucosisporites proxigranulatus* Brenner
Densoisporites velatus Weyland and Krieger
Gleicheniidites senonicus Ross
cf. *Lycopodiacidites varigranulatus* Levet-Carette
Lycopodiumsporites cf. *L. semimurus* Danzé-Corsin and Laveine
Osmundacidites wellmanii Couper
Perinopollenites elatoides Couper
cf. *Phyllocladidites microreticulatus* Brenner
Staplinisporites caminus (Balme) Pocock
Stereisporites sp.
Trilobosporites cf. *T. marylandensis* Brenner
Tsugaepollenites mesozoicus Couper
Vitreisporites pallidus (Reissinger) Nilsson
Unidentified acritarchs
Hystrichosphaeridium sp.
Hymenozonotriletes lepidophytus Kedo (Devonian spore)

(7) Johns Island, about 1.8 miles from northeast end.

Assemblage from thin bedded carbonaceous sandstone; section 7 (*see* Fig. 1); unit 2, 30 to 40 feet. Section tabulated in Appendix B. (GSC Loc. 7382).

Acanthotriletes sp.
Baculatisporites comaumensis (Cookson) Potonié
Gleicheniidites senonicus Ross
Leptolepidites bossus (Couper) Schulz
Unidentified dinoflagellates

Dinoflagellate cysts (W.W. Brideaux):

Oligosphaeridium complex (White) Davey and Williams
Muderongia asymmetrica Brideaux (in press)
Tenua hystrix Eisenack
Palaeoperidinium cretaceum (Pocock ex Davey) Lentin and Williams
Batioladinium pelliferum (Alberti) Brideaux
Subtilisphaera? sp.
Oligosphaeridium sp.
Gonyaulacysta sp.

(8) Johns Island, about 1.3 miles from northeast end.

Assemblage from banded argillaceous sandstone; section 8 (*see* Fig. 1); unit 1, 0 to 100 feet. Section tabulated in Appendix B. (GSC Loc. 7384).

Alisporites grandis (Cookson) Dettmann
Baculatisporites comaumensis (Cookson) Potonié
Chasmatosporites cf. *C. major* Nilsson
cf. *Cedripites canadensis* Pocock
Parvisaccites radiatus Couper
Podocarpidites sp.
Stereisporites antiquasporites (Wilson and Webster) Dettmann
Tsugaepollenites mesozoicus Couper
Many unidentified bisaccates
Microforaminifer

(9) Northwest of Lake Hazen and west of Mesa Creek, about 3.7 miles, bearing N34° W from mouth of Mesa Creek; section 9 (*see* Fig. 1). Section tabulated in Appendix B.

Unit 1; light yellow- to orange-weathering sandstone, at 42 feet. (GSC Loc. 7360).

Auritulinasporites sp.
Classopollis classoides Pflug, emend. Pocock and Jansonius
Cycadopites fragilis C. Singh
Corollina sp.
Lycopodiumsporites cf. *L. semimurus* Danzé-Corsin and Laveine
Podocarpidites sp.
cf. *Pseudopicea monstruosa* Bolkhovitina
Stereisporites antiquasporites (Wilson and Webster) Dettmann
Tsugaepollenites mesozoicus Couper
Unidentified bisaccate pollen
Unidentified dinoflagellates

(10) Northwest of Lake Hazen and west of Mesa Creek: reported by Christie, 1964, p. 50 (GSC Loc. 5236).

(11) Gilman River: reported by Christie, 1964, p. 51 (GSC Loc. 5238).

II. Permian (?), Triassic, and Cenozoic Rocks at Locality 12

(12) Northwest shore of Lake Hazen, about 1.2 miles southwest of mouth of Cuesta Creek; Locality 12 is section G of Fig. 2, Petryk, 1969.

Unit 1, 0-20 feet; sandstone with coal stringers and ironstone pebbles. (GSC Loc. 7349). Palynomorphs noted by G.E. Rouse, University of British Columbia, but not listed here; Cenozoic age assigned.

Units 2 and 3; 20-25 feet; 10 feet of purplish clay overlain by 5 feet of interbedded coal and grey mudstone. (GSC Loc. 7354). Palynomorphs noted by G.E. Rouse, but not listed here; Cenozoic age assigned.

Unit 4, 35-75 feet: interbedded sandstone, siltstone, mudstone, and coal; recessive. Assemblage is from interval 38 to 45 feet. (GSC Loc. 7357).

Identifications (D.C. McGregor):

Cycadopites sp.
cf. *Iraquispora labrata* H.P. Singh
Neoraistrickia ramosa (Balme and Hennelly) Hart
Limitisporites cf. *L. rectus* Leschik
cf. *Pityosporites granulatus* (Leschik) Grebe
Protohaploxypinus cf. *P. goraiensis* (Potonié and Lele) Hart
P. sp. cf. *Striatites medius* H.P. Singh
Vittatina cf. *V. cincinnata* Hart
Separated bodies of striate bisaccates
Cuticle fragments of bennettitalean affinity
Micrhystridium sp.
Unidentified acritarchs

APPENDIX B

STRATIGRAPHIC SECTIONS OF MESOZOIC AND TERTIARY ROCKS

Section, locality 1

Blister Hill, northwest of Lake Hazen

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
	Overlying beds: Heiberg Formation		
8	Sandstone and granule conglomerate; reddish stained, deeply weathered; fine to medium grained, quartzose, argillaceous, lithic, limonitic, conglomeratic sandstone, grading to light grey-green, subangular, poorly sorted dominantly chert granule conglomerate (about 4 mm); scattered, moderately well rounded woody fragments in conglomeratic layers	20 (6)	1,280 (390)
7	Sandstone, quartzose, carbonaceous, argillaceous, white to greyish, medium grained; faintly yellow weathered; carbonaceous matter scattered as flakes or woody fragments, 2-4 inches; scattered small pebbles to granules of chert from 1,055-1,200 feet	210 (64)	1,260 (384)
6	Sandstone, quartzose, carbonaceous, argillaceous, white to light grey to faintly greenish to yellowish weathered, fine grained; thin bedded to fine laminated; intervals of about 20-35 feet of sandstone separated by about 1 foot thick coaly intervals which grade into dark shale and siltstone; GSC Loc. 7374, at 780': Mesozoic, latest Triassic or Early Jurassic or younger (*see* palynological report, this paper)	375 (114)	1,050 (320)

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
5	Sandstone, quartzose, argillaceous, calcareous, fine grained, white to locally reddish stained; interbedded with shale and mudstone; reddish stain from ironstones in patches of loose cemented shale, mudstone and sandstone fragments	145 (44)	675 (206)
4	Sandstone, quartzose, calcareous, very fine grained to fine to medium at top of unit; white; disseminated iron mineral near top of unit	40 (12)	530 (162)
3	Recessive interval of very fine grained, calcareous quartzose sandstone	175 (53.5)	490 (150)
2	Sandstone, quartzose, coarse calcite spar cemented, fine to medium grained, massive white to buff	5 (1.5)	315 (96.5)
	Schei Point Formation		
1	Sandstone, quartzose, argillaceous, calcareous, very fine grained, thin bedded, 6-8 inches thick, current crossbedded, white to light grey; grading to shaly mudstone; relatively resistent, 6 inch beds of white, calcareous, argillaceous, quartzose sandstone, rib the smooth slope every 1.5-2 feet	310 (95)	310 (95)
	Underlying beds: Bjorne Formation.		

Section, locality 4

About 1.7 miles, bearing S65° E from Hazen Camp; on Johns Island

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
	Overlying Beds: Cretaceous?		
2	Sandstone, quartzose, carbonaceous, pyrite, locally minor chert granule conglomerate layers; light grey to yellow where pyrite altered to sulphurous bloom; spheroid pyrite nodules about 1 inch diameter; generally thin bedded, but locally 4 feet thick and torrentially crossbedded	60 (18)	95 (28)
1	Sandstone, quartzose, carbonaceous, pyritic, white and dark banded every 2-4 feet; locally yellow sulphurous staining; cliff forming; GSC Loc. 7386: Late Jurassic to Early Cretaceous (*see* palynological report this paper)	35 (10)	35 (10)
	Underlying beds: Jura-Cretaceous.		

Section, locality 5

Johns Island, at narrow neck

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
	Overlying Beds: Cretaceous?		
2	Oolitic beds, calcareous, indurated, yellow-orange weathered; cliff-forming	10 (3)	50 (15)
1	Sandstone, quartzose, carbonaceous fine grained, white to yellowish, with minor 10 inch thick chert granule layers; GSC Loc. 7385: Early Cretaceous (*see* palynological report, this paper)	40 (12)	40 (12)
	Underlying beds: Jura-Cretaceous.		

Section locality 6

Johns Island, at narrow neck

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
	Overlying Beds: Cretaceous?		
3	Siltstone, carbonaceous, light-grey, laminated to wavy banded to mottled; relatively well indurated and massive; traces woody fragments	40 (12)	86 (26)
2	Concretionary zone; very dense, siliceous orange-yellow, siliceous, ironstone concretions, 4-6 inches thick, or more, 1- 4 feet long diameter, separated by 1-2 feet of unit 3 siltstone[1]	10 (3)	46 (14)
1	Siltstone, as unit 3 above; GSC Loc. 7383: Early Cretaceous? (*see* palynological report, this paper)	36 (11)	36 (11)
	Underlying beds: Jura-Cretaceous.		

[1] This bed may be equivalent to the Ringnes Formation; *see* Balkwill, H.R., Wilson, D.G. and Wall, J.H., 1977: Ringnes Formation (Upper Jurassic), Sverdrup Basin, Canadian Arctic Archipelago; Bulletin of Canadian Petroleum Geology, v. 25, p. 1115-1144.

Section, locality 7

Johns Island, about 1.8 miles from northeast end

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
	Overlying beds: Cretaceous?		
2	Sandstone, quartzose, calcareous, medium grained light grey; thin bedded, well cemented; minor scattered rusty stained, granule and small pebble ironstones: GSC Loc. 7382: Jurassic or Early Cretaceous (*see* palynological report, this paper)	10 (3)	40 (12)
1	Sandstone, quartzose, argillaceous, calcareous, dark grey; massive, with minor dark siltstone containing oolitic horizons	30 (9)	30 (9)

Section, locality 8

Johns Island, about 1.3 miles from northeast end

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
	Overlying beds: Cretaceous?		
3	Siltstone, argillaceous, carbonaceous, light grey with basal 3 feet, dark brown to yellow spotted, very argillaceous and carbonaceous, quartzose, fine-grained sandstone	16 (5)	140 (42)
2	Sandstone, quartzose, argillaceous, carbonaceous, white, massive, current crossbedded; plant fragments partly replaced by pyrite	24 (7)	124 (37)
1	Sandstone, quartzose, argillaceous, carbonaceous, white to grey, banded or laminated; GSC Loc. 7384: Jurassic or Early Cretaceous (*see* palynological report, this paper)	100 (30)	100 (30)
	Underlying beds: Jura-Cretaceous.		

Section, locality 9

Northwest of Lake Hazen, about 3.7 miles,

bearing N55° W from the mouth of Mesa Creek

Unit	Lithology	Thickness feet (metres)	Height Above Base feet (metres)
	Overlying beds: Jurassic to Early Cretaceous?		
5	Sandstone, quartzose, orange to buff-brown weathered carbonaceous; interbedded with minor white weathered sandstone and scattered chert granules and pebbles; light coloured siliceous-weathered crust when broken is purplish (mauve) due to flaky, carbonaceous matter (about 2%); GSC Loc. 7361, at 400 feet: Mesozoic re-worked? (G.E. Rouse).	116 (35)	400 (121)
4	Shale, sandy, carbonaceous, dark grey to brownish black, deeply weathered; streak with 1-2 feet and 2 inches wide gossan-like, orangy lenses	60 (18)	284 (86)
3	Sandstone, quartzose, white-yellowish; recessive-slope	159 (48)	224 (68)
2	Sandstone, quartzose, white; recessive	16 (5)	66 (20)
1	Sandstone, quartzose, argillaceous; light yellow-orange weathered; scattered thin irregular, flaky lamination; bedding 2-6-8 inches thick; GSC Loc. 7360 at 44 feet: Jurassic or Early Cretaceous (*see* palynology report, this paper)	50 (15)	50 (15)
	Underlying beds: Upper Jurassic and Cretaceous.		