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OPEN FILE REPORT

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PRELIMINARY DRAFT OF 1:1,000,000 GEOLOGICAL ATLAS SHEETS EUREKA SOUND AND ROBESON CHANNEL AREAS, CANADIAN ARCTIC ISLANDS (NTS 560, 340, and Canadian part of 120)

Abstract

This unedited manuscript, based on information published prior to April, 1973, covers Axel Heiberg and Ellesmere Islands north of 80° latitude. It contains:

(1) Geological compilations plotted on an enlarged version of the original 1:1,000,000 sheets (1961 edition of #2007, 1963 edition of #2008) with legend and age determinations,*

(2) Sketch maps showing regional setting and tectonic subdivisions of the area,

(3) Geotectonic correlation charts,

(4) Index map for source materials,

(5) Brief summary of depositional history, stratigraphy, orogenic history, and regional stratigraphic-structural subdivisions, with references.

* Legend for symbols designating age determinations at back of these notes

OPEN FILE
174
OCT 1973
GEOLOGICAL SURVEY
OTTAWA

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PREFACE

This manuscript was completed in April, 1973 and is based on all information published prior to that date as well as some unpublished information obtained by Officers of the Geological Survey of Canada. The manuscript has since been reviewed by R. J. W. Douglas who has made various suggestions for improvement; but it is placed on Open File in its present, unedited form as a final version may not be handed in until the reconnaissance mapping of the region has been completed. The final version will utilize more recent editions of the topographic base maps and will include adjacent parts of Greenland and the results of studies on Judge Daly Promontory by R. L. Christie in August, 1973.

SUMMARY NOTES

Eureka Sound-Robeson Channel is the most complex area of the Innuitian Province and parts are poorly known. Only those regions that are known from reasonably detailed investigations are colored on the present map; reconnaissance information for the remaining parts is indicated by letter symbols. The area is underlain by three major successions that are separated by extensive angular unconformities; an Upper Proterozoic and lower Paleozoic succession deposited in the Franklinian Geosyncline and deformed by the Middle (?) Devonian to early Mississippian Ellesmerian Orogeny; an upper Mississippian to lower Tertiary succession deposited mainly in the Sverdrup Basin and deformed by the Late Cretaceous to mid-Tertiary Eurekan Orogeny; and undeformed upper Tertiary and younger post-tectonic deposits.

Depositional history and stratigraphy

The history of the Franklinian Geosyncline is divisible in two major phases. During the first, Late Proterozoic to Early Cambrian phase, a southeastward tapering wedge of clastic and carbonate sediments was deposited in central and southeastern Ellesmere Island (Kennedy Channel Formation, Ella Bay Formation, Ellesmere Group, Scoresby Bay Formation). The clastic sediments, which decrease in grain size to the northwest, appear to have been derived from the craton. Correlative units may be present within the metamorphic complex of northern Ellesmere Island but have not yet been identified, and the history of the central and northern parts of the map-area during this interval is unknown. During the second, Middle (?) Cambrian to Late Devonian phase, the clastic sediments were derived mainly from an orogenic welt on the northwest, that was situated in the present offshore region, but expanded into northern Ellesmere Island

during certain intervals marked by unconformities, regional metamorphism, and granitic plutonism. During this phase, the geosyncline is divisible into a northwesterly clastic province, characterized by compositionally immature clastic sediments but also including carbonates, volcanics, and chert, and a southeasterly carbonate province characterized by limestone and dolomite but also including evaporitic and clastic sediments. The carbonate province occupied the south-central and southeastern parts of the present map-area where it is represented by Parrish Glacier, Copes Bay, Baumann Fiord, and Eleanor River Formations, Cornwallis Group, and Allen Bay Formation. The oldest dated unit of the clastic province is the extensive Grant Land Formation which represents a tectonic delta complex of Early Ordovician or older, possibly Middle to Late Cambrian age. During the Early and early Middle Ordovician, a starved basin developed in the Hazen Plateau region that received pelites, chert, and deeper-water carbonate sediments (Hazen Formation). Equivalent deposits on the northwestern margin of the trough have not yet been dated precisely but may include pelites, chert, shelf-type carbonates, and siliceous to basic volcanics included in Rens Fiord Complex, Mount Disraeli Group, and map-units > uOc and > uOv. The late Middle and Late Ordovician interval was characterized by flysch sedimentation within the Hazen Trough (Imina Formation) and by carbonate, clastic, and volcanic deposition at its northwestern margin (Cape Discovery and M'Clintock Formations, Challenger Group). The trough expanded and included probably all of northern Ellesmere Island in Early Silurian (Landoverian) time as flysch deposits (Imina Formation) of that age occur at Phillips and M'Clintock Inlets. Shelf conditions, however, were restored in the Grantland Mountains by Late Silurian (Ludlovian) time when carbonates (Marvin Formation and map-unit Sc) and shallow marine clastic

sediments were deposited there. A southeastward expansion of the Hazen Trough from Early Silurian to Early Devonian time is apparent from the southeastward transgression of Cape Phillips pelites, Imina flysch, and Eids siltstones over Allen Bay carbonates. Late Silurian to Early Devonian movements in north-central parts of the Innuitian Province (including Rens Fiord Uplift of northern Axel Heiberg Island) produced marine deltaic sediments in northwestern Ellesmere Island (Lands Lokk Formation) and nonmarine to deltaic red-beds in Axel Heiberg Island (Stallworthy Formation). Later in the Early (?) Devonian, the submarine Svartevaeg Trough developed in northern Nansen Sound region, which received turbidites, mass-flow deposits, and volcanics.

Sverdrup Basin is a subelliptical crustal depression that developed, on the bevelled structures of the Ellesmerian orogen, from Carboniferous to early Tertiary time. The present map-area includes the northeastern half of the basin with excellent exposures of upper Paleozoic and Triassic formations. This succession has been traced as far northeast as Lake Hazen and Cape Columbia. The upper Paleozoic stratigraphy of northeasternmost Ellesmere Island, however, is different, and its relationship with the Sverdrup Basin remains to be clarified. The oldest unit of the Sverdrup Basin are local, nonmarine clastic deposits of late Mississippian age assigned to the Emma Fiord Formation. Widespread Upper Carboniferous clastic and carbonate sediments, commonly red, are assigned to the Borup Fiord Formation in the northwestern, and to the Canyon Fiord Formation in the southeastern parts of the map-area. Emma Fiord and Borup Fiord Formation, basal Pennsylvanian clastic sediments at M'Clintock Inlet (map-unit Cs), and probably also some Triassic and Jurassic strata in northern Axel Heiberg Island were derived from northwesterly sources;

the remaining clastic deposits of the Sverdrup Basin probably had southerly and easterly sources. The overlying Upper Carboniferous to Lower Permian sequence is divisible into: a southeastern carbonate belt (Nansen Formation); an axial evaporitic and pelitic belt (Otto Fiord and Hare Fiord Formations); a southeastern carbonate belt (Nansen Formation); and a carbonate, clastic and evaporitic belt at the southeastern margin of the basin (Antoinette, Mount Bayley, Tanquary, and Belcher Channel Formations). During the remaining part of Permian time, sand deposition prevailed in the southeastern half of the basin (Sabine, Assistance, and Trold Fiord Formations) while in the northwestern parts pelite and chert sedimentation (van Hauen Formation) was followed by limestone and chert deposition (Degerbøls Formation). Carboniferous basic volcanism appears to have been restricted to northwestern-most Ellesmere Island (Audhild Formation and map-unit Cv), but Early Permian basic volcanism (Esayoo Formation) extended from northern Axel Heiberg Island to west of Tanquary Fiord.

The Lower to lower Upper Triassic strata are divisible into an axial pelitic facies (Blind Fiord and Blaa Mountain Formations) and a marginal arenaceous facies (Bjorne and Schei Point Formations). The Upper Triassic to Upper Cretaceous column is characterized by the alternation of arenaceous, partly nonmarine deposits (Heiberg, Borden Island, Jaeger, Awingak, Isachsen, and Hassel Formations) with pelitic marine deposits (Savik, Deer Bay, Christopher, and Kanguk Formations). Basic volcanic rocks occurring locally in the Cretaceous system are probably related to widespread dykes and sills (not shown on map and correlation chart).

The upper Tertiary Beaufort Formation of Meighen Island forms part of a northwestward thickening continental-terrace wedge that includes the present continental shelf, slope, and rise. It occurs close to the thin

edge of the wedge and was deposited in paralic environments. Certain flat-lying sands and gravels in parts of Axel Heiberg and Ellesmere Islands are believed to be correlative with the Beaufort Formation. They are shown on the correlation chart, but have not yet been mapped.

Orogenic history

Six orogenic or diastrophic events are recognized in the present area, some firmly established and others conjectural; the first three appear to have been restricted to the northernmost regions.

(1) The Grant Land Formation appears to be a post-tectonic deposit derived from gneissic uplands to the northwest which may have included the oldest parts of the metamorphic complex of northern Ellesmere Island. If so, it would record a Middle (?) Cambrian or earlier orogenic event in that region.

(2) An Early or early Middle Ordovocian orogenic event is inferred from an angular unconformity beneath the upper Middle Ordovician Cape Discovery Formation; siliceous volcanics above and below the unconformity that may be surface manifestations of "granitic" plutonism; and the metamorphic state of supposed Lower to lower Middle Ordovician strata. A K-Ar age of 465 $\pm$ 19 m.y. from Cape Columbia may support this inference, although the metamorphic age determinations are too scattered to permit firm conclusions.

(3) Late Silurian-Early Devonian movements of the Rens Fiord Complex, coeval with the main deformation of the Boothia Uplift, are indicated by an angular unconformity at the base of the Cape Stallworthy Formation. The intrusion of a complex, syenitic to ultramafic plutonic assemblage at M'Clintock Inlet and Ayles Fiord, which has yielded Early Devonian apparent

ages of 376 ± 16 m.y. to 390 ± 20 m.y., is tentatively correlated with the subsequent formation of the Svartevaeg rift in Nansen Sound region. Undated mafic and ultramafic rocks on Kleybolte Peninsula (Bourne Complex and man-unit Dub) may also be related to this event.

(4) Three phases are tentatively distinguished in the Ellesmerian Orogeny, which appears to have progressed from northwest to southeast. (i) Folding in the northern regions accompanied by regional metamorphism and synkinematic quartz monzonite intrusion at Phillips Inlet. (ii) Post-kinematic quartz-diorite and quartz monzonite intrusion (dated as 360 ± 25 and 345 ± 15 m.y.) and uplift of the northern regions, accompanied by widespread and rapid clastic sedimentation in the central and southern parts (upper Middle to Upper Devonian Okse Bay Formation). (iii) Folding of Okse Bay and older formations in the central and southern parts, probably accompanied by further movements in the north. The Okse Bay is not preserved in the present map-area, but probably extended into its southern parts.

(5) An angular unconformity between the Sail Harbour and Guide Hill Groups of northeasternmost Ellesmere Island was reported by Blackadar (1954). The age of the Sail Harbour Group is uncertain; if late Paleozoic [Middle Pennsylvanian (?)] the unconformity may be related to the Melvillian disturbance.

(6) The extensive Eurekan Orogeny included an early phase of uplift and faulting, accompanied by the deposition of the nonmarine Eureka Sound Formation, and a later phase during which the Eureka Sound Formation itself was deformed.

Regional stratigraphic-structural divisions

The generalized outcrop areas of the three major successions constitute the first-order divisions of the present area. The Upper Proterozoic and lower Paleozoic succession occurs in two separate belts referred to as Northern and Central Ellesmere Fold Belts respectively.

Northern Ellesmere Fold Belt is underlain mainly by lower Paleozoic sedimentary, volcanic, metamorphic and plutonic rocks with some upper Paleozoic and Tertiary outliers. The volcanic rocks are mainly keratophyric in composition. The metamorphic rocks range from subgreenschist to amphibolite facies and generally increase in grade to the northwest. This belt is the only part of the map-area known to have been involved in pre-Ellesmerian orogenies. Structural trends are mainly westerly to southwesterly, parallel with the present coast, but are northerly in the Milne-M'Clintock fold complex and northwesterly in the Rens Fiord Uplift. Structural style varies with lithology and metamorphic grade.

Central Ellesmere Fold Belt, underlain mainly by Upper Proterozoic and lower Paleozoic sedimentary rocks, less common low-grade metamorphic rocks, and Carboniferous to lower Tertiary outliers, extends from Nares Strait to Devon Island. Nares Strait probably is the site of a major rift or transcurrent fault zone, elements of which are exposed on Judge Daly Promontory (Judge Daly Fault Zone). Three parallel, southwest-trending subdivisions are recognized in the present area.

(1) Grant Land Uplift is composed mainly of the Grant Land Formation and unconformably overlying Carboniferous and Mesozoic strata. The Grant Land Formation, metamorphosed in subgreenschist to greenschist facies, forms highly attenuated, narrow folds. The axial planes strike southwesterly and dip steeply both to the northwest and the southeast, parallel with

major faults. The Ellesmerian folding must have been followed by considerable uplift as all lower Paleozoic units younger than the Grant Land Formation were removed prior to Sverdrup Basin sedimentation except in local grabens. The Paleozoic uplift was rejuvenated during the Eurekan Orogeny by movements on the Lake Hazen and Porter Bay fault zones. The Lake Hazen zone consists of southeast-directed thrust faults; the complex Porter Bay includes both normal faults and a northwest-directed thrust. The culmination of the uplift is between Lake Hazen and Clements Markham Inlet where the post-Ellesmerian unconformity must exceed 5,500 feet (1.7 km - the present relief) in altitude. Thence the unconformity plunges relatively steeply northeast attaining sea level at the coast of Lincoln Sea.

(2) Hazen Plateau is underlain mainly by tightly folded strata of the Imina Formation which here probably is more than 10,000 feet (3 km) thick. The structural style, controlled by the alternation of thin but extensive greywacke and pelite units, is characterized by highly attenuated, complex folds with regular southwesterly trends. Most axial planes dip steeply northwest, but perhaps one third dip steeply southeast. The metamorphism is of subgreenschist facies. The present plateau corresponds roughly to the post-Ellesmerian unconformity which has mostly been stripped of its cover except for local patches of flat-lying lower Tertiary strata. A major structural depression adjacent to the Lake Hazen fault zone, however, contains more than 6,000 feet (1.8 km) of upper Paleozoic to lower Tertiary sediments. The post-Ellesmerian unconformity appears to have been warped and elevated to locally more than 3,000 feet (0.9 km), but Eurekan uplift and deformation were weaker than in the Grantland and Victoria and Albert Mountains.

(3) Victoria and Albert Mountains are formed in Upper Proterozoic and lower Paleozoic strata, generally unmetamorphosed but including some phyllites and slates. Flat-lying lower Tertiary strata occur in grabens on eastern Judge Daly Promontory. The broad, open style of folding is controlled by massive carbonate units such as the Ordovician Thumb Mountain Formation. The folds commonly are asymmetrical with steep northwestward dipping axial planes. Thrust faults, in part probably Eurekan in age, are directed to the southeast. Late Cretaceous-Cenozoic uplift must have been considerably more than 5,000 feet (1.5 km), the present physiographic relief of the lower Paleozoic rocks.

The generalized outcrop area of the Carboniferous to lower Tertiary strata is assigned to Eureka Sound Fold Belt which includes the deformed deposits of the central and northeastern parts of the Sverdrup Basin. Diapirs are common in the axial region of the basin where Otto Fiord evaporites are overlain by Hare Fiord pelites; they are associated with faults and appear to be tectonic in origin. Structural trends are mainly to the northwest in Axel Heiberg Island. The most important structural element there is the broad, complexly faulted Princess Margaret Arch, which is aligned with the lower Paleozoic Rens Fiord Uplift. In westernmost Ellesmere Island, structural trends swing from northwesterly to northeasterly directions; extensive north-trending normal faults occur in this transition zone. Farther to the west, the region north and south of Hare Fiord is characterized by extensive thrust faults and folds. Most thrusts dip northwest, but some (e.g. Blue Mountains thrust) dip southeast; several are soled by Otto Fiord evaporites. Lower Paleozoic inliers north of the

head of Tanquary Fiord represent an extension of the Grantland Uplift. The Tanquary Structural High is a segment of the Grantland Uplift marked by the absence of the entire stratigraphic interval between Cambrian (?) Grant Land and Upper Triassic Heiberg Formations. The northeastern parts of the Eureka Sound Fold Belt, bounded on the southeast by the Porter Bay Fault Zone, are poorly known.

The Beaufort Formation of Meighen Island is included in the Arctic Coastal Plain, a homocline that dips northwest at very low angles.

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LEGEND FOR GEOCHRONOLOGICAL DATA

IGNEOUS ROCKS

Colour No.		
		PLUTONIC ROCKS
741	●	Acidic-granite, quartz monzonite, adamellite, syenite, monzonite, granodiorite, quartz-diorite, tonalite, diorite, quartz gabbro
748	○	Basic and ultramafic-gabbro, anorthosite, norite, pyroxenite, dunite, peridotite
		DYKES, SILLS AND VEINS (Strike of dykes indicated by a bar Ø
745½	●	Lamprophyre
747½	○	Diabase dykes, gabbro
737	●	Pegmatite dykes, quartz veins
		VOLCANIC ROCKS
735½	○	Acidic: rhyolite, dacite, trachyte
738½	●	Basic: basalt, andesite
		OTHER
742	●	Carbonatite, kimberlite, nepheline syenite, nordmarkite etc.

METAMORPHIC ROCKS

Colour No.		
741	△	Gneiss, migmatite, granulite
748	△	Schist, phyllite, slate, meta-siltstone
738½	△	Greenstone, meta-gabbro, amphibolite
742	△	Contact rocks: skarn, calc-silicate, marble
745½	△	Quartzite meta-arkose, meta-greywacke

DATING METHODS AND MINERAL ABBREVIATIONS	
K: Potassium-Argon R: Rubidium-Strontium	U: Uranium-Thorium-Lead
Biotite — b	Zircon — z
Phlogopite — p	Sphene — s
Muscovite — m	Monazite — m
Lepidolite — l	Uraninite — u
Amphibole — a	Pitchblende — p
Glauconite — g	Other — o
Other — o	Concordia intersection — c
Whole-rock — w	
Whole-rock isochron — i	

Sample location: igneous, metamorphic, sedimentary other. . . . ⊕ △ ◊ □

Age in millions of years. 2500

Surface sample, subsurface sample, sills or flows. 2500, $\overline{2500}$, $\underline{2500}$

Example: rock type, mineral, dating method, age, laboratory. bK2500a