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NORTHEASTERN ELLESMERE ISLAND, DISTRICT OF FRANKLIN

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R. L. Christie

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INTRODUCTION

Ellesmere Island is the largest and most northerly of the Queen Elizabeth Islands, the northernmost group of the Canadian Arctic Archipelago. This report describes the northeastern part of the island, or the region surrounding Lake Hazen. The accompanying map is compiled mainly from data obtained by V.K. Prest in 1950, by R.G. Blackadar in 1953, and by the author in 1954, 1957, and 1958. Also included are some data from the early exploring expeditions, from the United States Air Force Cambridge Research Laboratories project at Ward Hunt Island (Lyons and Leavitt, 1961)[1], and from the several expeditions of the Defence Research Board on the ice-cap of the United States Range led by G. Hattersley-Smith. The results of reconnaissance of the east and north coasts carried out in 1950, 1953, and 1954 have been published previously (Prest, 1952; Blackadar, 1954; Christie, 1957) and are presented here in generalized form.

Accessibility and Methods of Travel

The area is accessible by air or by icebreaker. Travel by dog team is feasible along the fiords and channels from Thule, Alexandra Fiord, or Eureka weather station, but such journeys would be long and arduous, and rather hazardous in Kennedy Channel.

During August, modern icebreakers have little difficulty in navigating Lady Franklin Bay and Chandler Fiord, but in some seasons they have been unable to reach Alert weather station.

Wheel-equipped aircraft can land during most of the year on the airfield at Alert, and during the winter and early part of the melt season on Lake Hazen, where light snowfall and nearly windless winters provide good landing conditions for large aircraft. Ski-wheel-equipped Dakota aircraft have landed at Lake Hazen, Ward Hunt Island, on the ice-cap of the United States Range, and on the fiords. Float- and hull-equipped aircraft have landed in August on the fiords, on Lake Hazen, and on various small lakes. Light aircraft with oversize tires have landed at many places in the region.

Conditions for sledging by dog or motor-toboggan are good along the rivers, lakes and fiords. The lake and fiord ice may be used without much inconvenience until about early July. Snow-cover quickly disappears after the beginning of the melt period in early June, and foot travel on land then becomes generally easy.

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[1]Names and dates in parentheses refer to publications listed in the References.

Topography

Northeastern Ellesmere Island lies within a mountain belt that trends northeasterly across Axel Heiberg Island, Ellesmere Island, and Northern Greenland. Within the map-area are the northern continuation of the Victoria and Albert Mountains, an extensive inland plateau, and a northern mountain belt. The mountain belt comprises the United States Range, several lesser and flanking ranges, and coastal mountain groups. Lake Hazen lies on the northwestern edge of the plateau.

History of Discovery

Several well-known exploring expeditions have wintered and travelled in northern Ellesmere Island. In 1875-76, Capt. G.S. Nares, RN, wintered his ships 'Discovery' at Discovery Harbour and 'Alert' near Cape Sheridan, and the men of this expedition made lengthy journeys along the north coast of Ellesmere Island and up Archer Fiord. An expedition led by Lt. A.W. Greely of the United States Army established 'Fort Conger' in 1881. Parties from Fort Conger travelled widely, and Greely himself discovered Lake Hazen in 1882. On another journey two men walked up Archer Fiord, and crossed to and named Greely Fiord.

Commander R.E. Peary and members of his parties visited Lake Hazen on hunting trips from Fort Conger and Cape Sheridan between 1898 and 1900. In 1905, Peary's Eskimos established three winter 'settlements' on and near Lake Hazen, and sledge loads of meat were taken overland to the ship, which was frozen in near Cape Sheridan. Peary, concerned almost wholly with the attainment of the pole, confined his travels mainly to the east and north coasts of Ellesmere Island.

W. Elmer Ekblaw, naturalist of D.B. McMillan's Crocker Land expedition of 1913-17, travelled up Tanquary and Greely Fiords, and from the latter crossed to Lake Hazen and descended Ruggles River to Lady Franklin Bay.

Commander Godfred Hansen of the Royal Danish Navy sledged by dog in 1926 from Thule to Cape Aldrich, laying depots in support of Roald Amundsen's north polar drift in the 'Maud'.

A.W. Moore and Sgt. H.W. Stallworthy, both of the Oxford University Ellesmere Land expedition, travelled to Lake Hazen by sledge in 1955, and Moore and Nukapinguak, one of the accompanying Eskimos, climbed the ice-cap and a peak of United States Range.

J.C. Troelsen, geologist of the 1939-40 van Hauen expedition, crossed the plateau between Greely and Archer Fiords and collected fossils at Cape Baird.

Alert weather station was established in 1950 after reconnaissance to Cape Belknap in 1948 by U.S. Navy and Coast Guard icebreakers.

Acknowledgments

Field work in 1957 and 1958 was based at Lake Hazen, at the permanent camp of the Defence Research Board's 'Operation Hazen'. The author is indebted to the other members of Operation Hazen for considerable geological information and for their cooperation and assistance. G. Hattersley-Smith, leader of the expedition, has kindly provided several valuable fossil collections and other data from United States Range. The geological data was obtained in 1957, 1958, and 1961 during extended sledging journeys along the ice-cap of the range.

B.P. Walker of Ingersoll, Ontario, was geological assistant in 1958, and carried out his duties with ability and resourcefulness.

GENERAL GEOLOGY

Rocks covering a wide range of ages are found on northern Ellesmere Island: a gneiss-and-schist terrane, probably of early Palaeozoic age or older, is extensively exposed on the north coast; tightly folded, slightly metamorphosed sedimentary formations that underlie the plateau adjacent to Lake Hazen and parts of Judge Daly Promontory are probably of early to middle Palaeozoic age; open-folded, well-bedded Permo-Carboniferous sandstones and limestones underlie much of United States Range; and sedimentary rocks containing fossils ranging from Permo-Carboniferous to Cenozoic age underlie a narrow belt along the north shore of Lake Hazen and to the northeast.

Granitic rocks intrude the metamorphic formation of the north coast of Ellesmere Island. Dyke rocks intrude all but the youngest strata.

Precambrian or Palaeozoic

Cape Columbia Group

The Cape Columbia Group (1)* of metamorphic rocks is exposed along the north coast from Cape Aldrich to Ward Hunt Island and at the head of M'Clintock Inlet. The group, named and first described by Blackadar (1954), comprises biotite-feldspar gneiss, hornblende-biotite-feldspar gneiss and schist, garnet-biotite-feldspar gneiss, mica schists, quartzite, and micaceous quartzite. Narrow bands of spectacular augen gneisses in the vicinity of Cape Columbia consist of large, white or pink feldspar crystals in a matrix of biotite, sericite, fine-grained feldspar, and red garnet. Leucogranitic and pegmatitic dykes cut the gneissic rocks. The Cape Columbia Group, as currently used, includes rocks of a wide range of metamorphic grade, and more than one formation, of different ages and history, may be present. For the most part, however, the metamorphism seems to be of a considerably higher grade than that in other formations

*Number in parentheses following rock-group name is the number of the map-unit.

Table of Formations

Period or Epoch	Group or Formation	Locality	Lithology
Pleistocene and Recent			Till; fluvioglacial sand, gravel, and boulder deposits; stream gravels, talus, soil; ice
		Unconformity	
Paleocene to Miocene		'Watercourse Valley' Lake Hazen	Shale, sandstone, coal
		Unconformity on Jura-Cretaceous beds(?)	
Cretaceous or Cenozoic		Judge Daly Promontory	Sandstone, shale
Cretaceous(?)		Lake Hazen	Basalt sills and dykes; diabase, gabbro
		Intrusive contacts	
Probably Triassic to Cretaceous		Lake Hazen	Sandstone, shale, coal
Lower Permian		Lake Hazen	Sandstone, shale, limestone
Permian	Feilden Group Guide Hill Group Dana Bay Group	Feilden Peninsula	Limestone, sandstone, shale, conglomerate
Carboniferous and Permian		United States Range	Limestone, sandstone, arkosic sandstone, chert-pebble conglomerate, gypsum

		Angular unconformity	
Permian or Earlier	View Creek Group Sail Harbour Group	Feilden Peninsula-Clements Markham Inlet	Sandstone, quartzite, greywacke, slate, conglomerate, slate, limestone
		Relations not known	
Silurian(?)		Judge Daly Promontory	Argillite, slate, limestone, quartzite
Silurian	Cape Rawson Group	United States Range; plateau	Greywacke, impure sandstone, sandstone, slate, phyllite, impure limestone, gypsum
		Relations not known	
Ordovician	Challenger Group	M'Clintock Inlet	Limestone, sandstone, conglomerate, slate, basic volcanic rock
		Relations not known	
		Judge Daly Promontory	Limestone, sandstone, quartzite
		Relations not known	
Probably Ordovician	M'Clintock Group	M'Clintock Inlet	Andesitic and basaltic flows, breccias, tuffs; greywacke, arkosic sandstone, slate
		Relations not known	
Probably Ordovician or Earlier	Mt. Disraeli Group	Markham Bay to Clements Markham Inlet	Calcareous slate, phyllite, limestone, shaly limestone, calcarenite, conglomerate, quartzite, marble
		Relations not known	
Syenite and granitic and pegmatitic dykes intrude Cape Columbia Group rocks; relationship to all other groups unknown.			
		Intrusive contact	
Earliest Palaeozoic or Precambrian	Cape Columbia Group	Cape Aldrich to Ward Hunt Island M'Clintock Inlet	Biotite gneiss, garnet-biotite gneiss, augen gneiss, chlorite-feldspar schist, amphibole-mica-feldspar gneiss, quartzite

of the region, and an early Palaeozoic or a Precambrian age is presumed. An age determinaton of 545 m.y. has been obtained in the laboratories of the Geological Survey of Canada, using the potassium-argon method (see Blackadar, 1960). According to a time scale proposed by Kulp (1960), Middle Cambrian time began 540 m.y. ago; this would make the northern Ellesmere specimen probably of earliest Palaeozoic age or older. The age given by the K-Ar isotope method is that of the latest metamorphism undergone by the rocks, which may themselves be much older.

Middle Ordovician or Earlier

Mount Disraeli Group

Slightly metamorphosed, unfossiliferous sedimentary rocks west of Clements Markham Inlet were described and named the Mount Disraeli Group by Blackadar (1954). The group (2) comprises calcareous black slate and phyllite, grey limestone, and minor amounts of marble, limy sandstone, conglomerate, and quartzite. The slate and phyllite form one distinct assemblage, and the limy beds another. The beds are irregularly intruded by quartz-calcite veins, and are folded and steeply dipping.

Ordovician(?)

M'Clintock Group

The M'Clintock Group (3) of volcanic and associated sedimentary rocks forms approximately east-trending structures in the vicinity of M'Clintock Inlet and Disraeli Bay. Greenish grey, fine- to medium-grained tuffs and tuffaceous rocks predominate, and are interbedded with abundant andesitic to basaltic flows and breccias. A pre-Middle Ordovician age is inferred from the presence of volcanic rocks similar to those of the M'Clintock Group in the fossiliferous Challenger Group. Fossils identified as imperfect orthid (?) brachiopods found in greywacke talus near land on the Ward Hunt ice shelf are used by Lyons and Leavitt (1961, p. 2) as supporting evidence for an Ordovician age for the M'Clintock Group.

Ordovician

Ordovician Beds of Judge Daly Promontory

Ordovician fossils are fairly abundant in limestone beds on Judge Daly Promontory. The fossiliferous beds (4) lie in a region of variable attitudes and trends and numerous faults. The rocks are mainly grey and brown limestone, calcareous sandstone, and quartzite, and weather in shades of grey, light brown, and red-brown.

G.W. Sinclair of the Geological Survey has assigned a late Ordovician age to most of the fossil collections, and a Middle or Late Canadian (early Ordovician) age to one.

Challenger Group

The fossiliferous Challenger Group (5) is dominantly grey limestone and impure reddish sandstone. Fossils of Middle and of Upper Ordovician age have been obtained (Christie, 1957, p. 13). The strata are moderately to tightly folded into east-trending structures.

Silurian

Cape Rawson Group

The Cape Rawson Group (6) comprises mainly well-bedded, uniformly-dark-coloured greywacke, impure sandstone, and micaceous gritty slate, and underlies the extensive plateau and mountain ranges surrounding Lake Hazen. Thick beds of black chert are present south and west of Alert.

Rocks of the Cape Rawson Group change from fine-grained and calcareous in the southeast and east, to coarse and quartz-feldspathic in the northwest (especially northwest of Lake Hazen). Thick beds of black chert are present south and west of Alert. The change in character appears to be a facies change, or horizontal variation, and is general throughout the group of beds.

A weak cleavage in the Group is due in part to abundant detrital mica, and in part to secondary minerals developed during folding and slight metamorphism. Slaty cleavage and schistosity have developed in certain areas, and well-developed schistosity was observed, particularly in the vicinity of upper Gilman Glacier.

Cape Rawson strata lie in tight, isoclinal and chevron folds of various sizes, with axial planes dipping steeply northwestward. Moderate to steep dips obtain over almost the entire area of exposure, and the up-ended resistant strata produce the marked northeast lineation of the plateau and adjacent mountains.

A collection of fossils from a limestone bed in the Cape Rawson Group has been identified by T.E. Bolton of the Geological Survey as being: "Atrypella phoca, coarse ribbed spirifer (Delthyris?), and rugose and phacelloid corals. These all strongly suggest an early Upper Silurian age (the Arctic Atrypella phoca fauna) for this part of the Cape Rawson Group". Fossiliferous Middle Silurian limestone surrounded by Cape Rawson beds near Alert has been described by Blackadar (1954, p. 11). The limestone was inferred to overlie Cape Rawson beds unconformably but it now seems more probable that the limestone is part of the Cape Rawson Group.

The Cape Rawson Group is overlain unconformably by Permo-Carboniferous beds in the Lake Hazen and Tanquary Fiord regions.

Silurian(?)

A highly folded assemblage of beds (7) is exposed along the north shore of Judge Daly Promontory and for at least several miles along the north shore of Archer Fiord. The folding, and to some extent

the lithology, are similar to those of the Cape Rawson Group, but the general lithological character is quite distinct. Lighter-weathering, more calcareous and quartzose beds in Archer Fiord contrast with the monotonous greys of Cape Rawson strata to the north. The Archer Fiord rocks are mainly limy argillite, limestone, and micaceous feldspathic quartzite. A striking intraformational breccia of light grey limestone is widespread.

The beds in Archer Fiord are faulted against the Cape Rawson Group north of Keppel Head, and much of the southern boundary, on Judge Daly Promontory, lies along lineaments probably of fault origin. Ordovician limestone appears to unconformably overlie the Archer Fiord beds in the interior of Judge Daly Promontory, but it is uncertain whether this is a stratigraphic or a structural discordance.

The affinities and similarities of the beds of Archer Fiord with the Cape Rawson Group to the north suggest that the two are closely related. The Archer Fiord strata may, in fact, be merely a part or a facies of the Cape Rawson Group.

Permian or Earlier

Sail Harbour and View Creek Groups

The Sail Harbour Group (8) of black shale, slate, and argillaceous limestone, and the View Creek Group (9) of sandstone, conglomerate, slate, phyllite, limestone, and greywacke were named by Blackadar (1954, p. 12). He considered them to be possibly younger than the Cape Rawson Group because of their relatively slight metamorphism, and in the case of the View Creek Group because of similar structural attitudes to an adjacent Permian formation.

The Sail Harbour beds lie in both open and closed, overturned folds, and south of Parker Bay appear to pass into Cape Rawson beds. A divergence of trends in that region makes correlation uncertain, but the general structural and lithological similarities indicate a close relationship between the two groups.

Specimens of View Creek strata resemble closely, to the present writer, certain suites of the Cape Rawson Group, and it is possible that the View Creek beds are beds of the Cape Rawson Group faulted into their present site.

Carboniferous and Permian

Late Carboniferous and early Permian beds (10) underlie much of United States Range, and extensions and outliers are present along the north coast. Permian beds are present along Tanquary and Greely fiords and are exposed at Lake Hazen. Certain elevated, slightly to moderately folded strata in the Victoria and Albert Mountains and on Judge Daly Promontory may also be of Permo-Carboniferous age. The Permo-Carboniferous beds of Feilden Peninsula have been described by Blackadar (1954, pp. 12-16), and those to the west by the writer (Christie, 1957, pp. 18-22) and by Lyons and Leavitt (1961, p. 2).

Permo-Carboniferous Rocks of United States Range

Well-bedded, commonly fossiliferous grey limestone, varicoloured sandstones, and chert-pebble conglomerate (10) are the most widespread Permo-Carboniferous rocks and underlie much of United States Range. No systematic studies of sections have been made, and the total thickness of beds present can only be estimated as in the order of 4,000 feet. The Permo-Carboniferous formations, for the most part at least, represent a northeastern extension of the Sverdrup Basin of late Palaeozoic to Tertiary sedimentation, which was deformed in early Tertiary time (see Thorsteinsson and Tozer, 1960, p. 3).

A uniform sequence of grey, green, and red sandstone beds, at least 2,000 feet thick, occurs in the mountains at the head of M'Clintock Inlet, where the beds unconformably overlie mica schists of the Cape Columbia Group. Presumably equivalent and about equal thicknesses of grey, green, and red-brown arkose and sandstone unconformably overlie Cape Rawson beds at the Henrietta Nesmith Glacier. The arenaceous rocks are mainly compact and well sorted. A few beds are calcareous, and others are hematitic. Impure rocks, such as green-grey and red-grey subgreywacke, are rare in the areas examined.

Considerable thicknesses of limestone are exposed in the central parts of United States Range, where there are also beds of arkose, sandstone, conglomeratic quartzite, and jasper conglomerate. The limestone is thick bedded, dark grey to whitish, fine grained to coarse and vuggy, and weathers pale buff-brown, yellowish grey, and grey. The jasper conglomerate is a compact, tough, green or red rock, and on glacial excavation forms large blocks, many of which are presently scattered as conspicuous erratics on the plateau south and east of United States Range.

The Permo-Carboniferous beds of Clements Markham Inlet, near the northeastern end of United States Range, are predominantly limestone with important amounts of limestone breccia, anhydrite and gypsum, quartzite, and slate. The limestones are variously grey and buff-brown-weathering, and the slates green-grey and black-weathering. The limestone breccia is a striking and unusual rock of uncertain origin, but probably is related to underlying limestone breccias which contain evidence of solution or solution-and-collapse phenomena. About 6,000 feet of strata may be present, but the sequence and total thickness of beds is uncertain due to severe folding.

Fossil collections have been examined by P. Harker of the Geological Survey, who has assigned Pennsylvanian and Lower Permian ages to them.

A collection of plant remains, obtained in 1961 by G. Hattersley-Smith from a locality northwest of Clements Markham Glacier, has been examined by F.M. Hueber, of the Geological Survey, who considers it to be of Mississippian age. The relationship of the plant-bearing beds to Permian beds is at present uncertain. However, Mississippian fossils have been discovered within a few feet of the base of a Permo-Carboniferous section at Svartevaeg on the north coast of Axel Heiberg Island (Thorsteinsson, R., Trettin, H.P., and Kerr, J.W.,

unpublished information), and it seems most probable that similar relationships obtain on northern Ellesmere Island. The discoveries are important steps in determining more precisely the time of mid-Palaeozoic earth-movements in the region.

Permian and (?) Carboniferous Rocks of Lake Hazen

Brown sandstone, shale, and thin limestone beds (10 d), from which lower Permian fossils have been obtained, outcrop in a narrow zone along the foot of the mountains north of Lake Hazen. The late Palaeozoic beds are similar to those of younger age, and are recognized principally by their fossil content. The thickness of Permo-Carboniferous rocks at Lake Hazen is not known, but is estimated to be in the order of 1,000 feet.

The light-coloured Permo-Carboniferous sandstones overlie dark green and grey rocks of the Cape Rawson Group with profound angular unconformity north of Lake Hazen. The Lake Hazen fault zone, however, separates the two groups over considerable distances.

Dana Bay, Guide Hill, and Feilden Groups

Beds containing Permian fossils were mapped by Blackadar (1954) in the vicinity of Feilden Peninsula, and divided into three groups, two of which appear to be conformable and to overlie the third.

The Dana Bay Group (10a) of grey limestone and black, argillaceous limestone is folded to produce moderate and steep dips. The Guide Hill Group (10b) of red sandstone and conglomerate, black and purple shale, and grey limestone is commonly gently dipping, and forms a flat-lying cap on the mountains east of Clements Markham Inlet. The Feilden Group (10c), dominantly of buff-weathering, grey to dark grey limestone, lies in broad, open folds. At one site this group apparently conformably overlies the Guide Hill Group, and at another it apparently unconformably overlies Dana Bay and other beds.

Fossil collections from the three groups, earlier reported indefinitely as lower or early Permian, are now considered definitely to be Permian in age.

Triassic, Jurassic, and Cretaceous

Poorly indurated sandstone and shale beds in the vicinity of Lake Hazen have been dated, from fossil evidence, as probably Triassic and others tentatively as uppermost Jurassic or Lower Cretaceous in age. The Mesozoic beds (11) apparently form an open syncline north of Lake Hazen. They are not subdivided on the accompanying map.

The probably Triassic beds include white, grey, and yellow-brown sandstone, grey shaly sand, thin coal seams, and thin fossiliferous limy beds. The thickness and extent of Triassic rocks is not known, but appears to be relatively limited. About 400 feet of beds

below the fossiliferous horizon was examined, and the presumed Triassic beds pass conformably upward into the presumed Jura-Cretaceous beds.

About 2,000 feet or more of weakly cemented, yellow, greenish, and white sandstones, grey and brown sandy shales, and black shale are tentatively assigned a Jurassic or Lower Cretaceous age from spore analyses. The sandstone beds are more resistant to erosion than the shales, and certain beds stand out as prominent ridges.

Cenozoic

Very slightly indurated Cenozoic sandstone and shale beds (13) with coal seams and plant remains underlie an extensive area of rolling plateau northeast of Lake Hazen. These beds presumably unconformably overlie the Mesozoic formations. The similarity of the beds of various ages, however, makes their separation difficult, and the border and extent of the Cenozoic formation is uncertain. About 500 feet of Cenozoic strata is exposed locally, but the thickness of the formation is unknown.

The sandstones are white, brown, or grey, and in places exhibit abundant crossbedding and some minor disconformities. Coal beds are mostly about 6 inches to 2 feet thick. Five beds are exposed along the lakeshore west of Gilman River. The coal is compact, shiny black to brownish, and moderately friable. Proximate analyses of the coal indicate a rank of 'sub-bituminous B'. Small spheroidal nodules of brittle, lemon-yellow amber occur scattered and in concentrations along bedding planes in the coal. The nodules are generally about 1 to 3 mm. in diameter, but many are elongate or kidney-shaped, and about 5 to 10 mm. in length. A few thin beds of friable, carbonized woody and leafy material outcrop northeast of Lake Hazen. These woody beds, up to 2 feet thick, are interbedded with weakly cemented grey shaly sand, white sand, and light brown sand or sandstone.

The Cenozoic beds are flat lying or gently dipping; the structure seems to be one of irregular open undulations. Extreme folding was observed only in the coal measures along Gilman River, and apparently is restricted to this narrow zone.

Microfossils from coal exposed 1.2 miles west of Gilman River were identified by D.C. McGregor of the Geological Survey, who considers the age to be most probably in the range Paleocene to Oligocene. A coniferous cone from a locality at the eastern extremity of the soft beds was assigned by W.L. Fry (in Blackadar, 1954, p. 19) to an age not older than Miocene and possibly more recent.

Beds of soft shale and sandstone, and a coal seam at least 20 feet thick, are exposed in Watercourse Valley (13), and basal breccia, shale, and shaly sandstone are exposed in a smaller valley to the east. The coal was mined and burned by the Nares expedition, which discovered the seam, and has also been used to some extent by more recent parties.

Plant remains from Watercourse Valley have been examined by D.C. McGregor, who comments that the beds (assigned by Heer (1878) to the Miocene) are now regarded as Paleocene or possibly Eocene in age.

Cenozoic(?)

Weakly consolidated dark greenish grey shale, dark brown sandstone, and grey-brown sandy limestone (13) underlie a triangular depression through which Daly River passes. The area of soft beds is bounded on two sides by prominent lineaments that are almost certainly faults. A specimen of impure limestone was examined by D.C. McGregor, who reports that it yielded a few spores and pollen grains that indicate a post-Aptian (post-late Lower Cretaceous) age.

Impure, greenish brown sandstone and shale beds (13) with petrified trees on Judge Daly Promontory were discovered by Sgt. D.L. Brainard of Greely's expedition in 1883. The beds are flat lying or gently dipping and lie in a narrow down-faulted belt that cuts across the regional structure. The base of the formation may be exposed to the southwest, where soft-weathering beds appear to overlie the early Palaeozoic carbonate rocks.

Intrusive Rocks

Brown gneissic syenite (B) is exposed on Ward Hunt Island, and presumably is intrusive into quartzite, mica schists, and amphibolite of the Cape Columbia Group (1). The age of the syenite is uncertain, but assuming—and it seems probable—that it was affected by the latest period of metamorphism experienced by the Cape Columbia Group (which period perhaps produced the gneissic structure), its age is earliest Palaeozoic or older.

Granitic and pegmatitic dykes of Cape Columbia and Cape Aldrich are presumably related to a period of metamorphism of the Cape Columbia Group, and are probably, therefore, also of earliest Palaeozoic age or older.

The geology of Ward Hunt Island as shown on the map has been modified following work by Lyons and Leavitt (1961).

An early age or ages for granitic rocks of the region is indicated by the presence of granitic pebbles in Permo-Carboniferous and in Ordovician beds (Blackadar, 1954, p. 14; Christie, 1957, p. 14).

Dykes and sills of basalt, diabase, feldspar porphyry, and other rock types (A) cut Mesozoic and older formations. The commonest dyke-rock is fine- to medium-grained, dark blue-grey or green-grey, brown-weathering basalt or diabase. The dykes are generally less than 10 feet wide. Dykes and sills are widespread, but are shown on the accompanying map only in the Lake Hazen region, where they are larger and more abundant, and where they are easily mapped because of their contrast with lighter, softer rocks.

STRUCTURAL GEOLOGY

Orogenic deformation probably occurred during at least three different periods: earliest Palaeozoic or earlier; post-Silurian, pre-Pennsylvanian; and in late Cretaceous or early Cenozoic time. The earliest orogeny or orogenies consolidated the Cape Columbia Group of north coastal basement rocks. Ordovician and Silurian eugeosynclinal formations were deformed before the deposition of Pennsylvanian-Permian beds, which were in turn folded with overlying Mesozoic beds.

Fold axes generally trend east or northeast. The dominant structural feature is the uniform and persistent northeast trend of the Cape Rawson Group and of the beds adjacent to Archer Fiord. The upturned strata change direction in a broad sweep southwest of Lake Hazen to trend easterly in the vicinity of Greely and Tanquary Fiords, where they disappear beneath the Permo-Carboniferous limestones.

Variously flat-lying and folded strata with predominantly eastward but variable trends in the eastern part of Judge Daly Promontory are discordant to the regional structure. The significance of this anomalous structural province is at present not clear. The presence of Ordovician fossils in rocks that may overlie Silurian beds could be an indication of a possible major tectonic feature such as an overthrust or nappe structure.

The early Palaeozoic and older formations along the north coast are roughly east trending, though some southeast and south variations occur.

The degree of folding in the Permo-Carboniferous beds varies generally from nearly unfolded to moderate. A tightly folded belt in the northern part of United States Range swings northeasterly to the head of Clements Markham Inlet, where steeply dipping beds contain Permo-Carboniferous fossils.

Open folding in the Permo-Carboniferous to Jura-Cretaceous sedimentary rocks of Lake Hazen conforms with the northeast regional trend. The overlying Cenozoic beds, however, are only gently undulating.

Unconformities are inferred beneath the M'Clintock and Challenger Groups from the composition of conglomerates (Christie, 1957, pp. 12, 14). The unconformity between Permo-Carboniferous beds and the Cape Rawson Group is exposed on Henrietta Nesmith Glacier, and between Permo-Carboniferous beds and Cape Columbia gneisses at Cape Nares and at the head of M'Clintock Inlet.

The Lake Hazen fault zone, which evidently is one of considerable movement, separates softer-weathering rocks around Lake Hazen from the more resistant Cape Rawson Group to the north. Several faults on Judge Daly Promontory are known from the juxtaposition of rocks of different ages and from their expressions as strong lineaments. Several long scarps, presumed to be fault-line scarps, are evident in the region between Porter Bay and M'Clintock Inlet. Another fault, deduced from air photos, separates presumed Permo-Carboniferous beds from Cape Rawson beds west of Tanquary Fiord.

GLACIAL GEOLOGY

Large ice-caps and valley glaciers are presently active in the Lake Hazen region. Former, more extensive glaciation is indicated by the presence everywhere, of glacial erratics, and by glacial grooves and roches moutonnées. Certain gravels, sands, and silts, such as those at the east end of Lake Hazen, were presumably deposited by and in meltwater during the recession of the ice. The abundant small canyons, and perhaps some canyon-like valleys, of the plateau southeast of Lake Hazen were probably incised by numerous large meltwater streams. Marine silts, now at elevations up to about 250 feet, also were deposited during the ice-recessional period.

Granite and gneiss erratics are found in large numbers at elevations up to about 2,500 feet on Judge Daly Promontory and possibly are present along the eastern edge of the plateau east of Lake Hazen, but are not found inland to the west or northwest. It seems probable that the erratics came from Greenland, and that their westward limit marks the maximum extent of Greenland ice in northern Ellesmere Island.

Two groups of hills of coarse boulder-bearing gravel lie northeast of Lake Hazen and rise about 1,500 feet above the surrounding plateau surface. There are almost no obviously related landforms or surficial deposits, and the origin of the hills is uncertain. Possibly the debris was transported by meltwater from high parts of United States Range and deposited in 'wells' or 'moulins' in a stagnant ice-sheet which, on ablation, left the deposits as isolated hills.

Light grey-white marine silts form conspicuous banks or benches in the lowermost parts of the major river valleys up to about 250 feet above sea-level. The silts pass upstream into coarser silts and sands of fluvioglacial origin. Marine shells lie scattered in the silts, and a minimum height for the post-glacial marine inundation is estimated at about 250 feet.

ECONOMIC GEOLOGY

The coal seam at Watercourse Valley is the only deposit so far exploited by white men. The small tonnage available and the lignitic nature of this bed and similar beds at Lake Hazen make these deposits potentially valuable only as fuel for local use.

Amber nodules and finely broken coal are concentrated in bands along the beach at the east end of Lake Hazen. The yellow, red, and brown lumps of amber occur up to 1 inch in diameter, and are conspicuous in the black coal debris. This beach is almost certainly the source of amber beads found in ancient Eskimo habitations in this region.

Nodules of pale yellow chalcedony, presumably residual, were observed scattered on the surface of basalt conglomerate about 35 miles northeast of Lake Hazen. The conglomerate, which is probably Mesozoic or Tertiary in age, occurs as a small, isolated group of remnant caps on hills.

A gypsum body at least 400 feet by 1,000 feet outcrops with andesitic volcanic rocks on the east shore of M'Clintock Inlet (Christie, 1957, p. 34). Thick beds of Permo-Carboniferous anhydrite and gypsum are widely exposed at the head of Clements Markham Inlet.

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