CANADIAN ARCTIC EXPEDITION

1913-18

REPORT

OF THE

CANADIAN ARCTIC EXPEDITION 1913-18

VOLUME XI: GEOLOGY AND GEOGRAPHY

PART A: THE GEOLOGY OF THE ARCTIC COAST OF CANADA; WEST OF THE KENT PENINSULA

By J. J. O'NEILL

PART B: GEOGRAPHICAL NOTES ON THE ARCTIC COAST OF CANADA

By KENNETH G. CHIPMAN AND JOHN R. COX

SOUTHERN PARTY—1913-16

OTTAWA
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Travelling with whaleboat in Mackenzie river delta. Terraces left by receding flood waters. June, 1916.
(*Frontispiece*)

PREFACE

The series of reports of which this is Volume XI and the third complete volume to be issued, will give the narrative and scientific results of the Canadian Arctic Expedition, 1913-18. The expedition, under the command of Mr. Vilhjalmur Stefansson, was originally planned to remain in the field from 1913 to 1916, and earlier publications refer to it as the Canadian Arctic Expedition, 1913-16. Although many members of the scientific staff were officers of the Geological Survey of the Department of Mines, the general direction of the expedition for administrative purposes was placed in the hands of the Department of the Naval Service.

As the expedition was planned to work in two comparatively distinct fields at some distance from each other, it was divided into two parties. The Northern Party, whose field was primarily the Beaufort sea and the Arctic archipelago, remained in the field from 1913 to 1918 under the immediate supervision of Mr. V. Stefansson. The work of the Southern Party was confined more particularly to the Arctic mainland and the adjacent islands, under the direction of Dr. R. M. Anderson, and returned in the autumn of 1916. General accounts of the work of the two main parties and subsidiary parties, rosters of the scientific staffs and a portion of their contributions to the results of the expedition have been briefly given in various summary reports to the Government and in popular narrative and will be summed up in the forthcoming Volume I of this series.

In order to have the scientific results of the expedition properly worked up, the specimens distributed to specialists, and the reports adequately published, an Arctic Biological Committee was appointed jointly by the Department of the Naval Service and the Department of Mines in January, 1917. This committee consisted of Chairman, Professor E. E. Prince, F.R.S.C., D.Sc., Dominion Commissioner of Fisheries; Secretary, James M. Macoun, C.M.G., F.L.S., Botanist and Chief of the Biological Division of the Geological Survey; Professor A. B. Macallum, F.R.S.C., M.D., D.Sc., Ph.D., LL.D., Chairman of the Commission for Scientific and Industrial Research (later professor of biochemistry at McGill University); C. Gordon Hewitt, F.R.S.C., D.Sc., Dominion Entomologist and Consulting Zoologist of the Department of Agriculture; and R. M. Anderson, Ph.D., Zoologist of the Geological Survey (later Chief, Division of Biology, Victoria Memorial Museum), representing the expedition and the Victoria Memorial Museum, the final depository of the specimens collected by the expedition. Various members of the committee took up the editing of different sections, and Dr. R. M. Anderson was appointed general editor of the reports.

The Committee has been at work for over seven years and reports have been prepared or are in preparation by seventy-three specialists. Dr. Hewitt had virtually finished his work on Volume III (Insects) before his untimely death on February 29, 1920, but Mr. Macoun had not completed his work on the botanical volumes at the time of his death on January 6, 1920. The scope of the committee was later enlarged to include the geological, topographical, and anthropological work of the expedition and three new members were added in 1920, namely A. G. Huntsman, F.R.S.C., Ph.D., of the Biological Board of Canada; Edward Sapir, F.R.S.C., Ph.D., Chief of the Division of Anthropology, Victoria Memorial Museum; and M. O. Malte, Ph.D., Dominion Agrostologist and Honorary Curator (later Chief Botanist) of the National Herbarium.

For convenience in publication and distribution it was arranged that the Department of the Naval Service should issue Volumes I (Narrative of the Expedition), VI, VII, VIII, IX, and X (Marine Biology and Hydrography), and XII, XIII, and XIV (Ethnology), while the Department of Mines should issue Volumes II (Birds and Mammals), III (Insects), IV and V (Botany), XI (Geology and Geography), XV and XVI (Ethnology and Archæology.) After the amalgamation of the Department of the Naval Service with the Department of Militia and Defence in 1922, the interests of that department in the reports were transferred to the Department of Marine and Fisheries. Where several different reports are included under one volume, dated separates are issued for distribution to specialists interested in the particular branch covered, and copies are preserved to be bound in the complete series of volumes.

Information relative to distribution of the repors may be obtained by addressing respectively the Secretary, Geological Survey, Department of Mines, Ottawa, and the Records, Printing and Stationery Branch, Department of Marine and Fisheries, Ottawa.

ARCTIC PUBLICATIONS COMMITTEE.

OTTAWA, March, 1924.

PART A: THE GEOLOGY OF THE ARCTIC COAST OF CANADA, WEST OF THE KENT PENINSULA

THE GEOLOGY OF THE ARCTIC COAST OF CANADA, WEST OF THE KENT PENINSULA - - By J. J. O'Neill.

Issued July 8, 1924

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[1]Photographs in Part A by J. J. O'Neill unless otherwise stated.

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THE GEOLOGY OF THE ARCTIC COAST OF CANADA, WEST OF THE KENT PENINSULA

By J. J. O'Neill

Department of Geology, McGill University, Montreal

CHAPTER I

ITINERARY

Before leaving Ottawa to join the Canadian Arctic Expedition at Victoria, the writer was instructed by the Director of the Geological Survey that the primary object of the southern party, to which he was assigned as geologist, would be an investigation of the copper-bearing rocks and associated formations on the mainland coast of the Arctic ocean and on Victoria island. Copper-bearing formations were then known to extend along the coast from Franklin bay (Cape Parry) to Kent peninsula. Accordingly a belt of country not more than 100 miles wide was to be examined along the coast between these extreme points. An area on Victoria island east of Prince Albert sound, supposed to contain copper-bearing rocks, was also to be examined. This work, because of the great area involved, was to be of an exploratory nature, but, when, in localities, opportunity afforded, more detailed geological work was to be performed to elucidate the stratigraphy and nature of the ore deposits. The essential object, however, was to ascertain the economic value of the deposits of copper and other minerals which might be found.

In accordance with these and other instructions relating to the organization and conduct of the southern party the writer joined the expedition at Victoria in June 1913, and proceeded on the C.G.S. *Karluk* to Nome, Alaska. At Nome he was transferred to the C.G.S. *Alaska*, which had been purchased for the use of the southern party of the expedition, and proceeded on her to Collinson point, on the north coast of Alaska. There the ship was finally frozen in and the party had to make its headquarters for the winter.

In November, 1913, a geological reconnaissance was made up the Sadlerochit river into the Arctic mountains for a distance of about 50 miles from the coast; and the information obtained was given to E. DeK. Leffingwell who was making a general geological survey of the Canning River region of northern Alaska.[1]

On February 17, 1914, the writer left Collinson point by dog-team and proceeded to Herschel island, 155 miles to the east. A base was established at this place and the month of March was spent in making a geological section for 50 miles up Firth river into the Arctic mountains. The river was surveyed in detail later by J. R. Cox, one of the geographers of the expedition.

Leaving Herschel island on April 5 in company with K. G. Chipman, a trip was made to Iglukitaktok on the west branch of Mackenzie river, a distance of about 110 miles from Herschel island, and a trip into the Arctic mountains

[1]See Prof. Paper No. 109, U.S.G.S. Washington, 1919.

was attempted from this place as a base but had to be given up on account of deep, soft snow which made travelling very difficult. A visit was paid to Black mountain on the western edge of the delta, about 45 miles from the coast, and a collection of fossils was made from the rocks there exposed. The month of June was spent in making a geological reconnaissance of the delta of Mackenzie river and its borders, in company with K. G. Chipman who was making a topographical survey. On July 13, the party proceeded by boat to Herschel island, which was reached on August 4th.

The larger boats of the expedition having arrived from Collinson point, the Southern Party set out from Herschel island for their allotted field of operations, and reached Dolphin and Union strait without difficulty. A main base was established about 8 miles east of Cockburn point at a small harbour, referred to in this report as Bernard harbour. Five of the staff and one Eskimo were left at this place to build a cabin for general headquarters, and to cache the supplies in a suitable and easily accessible place. The remainder of the party left on the *Alaska* to collect drift-wood from the beaches to the westward, for building purposes and fuel. The *Alaska* was to have returned within a week; but, finding an open sea ahead, went on to Herschel island for additional supplies; and, on the return trip, was frozen-in at Baillie island 400 miles west of headquarters at Bernard harbour.

As soon as the coast ice was safe for travel, Mr. Chipman and the writer started west by dog-team from Bernard harbour to make a general reconnaissance of the coast and, more especially, to find out what had happened to the *Alaska*, and to place caches of food at intervals along the coast for the use of the party on board the vessel in case they were in need on their way back to headquarters. Having proceeded westerly about 200 miles, a party from the *Alaska* was met at Keats point, and all returned to Bernard harbour, arriving on December 25.

On March 17, 1915, Mr. Chipman and the writer again started west, and proceeded to the base of Parry peninsula. Returning, a detailed geological reconnaissance and topographic survey of the coast was made, from Parry peninsula eastward to Bernard harbour, about 250 miles, reaching the harbour on May 25. While this survey was being carried out, Mr. Cox made a survey of Rae river for 75 miles inland from its mouth at the west end of Coronation gulf, returning northeast across country to the coast, taking notes on the geology by the way.

On June 9, Mr. Cox and the writer started east from Bernard harbour, traversed the coast to cape Krusenstern, and thence struck southeast across Coronation gulf to Port Epworth at the mouth of the Kogluktualuk or Tree river. A reconnaissance was made up the western branch of Tree river for over 30 miles. As soon as the ice broke up on Coronation gulf, the party, using an Eskimo skin-boat or umiak, with Evinrude motor, went eastward from Port Epworth to cape Barrow, at the west side of Bathurst inlet, arriving there on August 3.

Having been joined at cape Barrow by R. M. Anderson, and K. G. Chipman with an 18-foot launch, the party proceeded to map the coast and geology of the west side of Bathurst inlet and of some of the larger islands, paying particular attention to the areas containing native copper. Owing to heavy storms the party had considerable difficulty in returning to Port Epworth before the general freeze-up, but arrived a few days in advance of it, on September 30.

As soon as the coast-ice was safe for travelling, the party proceeded by sled to Bernard harbour, arriving there on November 9.

On March 17, 1916, Mr. Cox and the writer started again for Bathurst inlet and spent April and part of May in completing the survey and geological investigation of the copper-bearing areas in that district. On the return journey the geological reconnaissance of the coast was completed, and headquarters were reached on June 4. In the meantime F. Johansen had made a collection of fossils from Liston and Sutton islands, and had made some notes on the geology of the south central coast of Victorialand. Notes on the geology of districts not visited by the geologist were also made by D. Jenness in the southwestern portion of Victoria island, by K. G. Chipman and R. M. Anderson on the canyon of Croker river, and by F. Johansen, K. G. Chipman and R. M. Anderson on the country about Coppermine river.

The writer is indebted to Inspector J. W. Phillips of the Royal North West Mounted Police[1] for courtesies and hospitality extended to him both at Herschel island and at McPherson while carrying on his work in 1914; he also wishes to pay tribute to the hearty co-operation and assistance of all the members of the Southern Party in accumulating geological data, and in furthering the geological work.

[1] The name of this organization was officially changed to Royal Canadian Mounted Police in 1919.

CHAPTER II

THE ARCTIC COAST FROM THE ALASKA BOUNDARY TO THE MACKENZIE RIVER, INCLUDING MACKENZIE RIVER DELTA AND FIRTH RIVER.

Physical Features

The Arctic coast-line from the international boundary eastward parallels the Arctic mountains at a distance of approximately 15 miles. A coastal plain rarely more than half a mile wide occurs in places along the coast. For most of the distance a rolling plateau rises abruptly from the coast, or from the coastal plain where it is present, and, gradually rising to a height of over 400 feet, extends inland to the north face of the mountains.

Near the mouths of rivers, bars of sand and fine gravel form long, narrow lagoons. Rarely are boulders seen anywhere and nowhere is bedrock exposed. Thus the ocean is held in check only near the rivers; elsewhere, it is fast destroying the coast and forcing a general retreat of the coast line.

The plateau apparently extends along the whole Arctic front from Colville river on the west, where Schrader[1] noted it and considered it to be a peneplain of undetermined age, and covered with a mantle of morainic and outwash materials, to Mackenzie river. The plateau, where not bordered by a coastal plain, rises from the beach in cliffs seldom lower than 20 to 30 feet and extends with a gentle upward slope to the foothills of the Arctic mountains. It is the eastward extension of the Anaktuvuk plateau, which follows the north coast of Alaska. The plateau is tundra covered and slightly rolling and bears many ponds without visible outlets.

Herschel island, separated from the mainland by a narrow strait, rises abruptly from the water or from bordering sand-spits, in cliffs 20 to 75 feet high and attains a maximum elevation of more than 500 feet. It forms a very conspicuous feature of the coast which, for 25 miles either way, is relatively low.

The Arctic mountains rise abruptly from the bordering plateau. From the Mackenzie delta to the international boundary, their northern front lies about 15 miles from the coast; but, to the west it recedes farther and farther inland until, at Colville river, it is 60 miles from the shore. The Arctic mountains are not a single, continuous range but are made up of several minor parallel chains which are offset at intervals to the north or south and are separated from one another by broad valleys. The mountains east of the international boundary have been variously named by explorers who viewed them from a distance but the now accepted name is the Arctic mountains for the Alaskan as well as the Canadian mountains. East of the international boundary for some distance, a sub-range lies north of the main range, separated from it by a broad valley. The general elevation of this sub-range is 2,000 feet while the mountains in the main range rise to 6,000 and possibly to 8,000 feet.

Geology of the Coastal Section

No bedrock is exposed along the Arctic coast from Demarcation point to the Mackenzie river. Except about the mouths of some of the rivers, the shores are formed of Pleistocene sands and sandy muds, containing, in places, an abundance of fossils of marine forms. The unconsolidated materials rise from the beaches in cliffs seldom less than 20 or 30 feet in height and in places, as at Herschel island, rise rapidly to heights of several hundred feet. Herschel

[1]Schrader, F. C., Reconnaissance in northern Alaska; U.S.G.S.; Prof. Paper No. 20, Washington, 1904.

island and other similar occurrences apparently are thick remnants of Pleistocene marine beds which elsewhere have been more deeply eroded and more largely removed. The same Pleistocene beds are believed to occupy the plateau region up to the foot of the mountains though along some of the larger rivers, such as the Firth, the Pleistocene deposits have been eroded and materials of recent age rest on bedrock.

Near its mouth, Firth river divides into several channels spaced over a distance of about 4 miles along the coast. These channels are separated by low bars of sand, gravel, mud and, in places, interbedded turf. East of Firth river the land along the coast gradually rises to 25 or 30 feet at Stokes point and continues to rise to the eastward to Kay point, where fossiliferous Pleistocene beds form steep slopes more than 200 feet in height. The plateau just west of Kay point is cut through by Babbage river, which empties into a large lagoon, and forms a fine harbour for small boats. Babbage river is about 75 yards wide near its mouth. It heads in the Arctic mountains 80 to 100 miles from the coast and flows in a direction north by west. Prospectors have found gold in the gravels near the head waters, but report that the overburden of gravel is too thick to permit of the gold being recovered at a profit.

Kay point is a ridge, about 200 feet in maximum elevation, and projects nearly due west from the mainland for about 9 miles. It is about a mile wide 4 miles from the tip, but at 7 miles from the tip is only a quarter of a mile across. The south side of the point is partly protected by sandbars, but at the west end, and on the north side, slump and wave action are rapidly wearing away the Pleistocene beds, and apparently it will be a matter of only a few years until the point is cut off from the mainland and finally destroyed. The Pleistocene beds composing the point closely resemble those of Herschel island. They are of interbedded sand and silty mud, with some gravel. Marine Pleistocene fossils were collected from the cliffs on the north side about 5 miles from the point, and a few, lying loose, were picked up about 100 feet above the beach.

The steeply rising shore continues from Kay point eastward to King point where a small river has built a sand-spit which encloses a lagoon and forms a harbour for small boats. The land along the coast from King point to Shingle point is low, the only notable features being three distinct mounds at intervals of 2 to 3 miles. At Shingle point the land rises steeply and is fronted by a long sandy hook and bar which extends to the east and forms a fine harbour for small schooners of 7 to 8 feet draught. From Shingle point the plateau extends inland for about 25 miles to the mountains, which there swing to the southeast and south, and border the western side of the Mackenzie delta.

Elevated country borders the coast eastward from Shingle point to Akpagviatsiak,[1] varying from 30 to 60 feet in height at the coast. Inland, the surface of the land is rolling and holds many small lakes and ponds. The shore sections are all of the same Pleistocene formation. At Akpagviatsiak there is a low, flat river valley one-half mile wide, covered with sand and gravel bars and bordered by steep bluffs of the Pleistocene beds. From this place to the mouth of the Mackenzie, the coast is fronted by low, broad sand-spits and at the mouth of the west branch, commonly known as Moose river, there is a broad flat, extending 5 miles inland to where the river flows against a 30-foot bank of the Pleistocene formation.

Herschel Island

Herschel island is situated in Beaufort sea, in latitude 69° 3′ 35″ N., and longitude 139° 05′ 55″ W., about half way between the international boundary line at Demarcation point, and Shingle point, near the western edge of the Mackenzie River delta.

The island is about 9 miles east and west, by, at its broadest, 5 miles north and south. There are three prominent sand-spits. The southwest sand-spit extends nearly to the mainland and is separated from it by a shallow gap less

[1]Near Franklin's Escape reef.

than one-half mile across, which is passable only for whale-boats and shallow draught schooners. From Flanders point at the south end of the island, a spit extends towards the mainland for one half mile. The third sand-spit is at the east end of the island. It is one-half mile long and takes the shape of a hook which extends towards the southwest and forms Pauline cove, a good summer and winter harbour for whalers and traders.

Around the whole of the island, either rising from the sand-spits or directly from the water, are cliffs of muddy silt or silty mud with, in places, considerable black loamy mud with twigs. In some localities there is a little gravel or an occasional boulder, and at least one log was observed protruding from the mud. Indistinct stratification may be seen in places but is usually masked by the slumping muds. The boulders are of granite, gneiss, sandstone, etc., and some are of fossiliferous Devonian limestone, none of which boulder-forming material is known to occur in the neighbouring Arctic mountains.

The cliffs surrounding the island range in height up to 40 and 50 feet. From their tops the surface slopes upwards to a maximum height of about 500 feet. The top of the island is rolling and is traversed by broad valleys in which, in places, small gorges have developed. Many small lakes and ponds occur without outlets. The island is being rapidly eroded by wave-action on the north, east and south sides and the undercutting by the waves is the cause of the formation of the cliffs. In these cliffs and on the hillsides in the interior of the island, slumps take place during the summer thaw. These slumps frequently uncover small bodies of solid, blue ice, which melt, form cliffs and gradually recede into the covered portion. These masses of ice are deeply covered with alluvium and, apparently, are part of the original formation, now exposed for the first time. They occur at different horizons above the sea, and some were seen as high as 300 feet. The fresh exposures in some cases have structures resembling cross-bedding as formed in a snow drift by winds from varying directions, but in most cases the ice is homogeneous throughout. In several cases the melting ice was seen to have hexagonal-needle-crystal structure similar to that of the ice of rivers or freshwater lakes. The ice cliffs vary in size, none seen were over 200 feet long and 15 feet high, but in no case was the bottom seen. The ice is perfectly clear, fresh to the taste, and no layers of dirt were seen in it. The cross-section always appears to be lens-shaped.

Marine Pleistocene fossils were collected from both the south and east sides of the island from the lower 200 feet of the unconsolidated material. The fossils are concentrated near the bottoms of the slopes as a result of being washed down with the mud. They are not uniformly distributed through the formation but occur in scattered localities. None were found above heights of 200 feet but the upper slopes are much more concealed by tundra than the lower. The fossils indicate the same horizon as those collected on the mainland in similar beds at Kay point, 22 miles to the southeast of Herschel island. These fossils were determined by Dr. Dall[1] to be of Pleistocene age and he considers the formation to be identical with that described by Schrader,[2] under the name of the Gubik sand, on the Arctic shore of Alaska.

Firth River

The Firth river reaches the Arctic coast 35 miles east of the international boundary. The river was traversed for 50 miles inland in the month of March, 1914, when weather and snow conditions made geological work difficult. Exposures of bedrock commence 6 miles inland. For 4 miles bedrock appears intermittently from beneath unconsolidated fluviatile or lacustrine deposits of Recent age. Ten miles from the coast, the river emerges from a canyon or trench in the valley floor, with rock walls 30 to 75 feet in height and this canyon affords good rock exposure for 40 miles to where the survey of the river terminated.

[1]See Dr. Dall's report on the Pleistocene fossils, pages 30A-33A.
[2]Schrader, F. C., U.S.G.S., Prof. Paper No. 20, 1904, p. 20 et seq.

The strata outcropping along Firth river as far as the river was traversed, are very similar to those found west of Demarcation point by Leffingwell, to whom the writer is indebted for a synopsis of the geology of that district given in advance of publication. The strata are also lithogically similar to the measures of the Colville river and cape Lisburne districts and so closely do the formations on Firth river, both lithologically and in their order of sequence, resemble those displayed to the west, that it seems probable the same series extends from cape Lisburne eastward along the entire Arctic face of the mountains. If so, the strata along Firth river may range in age from Carboniferous or Devonian to Jurassic. But on the Firth, fossils were found in the youngest horizon only and prove to be of Jurassic age. These fossiliferous beds occur along the lower reaches of the river outcropping for a distance of 2 miles. Upstream they are succeeded by strata divisible on lithological grounds into distinct groups that succeed one another without any visible unconformities or other breaks in sedimentation.

The following table presents the essential details of the strata arranged in descending order. The grouping of the strata as presented in the section is lithological only and is made without any intention of subdividing the measures into geological formations. The strata lie in overturned folds and have suffered minor faulting making it very difficult to arrive at accurate conclusions regarding the thicknesses of the various groups but it is believed the thickness assigned to each is a fair approximation except in the case of the youngest rocks. In the latter case the strata offer little, if any, contrast; they are repeated by folding for more than 2 miles, and it is only possible to be sure that they are more than 100 feet in thickness.

TABULAR STATEMENT OF STRATA EXPOSED ON FIRTH RIVER

(In descending order)

	Approximate thickness in feet
Grey, fissile shales, containing thin beds of sandstone and lenses of dark chert. In places schistose and slaty, even forming micaceous schists. Fossiliferous	100+
CONTACT NOT SEEN	
Massive, rusty conglomerate	20+
Black and light grey chert, in massive beds, weathering brown	50+
NO APPARENT UNCONFORMITY	
Green schist and dark grey slates, with red and brown shales; thin-bedded	300±
NO APPARENT UNCONFORMITY	
Grey shales and sandstone, interbedded with coarse, dark grey sandstone and a 25-foot bed of conglomerate holding pebbles of light and dark chert, green and black shale and schist, and a smaller number of light grey marble and also of a buff-coloured sandstone which forms some pebbles measuring 3 inches by 8 inches	100±
NO APPARENT UNCONFORMITY	
A series of thin-bedded, black and grey limestones, black and grey cherts, and some sandstone. Beds are 4 to 6 inches thick	40±
NO APPARENT UNCONFORMITY	
Medium grained, massive, grey sandstone; one layer is finely conglomeratic and contains pebbles of black chert	20+
Thin-bedded, light grey shale and quartzite; weathers reddish	20
Black shale and rusty-weathering chert, with a red conglomerate, a few inches thick, near the base	20
Light and dark grey cherts, in beds of 2 to 10 inches	75
Massive grey quartzite	200
NO APPARENT UNCONFORMITY	
Dark grey to black, coarse sandstone, with some beds of black, sandy shale	75 to 150
Grey sandstone and shale	100
The greater part of the two last mentioned members contain small pebbles of black shale and limestone	
CONTACT NOT SEEN	
Black, massive limestone, mostly changed to marble; base not observed; outcrops at intervals for 8 miles and for an unknown distance beyond end of traverse	

All the rocks in the section have been subjected to complex folding, and most of them, to some degree of faulting. The section is located in a great bend of the mountain system, and the rocks have yielded to stresses resolvable into at least two directions. The result has been drag-folding, or folding in two directions nearly at right angles. Only a vertical section was available for study, and this was naturally a handicap to obtaining definite results. The major folding has been along nearly east-west lines, and is in the nature of overturned anticlinoria, with axial planes dipping towards the south, at angles ranging between 45 and 75 degrees; the axial lines strike east and west with a plunge ranging between 10 and 25 degrees towards the east in most of the cases observed, but occasionally towards the west. Minor thrust-faulting is common; cleavage is well developed in the shales; but there has apparently not been much crushing except at the sharp crests and troughs.

Igneous activity has not been a factor in this region. No igneous rocks of any description were observed.

All the rocks have suffered from the intense folding. The shales have been altered to slates in some cases and in one case they have become micaceous schists. The sandstones and conglomerates have in many cases become quartzites. The cherts are apparently unaltered. The limestones are mostly changed to fine-grained marble, but in one place a thin bed was observed to be changed to amphibolite.

The fossils collected from the grey shales of the highest horizon in the section were submitted to S. S. Buckman who has furnished the following report concerning them:—

1. *Cadoceras sublaere*, Quenstedt sp.
   Amm. Schwäb. Jura LXXXIX, 3 only; not figs. 2-7, not *Am. subtaevis* Sowerby.
2. *Cadoceras* cf. *motogae*, Nikitin sp.
   Rybinsk: Mem. Ac. Imp. Sc. St. Petersburg, VII, 1881, I, II, 12. Nitikin has 2 species and it is doubtful if either belong to *Cadoceras* strictly. The fragment which is somewhat distorted has something of side view of fig. 11 but straighter ribs and something of periphery of 12; but it is more umbilicate and thinner than either. May also be compared to *Am. fearsi*, d'Orbigny, Geol. Russ. II, 1845, XXXVII, 1, 2, but has straighter and coarser ribbing. Doubtful if this (the Canadian) form is a *Cadoceras.*
3. *Cadoceras tchefkini* Pompeckj.
   Norw. Polar Exp. 1899, II, 7. Doubtful if young of *Am. tchefkini* d'Orbigny.
4. *Cadoceras* cf. *tchefkini* Pompeckj, Id.
5. *Cadoceras stenolobum*, Pompeckj, Id.
   p. 84 footnote 5. Am. (*Cadoceras*) *tchefkini* Newton, Foss. Franz Josef Land; Q.T. G.S. LIII, 1897, XXXIX, fig. 4 only. Agree with Newton's fig. which Pompeckj interprets as above.
6. *Cadoceras nanseni.* Pompeckj, Id. II, 1-3.
7. *Cadoceras* cf. *nanseni*, Pompeckj.
8. *Cadoceras* cf. *catostoma*, Pompeckj.
   Jur. Foss. Alaska; Verhandt. Russ. Kaiserl. Min. Ges. XXXVIII, V, I. The Canadian envolute and ribs run straight over periphery.
9. *Cadoceras.*
   A fine-ribbed form.
10. *Cadoceras sp.* This looks as if it would swell and obtain a deep umbilicus. It may be a young *Cadoceras.*

It is very doubtful to my mind if the forms Nos. 3-9 are young examples of large Cadocerates like *C. tchefkini, C. stenolobum*, or if Pompeckj is correct in his determinations. Nothing has been published concerning young stages of *Cadoceras.* Pompeckj says he worked them out; but he did not figure them for comparison.

I am inclined to think that Nos. 3-9 belong to a dwarf race or genus allied to my *Pseudocadoceras* Yorkshire Type Ammonites II, p. XIV, Pl. CXXI B. Certainly *Cadoceras catostoma* Pompeckj is such and Newton's XXXIX f. 4, (see above) No. 5 appears to be rather an adult of a dwarf race than the young of the species with which Pompeckj has identified it. I think the same remark applies to Pompeckj's *Cadoceras nanseni*—it is not truly a *Cadoceras* but more allied to *Pseudocadoceras.*

The horizon of these Canadian specimens is fairly certain,—it is the same as the main part of the south of England Kelleway Rock—the third horizon upwards of the Callovian as now dated.

3. Calloviense (*Cadoceras sublaere*).
2. Koenigi.
1. Macrocephalus.

It will be noted that in general the agreement of the Canadian forms is with those obtained from Franz Josef Land and not with the species from Alaska. There are only two specimens which give any suggestion of Alaskan forms and that is not satisfactory. The Alaskan forms are fairly distinctive and must be of the same date (Callovian 3) according to our present time tables, yet their absence from the Canadian collection is rather suggestive.[1]

[1]For the Alaskan forms see:

Grewingk, C.: Beitrag sur Kenntnis der orographischen und geognostischen Beschaffenheit der Nordwestküste Amerikas mit den anliegenden Inseln, Verhandl. d. Russ. Kais. Mineral. Ges. St. Petersburg, 1848, 49, p. 344.

Eichwald, E. V.: Geognostisch-Palaeontologische Bemerkungen uber die Halbinsel Mangischlâh und die Aleutischen Inseln; 1871.

The most satisfactory identification, that of No. 1, is with a species from Germany. However, similar forms have a wide range. There is a like form from Franz Josef Land figured as *Am.* (*Cadoceras*) *modiolaris* by Newton op. cit. XXXIX, 9 (Pompeckj says it is *Cadoceras stenolobum*, but this is by no means satisfactory). There is also a similar form, *Cadoceras tchefkini* d'Orbigny, from Russia. *Cadoceras sublaere* (Sowerby) and *C. modiolare* (d'Orbigny) from England and France are perhaps not so closely related to the above mentioned—they are, rather, morphic equivalents, in the same stage of old-age smoothness.

The Kelleway Rock horizon with which Mr. Buckman thus correlates the beds on Firth river is the equivalent, broadly speaking, of the Middle Jurassic of North America.

MACKENZIE RIVER DELTA

A geological reconnaissance of the Mackenzie River delta was undertaken in conjunction with the party which during the summer of 1914 made a geographical survey of the delta. In April a sled-trip was made to Black mountain, on the west side of the delta, with the intention of making a section southwest into the Arctic mountains; but the snow was too soft to permit of this and an examination of the face of the mountain was all that could be accomplished. During the month of May conditions rendered travel on the river practically impossible. The ice on the west branch broke on May 25, and within twelve hours the branch was apparently clear of ice. The middle branch broke on June 2nd, part of the ice coming through the Aklavik and down the west branch.

As only the month of June was available for the undertaking and the work had to be carried out by whale-boat, the scope of the reconnaissance was limited. The route followed was from the mouth of Moose river, up that river to Tuktuwuktuayuk, and thence via the west branch of Nunaviaktchuk, to the Ministikug river, up that river to the Aklavik, a cut-off to the middle branch, along the Aklavik and down the middle branch to Niak river, and thence to the east branch and down it to Nanereak, opposite the south end of Richards island; from there up the east branch to its head, and on upstream to Arctic Red river.

The head of the delta is at point Separation, about 15 miles below Arctic Red river. At this place the river begins to spread out into a great fan-shaped labyrinth of channels which, at the Arctic coast, has a width of over 90 miles. On the west side of the delta, near its head, the foothills of the Arctic mountains rise abruptly from the alluvial plain; farther north the mountains recede and the delta is bordered by rolling tundra-covered hills of sand and gravel. On the east side, rolling hills of sand and gravel border the delta from Kittigazuit south to near the entrance to the Eskimo Lakes region, where exposures of rock appear on the hillsides, forming cliffs. From there south, no further exposures of rock occur until in the vicinity of point Separation, a cliff of stratified rocks forms the east bank of the river and continues up past Arctic Red river.

Tree-limit is about north latitude 68° 32,′ that is, about the entrance to Ministikug (Minnisticoog) river on the west side, and at Turnrait on the east branch of the river. Birch is common in the upper part of the delta, the largest seen being about 6 inches in diameter and 30 feet in height; it becomes scarcer and smaller as the tree-limit is approached. Poplar and alder are smaller, but have the same range as the birch. Willows are found as far down as the coast; within a few miles of the coast they are 8 to 10 feet in height, but the coast willows are usually not more than 2 feet high. Spruce is by far the most abundant and important tree in the delta; it is universal and not infrequently attains a diameter of 9 inches; the spruce near the tree-limit is about 25 feet in height and 5 inches in diameter.

The islands of the delta are composed of interstratified sand, gravel and mud, sometimes with interbedded turf. The islands of the west side of the delta are predominantly of mud; the central islands are mostly of sand; and those on the east side are commonly of gravel with some boulders.

The inner or southern islands of the delta rise about 4 feet above average high water (after the break-up in 1915, the water dropped 12 feet in a few days at Iglukitaktak, on the west branch, about 100 miles below McPherson). The outer or northern islands are higher. Richards island rises to 90 or 100 feet above high water, and Garry, Pelly, and Pullen islands though not so high as Richards, present an irregular profile and a hummocky appearance. The three latter islands were not seen at close range.

Richards island is composed of coarse sand interstratified with mud. The top of the island is rolling and covered with tundra, and patches of gravel occur on the surface, concentrated, partly at least, by wind erosion. The land rises in cliffs from sand beaches. Coarse sand with a little gravel makes up the lower 20 feet of the cliffs and is overlain by apparently unstratified, muddy sand with some pebbles. No boulders were seen either in the cliffs or on the beaches.

The small island just south of Richards island, was apparently joined to it at one time; two sand-spits, one from each island, lead towards one another. The small island is about 75 feet in height, with cliffs facing to the southwest and northwest, and with gentle slopes to the southeast and south. The cliffs are mostly of sand containing patches of mud at intervals. The lower layers show distinct cross-bedding, others are evenly-bedded, and in places no stratification at all is apparent, and a gravelly layer appears near the top of the cliffs. The whole interior of the island is covered with tundra. A few boulders were seen on the beach.

West of the delta, near the southern end, gradual slopes of gravel and sand rise to over 300 feet above the river and lead up to the rock cliffs of Black mountain. Farther north, the sand and gravel forms drumlin-shaped hills, running approximately northwest-southeast and which occupy the country between the delta and the foothills. The east face of Black mountain is made up of interbedded sandstones and shales dipping towards the west at angles of about 12.° Some of the sandstones are weathered brownish-red and one stratum contains concretionery nodules which, where weathered out, are almost spherical, the largest seen being about 14 inches in diameter. The formation is over 800 feet thick and some layers contain abundant fossils, a collection of which has been described by Dr. T. W. Stanton and placed provisionally at the top of the Jurassic.

The fossils from Black mountain as determined by Dr. Stanton are as follows:—

Pentacrinus sp., parts of columns.
Pecten sp., coarse-ribbed form.
Pecten sp., large smooth form; possibly two species.
Lima sp.
Aucella sp. cf. *A. fischeriana* (D'Orbigny) very abundant.
Panopaea? sp.
Natica sp.
Pseudomelania sp.
Undetermined small slender gastropod with sculpture of strong vertical ribs.

Dr. Stanton writes, "the *Aucella* fixes the age as either *Upper Jurassic* or *Lower Cretaceous*, more probably the former."

On the east side of the delta, a cut bank of gravel at Nanereak, on the mainland opposite the south end of Richards island, rises 10 feet above the beach. The lower beds are of sand and gravel, well cross-bedded. They contain pieces of wood and coal in all stages of alteration from the former to the latter; the largest piece seen being 30 inches by 12 inches in cross-section. The wood and coal appear to be the remains of driftwood which was laid down with the gravels. A jaw of a rodent (*Citellus* sp.) was dug out of this layer, within 2 feet of a piece of coal. The upper 2 feet of the section is made up of interbedded sand and turf; the lower strip of turf, 3 inches in thickness, contains numerous bones of birds and fishes, and one piece of carved bone was also obtained from the same horizon.

South from Nanereak, the country has about the same elevation as Richards island and the hills have the shape of drumlins with their long axes running approximately northwest. There is little difference in the altitude of their tops, but there is a gradual general rise towards the south where they merge into a more or less rolling plateau. The highest elevation is at about latitude 68° 43′ 15″ and a section taken at this point is as follows:—

Section taken at 68° 43′ 15″ on the east side of the Mackenzie delta, descending from 530 feet elevation, through apparently horizontal beds:—

Description	Thickness Feet
Very fine-grained sand and mud with boulders ranging from 16 inches in diameter down to pebbles; the boulders are mostly of granite and quartzite, with some limestone, and slabs of sandstone and conglomerate, and are usually well rounded although some are more or less facetted. No stratification	80
Partly consolidated sandstone and sandy shale, distinctly stratified; no fossils found; limonite stain in some layers and along seams; cross-bedded. Followed by fine-grained sandy mud; then a thin layer of shale; then more mud or silt, which contains angular pieces of a reddish sandstone or arkose. There is much iron oxide in some layers and in places the sand is cemented by it, forming conspicuous red coloured layers	70
Coarse quartz sand with some gravel, but no boulders. Sand very light in colour, and distinctly cross-bedded	30
Fine, nearly white, silty mud with some boulders; resembles the formation at the top of the section, passes into	220
Silt with more small pebbles than in the overlying formation	60
Similar silt with but few pebbles; extends down to beach	70+

From the top of the hill on which the above section was measured, two small lakes, each measuring about 800 feet by 400 feet, may be seen, situated in pockets between hills. They are without outlet, except at high water, and resemble glacial-kettle lakes.

A second section was made about 8 miles north of this place, where the hills are about 450 feet in height. No stratification was seen in the formation. The top is of muddy silt with a very little gravel. It passes down into an extremely fine, chalk-like silt containing patches of coarse sand and pebbles and this overlies fine sand containing small boulders. The lower 150 feet is of coarse sand and gravel.

South of the first mentioned section the hills are lower; the horizons above the stratified sand thin out; the red layers disappear; and the chalky-white layer forms the capping. Finally the hills are tundra-covered, with gentle slopes, and closely resemble those immediately to the south of Nanereak.

About 40 miles south of the first mentioned section, around the entrance to the Eskimo lakes portage, occurs the first rock in place on the east branch of the river. A cliff examined showed at the base 75 feet of coarse sandstone, weathering red, and towards the top becoming finer grained. The sandstone passes abruptly, but apparently conformably, upward into very thin-bedded, muddy sandstone or sandy shales, 75 feet in thickness and with the top not exposed. The sandstone is composed of quartz grains, together with much very fine-grained black oxide of iron. The strike of the beds is S 50° W (true) with a dip of 11° to the southeast.

South of this place the river winds through mud flats and no more rock is seen until point Separation is reached.

On the eastern mainland, about point Separation, a number of tree-stumps are exposed in a cut bank with their roots at a common horizon 6 feet below the top of the bank. The stumps are all upright, mostly over 18 inches in diameter, and the wood breaks off in circular slabs about one-quarter inch thick. There is still 3 to 4 feet of trunk attached to some of the roots and the tops are ragged and splintered, as if the trees had been broken while still alive. They appear to indicate an old level of the delta, that existed at a time when the trees attained a much greater size than at present, and when different trees were represented. The present tree-growth on top of the bank includes birch, spruce, and poplar, none of them over 9 inches in diameter.

Origin of the Pleistocene Deposits and of Mackenzie River Delta.

The question arises, what was the origin of these thick deposits? The known facts are these:—

It has been well established by the finding of marine fossils in high-level glacial deposits, as well as by high terraces on mountains facing the Arctic ocean, that glacial or post glacial submergences of the Arctic coast were at least 500 feet above present sea-level. Such a submergence brought the shoreline well up on the slopes of the foot-hills of the Arctic mountains, and normally would extend up the Mackenzie valley as far as Great Slave lake.

Thick deposits of sands, silts and silty muds occur about the mouths of the larger rivers, and especially about the mouth of the Mackenzie, but similar deposits cover the sloping plateau from the Arctic mountains to the coast, and at Herschel island, 75 miles west of the present mouth of the river, attain a thickness of at least 500 feet. Boulders of gneiss, etc., together with blocks of fossiliferous limestone found in the Herschel island deposits apparently had their origin east of the valley of the Mackenzie river and not in the neighbouring Arctic mountains. About half way between Herschel island and the mouth of the Mackenzie, at Kay point, there are similar thick deposits containing Pleistocene fossils. The outer islands of the present delta of the Mackenzie rise to about 100 feet above sea-level and are of similar silts, etc., but no fossils have been found on them. Franklin reported a thin bed of poor lignite on Pullen island and there are thin beds of peat in some isolated hills of similar silty muds, near the coast just east of the present delta.

On the east side of the river, about forty miles from the coast, the banks are over 500 feet high, and entirely composed of silts, sands and silty muds. Some sands are cross-bedded and some are red as if they were sub-aerial deposits, but no fossils have been found in them, nor, so far as the writer knows, have marine fossils been found in glacial deposits anywhere in the Mackenzie valley.

The data available is altogether insufficient to draw any definite conclusions, but the writer is of the opinion that a considerable amount of this material was furnished by the Keewatin ice-sheet, and that the waters of the Mackenzie bore this material in great quantities to the coast, and spread out an enormous delta, which built up, at a rate practically equal to the rate of submergence of the coast, and of which parts were at times exposed to the air.

The delta was a sufficient barrier to the encroachment of the sea into the valley of the Mackenzie, so that instead of marine deposits one would expect to find river and lacustrine high-level deposits in this valley at suitable places, even up to the basin of Great Slave lake.

It seems highly probable that Herschel island is a remnant of the Pleistocene Mackenzie delta, probably augmented by material from the neighbouring mountains. It would be interesting to know if parts of these deposits are interglacial but there is no conclusive data on this point; and, provisionally, they are all considered to represent the close of the Glacial period.

CHAPTER III.

THE ARCTIC COAST FROM PARRY PENINSULA EAST TO BATHURST INLET

Physical Features

Probably nowhere, in the whole region from Darnley bay to Bathurst inlet, does the land rise to more than 2,000 feet above sea-level. Along the east side of Darnley bay, the hills have a rugged appearance due to the rapid erosion of the unconsolidated materials capping them but they are only about 600 feet in elevation. In the vicinity of Brock river, five distinct terraces have been cut in these hills. From cape Lyon, east to cape Kendall in Coronation gulf, the country rises from the coast with a rolling slope extending to the Melville mountains about 25 to 30 miles distant. No rock is exposed except occasional cliffs along the coast, and the land surface is of silty mud, sand or gravel, with occasional boulders and very little vegetation.

The Melville mountains are a series of low, rounded hills, apparently composed of the same unconsolidated deposits that floor the plain. They parallel the coast and are conspicuous only because of the general lack of relief. Some of the hills rise from 1,200 to 1,500 feet above sea-level, but even these are only a couple of hundred feet above the general level of the surrounding country. South of the Melville mountains, the land rises and a few miles to the south, the level of the plain is as high as the Melville mountains.

South of Stapylton bay three series of hills occur within 33 miles of the coast, each paralleling the general coast line. The hills rise about 200 feet above the general level of the country which has a northward slope of about 21 feet to the mile. These ranges of irregular hills may be moraines that mark halts of the face of the ice-sheet during its retreat.

The islands in Coronation gulf are the results of differential erosion. All are capped by hard diabase, which in many places overlies sediments. The diabase occurs in large sills, striking about northeast. Four of these sills have produced four different broken ridges extending across the gulf as parallel chains of islands. The sills have a low dip towards the northwest and, as a result, the islands have gentle slopes on the northwest sides and abrupt cliffs rising from the water's edge as high as 200 feet on the southeast sides.

The mainland south of Coronation gulf, as far east as port Epworth, has the same topographic features noted on the islands. Similar sills of diabase occur at intervals producing a succession of gentle rises in the country to the south alternating with abrupt drops. These ridges are apparently old cuestas. The diabase ridges have been cut through at intervals; consequently, the skyline has a broken and rough appearance with abrupt cliffs rising from a general subdued country. The broad valleys between the ridges have usually considerable vegetation and make splendid grazing ground for caribou.

From port Epworth to Bathurst inlet typical Laurentian topography has developed on Precambrian granites. All the hills are rounded and do not rise much more than 1,200 feet above sea-level. Lakes are numerous and grassy valleys scattered through the country make a fine refuge for the few musk-oxen remaining on the northern mainland.

About Bathurst inlet the country east of the granite area is relatively low—not more than 400 feet in elevation. Among the islands the topography is diversified by ridges of diabase striking northeast across the inlet, and forming a framework for the islands whose average height is probably less than 100 feet above sea-level. Differential erosion has been prominent in determining the character of the topography. Nearly all the islands are bounded in part by cliffs formed by the rapid erosion of the softer upper parts of the low-dipping beds of amygdaloid. Many of the islands show a step-structure on one side and a gentle slope on the opposite side.

In places on the islands, isolated pillars of amygdaloid stand on a general lowland. One such pillar on central Barry island is about 20 feet in height and gives a measure of post-Glacial erosion.

A conspicuous feature on some of the islands, and at places on the mainland coast, is a long series of beach-lines in the broken rock. These rise one above another to heights of 150 to 300 feet, demonstrating a gradual emergence of the land. At other places, not so well suited for their preservation, one or two terraces represent the several dozen distinct beaches of the first-mentioned localities.

General Geology

PRECAMBRIAN

Precambrian Granite

The region lies on the northern border of that great area of Precambrian granites, gneisses, etc., commonly known as the Canadian shield. The oldest rocks exposed in place are Precambrian granites, but they contain numerous inclusions of still older schists. It is quite probable, therefore, that formations older than the granites occur in neighbouring districts. Of all the unfossiliferous formations occurring in widely separated areas, the Precambrian granite is the only formation which can be correlated with some degree of assurance.

East of the region explored by the present writer, Precambrian granitic rocks are known to be widely spread in the vicinity of the Arctic coast. They extend westward from the shores of Hudson bay to Kent peninsula, sending a long arm-like area northward along Boothia peninsula, and they recur at intervals on the west side of Kent peninsula, that is, along the east shore of Bathurst inlet. Within the region examined, they lie a few miles inland from the west side of Bathurst inlet and reappear on the coast to the northwest, just south of Galena point. Granite forms the coast all the way from Galena point to cape Barrow and on, westward, to the west side of Gray bay. There it leaves the coast, its northern margin being displayed at the heads of some of the deeper bays only. It continues west almost to the shores of port Epworth harbour where the boundary swings to a practically due south course which it follows for 35 miles at least. Beyond this, it curves to the southwest and west, crosses the Coppermine river a few miles above the junction of the Kendall river, and continues to the southeast end of Great Bear lake. A small granite outlier occurs along the coast, commencing 12 miles west of port Epworth and extending west for 8 miles. No more granite is exposed at or near the Canadian Arctic coast as far west as Parry peninsula and, possibly, does not occur anywhere to the west.

The geological map of North America published by the United States Geological Survey[1] shows a large area of granite, lying north and northwest of Great Bear lake, and extending nearly to the Arctic coast. The valley of Horton river extends across the eastern part of this area; but, according to Stefansson and Anderson[2], all the rocks exposed along it are younger than the Palæozoic, and granite does not occur. The upper part of the valley is occupied by drift and, possibly, may be underlain by Precambrian granitic rocks.

The granites exposed near Bathurst inlet and westward, are grey in colour for the most part, and practically everywhere contain inclusions of older rocks.

[1]Accompanying Prof. Paper, No. 71, U.S.G.S., Washington, 1911.
[2]"My Life with the Eskimos," V. Stefansson, Macmillan Co., New York. See also—Geological map of the Dominion of Canada and Newfoundland; Geol. Surv., Can., Map 91A; 1913.

At cape Barrow two distinct granites occur and are easily separable by reason of a difference in colour. The older granite is dark grey, and contains some secondary biotite and a little unaltered augite. This grey granite is intruded in complex fashion by a bright pink granite accompanied by pegmatitic phases of a very brilliant pink colour. The predominant feldspar in the pink granite is microcline, but the other constituents are similar to those in the grey granite.

The inclusions in the granites are very numerous in places and in some instances are of considerable size. Near the south shore of Grays bay, for instance, a large inclusion shows, in nearly vertical attitude, about 200 feet of thin-bedded, light and dark grey limestones with some shale and sandstone and a few layers of mica and chloritic schists. At port Epworth the granite holds inclusions of talc-chlorite schist, which the Eskimos quarry for pots and lamps. A large inclusion of quartzitic mica schist occurs in granite about 2½ miles west of the first cascade on Hood river. The inclusion is 300-feet wide and the beds strike nearly parallel with nearby, much younger quartzites, but dip about 35 degrees to the west whereas the quartzites dip to the east.

Epworth Dolomite

The thickest development of the Epworth dolomite occurs in the region about port Epworth harbour, from which the name of the formation is derived. At port Epworth, the formation occurs in a synclinorium about 6 miles broad that stretches across the inner part of the harbour in a direction northwest-southeast. The dolomite abuts on the Precambrian granites on the east, and passes under the Coppermine River series on the west. At the base of the formation there is 1 to 5 inches of conglomerate containing pebbles of quartz; this conglomerate rests directly on the granite and follows its contour approximately. Overlying the conglomerate is from 3 to 5 feet of arkose with a cement of dolomite. The arkose contains many large fragments of granite. Overlying it are beds with a total thickness of perhaps 75 feet, of dark grey, fine-grained, impure dolomites and sandstones, with a little reddish sandstone. These beds are followed by strata among which cherty dolomites predominate.

The Epworth formation is composed mainly of cherty dolomite in beds from a fraction of an inch up to 5 feet thick and ranging in colour from light to dark grey, and through buff to light brown. Concretionary structure is prevalent in some layers giving in cross-section an appearance of complex folding, and a dome-and-cup weathered surface. Most of the layers apparently lack these concretions, and thin beds can be traced along cliff faces for considerable distances. The disturbance due to concretionary growth has had slight, if any, visible effect on the even bedding of adjacent layers. The concretions average about 10 inches in diameter and are of alternate layers of dolomite and chert.

Dolomite occupies a similar position in relation to the Precambrian granite at various places along the west side of Bathurst inlet, and is well exposed on the west side of Arctic sound. Farther east, the Epworth dolomite occurs in an 850-foot hill at the east base of Banks peninsula, in cliffs at the south end of Uvignok island and is also exposed along the east coast of Algak, Barry, and Kanuyak islands, and on a small island off the northeast coast of Goulburn peninsula. The formation, as it occurs at all these places, is lithologically similar to its development at port Epworth. Where the dolomites are immediately overlain by Coppermine River amygdaloid, as is the case at nearly all the localities mentioned, the upper layers of dolomite frequently show a partial replacement by sulphides of copper, covellite, and chalcocite.

Inland on Coppermine river, a limestone or dolomite formation immediately underlies the Coppermine River series as at port Epworth and may be the equivalent of the Epworth dolomite. It occurs just south of the Copper mountains and extends at least as far west as the Dismal lakes and has apparently about the same strike and dip as the overlying Coppermine River series.

Farther west, on Brock river, emptying into Darnley bay, and along the coast at intervals from Pierce point to east of Deas Thompson point, dolomites lie unconformably below rocks considered to belong to the Coppermine River series. At Pierce point the dolomites are at least 1,800 feet thick, and are gently folded. These dolomites conform in general appearance to those of the Epworth formation farther east, but some of the beds are massive, and in places, as at Deas Thompson point, dolomitization with strong concretionary action was apparently halted before completion. Because of their position below a great series of red and grey sandstones, shales, etc., cut by large sills and dykes of diabase and corresponding to the strata of the Coppermine River series, these dolomites are thought to represent the Epworth dolomite.

Kanuyak Formation

The Kanuyak formation was not recognized anywhere except on the islands in Bathurst inlet. It is typically developed along the east coast of Kanuyak island, and also occurs near the northeast end of Barry island, on the southwest side of Algak island, and the south side of Uvignok island. On Uvignok island the formation rests, with structural unconformity, upon the Epworth dolomites, and on Kanuyak and Algaq islands it lies, with a basal conglomerate, upon an eroded surface of the dolomite. Similar sediments exposed on the Cheere islands are also thought to belong to the same formation.

The rocks of the Kanuyak formation resemble sandstones and shales, but microscopic examination shows them to be fine-grained, calcareous tuffs and tuff-conglomerates. A great part of the carbonate content appears to be secondary, and, in some layers, even the pebbles are replaced.

A thickness of not more than 100 feet of the formation is exposed on Kanuyak island, and in many places it has been completely eroded away. On Kanuyak island, the formation consists of thin-bedded, grey to brown and red-brown, shaly and sandy limestones which are apparently altered tuffs or ash rocks. These pass downward into 10 feet of buff-coloured conglomerate with well-rounded pebbles of chert and dolomite in a matrix of dolomite, and this passes sharply into 1 to 3 feet of dolomite breccia, which rests directly on the eroded surface of the Epworth dolomites.

On the northeast side of Barry island the base of the Kanuyak formation is not visible. The exposed strata are 23 feet thick and consist of 10 feet of purple-brown, fine-grained, calcareous ash with numerous small fragments of quartz, plagioclase and basalt overlain by 8 feet of thin-bedded, sandy conglomerate with a matrix of sandy limestone and pebbles of quartz, feldspar, tuff, and black iron ore, both the matrix and pebbles for the greater part replaced by carbonate. Above are 5 feet of thin-bedded, calcareous, sandy conglomerate, similar to the lower beds but with fewer pebbles and an abundance of angular grains of quartz. Brown and grey bands alternate and some of the layers are crossbedded. The upper surface has been eroded, and on it rests the Coppermine River amygdaloids.

The Cheere islands, lying about 5 miles southeast of Kater point, are mainly formed from a diabase sill which strikes about northeast. At several places sediments are exposed which very probably are part of the Kanuyak formation. The beds have a base of ash or tuff more or less replaced by carbonate. The colours of the rocks range through greys to brown and black. One black bed, 20 feet thick, is a fine-grained ash. The total thickness exposed is something over 100 feet and there is a basal dolomitic conglomerate. The beds strike about northeast (true) and dip at angles of about 10 degrees to the southeast.

The Kanuyak formation was not recognized at any place other than in Bathurst inlet.

Goulburn Quartzite

The Goulburn quartzite, like the Kanuyak formation, was observed only in Bathurst inlet where it is best developed on Goulburn peninsula, the whole of which, practically, it occupies. The quartzites also occur in the valley of Hood river, extending westward for 2½ miles towards the Precambrian granites. In both places the thickness of the formation is more than 4,000 feet. The only other exposures of these quartzites seen, were on the south side and towards the centre of Barry island, where isolated hills of the quartzite remain, protected by caps of diabase.

The Goulburn formation was not seen in direct contact with any of the older formations, but several beds in the formation contain rounded fragments apparently of the Epworth dolomite and the Kanuyak formation and for this reason the Goulburn is considered to be younger than either the Epworth or Kanuyak formations. But, possibly, part of the quartzites now included in the Goulburn is much older. Bodies of pegmatite observed within the area of the formation, on the west side of Goulburn peninsula, may cut or do cut the quartzite and may belong to a younger granite. Likewise in Hood river valley, the quartzite now referred to the Goulburn outcrops in places only a few hundred yards away from exposures of granite which hold masses up to 900 feet broad of micaceous quartzite, which may be of the same formation and thus very much older than the true Goulburn; otherwise one granite must be post-Goulburn.

The Goulburn formation is made up of pink and grey quartzites, and many beds are conglomeratic. In the lower part of the series the beds range from 3 to 60 feet in thickness. Towards the top, the quartzite beds become thinner but occasional 60-foot beds of conglomerate still occur. They are coarse in grain, and almost wholly of quartz. The bedding in all cases is distinct and some of the layers show crossbedding. The conglomerate beds differ only in the presence of pebbles and boulders, which vary greatly in amount in different layers. The pebbles and boulders are mostly well rounded and of milky quartz, but some beds contain rounded and angular fragments of dolomite and of variously coloured calcareous tuffs, resembling the rocks of the Kanuyak formation. As a rule, the pebbles and boulders are not more than 2½ to 3 inches in diameter and are usually much smaller but some measure as much as 6 and 8 inches across.

Coppermine River series

The type occurrence of the Coppermine River series is along the Coppermine river from the south side of the Copper mountains northward to the coast, where the upper part of the series is exposed at capes Richardson and Kendall. The type section was described and mapped by Dr. A. Sandberg[1] whose report is in part quoted on the following pages. Sandberg, on the map accompanying his report, gives a cross-section of the Coppermine series along the Coppermine river as far north as Bloody fall. Assuming the angle of dip to be 10 degrees, although Sandberg found it to be uniformly about 12 degrees, the thickness represented in Sandberg's cross-section of the strata is calculated to be 37,000 feet. The rocks of the series continue northward as far as cape Kendall, at which place the dip is about 6 degrees to the northwest. Using an average dip of 8 degrees for the northern section, the thickness of this part of the series is calculated to be 11,000 feet, approximately, so that a conservative estimate of the total thickness of the Coppermine River series is about 48,000 feet.

The lower 14,000 feet of the series is predominantly of flows of basaltic lava with thin interbeds of conglomerate. These are succeeded by dark red to brown, sandy shales and these by fine to medium-grained, red to brown sandstone, extending 30 miles northward to Bloody fall. Sandberg's description of the strata of this part of the section is as follows:—

[1] Douglas, James: The copper-bearing traps of the Coppermine River: Trans. Can. Min. Inst., vol. XVI. pp. 83-101, 1913.

The sandstone consists of grains of quartz and feldspar with a highly ferruginous matrix. The feldspar grains, which are smaller than the quartz grains, predominate. These sandstones are similar to the sandstones of the "Nonesuch" group of Keweenaw series. The deposition of the sandstone was interrupted at four different times by eruptions of basalt, which flowed over the floor and became interbedded in the sandstone. None of these flows attained more than a few hundred feet in thickness. The rock shows a somewhat coarser crystalline texture than the basalt at Copper mountains and the amygdaloidal phase of the flow is either scantily developed or non-existent. Between the last two basalt ridges occurs thin strata of a greenish grey slate interbedded with the sandstone.

Of the upper 11,000 feet of the series occurring between Bloody fall and cape Kendall, the only exposures seen, were on an island in Coronation gulf, at cape Richardson, at cape Kendall, and along Rae river. At cape Richardson are exposures of sandstone cut by diabase. Red sandstone capped by a large sill of diabase occurs on an island in the second chain southeast of cape Krusenstern. At cape Kendall sandstone, shale, and limestone occur, cut by sills of diabase. Red sandstone, dolomite, shales and limestone occur in various places along Rae river, all of them older than the sills of diabase and, from notes and specimens supplied by Captain Jos. F. Bernard, similar limestones, etc., occur on the Berens islands about 10 miles N. by E. of the Coppermine river.

From the Coppermine river eastward to Bathurst inlet, grey shales and sandstones occur, underlying sills of diabase, and at Tree river and at the west end of Gray bay, red sandstone underlies grey shales.

In Bathurst inlet, apparently only the lower part of the Coppermine River series remains and is represented by more than 900 feet of basaltic amygdaloids with a few, thin interstratified beds of tuffaceous conglomerates and ash.

On Kent peninsula, east of Bathurst inlet, it is reported, sandstones cut by sills or dykes of diabase occur along the coasts. Red sandstones are known to occur on the opposite or north side of Dease strait, about Cambridge bay, and farther west, on Victoria island north of the Richardson islands, Johansen saw red sandstones and limestones cut by sills of diabase. Dease and Simpson noted red sandstone on the coast at Wellington bay, Victoria island, and Capt. Jos. F. Bernard brought back specimens of ripple-marked red and green dolomitic rock overlain by pinkish sandstones from the same locality. It is probable that all these beds belong to the Coppermine River series and that the formation occurs along the whole of the central part of the south shore of Victoria island and extends some distance into the interior, possibly on north of Prince Albert sound to the place from which the Eskimos are said to secure their native copper.

To the west, along the east side of Darnley bay and for some distance thence, eastward along the coast, are exposures of grey and red sandstones and shales thought to belong to the Coppermine River series, because of their stratigraphic position and their occurrence on the projection of the strike of the series about Coppermine and Rae rivers. On Brock river, which flows into Darnley bay, red and buff, massive sandstones and variegated shales have a total thickness of about 850 feet. A thick series of grey shales and sandstones overlies these red sandstones and is developed along the coast for several miles on either side of cape Lyon. Red sandstones and conglomerates occur between Pierce point and Keats point, and between Keats point and Deas Thompson point; although at these localities the strata occupy several miles of the coast, only a few exposures were visible through the snow at the time of examination, and therefore no very good estimate of the total thickness could be made. The beds occupy depressions in the underlying Epworth dolomite.

Diabase Intrusives

Large dykes and sills cut the Coppermine River and older formations and have already been referred to in describing these formations. The dykes and sills are prominently developed throughout the Precambrian areas and have been assumed to be of Precambrian age and to belong to one period.

PALÆOZOIC

Upper Cambrian, Ordovician and Silurian

A series of thin-bedded, grey, cherty dolomites, younger than the Coppermine River series, occurs for a long distance along the coast from just north of Rae river in Coronation gulf westward to the vicinity of Tinney point. Although these dolomites were closely searched for fossils none was found. Fossiliferous fragments of dolomite were found, however, on the beach at Bernard harbour on the south side of Dolphin and Union straits, and the fossils were examined by L. D. Burling, of the Geological Survey of Canada, who reports as follows:

"The fossils represented apparently belong to one species, a brachiopod closely allied to *Elkania* and *Obolus* (*Fordinia*) as described in Monograph 51 of the U.S. Geological Survey. Nothing more definite can be said regarding its affinities for the reason that the internal markings are unknown, but the horizon represented is almost indubitably *Upper Cambrian* or *Lower Ordovician.* The occurrence has special value as being the first recorded discovery of fossils so old in rocks so far north, and the fossils are sufficiently diagnostic to render the presence in this region of rocks of Upper Cambrian or Lower Ordovician age more or less certain."

The fossiliferous rock fragments probably came from the south, from the mainland north of Rae river; but no break was anywhere observed in the series of dolomites which, apparently, are similar in lithology and structure throughout the series, up into the part known to be Silurian.

The dolomitic series occurs on the Liston and Sutton islands in the centre of Dolphin and Union strait. A collection of corals made from one of the Liston islands by Frits Johansen, a member of the Canadian Arctic Expedition, was determined by Dr. E. M. Kindle to be of Silurian age and of about the horizon of the Lockport. The same dolomites occupy all the western part of Victoria island, but no fossils were found there.

The dolomitic series also occurs on Parry peninsula, where Silurian corals were found in loose blocks on the western shore by Richardson. At cape Parry the series is made up of grey limestones and maroon-coloured dolomites that dip gently towards the north. Exposures occur near Sellwood bay on the west side of the peninsula, around the north end, and for about 25 miles south along the east side.

East of Parry peninsula, they first appear on the coast, at the base of Tinney point, and from there eastward are exposed at intervals in cliffs, all the way to cape Hearne in Coronation gulf. A good section is exposed in the canyon of Croker river, which reaches the coast some distance east of Tinney point. The beds have a general low dip to the north or northwest but are gently rolling in detail, and no reliable estimate could be made of the total thickness which, however, must amount to at least several hundred feet. About Croker river and farther east, at Inman river, the beds are mostly of massive, brownish grey dolomite, which is very cherty in layers and considerably brecciated. Some of the beds contain lenses of conglomerate with fragments and pebbles of dolomite, and small pebbles of white jasper, chert and quartz in a base of medium-grained calcareous sandstone. About Bernard harbour and cape Krusenstern, the formation is thin-bedded and cherty in layers. Some layers have concretionary structure, a few show well-developed ripple markings, and others, distinct mud-cracks. On Liston and Sutton islands the beds are massive and often conglomeratic. Their weathered surfaces resemble those of the strata about Inman and Croker rivers.

The lower part of the series has the same or nearly the same strike and dip as the adjacent beds of the upper part of the Coppermine River series but the contact was not exposed. The two formations were arbitrarily separated in the field on the assumption that all rocks older than the Palæozoic are cut by sills and dykes of diabase, and that no igneous rocks invade the younger formations.

Dr. E. M. Kindle has furnished the following report on the fossils collected from the supposedly Silurian horizons:

"The Palæozoic fossils collected by the Canadian Arctic Expedition from the Arctic coast of Northwestern Canada consist almost exclusively of corals which are not very well preserved.

Lot 5303, northeast end of Sutton island, Dolphin and Union strait, Coll. Frits Johansen.

Halysites sp.
Favosites cf. *niagarensis*.
Streptelasma sp.

Lot 5306. East end of Liston island, Dolphin and Union strait, Coll. Frits Johansen.

Crinoid stems.
Favosites sp.
Streptelasma cf. *patula*.
Streptelasma? sp.
Diphyphyllum cf. *multicaulis*.
Diphyphyllum sp. undt.

Lot 5307, Beach at east end of Liston island, Dolphin and Union strait.

Halysites catemulatus var. *gracilis*.

Lot 5308. Beach at west end of Sutton island, Dolphin and Union strait.

Streptelasma? sp.

Lot 5310. Beach, Bernard harbour. Grey magnesian and argillaceous limestone with fossils of uncertain affinities; probably sponge or plant remains.

Lots 5303, 5306, and 5307 are all of Silurian age and represent a horizon which is probably about the same as that of the Lockport limestone. All of the lots occur in a magnesian limestone. The general appearance and composition of the lots of specimens with few or no fossils suggest that they represent the same horizons as those with fossils."

Post Silurian

At the western base of Tinney point supposedly Silurian dolomites are overlain, without apparent structural unconformity, by a series of conglomerates and sandstones containing fragments of carbonaceous material and having a basal conglomerate. The beds are about horizontal and at least 60 feet in thickness. They extend 1½ miles inland. Conglomerate layers preponderate but sandstone is more abundant near the top of the exposure and there is a capping of 8 feet of sandstone.

The conglomerates have a groundmass of rather coarse, light grey quartz sand, much of it stained light brown. The pebbles are entirely of chert and jasper, some milky, but mostly banded, and probably were derived from similar rock occurring interbedded with the Silurian dolomites not far to the east. They are all well rounded and range in size from small grains to boulders 10 inches in diameter; the intermediate sizes being by far the most abundant. The conglomerate is well bedded, and shows crossbedding in places. The pebbles are more or less sorted in layers.

The sandstone is medium grained, and purplish, weathering to light grey. It usually contains a few small pebbles, and at least one layer shows well-developed ripple marking.

It is not known to what horizon this formation belongs; but it appears to be separated by an erosion interval from the supposedly Silurian beds and is presumably post-Silurian.

TERTIARY

Strata of Tertiary age were found only on Brock river, where they occur for some miles above the river mouth, in Darnley bay. The measures consist of slightly consolidated, light grey, dark grey and brown shales containing lenses of fine-grained sandy limestone up to 20 feet in length and 5 or 6 feet in thickness.

The measures are nearly horizontal and have a total thickness of more than 125 feet. The beds, as a rule, are from 1 to 3 inches thick; some are crossbedded and some contain abundant willow fragments. Fossils collected from the shales and the included lenses of limestone were examined by Dr. W. H. Dall, who states they indicate the deposits to be of upper Eocene or Oligocene age, "probably contemporaneous with the leaf beds of Nenilchik on Cook inlet, Alaska." The intermingling of freshwater and marine forms indicates, in Dr. Dall's opinion, that the strata are of estuarine origin. Dr. Dall's report on the fossils is as follows:—

REPORT ON TERTIARY FOSSILS FROM BROCK RIVER

By William Healey Dall

The specimens herein discussed were obtained at two localities on Brock river about 15 miles south of cape Lyon. Station 5296 was situated 10 miles up the river and station 5297 about 2 miles further up. The formation consists of horizontal, thin-bedded, partly consolidated light and dark grey or brown muds showing some five horizons, containing lenses of sandy limestone, and forming a cliff about 125 feet high.

These are stated to rest on Precambrian rocks and, as the fossils from both localities are the same, the deposits from which they came may be assumed to be of the same age.

The specimens received comprised soft, grey shale with thin sandy layers and the fossils for the most part occurred in the sandy portion. The estuarine character of the deposit may be inferred from the presence among the freshwater shells, which make up the great majority of the remains, of three marine forms. There were also a few vegetable fragments which recalled the leaflets of *Sequoia*.

The age of the deposit is *upper Eocene* or *Oligocene*, probably contemporaneous with the leaf beds of Nenilchik on Cook's Inlet, Alaska, one of the most abundant of the Arctic species being identical with an *Anodonta* described from the latter locality by Mayer.[1]

The species obtained were as follows:—

Freshwater species.

Lymnaea oneilli Dall
Aplexa hypnorum? (fragment)
Vivipara sp.?
Amnicola stefanssoni Dall
Goniobasis borealis Dall
Anodonta athlios C. Mayer
Unio sp.? (fragment)
Sphaerium aquilonarium Dall
Sphaerium gemma Dall
Sphaerium sp. aff. *similis* Lam.
Cymatocyclas diacis Dall

Marine species.

Nucula johanseni Dall	3 valves
Macoma sp. aff. *calcarea* Gmelin	1 valve
Mactra epidema Dall	1 valve

NOTES AND DESCRIPTIONS[2]

Lymnaea oneilli n. sp.

Shell small of three whorls or more, the apex lost, the suture rather deep, whorls roundly shouldered the last slightly axially flattened; surface finely axially striated, with a silky aspect.

This is rather abundant in the sandy parts of the matrix but usually broken.

Goniobasis borealis n. sp.

Shell small, slender, subcylindric, the apex lost in the specimens; the whorls four or more, moderately rounded with a deep suture; early whorls with eight or more prominent flexuous ribs which gradually disappear on the later turns; when numerous their posterior ends coronate the suture; the sculpture is variable on different individuals, in some there are a few spiral threads on the earlier whorls and there are individuals in which the profile is more conical than in others; base rounded, imperforate, the aperture ovate, the outer lip conspicuously retractively arcuate in the middle. Height of three and a half whorls 10; diameter 2·5 mm.

[1] O. Heer, Flora fossilis Alaskana, K. Svenska Vetensk. Akad. Handlingar, Bd. VIII, No. 4, 1869, p. 40, pl. X, fig. 7. Mollusca, Dr. Carolus Mayer.

[2] Species figured in Plate XXXV, p. 107 A.

Stations 5296 and 5297.

This belongs in the group of *G. deshayesiana* Lea and has no resemblance to the species described by C. Mayer from the leafbeds of English harbour, Cook inlet.

Unio sp. indet.

The flattened remains of the *Anodonta athlios* are abundant in the shales but occasionally one comes upon a much heavier and thicker shell which seems to be a *Unio*. It is not the *Unio onariotis* C. Mayer, described from Cook inlet, but none of the fragments show the hinge or the complete outline so it is impossible to do more than indicate the probable presence of the genus in this horizon.

Sphaerium aquilonarium n. sp.

Shell of moderate size, short and subquadrate, rather compressed; beaks high, prosocoelous over a lanceolate lunular impression not circumscribed by any definite line; behind these is a longer, very narrow and shallower depression simulating an escutcheon; dorsal slopes rather direct; anterior end rounded, posterior subtruncate, base evenly arcuate; surface finely concentrically striated; hinge mostly concealed or lost in the specimens but the lateral laminae are short the pallial line entire, the inner margins of the valves simple. Height 8·0; length 11·5; diameter 3·75 mm.

Stations 5296 and 5297.

This species, if a true *Sphaerium*, would seem to belong in the vicinity of *S. partumeium* Say but it is possible the species belongs to *Cyrena* or one of its allies.

Sphaerium gemma n. sp.

Shell small, trigonal, inflated, with high beaks and a marked lanceolate depression on either side of them; shell nearly equilateral and both ends nearly equally rounded; surface concentrically rather irregularly threaded, the sculpture disposed in zones; base evenly arcuate; hinge normal, inner margins simple; muscular impressions and pallial line distinct. Height 4·5; length 5·5; diameter 3·5 mm.

Stations 5296 and 5297.

This is a quite small and robust species not referable to *Pisidium*. Fragments of it are rather abundant in the shale.

Sphaerium aff. *similis* Say.

A defective valve of a *Sphaerium* resembling in form *S. similis* Say but with a much smoothe) surface was obtained at station 5296. It measures: height 10, length 13; diamēter (doubledo 8 mm. approximately. It is clearly distinct from either of the other species mentioned but tor defective to name.

Cymatocyclas diacis n. sp.

Shell small, subequilateral, rather long with prominent beaks; prodissoconch conspicuous with two prominent strong sharp concentrically located projecting blades; remainder of shell concentrically smoothly, irregularly waved, about three of the waves more conspicuous than the rest; both ends evenly rounded, the anterior slightly narrower, base evenly arcuate. Length 5·5; height 3·5; diameter (double) 2·0 mm.

Station 5297.

The single specimen of this shell is very distinct. A fragment shows that the exterior was polished. The major part of the specimen is an internal cast but the hinge is hidden. There can be no doubt as to its systematic relations. The outline is not unlike that of *Sphaerium transversum* Say, but more equilateral.

Nucula johanseni n. sp.

Three valves of a large and very thin *Nucula* crushed flat were obtained. Shell ovate, inequilateral, the anterior end longer, rounded, the base arcuate, the posterior end shorter and more attenuated; exterior smooth; beaks low; hinge with about thirteen large anterior teeth, a small resilifer, and more than ten small pustular posterior teeth. Length 17; height 13 mm.

Stations 5296 and 5297.

Macoma aff. *calcarea* Gmelin.

A single cast of the left valve of a *Macoma*, very similar in outline to the well known *calcar ea*, but with apparently a differently shaped pallial sinus, was obtained at Station 5297.

Mactra? epidema n. sp.

Shell small, subdonaciform, anterior end longer, attenuated, rounded; base arcuate, posterior dorsal slope slightly arcuate, coming to a point at the basal junction to which a well marked sharp ridge extends from the low beaks; hinge hidden; pallial sinus small, rounded, hardly reaching the vertical of the beaks; shell rather thick for its size, the interior margins simple. Height 11·5; length 19·0; double diameter of the valve 6·0 mm.

Station 5297.

This is a single valve mostly reduced to an internal cast so that the generic reference is doubtful. However the form is rather that of the typical *Mactra* than *Spisula*.

These three marine forms are mixed with the freshwater shells from the river in a way to demonstrate the estuarine character of the formation.

QUATERNARY

PLEISTOCENE

A marine Pleistocene formation mantles the coast from Darnley bay to Kent peninsula. It holds fossils at various elevations up to 500 feet above sea-level. On the east side of Darnley bay the Pleistocene beds are of silty mud and gravel, often yellowish brown in colour, and containing well-rounded pebbles and a few scattered boulders up to 18 inches in diameter. These beds have a total thickness of over 200 feet and, a few miles back from the coast, are overlain by 150 to 200 feet of coarse, well-sorted gravels, which, in turn, are overlain by about 50 feet of sand. The gravel and sand cap hills at elevations of 600 feet above sea-level. No fossils were found in them and these formations were not seen at any other locality.

At Clinton point, the Pleistocene strata are of reddish brown to buff, gritty, plastic mud with well-rounded pebbles and slabs of sandstone and limestone. The material occurs up to elevations of 380 feet, capping rounded hills.

At Croker river, the Pleistocene is somewhat over 100 feet in thickness, and apparently the same material overlies the whole country inland for about 25 miles to the Melville mountains, of which mount Davy is a prominent peak. These Pleistocene deposits form the summit of mount Davy itself although the top is more than 1,200 feet above sea-level. No fossils were found near mount Davy. Similar material occurs the whole way along the section traversed by Mr. Cox from the head of Rae river to Stapylton bay. On this route three ridges, rising about 200 feet above the general plain, are composed of reddish clay and well-rounded gravel. The highest and farthest south of these ridges lies about 33 miles from the coast and rises to about 690 feet above sea-level. No fossils were found along the route but they occur near the coast up to heights of more than 75 feet above sea-level.

For 9 miles up the Coppermine river, on both sides, there are hills of silty mud containing Pleistocene marine shells in some, at least, of the layers. Occasional layers of turf are also present in the formation. Just south of Bloody fall a stream entering Coppermine river from the east is bordered by 200-foot banks of silty mud.

At the foot of Port Epworth harbour the marine, Pleistocene formation occupies the valley of Tree river and caps hills up to elevations of at least 500 feet above sea-level. Fossils were found 500 feet above sea-level, in small pockets of sand and gravel on the granite hills on the east side of the harbour.

At cape Barrow, Pleistocene fossils occur up to 150 feet above sea-level and the containing formation extends up to the tops of the highest hills, 350 feet above sea-level. It is very thin, however, and remains only as pockets in the granite. On the west side of Arctic sound, sands and gravels containing marine Pleistocene fossils and more than 75 feet in thickness, cap hills over 250 feet in elevation. Hood river flows between banks of muddy sand and gravel, rising to over 100 feet above the river and marine Pleistocene fossils were collected from these beds about 10 miles up the river.

On the east side of Banks peninsula, 17 miles from Wollaston point, Pleistocene sands rise in terraces to a height of about 500 feet and abut against cliffs rising to 870 feet above sea-level. Pleistocene marine fossils were found in the sand up to 250 feet elevation and similar sands, in which no fossils were found, occur on top of the bluffs, lying on glacially striated rock surfaces.

At various localities the unconsolidated formation was seen resting on polished and striated rocks, and, therefore, it probably represents the closing phase of the Pleistocene period. Marine fossils were found to heights of 500 feet above the present sea-level and indicate a former submergence of at least this amount. Possibly this late Pleistocene submergence was of greater depth than 500 feet, for it cannot be stated that marine fossils do not occur above heights of 500 feet above sea-level.

The fossils collected from the Pleistocene deposits were submitted to Dr. Dall, whose report thereon is as follows:—

REPORT ON THE PLEISTOCENE FOSSILS COLLECTED ON THE ARCTIC COAST

By William Healey Dall[1]

The fossils listed in this report are without doubt all Pleistocene. They belong to species now living in adjacent waters which form part of the Western Arctic fauna. The collection was made largely by J. J. O'Neill, and from the notes on the labels, the horizon in which the fauna occurs seems to be represented over a very large extent of the Arctic coast from Herschel island, Yukon Territory to Bathurst inlet, Northwest Territories, and to be identical with that described by Schrader[2] under the name of the Gubik sand, on the Arctic shore of Alaska.

It is rather surprising that the Pliocene Nuwok formation which in Alaska underlies the Gubik sand in many places, with a very characteristic and interesting fauna, is not represented in the Canadian collection.

The material from Herschel island, and from Kay point, is in a matrix, which in each case is of a fine grey silt which immediately dissolves in water, but has when nearly dry a certain hard toughness, and when quite dry breaks up into angular fragments. It contains, intermixed with Pleistocene marine shells, a proportion of rock fragments containing fossils of the Devonian formation so extensively developed in the Yukon Territory to the south and which may have been transported on ice cakes or in the roots of uprooted trees in the spring freshets. Three pieces of brown sandstone from the delta (No. 1885) contain Devonian brachiopod remains, and small palaeozoic brachiopods, possibly young *Meristella*, were found loose in the silt from Herschel island.

The following are the species represented in the collection from each of the numbered stations.

Station 1926, south side of Herschel island.
- *Chrysodomus* cf. *saturus* Martyn, (fragm.)
- *Buccinum tenue* Gray, (fragm.)
- *Natica* sp. cf. *clausa* Brod. and Sby., (very young.)
- *Boreotrophon beringi* Dall (fragm.)
- *Tachyrhynchus erosus* Couthouy
- *Astarte borealis* Schumacher
- *Astarte arctica* Gray
- *Astarte fabula* Reeve
- *Astarte alaskensis* Dall
- *Cyrtodaria kurriana* Dunker

Station 1942, East side of Herschel island, Y.T.
- *Natica* sp. (very young).
- *Astarte borealis* Schumacher
- *Astarte fabula* Reeve
- *Astarte alaskensis* Dall

Station 3486, Kay point, Y.T.
- *Dentalium* sp. (fragm.)
- *Natica* sp. (young fry.)
- *Leda (Portlandia) arctica* Gray
- *Modiolaria* sp. (fragm.)
- *Pseudamusium* sp. (fragm.)
- *Macoma sabulosa* Spengler
- *Astarte borealis* Schumacher
- *Astarte fabula* Reeve
- *Saxicava arctica* Linn. (fragm.)

Station 5282, Arctic Sound, N.W.T.
- *Cardium ciliatum* Fabricius
- *Serripes grönlandicus* Gmelin
- *Macoma calcarea* Gmelin
- *Mya truncata* Linn.
- *Saxicava pholadis* Linn.

Station 5283, Coppermine river, N.W.T., east side about 3 miles from mouth.
- *Leda (Portlandia) arctica* Gray.
- *Cardium ciliatum* Fabricius
- *Macoma brota* Dall

Station 5284, W. side Coppermine river (mouth).
- *Leda pernula* Müller
- *Cardium ciliatum* Fabricius
- *Macoma calcarea* Gmelin
- *Macoma balthica* Linn.
- *Macoma brota* Dall

[1]By permission of the Director of the U. S. Geological Survey.
[2]Schrader, F. C., U.S.G.S., Prof. Paper No. 20, Washington, 1904, p. 20, et seq.

Station 5285, Victoria island, N.W.T. Up to 300 feet none above (Jenness).
Macoma inconspicua Broderip and Sowerby
Mya truncata Linn.
Saxicava pholadis Linn.

Station 5286, Bernard harbour, Dolphin and Union Strait, N.W.T.
Mytilus edulis Linn.
Astarte borealis Schumacher
Cardium ciliatum Fabricius
Serripes grönlandicus Gmelin
Mya intermedia Dall
Balanus sp. (fragment).

Station 5287, Kogluktualuk river, Coronation gulf, N.W.T.
Leda (Portlandia) arctica Gray
Macoma calcarea Gmelin

Station 5288, Port Epworth harbour, Coronation gulf, N.W.T.
Mya? (fragment.)

Station 5289, South end of Port Epworth, Coronation gulf, N.W.T.
Saxicava pholadis Linn.
Mya truncata Linn.
Balanus sp. (fragment.)

Station 5290, Mouth of Inman river, Amundsen gulf, N.W.T.
Mytilus edulis Linn.
Macoma calcarea Gmelin
Saxicava arctica Linn.
Saxicava pholadis Linn.
Mya truncata Linn. (young.)

Station 5291, South side Bernard harbour, N.W.T.
Astarte borealis Schumacher
Saxicava arctica Linn.
Buccinum sp.? (fragment.)

Station 5293. North side Bernard harbour, N.W.T.
Acmaea emydia? Dall
Mytilus edulis Linn.
Astarte borealis Schumacher
Macoma calcarea Gmelin
Saxicava pholadis Linn.
Saxicava arctica Linn.
Mya truncata Linn.
Mya intermedia Dall
Balanus sp. (fragment.)

Station 5294, Cape Barrow, Bathurst inlet, N.W.T., at 150 feet elevation.
Fragments of:
Macoma calcarea Gmelin
Saxicava pholadis Linn.
Mya truncata Linn.

Station 5295, Bernard harbour, N.W.T.
Astarte borealis Schumacher.

Station 5298, 5299 Bernard harbour, N.W.T.
Cardium ciliatum Fabricius
Serripes grönlandicus Gmelin
Astarte borealis Schumacher
Macoma calcarea Gmelin
Saxicava pholadis Linn.
Saxicava arctica Linn.
Mya truncata Linn.

Station 5300, cape Lyon, Darnley bay, N.W.T.
Saxicava pholadis Linn.

Station 5301, 15 miles southwest of cape Lyon, Darnley Bay, N.W.T.
Astarte sp. indet.

Station 5302, Bernard harbour, N.W.T. 15 feet elevation north side of harbour.
Astarte borealis Schumacher.

Station 5497, (40a) five miles inland from Bernard harbour, N.W.T.
Saxicava pholadis Linn.
Mya truncata Linn.

All of the thirty species recorded from the several local collections given above are included in the following systematic list.

Systematic List[1]

Leda (Portlandia) arctica Gray	Sta. No.	5283, 5287.
Leda pernula Müller	" "	5284.
Mytilus edulis Linn	" "	5286, 5290, 5293.
Modiolaria sp	" "	3486.
Astarte borealis Schumacher	" "	5286, 5291, 5293, 5295, 5298, 5299, 5302.
Astarte sp. indet	" "	5301.
Astarte alaskensis Dall	" "	1926, 1942.
Astarte fabula Reeve	" "	1926, 1942, 3486.
Astarte arctica Gray	" "	1926.
Cardium ciliatum Fabricius	" "	5282, 5283, 5283, 5286, 5298, 5299.
Serripes grönlandicus Gmelin	" "	5282, 5286, 5298.
Macoma calcarea Gmelin	" "	5282, 5284, 5287, 5290, 5283, 5294, 5298.
Macoma sabulosa Spingler	" "	3486.
Mya truncata Linn	" "	5282, 5285, 5289, 5290, 5293, 5294, 5497, 5298, 5299.
Macoma balthica Linn	" "	5284.
Macoma brota Dall	" "	5283, 5284.
Macoma inconspicua Broderip and Sowerby	" "	5285.
Mya intermedia Dall	" "	5286, 5293.
Saxicava arctica Linn	" "	5290, 5291, 5293, 5299.
Saxicava pholadis Linn	" "	5282, 5285, 5289, 5290, 5293, 5294, 5497, 5298, 5299, 5300.
Cyrtodaria kurriana Dunker	" "	1926.
Dentalium sp	" "	3486.
Chrysodomus cf. *saturus* Martyn	" "	1926.
Boreotrophon beringi Dall	" "	1926.
Natica sp. cf. *clausa* Brod	" "	1926.
Tachyrhynchus erosus Couthouy	" "	1926.
Buccinum sp.? (fragment)	" "	5291.
Buccinum tenue Gray	" "	1926.
Acmaea emydia? Dall	" "	5293.
Pseudamusium sp	" "	3486.
Balanus sp. (fragment)	" "	5286, 5289, 5293.

List of Collecting Stations.

5282. Arctic sound, Bathurst inlet, west side 250 feet altitude sand-gravel formation.

5283. Coppermine river, N.W.T.

5284. West side of Coppermine river 5 miles from mouth, from clay banks 50 feet high. Altitude above present level of river 3 to 15 ft. Ice-covered. Sticking in the clay on limited stretch of banks; more shells seen higher up the bank. Frits Johansen collector.

[1]For comparison with this list the reader is referred to J. Gwyn Jeffrey's list of Pleistocene fossils found in the N.E. part of the Arctic archipelago. (The Post-Tertiary fossils procured in the late Arctic Expedition; with notes on some of the Recent or Living Mollusca from the same Expedition. Annals Natural History, vol. 20, Ser. 4, 1877, pp. 229-388.)

5285. Southwest part of Victoria island, N.W.T.; mud formation between the Colville hills and south coast. Collector, D. Jenness. Up to 300 feet.

5286. South side Bernard harbour, Dolphin and Union Strait, N.W.T. From greenish grey sand in cut banks at high water level.

5287. The mud-gravel formation 11 miles up the Kogluktualuk river, Coronation gulf, N.W.T. 75 feet above river bed.

5288. East side Port Epworth harbour, Coronation gulf. From mud-gravel at 500 feet elevation.

5289. Mud-gravel of dolomite hills at south end of Port Epworth, Coronation gulf, 320 feet elevation.

5290. Mud-gravel about the mouth of Inman river, 60 to 200 feet, Amundsen gulf, N.W.T.

5291. South side of Bernard harbour, Dolphin and Union strait, N.W.T. 30 feet above high-water level.

5293. North side Bernard harbour from 30 feet above high-water level.

5294. Cape Barrow, Bathurst inlet, 150 feet elevation.

5295. North side of Bernard harbour, Dolphin and Union strait, N.W.T. 15 feet above high-water level.

5297. 5 miles inland from Bernard harbour, Dolphin and Union strait, F. Johansen, collector, June, 1915. About 10 feet elevation.

5298-5299. Sand and gravel terraces from 15 feet above high water south side Bernard harbour, winter quarters, Dolphin and Union strait N.W.T.

5300. Twenty-five miles southwest of cape Lyon, Darnley bay, N.WT. From gravel 50 feet elevation on coast.

5301. From debris on slope of partly consolidated mud, roughly, 200 feet elevation, underlying gravel near the top of Brock river, 10 miles from mouth, about 15 miles southwest of cape Lyon.

5302. From 15-foot elevation on north side of Bernard harbour, south side of Dolphin and Union strait.

1942. East side of Herschel island, Y. T., about 50 feet elevation.

1926. South side of Herschel island, Y.T., the island is made up of silty mud with more or less gravel mixed. Fossils were collected from over 100 feet above sea-level, downward.

3486. From sandy mud cliffs on Kay point, Arctic coast, Y.T., east side of point and 3 miles from the end. Sand and sandy mud, almost clay, with thin seams of gravel. Sandy mud contains pebbles stratified and crossbedded deposits. Apparently part of the Anaktuvuk plateau feature. About 25 feet above sea-level, although formation extends about 200 feet above sea-level at this place.

At several localities along the coast in favourable places, terraces indicate that the emergence after maximum submergence of over 500 feet, was practically continuous and not intermittent, because the beach lines are so closely spaced vertically as to be almost continuous. At Brock river, Darnley bay, there are three terraces, at 100 feet, at 140 feet, and at 220 feet above sea-level, and higher ones were seen inland up to a maximum of about 600 feet. At Clinton point two terraces occur at 130 feet and 300 feet elevation, respectively, and there may be more inland. Between Moore bay and Kater point, Bathurst inlet, gaps in a ridge of diabase are filled with beach-shingle up to 150 feet elevation. The shingle is arranged in distinct beach-lines one to five feet apart vertically, and only a few feet horizontally. They are in perfect preservation, and continue to the top of the pass at 150 feet elevation, where they overlie glacially striated diabase.

Steep terraces at the east base of Banks peninsula rise to a total of about 500 feet elevation. On the islands of Bathurst inlet, shingle derived from local rocks rises, in many places, in numerous low terraces to altitudes of 100 to 300 feet.

Glaciation.—The following table gives the direction of glacial striae observed along the coast from Darnley bay to near the base of Bathurst inlet. Wherever the direction of movement of the ice could be determined, it is noted.

Locality	Strike of Striae (Astronomic)	Remarks
Darnley bay, east side, 15 miles south of cape Lyon	N. 31 E.	
Ten miles east of Pierce point	N. 48 E. N. 56 E.	Striae.
Inman river	N. 21 E. N. 31 E. N. 44 E. N. 56 E. N. 40 W.	Groovings.
Cape Krusenstern	N. 23 W. N. 42 W. N. 52 W. N. 70 W. N. 50 E.	These may not all be true striae; some may be scratches by sea ice. The intersections of striae are usually smooth.
Cape Kendall	N. 41 W.	Only one set here.
Satualik island, 15 miles southeast of Krusenstern	N. 40 W.	Glacial groovings.
Port Epworth harbour, west side, at 500 feet elevation	N. 50 W. N. 55 W.	Minor set. Major set. Erratics from the south.
Foot of Port Epworth harbour, on dolomite at 350 feet elevation	N. 25 W.	Crag and tail structure with steep faces to south.
Tree river, 25 miles inland, top of bluff on west side, elevation 1,000 feet above the river	N. 45 E.	
Tree river, 25 miles inland, on slates at foot of bluff in valley of river	N. 25 W. N. 5 W.	Older set. Younger set. Movement apparently from southeast.
Island 7 miles southeast of Galena point, Bathurst inlet	N. 41 W.	Main set.
Western mainland, opposite above island, and 3 miles southwest	N. 21 W.	
Island at west entrance to Moore bay	N. 13 W.	
West side of Arctic sound, 5 miles north of Hood river	N. 26 W. N. 11 W.	Older set. Younger set.
Six and a half miles up Hood river, at 1st cascade	N. 19 W. N. 6 W.	
West base of Banks peninsula, top of 870-foot bluff	(1) N. 26 W. (2) N. 14 E. (3) N. 29 E.	No. 2 set is older than No. 3.
West side of Goulburn peninsula, 2½ miles northeast of last locality, just above high-water level	N. 26 W. N. 16 W.	Older set. Younger set.

From the above table it is seen that the ice, in the region about cape Lyon and east for at least 20 miles, moved in a general northeast direction. For about 100 miles east of the most easterly of the recorded northeastward trending striae, no striae were observed until near the mouth of Inman river. From there east to the east end of Coronation gulf, the ice-movement as indicated by the striae was towards the northwest, practically at right angles to the strike of the western striae. In Bathurst inlet the striae occur in two distinct sets, trend more to the north, and indicate a movement from south to north.

No terminal moraines were seen on the mainland, and the same great accumulation of marine Pleistocene deposits occurs on southwestern Victoria island. The widespread, thick, Pleistocene deposits are probably reworked morainic deposits, or else outwash deposits.

Where hard rocks are exposed on the tops of hills, their surfaces, wherever observed, are polished and usually are well striated. All such hilltops have been glaciated, have rounded and polished rock surfaces, and occasional erratics are present. The highest of these hills noted was about Tree river; on the west side, 25 miles from the coast, a bluff of diabase rises 1,000 feet above the river with a glaciated top covered with erratics; on the east side of the river, about 6 miles from the coast, a rounded hill of granite, 1,090 feet in elevation, is also glaciated, and bears erratics of dolomite.

Recent

Recent deposits, as a general rule, occur only on the flood plains and in the deltas of the rivers. Since Pleistocene time the land has been relatively elevated more than 500 feet and as a result erosion has predominated over deposition. Great quantities of the loose Pleistocene material have been carried away and, in places, gorges have been cut down into the underlying rock by the rapid streams. The gorge of Croker river is 300 feet deep in places and is presumably of Recent origin, otherwise it is hard to explain the occurrence of isolated pinnacles of dolomite in the canyon itself, and on top of the cliffs which border the river. About 100 feet of silty muds and gravels have been eroded by the river before it reached the bedrock, and it seems improbable that the river could have selected a course through these muds, immediately over an old drainage channel.

Recent wave-action has rapidly eroded the coast, especially where dolomites are exposed, and has left pillars and pinnacles protruding from the water a short distance from the shore.

Structural Geology

It seems clear that the great series of stratified Precambrian and Palæozoic rocks in this region have been preserved because they occupy a deep embayment in the northwestern border of the great area of Precambrian granitic rocks. The stratified rocks in this embayment strike roughly parallel to the granite boundary and dip in general towards the centre. It is an oval synclinal basin, of which the eastern, southern and western borders occur on the mainland, and there are reasons for expecting that the northern border may yet be found in the central part of Victoria island. The longer axis of the oval extends from cape Lyon east to Boothia peninsula, a distance of about 600 miles and the shorter axis probably measures about 300 miles south to north, although there are irregular embayments on the south side which increase this distance. One of these embayments, namely that at Bathurst inlet, although connected with the main basin, has a basin structure of its own.

The older formations, from Darnley bay to near Deas Thompson point have a general northwesterly strike with small dip to the northeast and farther east the strike becomes more east - west with low dip to the north. In Coronation gulf the strike changes to the northeast again, and the dip to the northwest. On the west side of Boothia peninsula the rocks are reported to dip to the west and, there, stratified rocks older than Silurian probably occur, for Ross describes red sandstones and sills of trap at this place. However, the masses of native copper reported from Prince of Wales island to the northwest, probably occur not far from their mother rock, presumably of Precambrian age. It seems improbable that the masses of copper were transported from a distant source for there are no known copper-bearing rocks along the track of the ice sheet which passed over this island.

Although no white man has explored far into the interior of Victoria island, it is thought that the Precambrian copper-bearing rocks there come to the surface on the northern rim of the basin, about 40 miles northeast of Prince Albert sound, and that they possibly extend north from the known occurrence along the central part of the south coast, and occupy most of the central part of the island. Eskimos find large masses of copper protruding from cliffs, about 40 miles northeast of Prince Albert sound and this copper is probably nearly if not exactly in its original location.

Most of the central portion of the main basin is occupied by Palæozoic dolomites. These occur on the mainland from Tinney point east to cape Kendall, and form all the western and probably also the eastern side of Victoria island. Silurian dolomites also occur on King William island, and on Prince of Wales island, northwest of Boothia peninsula. They have a gently wavy structure with angles of dip much lower than those of the older formations.

The long embayment of Precambrian stratified formations which extends from the southeastern border of the main basin at Bathurst inlet, is a miniature of the main basin. Since all of the formations below the Palæozoic are represented in this area, it furnishes a nearly complete record of the general development of the structure of the entire region. The Epworth dolomites, which immediately overlie the Precambrian granites, were gently warped and deeply eroded before the Kanuyak formation was deposited upon them. The Kanuyak and the Epworth formations after suffering a gentle folding along axial lines trending a little east of north, were deeply eroded before the Goulburn quartzites were laid down on them. The Goulburn quartzite is very thick for a formation which is apparently confined to Bathurst inlet. Deep erosion followed the deposition of the quartzites, and then the great series of amygdaloidal basalts flowed over exposed surfaces of all the earlier formations, filling irregularities in the general surface, and restoring something of a plain surface to the district. Readjustment of the crust, following the extrusion of this great volume of lava, produced a gentle warping, and some normal faulting. The main faulting apparently occurred along the east side of what is now Banks peninsula, for there appears to be a vertical displacement of about 4,000 feet in that neighbourhood; but the only expression of this faulting is in the abrupt cliffs which form the eastern side of the peninsula, and in the reversed stratigraphical positions of the Epworth dolomite and the Goulburn quartzite. The whole low valley between is deeply covered with drift. The fault seems to have been hinged, since the throw was apparently greatest towards the south, a few miles south of the base of Banks peninsula, and decreases to nothing towards the north. A number of minor faults were observed striking in various directions, but they are relatively unimportant.

On both sides of Port Epworth harbour, which lies about 50 miles west of Bathurst inlet, the Kanuyak and Goulburn formations are missing and rocks of the Coppermine River series directly overlie the Epworth dolomites. At this place the dolomites are folded into a shallow synclinorium extending north 40 degrees east, while the overlying Coppermine River sandstones, etc., strike northeast and dip uniformly at an angle of 12 degrees northwest. This considerable discordance in structure is especially noticeable on the west side of the harbour, where the dolomite dips 22 degrees southeastward.

Details of Geology Along Routes Traversed

Parry Peninsula and Darnley Bay to the Mouth of Brock River

Parry peninsula is made up of grey limestones and maroon-coloured dolomites, which dip gently towards the north. The first exposures on the west coast are at Sellwood bay, and from the beach near this place corals of Silurian age were collected by Richardson in 1848. No fossils have been found in place on the peninsula. The exposures continue around cape Parry, and for 25 miles down the east side of the peninsula. The southern portion of the peninsula is low, and a portage is easily made from Darnley bay to Franklin bay, along a chain of small lakes.

The southwest corner of Darnley bay is bordered by cliffs 15 to 20 feet high, of partly consolidated sandstone holding thin beds of coal and overlain by gravel, and the rest of the southern coast is low and, as a rule, sandy.

At intervals along the east coast of Darnley bay are exposures of Pleistocene silts and gravels. Thirty miles south of cape Lyon the beds along the coast rise in cliffs 50 feet above sea-level and attain over 340 feet, 2 miles inland. The strata contain pebbles which vary in size from one-quarter of an inch in diameter, up to about 18 inches in the case of a few scattered boulders. The pebbles and boulders are of diabase, limestone, chert, buff to reddish-coloured sandstone, light grey shale, green mudstone, and a mudstone conglomerate with pebbles of quartz and jasper. Fossils were collected from the formation up to elevations as high as 150 feet. They are marine, of Pleistocene age, and from the horizon of the Gubik sand of Alaska. The country inland is gently rolling, and rises towards conspicuous, rougher hills, situated within 5 miles of the coast. The hills rise to heights of 500 or 600 feet and are formed of coarse gravel, capped by well-sorted sand.

Traverse from Darnley Bay up Brock River

In Darnley bay, 23 miles south of cape Lyon, a small river, Brock river, coming from the southeast, causes a break 1½ miles wide in the general coast-line. This gap is occupied by a fan-shaped delta which extends into Darnley bay for about a mile and is thickly covered with willows. On the west side of the delta, the banks at the coast are 50 feet high and are composed of mud and gravel for the lower 30 feet, and of sand and gravel for the upper 20 feet. The mud, sand and gravel contain well worn pebbles and some slabs of sandstone, limestone, etc. Across the valley, on the east side, is a 100-foot cliff of thin-bedded, silty mud, with, in places, lenses of crossbedded sand and numerous concretions of pyrite, apparently replacing charred wood. No fossils were seen in the cliff. Near the base is a buff coloured sand, with coarse grains of quartz, small fragments of carbonized wood, and a little shale embedded in the sand. The top of the cliff forms a terrace. A second terrace of gravel, mud and sand, apparently not stratified, occurs 40 feet above the first. A third terrace occurs at a height of 220 feet above sea-level, or 80 feet above the second terrace. It is composed of well-sorted gravel and sand, and forms the top of the plateau.

About 2 miles up Brock river an exposure of thin, partly consolidated, light grey sandstones occurs interbedded, with dark and light grey shales with concretions of pyrite. So friable are the edges of the beds that it is impossible to get a good dip and strike, but the strata appear to be about horizontal. The exposure is about 10 yards long and 20 feet high and is covered on both sides and top by gravel and sand. Similar exposures of the partly consolidated formation occur at intervals for 10 miles up the river. Commencing 3 miles from the coast and extending up-river for 7 miles, the hills on both sides are composed of sand and coarse gravel up to heights of about 250 feet, overlain by 150 feet of fine sand or gravel. About 10 miles up the river, cliffs of the partly consolidated formation rise about 125 feet. They are made up of inter-stratified light grey, dark grey, and brown shale, only slightly consolidated and containing lenses of fine-grained, sandy limestone about 20 feet long at the most, and up to 5 or 6 feet in thickness. The beds of shales are usually from 1 to 3 inches in thickness, some of them cross-bedded, and some containing abundant remains of willows. Fossils were collected from several of the shale layers, and from lenses of the limestone. The forms are estuarine species of upper Eocene, or Oligocene age.

About 11 miles up the river, the Eocene or Oligocene formation, is overlain by about 30 feet of thin-bedded, cross-bedded brown sand, and light grey silt, with a little gravel. Some of the silty layers contain sticks and roots of willows. The beds are about horizontal. Individual layers thicken and thin along the strike but are remarkably continuous, and constant in colour. No fossils were found in these beds. This series is overlain, apparently conformably, by coarse, well-sorted gravels.

Twelve miles up, the river cuts through beds of sandstone, quartzite, shales and dolomite, which strike north 21 degrees east, (true), and dip at an angle of 16 degrees to the northwest. The section at this place in descending order, is as follows:

Thickness in feet.	
150	Fine-grained, buff-coloured quartzite.
100	Red and green sandy shales, containing muscovite; with a few beds of buff quartzite.
40	Massive, reddish-brown sandstone.
60	Greyish brown sandstone, thin-bedded, 2 to 6 feet beds, passing down into dark reddish sandstone and green and red shale as before.
75	Massive, argillaceous, buff-coloured sandstone.
25	Thin-bedded, buff sandstone, with limonite stain.
425+	Interbedded, buff, reddish-brown and dark red-brown sandstones, with green and red brown shales in thin layers. The sandstones are cross-bedded in many layers. The lowest member exposed contains a few soft pebbles.
150	No exposure.
30	Fine-grained, maroon-coloured, cherty dolomite. (Top not exposed).
50	Light grey, cherty dolomite, some of which is conglomeratic.

The beds of the formation strike north 21° east, (true), and dip 16° towards the northwest. The whole sandstone formation is more than 900 feet thick and is believed to belong to the Coppermine River series. The underlying dolomites have apparently the same strike and dip as the sandstones, but they are probably separated by an erosional unconformity, and the dolomite is possibly equivalent to the Epworth dolomite. There are no more exposures for more than a mile upstream.

The beds of the Coppermine River series form cliffs and are overlain by about 50 feet of stratified silts and gravels. Coarse gravels overlie these and occur to heights of more than 500 feet above the river bed, which is here about 100 feet above sea-level. The tops of the gravel hills are thus at least 600 feet above the sea-level, and the thickness of the silts and gravels is more than 400 feet. On the sides of the river valley in the silts and gravels there are five distinct terraces, apparently made by the river.

Coast from Brock River to Croker River

Along the east coast of Darnley bay, from the mouth of Brock river north to cape Lyon and thence along the main coast, east to within 1½ miles of Pierce point, the rocks are thin-bedded, light and dark grey shales and sandstones. They dip west and southwest in the southern part, while the northern beds dip 5 to 10 degrees to the northeast. The most eastern exposures of these beds are separated, by an exposureless interval of 1½ miles, from dolomites that outcrop at Pierce point. It is believed that the shales and sandstones belong to the Coppermine River series and occur at a higher horizon than the sandstones of Brock river. The dolomites of Pierce point are thought to belong to the Epworth series and are correlated with the dolomites already noted as occurring on Brock river. The shales are intruded by two or three large sills of diabase, which strike roughly northwest-southeast, and dip at various angles to the northeast. The sills are of coarse quartz diabase, with well developed ophitic texture, and become quite fine-grained at the contact.

The Epworth dolomites at Pierce point form cliffs. The lower beds are of grey, cherty dolomite, baked and re-crystallized near intrusions of diabase, and apparently are more than 150 feet in thickness. They strike north 34 degrees west (true) with an angle of dip of 7½ degrees to the northeast; they are in

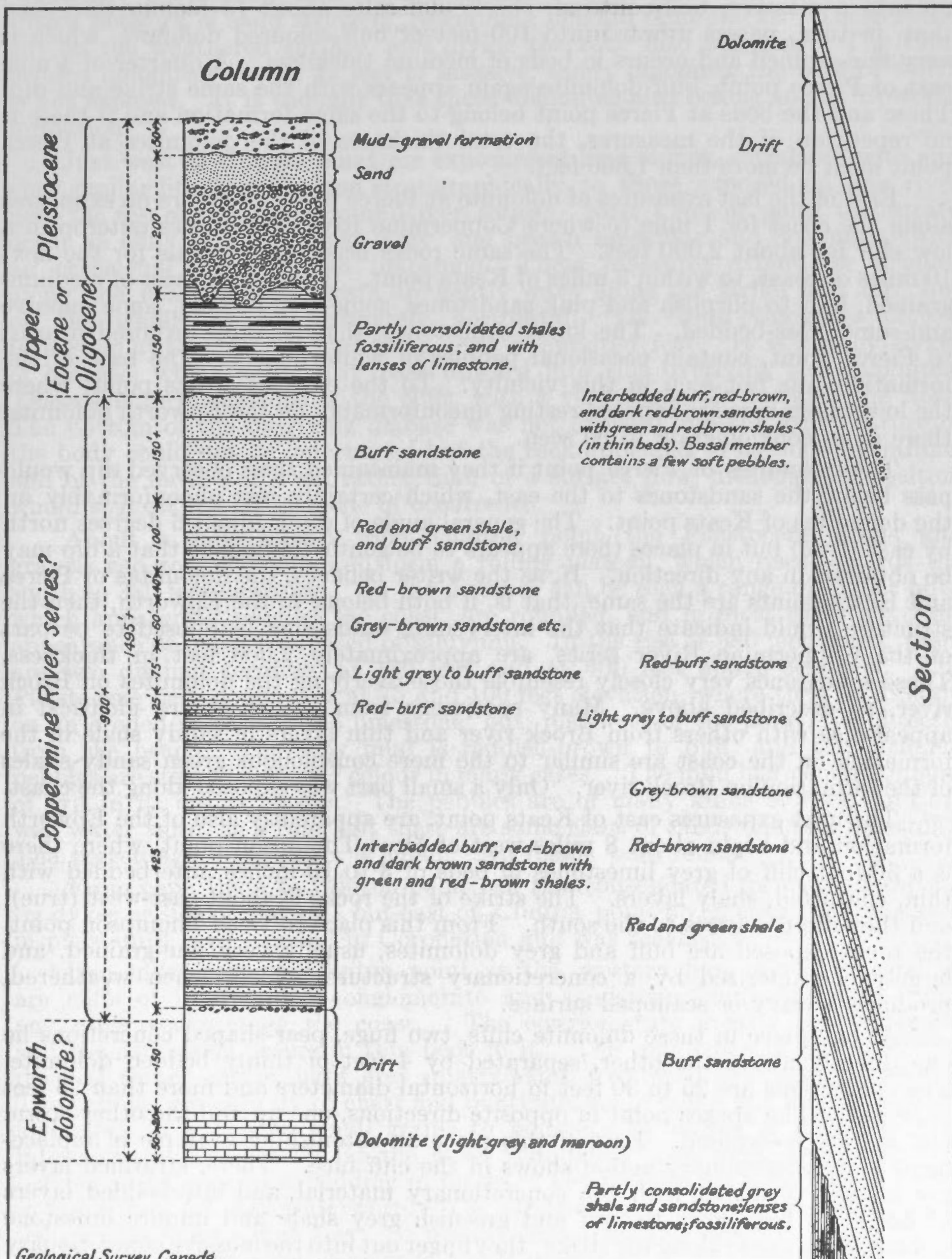

Figure 1. Diagrammatic stratigraphic column and section on Brock river., Darnley bay, Northwest Territories.

thin beds 2 inches to 8 inches thick and contain cherty layers and lenses. The rock apparently contains no fossils. The lower thin-bedded dolomites pass up into a massive, buff-coloured, cherty dolomite about 75 feet in thickness, that, in turn, passes upward into 100 feet of buff-coloured dolomite, which is very fine-grained and occurs in beds of medium thickness. A quarter of a mile east of Pierce point, buff dolomite again appears with the same strike and dip. These and the beds at Pierce point belong to the same formation and if there is no repetition of the measures, the total thickness of the dolomites at Pierce point must be more than 1,800 feet.

East of the last exposures of dolomite at Pierce point, there are no exposures along the coast for 1 mile to where Coppermine River sandstones outcrop in a low cliff for about 2,000 feet. The same rocks occur at intervals for the next 10 miles of coast, to within 3 miles of Keats point. The beds consist of medium-grained, buff to purplish and pink sandstones, some thin-bedded, some massive and some cross-bedded. The lower sandstones, that is, those exposed nearest to Pierce point, contain occasional pebbles of white quartz. The base of the formation was not seen in this vicinity. To the east, at Keats point, where the lower members are exposed resting unconformably on the Epworth dolomite, there is no conglomerate to be seen.

The dolomites of Pierce point if they maintained their observed dip would pass below the sandstones to the east, which certainly rest unconformably on the dolomites of Keats point. The general angle of dip is about 6 degrees north by east (true) but in places there appears to be gentle folding, so that a dip may be obtained in any direction. If, as the writer believes, the dolomites of Pierce and Keats points are the same, that is, if both belong to the Epworth, then the structure would indicate that the intervening sandstones, supposed to be part of the Coppermine River series, are approximately 2,000 feet in thickness. These sandstones very closely resemble those overlying the dolomites on Brock river, as described above. Many specimens from the coast are identical in appearance with others from Brock river and thin layers of sandy shale in the formation on the coast are similar to the more conspicuous green sandy shales of the formation on Brock river. Only a small part was exposed along the coast.

The next exposures east of Keats point, are apparently also of the Epworth formation and begin about 8 miles west of Deas Thompson point, where there is a 30-foot cliff of grey limestones in beds of 3 to 10 inches, interbedded with thin, contorted, shaly layers. The strike of the rocks is about east-west (true), and they dip 6 degrees to the south. From this place to Deas Thompson point, the rocks exposed are buff and grey dolomites, usually very fine-grained, and largely characterized by a concretionary structure, which, when weathered, produces a wavy or scalloped surface.

At one place in these dolomite cliffs, two huge, pear-shaped concretions lie one directly above the other, separated by 4 feet of thinly bedded dolomite. The concretions are 25 to 30 feet in horizontal diameters and more than 25 feet in height. The apexes point in opposite directions, one up and the other down, and neither is exposed. East of this place an astonishing example of replacement and concretionary action shows in the cliff face. There, stratified layers are intimately mixed with the concretionary material, and interbedded layers of dark and light grey to buff and greenish grey shale and impure limestone suddenly terminate along the strike; they finger out into the massive concretionary material of which most of the cliff is formed, and entirely lose their identity, although a few feet away, they are perfectly distinct and quite conspicuous. It is not possible to estimate correctly the thickness of the sediments at this place, but it is more than 100 feet. The dolomites are cut in several places by large dykes of quartz diabase.

Along the coast many fine arches, natural bridges, and some chimneys, together with a few isolated pillars have been carved out of the dolomite cliffs.

Ten miles east of Deas Thompson point there is a cliff capped by 15 feet of practically horizontal, thin-bedded, sandy dolomites. Some beds are filled with a network of sand stringers, resembling filled-in mud-cracks. These stand out on the weathered surface, and divide the rock into polygons. The thin-bedded dolomites overlie 12 feet of massive, sandy dolomite, the base of which is not exposed. It is thought that these dolomites also belong to the Epworth formation.

Just west of Clinton point are exposuresof lime stones, correlated with and very similar lithologically and stratigraphically to those exposed on Rae river near the top of the Coppermine River series. Near Clinton point the strata occur as cliffs of fine-grained, grey and brown limestone and dolomites, with an occasional bed of green limestone. These measures extend for 3 miles along the coast and the strata are gently wavy along the strike and dip, but on the whole are approximately horizontal. The total thickness of the formation at this place is something over a hundred feet. It is cut by dykes of diabase, which apparently pass upward into sills overlying the dolomites. These sills form the tops of the cliffs, with a very slight dip towards the west. The bottom of the overlying diabase was not exposed and the exact nature of the body could not be determined but the rock appeared to be holo-crystalline, and of the nature of a sill rather than of a surface flow, although its position would suggest the latter mode of occurrence.

About a mile inland from Clinton point the Pleistocene muds and gravels cap rounded hills and form a rolling plateau, which rises towards the south to 380 feet elevation. In the distance can be seen a range of higher hills, which apparently parallel the coast, are rounded, and in most cases have the appearance of being composed of alluvium. In the rise of 380 feet noted, there are two distinct terraces, at 130 feet and at 300 feet above sea-level. The Pleistocene beds commence at 75 and 100 feet elevation, where they lie directly on an eroded surface of the limestone; but, just west of the point, rise directly from the beach. The silty mud is reddish-brown to buff, and the included pebbles are stained a similar colour in many cases. The mud has a small amount of grit in it, but is plastic. The pebbles are of many kinds of rock, and are well water worn, as a rule, but there are some slabs of sandstone and limestone. The percentage of boulders is small. No fossils were found.

From cape Lyon to Clinton point, all the consolidated formations are cut by dykes or sills of diabase; but east of Clinton point no igneous rock was seen in place until cape Kendall in Coronation gulf was reached.

Ten miles east of Clinton point at the western base of Tinney point, are cliffs of interbedded conglomerate and sandstone, quite different from any other rocks along the coast. The conglomerate greatly preponderates and the sandstone occurs in thin beds in it. The conglomerate has a ground-mass of rather coarse, light grey quartz sand, frequently stained light brown. The pebbles are entirely of chert and quartzite, some milky but mostly banded, and range in size from small grains to boulders 10 inches in diameter; the intermediate sizes are by far the most abundant. The conglomerate is well-bedded and shows cross-bedding in places. The pebbles are more or less sorted in layers and are well waterworn. The sandstone is medium-grained and purplish, weathering to light grey. It usually contains a few small pebbles, and one layer at least shows well developed ripple markings.

The formation is at least 60 feet thick, and is apparently about horizontal, although it is gently wavy in detail. The sand layers are more numerous near the top, and the conglomerate is capped by 8 feet of sandstone. The strata extend for 1½ miles inland where, interbedded in the conglomerate near the base of the formation, are 3 to 5 feet of purplish, medium-grained sandstone containing fragments of carbonized material resembling the remains of roots. Below the conglomerate there is a very light brown, finely crystalline, cherty dolomite, which is apparently conformable with the conglomerate but is probably part of the Palaeozoic dolomites so well developed in the Croker river section a few miles to the east. The chert pebbles in the overlying conglomerate are identical in appearance with the cherty material found elsewhere in the Palaeozoic beds. Presumably, the Tinney point beds are separated from the Palaeozoic dolomites by an erosion interval and are at least post-Silurian in age.

Croker River Section

The following account of Croker river and of the strata along it is compiled from notes and specimens supplied by Mr. Chipman, who surveyed the river for about 30 miles from its mouth.

The delta of Croker river is about 5 miles wide at the coast, and extends 4 miles inland to an apex. The front of the delta, or more properly, of the flood-plain, is a ridge of gravel with a steep face bowed slightly seaward, through which the stream-channel is cut. At high tide the bed of the river delta is very little above sea-level. The several channels through which Croker river flows as it approaches the coast, converge and unite at a point 4 miles inland, where the river debouches from a canyon. From this point the canyon continues southward for 25 miles, and except for occasional talus slopes, the walls are sheer and continuous. There is no place where a sled may get out, and very few where a man may climb to the top. One creek comes in from the east, and there is a small gully on the west side. For 20 miles the walls of the canyon are of supposedly Silurian strata consisting of brownish grey dolomite, in which there is an occasional mass of medium-grained, calcareous sandstone, containing fragments and pebbles of dolomite, and small pebbles of flint, quartzite and quartz. These masses of sandy conglomerate have no continuity along the strike, but are apparently local phases in the dolomite. In places the dolomite has a brecciated appearance, and, among fragments of chert, are pieces of distinct oolite.

The formation is practically flat on the whole, although it is gently wavy in detail. About 20 miles inland, there is apparently a general dip of about 5 degrees towards the northeast. At one place there is a section of 300 feet of dolomite overlain by 40 feet of gravel. About 25 miles inland, the cliffs of dolomite end abruptly and a partly consolidated conglomerate forms the walls of the river for some distance and, as was the dolomite, is overlain by the loose Pleistocene sand and gravels. The actual contact of the conglomerate with the dolomite was not seen. The pebbles in the conglomerate vary in size, are well rounded, and are composed of diabase, granite and dolomite.

About 25 miles up the river, a 7½ mile traverse was made across country to mount Davy, which rises about 200 feet above the level of the surrounding country. From the river banks the traverse crossed a succession of small ridges, running in a general east-west direction. No rocks occur in place and the surface is altogether of the Pleistocene muds and gravels. Mount Davy is of the same material. Its top is shaped like an inverted cup, with a rounded shoulder extending northwestward to a pile of well rounded boulders of granite and diabase, and of angular pieces of dolomite in about equal amounts. The fine material is composed largely of small pieces of dolomite mixed with other materials. Many hills similar to mount Davy, although somewhat lower, lie to the east and southeast. The country to the south rises with uniform slope and, in a few miles, attains the elevation of mount Davy, which is 1,220 feet above the level of Croker river 25 miles from the coast, or 2,000 feet above the sea. From these the valley of the river can be seen extending to the southwest, as a shallow canyon winding through a broad plain that rises gradually towards the south. The canyon becomes very narrow in this direction and, apparently, the source of the river is not more than 20 miles distant, at a total distance of about 50 miles from the coast.

Coast From Croker River to Rae River

The first exposure along the coast of supposedly Silurian dolomite occurs in the vicinity of Inman river about 24 miles east of Croker river. The intervening coast is of gravel, or of silty mud and gravel, rising towards the south in a rolling plain.

At the first exposure, the dolomite occurs in cliffs about the mouth of Inman river, where it issues from its canyon and passes through a mile of gravel and sand flats to the ocean. The dolomite strikes approximately S. 65° E. (true) and dips 4 to 6 degrees to the south. The unaltered dolomite is massive, fine-grained and maroon-coloured, and is interbedded with bands of white and bluish grey chert, and irregular masses of milky jasper which are broken and brecciated in many places. The dolomite in places is apparently greatly metamorphosed and is now really a chert-breccia, extremely fine-grained and hard, with little or none of the dolomite remaining. Beds of this chert-breccia were, apparently, the source of most of the pebbles in the conglomerate seen near Tinney point; for the materials of the pebbles and of the breccia are identical in appearance and this chert-breccia is the only rock of the kind seen anywhere along the coast.

The cliffs about the mouth of Inman river range from 20 to more than 150 feet in height, and in the canyon of the river, 100 feet of the Pleistocene mud, sand, and gravel beds occur, in which marine fossils were collected up to 170 feet in elevation. To the south, the country is a rolling plateau, covered with the alluvial formation and rising gradually to the hills of the Melville range, visible in the distance. Rock exposures appear to be confined to the cliffs along the river. Glacial striae are distinct and strike N. 35° to 40° W. (true). In the cliffs facing the coast, one-quarter of a mile back from the shoreline, is a small arch with a chimney overlying it. There are also deep embayments cut into the cliffs, which are here 150 feet in height.

The next exposures along the coast east of Inman river, occur near Wise point, where dolomite outcrops in cliffs 220 feet high. The strata strike north 43 degrees east, and dip 6 degrees to the northwest, although the structure is wavy in detail. The beds range from a few inches to several feet in thickness, and all are of light grey, sandy or cherty dolomite. A few of the beds contain large numbers of vugs, partly filled with crystals of calcite. Some of the layers are of shattered, banded, milky jasper, embedded in dolomite, and resemble those seen near Inman river. There is typical karst weathering in the cliffs, which present castellated fronts.

Three miles southeast of Hope point, in Stapylton bay, there are cliffs of dolomite 25 feet high in which the beds strike north 25 degrees east, and dip 12 degrees to the southeast. Exposures of the same or similar dolomite occur at intervals along the coast from this place to Locker point, in Coronation gulf, and are also present about 2 miles inland from the tip of cape Hearne. The same dolomite also occurs on the Liston and Sutton islands in Dolphin and Union strait, where it contains abundant corals, which have been determined to be of Silurian age and of about the horizon of the Lockport.

Although diligent search for fossils was made wherever the supposedly Silurian dolomite of the coast section was encountered, no fossil localities were found. Two fragments of dolomite, found on the beach at Bernard harbour, Dolphin and Union strait, contain fossils of Upper Cambrian age.

The contact of the dolomites with the underlying Coppermine River formation occurs at the west end of Coronation gulf, somewhere in a broad drift-covered valley between capes Hearne and Kendall, but was not seen. The two formations have approximately the same strike and dip, and probably there is no structural unconformity; but the lower series is intruded by sills of diabase whereas the upper is not.

Rae River Section

The following account of the rocks which occur along Rae river is based on notes and rock specimens taken by Mr. Cox who traversed the river for 75 miles, and from the end of the river traverse followed a northeast course across country, to the south side of Stapylton bay.

The strata of Rae river valley consist of sediments of the Coppermine river series, cut by sills or dykes of diabase and bordered on the north by Palæozoic dolomites. At cape Kendall, olivine diabase overlies 50 feet of fine, compact, thin-bedded dolomite, in which dark grey, and brown layers alternate. Glacial striae at this point strike north 41 degrees west. Four miles up Rae river, on the north side, there is a hill of red sandstone, 150 feet in height, in which the beds strike east 8 degrees south and dip 4 degrees to the north. Six miles up the river, diabase bluffs occur on the north side and continue for about 60 miles farther. The south side of the river is mainly low, and bordered by grassy slopes which rise gently to the south in ridges until terminated by abrupt cliffs that face south and parallel the river. These ridges in many places have been cut through, leaving monadnocks with abrupt cliff faces. On the north side, there are also grassy plains which terminate against a similar broken line of diabase cliffs.

The falls mentioned by Rae are 10 miles up-stream at a place where the river narrows to 200 feet. The falls are about 25 feet wide and drop 10 feet over fine-grained, thin-bedded dolomite of various shades of colour.

Twenty-eight miles up river there is a canyon 150 feet in width, with cliffs 70 feet in height and 1,000 feet in length. The cliffs are of fine-grained, buff dolomite, with thin beds of limestone and calcareous conglomerate and of a breccia of jasper and chert in a limy matrix. The strata are cut and overlain by quartz diabase.

Forty-five miles up, there is a rapid where the river cuts through a ridge of quartz diabase. Above the rapid the valley widens and is occupied by a lake one-quarter to two-thirds of a mile in width, and about 10 miles long, bordered by low, rolling, grassy country. On the south side this rolling country terminates in a gently rising slope, and on the north side it ends within a few miles against a bluff of diabase.

Fifty-seven miles up the river, there is a second lake about 6 miles in length, and just above it the river forks three times within a few miles, the branches at each fork being separated by bluffs of diabase. Above this, the river breaks up into small branches, which flow between similar rocky bluffs. The general dip of these sills or broken sill, of diabase is about 4 degrees to the northwest.

From a point 75 miles up Rae river, a course was followed northeast, across country to Stapylton bay. The diabase that intrudes the Coppermine River series outcrops at intervals for the first 4 miles, beyond which, after 4 miles without exposures, the first outcrops of the Palæozoic strata commence, represented there by sandy dolomite. Sixteen miles from the river occurs a long low ridge of fine-grained, buff dolomite which strikes south 27 degrees east, and dips 2½ degrees to the northeast. Beyond the ridge, between points respectively 20 and 35 miles from the river, the country is low, flat, and tundra-covered. About 35 miles from the river, a rolling country begins, with a surface of mud and gravel and numerous fragments of dolomite. Some of the hills rise 200 feet above the plain and beyond them there is a tundra plain with a gentle slope to the northeast of about 21 feet to the mile. This plain extends for 12 miles to another series of mud-gravel hills one mile wide. Sandy dolomite, which outcrops on the north slopes of these hills, is the first exposure of solid rock in 30 miles.

The north side of the second group of hills lies 48 miles from the river or 20 miles from the coast. The country for the next 4 miles is level and tundra-covered. To this level stretch succeeds a third group of hills, stretching as far as one can see southeast and northwest. The hills rise about 200 feet above the plain or 300 feet above sea-level and are 3 miles broad along a north-south course. The hills are formed of reddish clay and gravel and are well rounded. North of the hills the country is tundra-covered and slopes down with an average grade of about 23 feet to the mile. Within 2 miles of Stapylton bay there is a low ridge of broken rock, parallel to the coast. Dolomite occurs in a creek canyon a few miles from the coast and at the mouth of the creek, where the beds strike south 27 degrees east and dip 2½ degrees to the northeast.

Coronation Gulf.

Islands

A traverse was made from cape Krusenstern southeast across Coronation gulf to port Epworth. At 15 miles from Krusenstern, a chain of islands, with cliffs to the south and gentle slopes to the north, extends in a general northeast direction. All the islands, apparently, are of diabase, and the tops are well polished and striated in a direction north 40 degrees west.

Sixteen miles southeast of the first chain of islands, there is another parallel chain, also of diabase and similar to the first, and nine miles farther, a total of 40 miles from Krusenstern, lies a third chain of islands similar to the other two. On one of the islands of the third chain, several small veins were seen, filled with calcite and containing a little chalcopyrite. At 55 miles from cape Krusenstern, or 5 miles from the south shore of Coronation gulf, there is another chain of small islands, of quartz diabase. A day was spent examining two of these islands but no trace of copper was met with.

Apparently all the islands in Coronation gulf are capped by sills of diabase, in some cases overlying low cliffs of sandstone or shale belonging to the Coppermine River series.

North Shore

The following notes on the geology of the north shore of Coronation gulf are based on observations, supplemented by photographs and numerous rock specimens, taken by Mr. Johansen during a trip along the north shore of the gulf in the spring of 1916.

Red sandstones and some limestone of the Coppermine river series, cut by diabase, outcrop along the coast between west longitude 111 degrees and 112 degrees, and are especially well developed about Murray point, and on the mainland north of the Richardson islands. The Coppermine River series apparently extends northward some distance into central Victoria island. Dease and Simpson noted red sandstone, presumably of the Coppermine River series, on the southern Victoria island coast as far east as west longitude 105½ degrees, or due north of the east end of Kent peninsula. Judging by the notes of Franklin and Hanbury, all of Kent peninsula is apparently occupied by the Coppermine River series; apparently the copper-bearing amygdaloids are not present. Eskimos report the occurrence of native copper in large masses in the hills about 40 miles northeast of Prince Albert sound, Victoria island. Whether the copper occurs in solid rock or in drift, could not be determined from the descriptions furnished, but it seems probable that the copper-bearing rocks outcrop at this place.

South Shore and Tree River

Along the southern shore of Coronation gulf, from cape Kendall to within 20 miles of Port Epworth, all the rock exposures are of the Coppermine River series and consist of shales and sandstones, usually overlain by diabase. Approaching Port Epworth, the small islands immediately off shore and the coast for 8 miles are occupied by granite, apparently older than the Coppermine River series. Beyond this, for the next 12 miles to Port Epworth, the outcrops along the coast are of diabase which overlies sandstones and shales of the Coppermine River series.

Port Epworth harbour is a bay 6 miles deep, into which Tree river empties. The rocks along the shores of port Epworth harbour, for the outer mile and a half, are of diabase, overlying and cutting shales and sandstones of the Coppermine River series. The Coppermine River beds overlie, with structural unconformity, a series of cherty dolomites, the Epworth formation, which occupies both sides of the bay for 4½ miles, to its head, and outcrop for some distance south along Tree river. East of the harbour, at about one-quarter mile

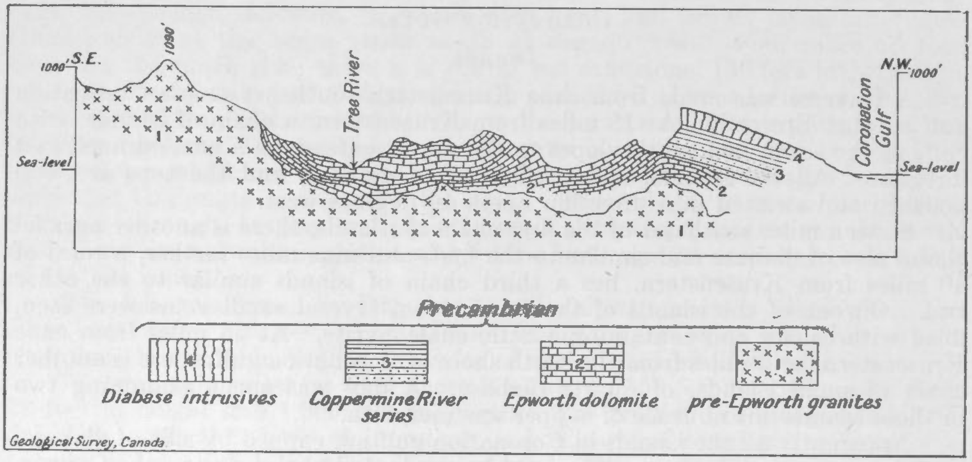

Figure 2. Diagrammatic vertical section from northwest to southeast across the Epworth dolomites at Port Epworth, Coronation gulf. (Vertical scale exaggerated.)

from the shore, granite underlies the dolomite and the granite contact extends practically true south for at least 40 miles, beyond which point it swings towards the southwest. At the foot of port Epworth harbour the cherty Epworth dolomite occupies the valley of Tree river, in the form of a gentle synclinorium whose axis runs about south 30 degrees west. The dolomite abuts against the granite on the east and is overlain by the sandstone and shale of the Coppermine River series on the west.

The dolomite is more than 1,000 feet thick at this place. It consists of thin beds varying from a fraction of an inch up to 5 feet in thickness and varying in colour from light to dark grey, through buff to light brown. Concretionary structure is prevalent in some layers, giving them an appearance of complex folding in cross section. Most of the layers, apparently, lack the concretions and thin beds can be traced along the cliff faces for considerable distances. The disturbance due to concretionary action has had slight, if any, visible effect on the even bedding of the adjacent layers. The concretions average about 10 inches in diameter and stand up as knobs on the weathered surface.

The Epworth dolomite apparently underlies the whole width of Tree River valley, which is from 1½ to 3 miles broad, for a distance of at least 30 miles from the coast. Judging by the topography, the dolomite probably continues for 20 miles farther to where the granite contact swings to the southwest. The granite highland, is fronted on the north by low land, which is possibly occupied by the dolomite. The dolomite may continue westward and join the limestones exposed on the Coppermine River section about the mouth of Kendall river.

Close to the granite, the Epworth dolomite is underlain by a thin basal conglomerate, which in places is quite arkosic in the lower 3 to 5 feet. The conglomerate contains pebbles of quartz and rounded blocks of unaltered granite and passes upwards into coarse sandstone and slaty material, which, towards the top, are interbedded with massive beds of dolomite.

For the most part, the valley of Tree river is occupied by the Pleistocene muds and gravels so common along the coasts, and marine fossil were collected 11 miles up the river, at about 100 feet above sea-level. Similar fossils were collected from similar beds, overlying the dolomite at the foot of the harbour, at an elevation of 320 feet. The Pleistocene beds are of silty mud, dark grey in colour when damp, but light grey to buff and powdery when dry. Fossils were collected from similar beds overlying the granite, on the east side of the harbour at an elevation of 500 feet above the sea-level, and similar material but without fossils was seen at much higher levels. The granite at this place contains numerous inclusions, some of which are of talc-chlorite-schist and are quarried for pots and lamps by the Eskimos. Inclusions in the granite are apparently more numerous towards the north.

The points along the coast from port Epworth to Grays bay are of diabase, overlying Coppermine River shale; but the deeper bays extend through the belt of these rocks, into the granite area that stretches eastward from the east side of the Tree River valley and parallels the coast at about 1½ miles inland. The Epworth dolomite is not exposed between port Epworth and cape Barrow. From the west side of Grays bay to cape Barrow and down the west side of Bathurst inlet nearly to Moore bay, granite occupies the whole coast. The granite at Grays bay holds numerous large inclusions of thin-bedded sediments, standing on edge. The beds are from 2 to 6 inches in thickness and are of light and dark grey limestone, sandstone, shale and, less commonly, mica and chloritic schist. One of the larger of these inclusions is 200 feet in thickness. Numerous inclusions were seen in the granite all the way to cape Barrow.

Two varieties of granite, one dark grey, the other pink, occur at cape Barrow and occupy about equal areas. The dark grey variety is a biotite granite, in which the biotite is apparently secondary, and contains a little unaltered augite. The pink granite is composed chiefly of pink feldspar and quartz, the feldspar predominantly microcline and all of the abundant quartz individuals showing strain shadows. Some secondary biotite is present, also either hornblende or augite, evenly distributed in small crystals. Both granites contain many inclusions of hornblende or chlorite schist and pyroxenite and are cut by numerous dykes of fine-grained diabase, varying in width from a few inches to 15 feet. The grey granite is penetrated intricately by the pink granite and is cut by numerous veins and dykes of bright pink pegmatite.

The Pleistocene mud and gravel beds occur on all the hills at cape Barrow, up to a height of 350 feet, if not higher, and fossils were found in them up to an elevation of 150 feet.

Bathurst Inlet

At Galena point, in Bathurst inlet, granite outcrops and is much weathered and has disintegrated to a depth of a few inches. Near the middle of the point, about 200 yards back from the beach, galena occurs in three places. At one place a small pocket of pegmatite, 6 inches in length, contains white feldspar, quartz, some muscovite, and, on one side, 2 inches of galena. The two other occurrences are lenticular veins, 9 and 20 feet in length, respectively, and about 3 inches in width, composed of milky quartz carrying a little galena. No more galena was seen in the northern part of the point although narrow veins of quartz are numerous.

Inland from the hills, along the shore of Galena point, are broad, grassy valleys, containing several lakes, separated from Detention harbour by another low range of hills.

Seven miles southeast from the east end of Galena point there is group of islands. The northwest tip of the first island is of Epworth dolomite in massive and slaty beds, some of the layers being practically chert. The strike of the dolomite is north 45 degrees west and the dip is to the northeast at an angle of 15 degrees. Glacial striae strike north 41 degrees west. The remainder of the island is of amygdaloid belonging to the Coppermine River series.

On the mainland southwest of these islands, the Epworth dolomite overlies the Precambrian granite as at port Epworth, and is itself directly overlain by amygdaloid. The dolomite occupies a valley about 1,000 feet wide, bordering the granite area and extending to the south as far as could be seen. The dolomite dips 13 degrees to the east and the part exposed is calculated to be 225 feet thick. Amygdaloids of the Coppermine River series occupy the coast to Moore bay and occasionally show thin seams of malachite. In Moore bay, the Precambrian granite borders the bottom of the bay, but on the north and south shores the granite is overlain by Epworth dolomite, succeeded farther east by amygdaloid, as before. On an island of diabase in Moore bay, a few veins were seen, one 2-inch vein containing pieces of copper as large as walnuts.

The coast and adjacent islands from Moore bay to Arctic sound are of amygdaloid, in places capped by diabase. At one place, between cliffs, a series of shingle terraces, 1 to 5 feet apart, rise to about 150 feet. At Kater point, a thick sill of diabase strikes south 34 degrees east and dips at an angle of 25 degrees to the northeast. It is cut by small fissures coated with malachite.

On the west side of Arctic sound, about 5 miles northwest of the mouth of Hood river, Epworth dolomite comes near the coast but is fronted to the northeast, north, and northwest by amygdaloid. The dolomite is concretionary, some cherty, and some of a reddish colour and a few thin beds of sandstone and sandy shale are interbedded with it. The strike of the formation is south 75 degrees west and the dip 18 degrees north. The dolomite appears to continue inland as far as could be seen. Glacial striae at this point run north 11 degrees west, and cut other striae striking north 26 degrees west (true). The Pleistocene mud, sand and gravel beds are here over 75 feet in thickness, and cap hills 200 to 250 feet high; marine shells were collected from the sand 150 feet above sea-level. The country for several miles inland shows low, grassy valleys, diversified by lakes and cliffs of dolomite overlain by amygdaloids.

Two miles up Hood river there is an exposure of red, fine-grained quartzite, the Goulburn quartzite, which is highly crushed and faulted. The same rock is exposed at the cascade 6½ miles up the river. Two sets of glacial striae at this point strike, respectively, north 6 degrees west and north 19 degrees west.

A section was made from the river, at the cascade, west to the granite contact which occurs about 3 miles from the river. The banks of the river are about 100 feet high and are of Pleistocene sands and gravels. One and one-half miles west of the river a ridge of red Goulburn quartzite, 200 feet in height, slopes gently to the southeast. The beds of quartzite strike south 26 degrees west, and dip 12 degrees southeasterly. One-third of a mile west, in a higher ridge, the quartzite has a wavering strike south 14 degrees west and dips 45 degrees to the northeast. One-quarter of a mile farther west Precambrian granite is exposed. The thickness of the quartzites from the Hood river to the westernmost exposure, calculated from the average angle of dip, is approximately 5,000 feet. The first exposures of granite form an isolated hill, 150 yards long by 100 yards broad. The rock is a muscovite-biotite-granite, enclosing fragments of schist and, a short distance north, a band of similar schist is exposed for 900 feet, striking south 19 degrees west and dipping 35 degrees northwest. A thick sill of diabase cuts across country at this place and the main granite mass lies about half a mile to the west. The edge of the granite hills strikes about south 16 degrees east. No dolomite was seen in this section, but exposures west of the quartzite are limited and dolomite may there underlie a low valley.

Banks peninsula is largely underlain by amygdaloids of the Coppermine river series; but, on the east side, 9 miles south from cape Wollaston, there is a 100-foot cliff of Epworth dolomite, striking north 5 degrees east and dipping 11 degrees to the west. The dolomite extends as a band south along the east side of Banks peninsula. At the foot of Brown sound, on the east side of the peninsula, the dolomite with about the same strike and dip occurs in a cliff

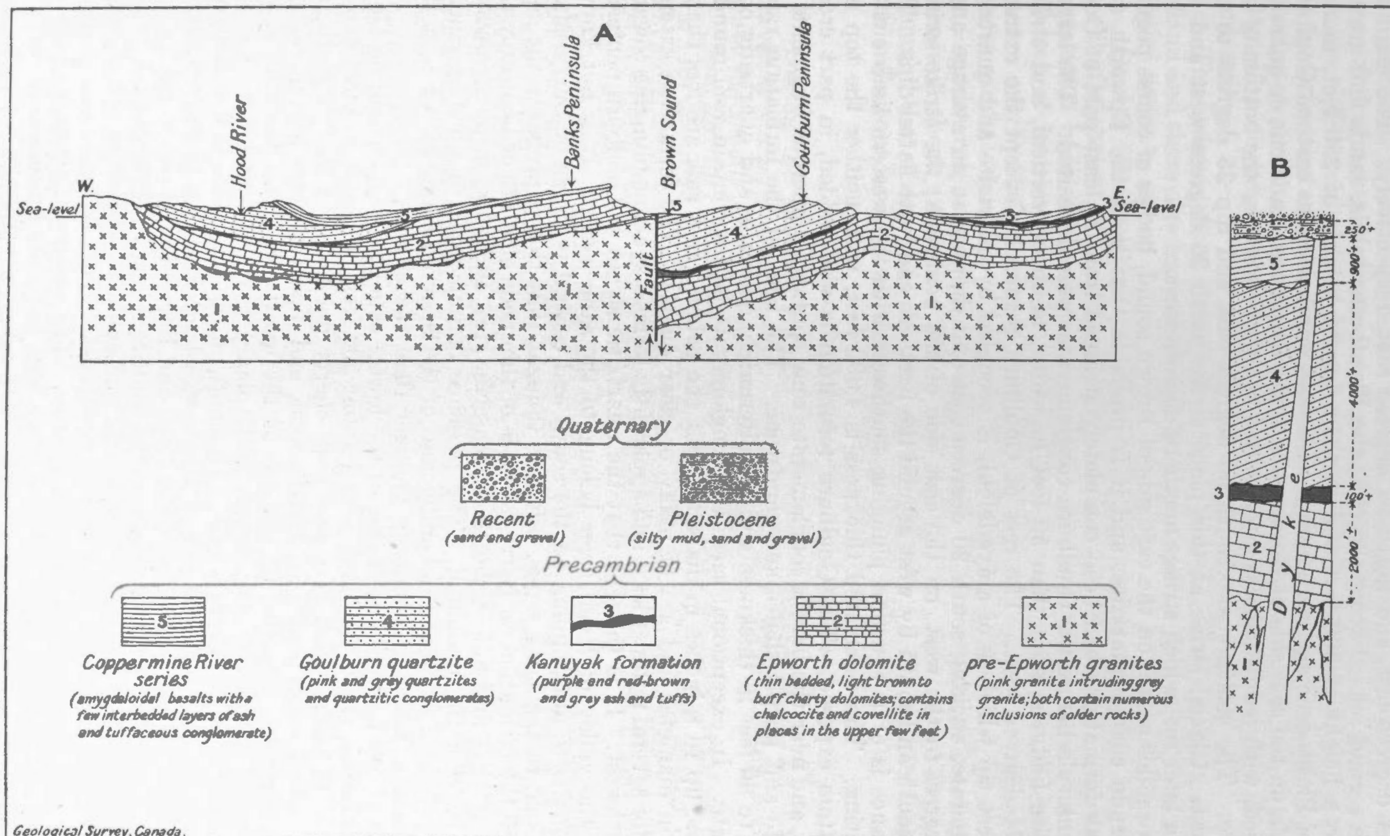

Figure 3. (A) Diagrammatic vertical section from east to west across Bathurst inlet and base of Banks peninsula. (Vertical scale exaggerated.)
(B) General stratigraphic section in Bathurst inlet.

rising 820 feet above sea-level, the upper 50 feet of which is amygdaloid. On the top of the bluffs three sets of glacial striae trend north 26 degrees west, north 14 degrees east, and north 29 degrees east, respectively. The third set cuts the second set. Facing the cliff, the Pleistocene muds, sands and gravels occur to a height of 500 feet and in them, up to heights of 250 feet, marine fossils of Pleistocene age were found. One and one-half miles east, on Goulburn peninsula on the east side of Brown sound, the Goulburn sandstone or quartzite is exposed, with reddish shales interbedded in thin bands near the bottom of the exposure. The strata strike south 66 degrees east and dip 25 degrees to the southwest. Glacial striae at this place strike north 26 degrees west and are cut by a later set, which strikes north 16 degrees west.

Five miles north, on the east side of Brown sound, bodies of coarse pegmatite intrude coarse quartzite, and it is probable that both the Epworth and Kanuyak formations had been completely stripped from at least part of Goulburn peninsula before the Goulburn conglomerates were deposited. The largest pegmatite body is more than 50 feet in width, is about vertical, and strikes south 74 degrees west. The rest of Goulburn peninsula, except the extreme northwest tip which is of amygdaloid, is occupied by quartzite and quartzitic conglomerate, striking south 20 degrees east and dipping at an average angle of 22 degrees to the west, on the east side of the peninsula; the strike swings to the south and south by west around the northern end, with flatter dips. The appearance is of a syncline plunging southwest with the western limb cut off by faulting. The calculated thickness is 4,000 feet, with neither the top nor the bottom exposed. The Goulburn formation is well-bedded, in part cross-bedded, and near the base a conglomerate zone contains numerous fragments of dolomite and purple shales and sandstone. The beds of the formation range from 3 to 60 feet in thickness and are alternately quartzite and quartzitic conglomerate. In exceptional cases the conglomerate layers contain well rounded boulders, up to 8 inches in diameter; but the pebbles as a rule are less than 2 inches in diameter and are of milky or clear quartz. The formation extends inland for several miles at least and apparently forms a syncline plunging towards the southwest. It is thought that the quartzitic strata of Goulburn peninsula and of the valley of Hood river belong to the same series. It is not known if the quartzite outcropping on the south and central portions of Barry island also belong to the same series, but it is thought that this is probably the case, although the formation on Barry island is of thin beds of white or light grey and pink quartzites and not of the thick, massive, grey and pink, in part conglomeratic, beds of the mainland. The presence of numerous rounded fragments of characteristic Goulburn dolomites and of the coloured Kanuyak series, in this conglomerate, makes it definitely younger than the latter.

About one-half mile northeast of the lowest exposure of quartzite on Goulburn peninsula, there is a small island about 500 feet long, and 300 feet across, composed of interbedded grey and pink cherty dolomites of the Epworth formation, which strike south 35 degrees west, and dip 48 degrees southeast, that is, in a direction opposite to the dip of the quartzite. The dolomite shows considerable brecciation and minor fault planes that are nearly vertical and strike about south 70 degrees east. Dolomite on the south side of Kokavingnak island and on the southwest side of Kanuyak island, also dips to the east, while similar strata on the east sides of Kanuyak and Barry islands dip to the west.

The Kanuyak formation occurs on the southeast side of Kokavingnak, where it is represented by 25 feet of purple and buff-coloured sediments, which strike south 10 degrees west and dip 7 degrees northwest. They were not seen in direct contact with the Epworth dolomite nearby. The sediments, examined microscopically, were found to be volcanic ashes and fine tuffs considerably replaced by carbonate. The strata are in part finely conglomeratic and occur in beds from 3 inches to 1 foot thick. Similar strata outcrop at several places along the east side of Kanuyak island and, at a locality about a mile north of the

Narrows, grade downwards into a buff coloured conglomerate, with a groundmass of dolomite and pebbles of quartz, chert, and limestone or dolomite. The conglomerate is about 10 feet thick, and the lower portion contains some large angular fragments of an underlying dolomite, one fragment being 1 foot by 4 inches. The underlying dolomite is correlated with the Epworth dolomite. It has an eroded upper surface, on which lies one to 3 feet of a breccia, composed chiefly of pieces of dolomite. This breccia passes up into the overlying conglomerate already described. All the beds have approximately the same dip and strike.

The beds of tuff and conglomerate are exposed on the western side of Barry island and these also have an eroded upper surface on which lies the Coppermine River series.

On the Cheere islands, sediments are exposed at several places, bordering a sill of diabase. The sediments include light greenish grey, volcanic ash, with occasional beds of limestone apparently replacing volcanic ash. At one place, 20 feet of interbedded light brown, yellow-brown and black shales and sandstones overlie 20 feet of very fine-grained, massive, black, argillaceous or tuffaceous sandstone, which in turn overlies 10 feet of mottled, and brownish shales and sandstones, whose base is not exposed. The average strike of these sediments is about south and they dip easterly at an angle of 12 degrees. It is thought that these beds are part of the Kanuyak formation, to which belong the tuffaceous beds found elsewhere.

Southwestern Victoria Island

During the summer of 1915, D. Jenness, ethnologist of the Expedition, travelled through southwestern Victoria island. The following account presents the results of Mr. Jenness's observations.

The territory explored lies between the coast and a line running northeastward for about 40 miles from Forsyth bay, on the south coast, to lake Tahiryuak and from there west to the bay immediately north of cape Kendall on the west coast. Lake Tahiryuak is about 10 miles in diameter and drains into Prince Albert sound.

Most of the region is occupied by ridges and hills, generally not higher than 800 feet, but rising to a maximum elevation of about 1,500 feet above sea-level. These elevations are east-west ridges, broken through by wind-gaps and often connected by cross-ridges lower than the main ones. Long valleys are enclosed by the ridges and are usually occupied by lakes, which overflow or drain underground into one another. The Colville hills, or mountains as they are called, extend nearly continuously in a wavy line at a distance from the coast of 2 miles at the west end and 15 to 20 miles at the east end, from behind cape Baring on the west coast to beyond the eastern extremity of this area. Ten miles farther east, they merge without apparent break into the Museum range, which is higher and extends from the point of junction both to the north and to the south. The Colville hills average about 20 miles in width and on both the north and south sides merge into a rolling country with a few isolated hills.

The drainage of the area, except towards the east, flows radially from the Colville hills. The south-flowing streams are very rapid, wind in and out among the hills and, in places, have cut gorges in the unconsolidated materials and even into the underlying dolomite. In most places where the dolomite is thus exposed, falls, cascades, or rapids have formed. Away from the immediate vicinity of the rivers, the country is dotted with small lakes which overflow from one to another.

The whole area is mantled by a deep layer of silty mud, which covers even the highest hills and is only cut through on the lower reaches of some of the rivers and, in places, along the sea coast. In some of the valleys sand occurs instead of the mud, but no sand was observed on any of the hills. The mud is brownish and is very sticky and clayey in places, for example, near the lakes, in the Colville hills. No signs of stratification were anywhere observed. The mud contains many fragments and blocks of dolomite as well as occasional boulders of pink granite and diabase. Bivalve shells were found in it at many places up to elevations judged to be about 300 feet above sea-level. No fossils were observed above this elevation though the mud-formation is apparently the same at all altitudes. The fossils collected were determined by Dr. Dall to be marine species of Pleistocene age, and he considers the formation to be equivalent to the Gubik sand of northern Alaska.

Within 7 miles of the coast, ridges of Silurian dolomite cross some of the river-beds, the water flowing over sharp cliff faces. The Kugaluk river, 4 miles from its mouth in Penny bay on the southwest coast, flows through a gorge 50 to 100 yards wide and 300 yards long. The walls of the gorge, to a height of 40 feet, are of dolomite striking southeast. The dolomite is overlain by the Pleistocene silty mud, from which fossils were obtained on the east bank of the river, a quarter-mile south of the gorge. No fossils were seen in the dolomite. Pyrites occur in the bed of the river below the gorge, and are collected by the Eskimos for use in lighting fires in the absence of flint and steel.

CHAPTER IV

DEPOSITS OF NATIVE COPPER IN ARCTIC CANADA

Previous Accounts[1]

The only copper-bearing rocks along the Arctic coast, from cape Parry to Kent peninsula, occur in Bathurst inlet and are part of the Coppermine River series. Formations which are probably equivalent to part of the Coppermine River series occur in the western portion of the area, from Darnley bay to Buchanan river and in the central part of the area, from cape Kendall to Gray bay, also on the islands in Coronation gulf, and along the middle part of the south shore of Victoria island; no amygdaloids occur at these places and no native copper has been found there.

There is considerable indefiniteness as to the country traversed by Richard Norton in 1717, northwest of Hudson bay; but, possibly, he was the first white man to reach the copper-bearing area of northern Canada. Samuel Hearne was sent, in 1769 by the Hudson Bay Company, from Fort Churchill, to find the copper mine which Indians had reported to exist. After three attempts and great hardships, he reached the Coppermine river on July 17th, 1771. His report is very vague, owing to his lack of knowledge of mines or minerals.

In 1821 Captain (afterward Sir John) Franklin, fully equipped by the British Government for scientific work, and accompanied by Richardson, Back and Hood, descended the Coppermine river and surveyed the coast eastward to point Turnagain. They observed native copper-float along the Coppermine river and Richardson noted the striking similarity of the rocks to those of the Keweenawan formation in Michigan. They also reported the occurrence of native copper in basalts on Barry island, Bathurst inlet.

In 1825-26 Franklin again wintered in the north, at Fort Franklin, on Great Bear lake. In the spring, Franklin and Back surveyed the coast west of the Mackenzie river, while Richardson and Kendall went east to the mouth of the Coppermine to join up the former survey.

In 1838 and 1839 Peter Warren Dease and Thomas Simpson, of the Hudson's Bay Company, wintered at Fort Confidence on Great Bear lake, and in the spring descended the Coppermine river and followed the coast eastward. They also, noted the occurrence of native copper on Coppermine river and on Barry island in Bathurst inlet and reported the presence of red sandstone on Victoria island about cape Colborne, north of Kent peninsula.

At a later date came those expeditions known collectively as the Franklin Search Expeditions. On these Richardson, accompanied by Rae, searched the Coppermine river region in 1849. Rae continued the search and, in 1851, mapped a considerable portion of the Victoria Island coast. In 1852, Collinson sailed between Victoria island and the mainland and wintered in Cambridge bay.

More recently, David T. Hanbury made the trip overland from Baker lake at the head of Chesterfield inlet to the Arctic coast east of Kent peninsula, followed the coast westward to Coppermine river and, in 1902, ascended the river on his way back by Great Bear lake and Mackenzie river. He reported native copper in the basalts on many of the islands in Bathurst inlet and saw float-copper along the Coppermine river.

[1]For a good historical account the reader is referred to a paper by J. B. Tyrrell, entitled "The Coppermine Country," published in the Trans. of the Can. Min. Inst., 1912.

Roald Amundsen sailed through Coronation gulf in 1905 but saw no people. Capt. Charles Klengenberg spent the winter of 1905 and 1906 on Victoria island and saw many Eskimos. His report of the Eskimos led Vilhjalmur Stefansson to undertake an expedition to this region. In the spring of 1910 Stefansson travelled eastward from his winter quarters at Langton bay and met Eskimos near cape Bexley in Dolphin and Union straits. He spent some time among them then and obtained information regarding the occurrence of copper on Victoria island.

Capt. Joseph F. Bernard in the summer of 1910 entered Coronation gulf with his trading schooner Teddy Bear and wintered about 20 miles east of Coppermine river. In 1911 he went west to Baillie island, but returned in 1912 and wintered in a small harbour in Dolphin and Union strait. The southern party of the Canadian Arctic Expedition used this harbour for a permanent headquarters from 1914 to 1916 and gave it the name, Bernard harbour.

In 1911-12, George M. Douglas, Lionel Douglas and August Sandberg, a Swedish chemist and geologist, visited the Coppermine river. Dr. Sandberg has furnished the latest and most complete account of the strata and copper-bearing rocks along the west side of the river.

In 1912, two travellers, Harry V. Radford and George R. Street came to Bathurst inlet from the east. Both were there killed by Eskimos. In 1913, two French priests, Rouvier and Le Roux, O.M.I., who had been working among the Indians of Great Bear lake, made a trip down Coppermine river to the coast to visit the Eskimos and they, also, were killed on their return trip.

The southern party of the Canadian Arctic Expedition spent from August, 1914, to July, 1916, in this general region and were followed by several traders and trappers, including the Hudson's Bay Company, which, in 1916, established a post at Bernard harbour, now the site of an Anglican mission and a post of the Royal Canadian Mounted Police.[1]

Thus, for about two hundred years, it has been known that native copper exists in the vicinity of the coast of Arctic Canada.[2] Samuel Hearne, when, in 1771, he reached the Coppermine river, was perhaps the first white man to actually visit any of the deposits. Franklin, in 1821, found native copper along Coppermine river and on the Barry islands of Bathurst inlet. Richardson, Rae, Dease and Simpson and Hanbury, all have confirmed Franklin, but none of these explorers, with the exception of Richardson, had sufficient training to enable him to interpret correctly what he saw of the copper occurrences. Most of the reports were exceedingly optimistic as to the amount and grade of copper ore to be found.

Sir James Ross,[3] in 1835, found copper ore on Agnew river on the east side of Boothia peninsula. According to De Rance[4] large masses of native copper are picked up by the Eskimos on the shores of Princess Royal island, in Prince of Wales strait, northwest of Victoria island, and on the shores of Prince of Wales island northwest of Boothia peninsula. The copper found on Princess Royal island may have been carried there by the continental glaciers, but the copper on Prince of Wales island is not so easily accounted for and may occur not far from its original source.

Copper in large masses is said to occur on Victoria island about 40 miles northeast of the head of Prince Albert sound on the west coast of the island. This occurrence was reported to Mr. Stefansson by some Eskimos in 1910. In 1915, many Eskimos testified to the Canadian Arctic Expedition concerning the same occurrence. They produced some of the copper and said that masses much larger than a man protrude from the hillside, but whether the copper occurs in solid rock or in drift could not be determined from the accounts given.

[1]Trading posts have since been established at Tree river (1917), Kent peninsula (1918), Ellice river (1923), and Prince Albert sound (1923).

[2]The various districts where copper has been reported to occur, are indicated on figure ..

[3]Narrative of Second Voyage in Search of a Northwest Passage, by Sir James Ross, 1835.

[4]De Rance, Nature, vol. XI, p. 492.

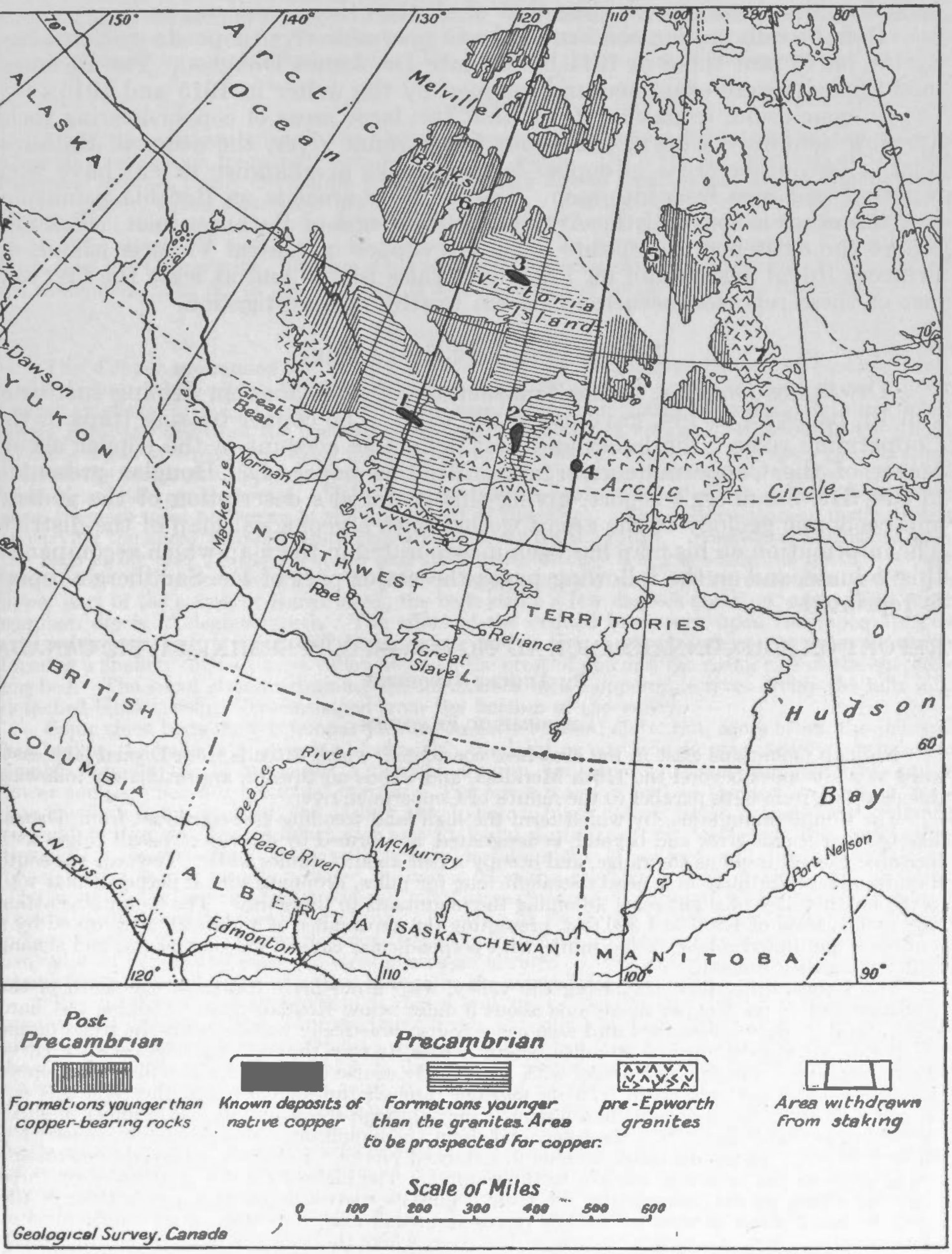

Figure 4. Diagram showing the geology of central arctic Canada, and the known deposits of native copper

In 1917, a patrol of the Royal North West Mounted Police reported finding native copper *in situ*, about 60 miles east of Bathurst inlet. The information regarding this occurrence is, like that of all the others, very vague.

Definite information concerning the Coppermine river deposits was obtained by the party sent there in 1911 by the late Dr. James Douglas. The Bathurst inlet deposits were examined and mapped by the writer in 1915 and 1916.

In conclusion, it may be stated that two large areas of copper-bearing rocks are now definitely known, one about Coppermine river, the other in Bathurst inlet. Two other areas of copper-bearing rocks of unknown extent have been reported and seen by white men. One of these areas is on Boothia peninsula, and the other is south of the Arctic coast and east of Bathurst inlet. Eskimos report the existence of deposits of native copper in central Victoria island, on Princess Royal island, and on Prince of Wales island, and at least the first and last of these reported occurrences seem worthy of investigation.

The Coppermine River Area

Dr. James Douglas, in the Transactions of the Canadian Mining Institute, vol. 16, pages 83 to 144, gave under the title, "The copper bearing traps of the Coppermine river," the latest and best, available account of the copper occurrences of the Coppermine river area. In this paper, Dr. Douglas presented in full, Dr. Sandberg's report, giving this geologist's description of the general and economic geology of the area together with a geological map of the district. The information on his map has been incorporated in the map which accompanies this volume, and on the following pages the major part of Dr. Sandberg's report is reprinted.

REPORT ON A RECONNAISSANCE ALONG LOWER COPPERMINE RIVER, CANADA

By August Sandberg

Topographic Features

No high mountains exist in the area here considered, which extends from Dismal lake eastward to a few miles beyond the 116th Meridian, and trends northward, approximately following this meridian from 67th parallel to the mouth of Coppermine river.

The Copper mountains, by which term the high land trending east-southeast from Dismal lake to Coppermine river and beyond, is designated, are formed by a series of basalt ridges with the same general trend as the range, and occupy a belt about 15 miles wide. Towards the south they terminate abruptly in a nearly straight line, for miles, dropping with a perpendicular wall to the broad valley of slight relief adjoining the mountains to the south. The mountains attain only an elevation of 1,200 to 1,500 feet, presenting the appearance of a plateau, interrupted by a number of mutilated ridges, facing south, with perpendicular cliffs of varying height, and sloping gently towards the north.

The Coppermine river, traversing the valley, with a northerly course to the south of the mountain, enters the Copper mountains about 5 miles below Kendall river. Striking the hard basaltic rock it curves eastward and assumes a course practically parallel with the trend of the basalt ridges for a distance of 20 miles before it cuts its way through the ridges with a curve toward northwest and finally emerges with a northerly course on the plain to which the Copper mountains slope towards north. In its passage through the double curve the river has cut deep, and in some places has made a narrow valley through the mountain. A number of small creeks flow at right angles into the river, and drain the mountains through narrow, constricted gulches, in many places dividing the hills in detached blocks. From the valley the mountains rise by steps in the nature of terraces to the summit. The highest altitude is attained by three adjoining peaks, at the point where the river begins its eastward course. The bottom of the valley in many places is occupied by low ridges and small hills, consisting of clay and gravel of glacial origin. On the northwest course of the river, where the valley is quite broad, these clay and gravel deposits extend about a mile from the river on the south shore, forming a typical miniature glacial landscape. A good growth of spruce is sustained on this soil, especially along the north shore of the east course and on both sides of the northwest course of the river.

To the north of Copper mountains the country presents the character of a plain with slight relief, traversed with narrow basalt ridges of the same general trend as the copper mountains. Only the first and last of these ridges attain an elevation of about 400 feet. Through this plain the river has cut a channel about 100 feet deep with perpendicular sides of sandstone, alternating, in some places with shelving clay banks. Where the river cuts through the basalt ridges the channel becomes tortuous and constricted to about 50 yards or less from its average width of about 300 yards.

Geological Sketch

The results of our observations regarding the distributions of the geological formations are represented on the accompanying geological map. In making the map the observations of latitude and longitude made by Franklin have been used. All locations represented on the map have been made by compass and pacing. The magnetic declina tion is 48 degrees east.

Limestone

Along the southern edge of the Copper mountains, limestone froms part of the cliffs in which the mountains frequently terminate toward south. On a freshly fractured surface the limestone shows a highly crystalline texture, generally fine to medium grained, of impure white or grey colour, which sometimes has a reddish tinge. Farther south, between the mountains and Kendall river, the in part precipitous west shore of Coppermine river is composed of limestone cliffs about 100 feet high. At the exposure in the gorge, through which Kendall river flows into the Coppermine, the limestone beds are interleaved with thin strata of fine grained red sandstone. The dip of the limestone is flat, towards the north, under the mountains.

Coppermine Series

The Copper mountains are composed of a series of superimposed flows of basaltic lava, which occupy a belt about 16 miles wide in a direction at right angles to their strike. Their lateral extension is large, probably reaching east more than 200 miles across Bathurst inlet, where Hanbury describes the occurrence of basalt with native copper.[1] Westward, and about 40 miles north of Great Bear lake, there is said to exist basalt, exhibiting the same general character as the basalt at Coppermine river. Interstratified with the basalt are a number of detrital beds of reddish conglomerate. These occupy various horizons, but as far as our observation goes, they are most numerous in the upper part of the series. The basalt occurs in distinct beds of varying thickness, striking approximately parallel with the range. Westward, at Dismal lake, the beds strike east 22 degrees south and show a dip of only 8 degrees towards north. At the great bend of Coppermine river, the strike is approximately east 12 degrees south and in the upper part of the series, at Burnt creek, the beds strike a few degrees north of east. The most common dip is 12 degrees north. The effect of the bedded basic rock upon the topography is everywhere marked; a steep cliff facing south and a long backward slope towards the north forming a shallow drift-covered valley between the crest of one and the rising cliff of the succeeding bed. The small streams draining the mountains into Coppermine river divide the hills into detached blocks, rising terrace-shaped from the bottom of the valley.

Some thick beds show columnar jointing in their exposed cliffs, but, more often, the jointing has broken the beds into irregular blocks with the jointing surfaces dipping steeply towards the north. Usually the beds present a twofold division, an upper narrower amygdaloidal, and a lower compact non-amygdaloidal portion. The lower massive part of the bed is dense, crystalline, medium to fine-grained, and of dark grey to nearly black colour, which in some places change to reddish brown. The compact and amygdaloidal portions of the bed grade into each other through an intermediary zone, with scanty development of amygdules. The amygdaloidal phase of the flow is usually covered by debris from the crumbling cliffs and by drift material. The slope of the bed is always covered with grass-grown soil, through which little mounds of broken amygdaloid frequently stick up. In some of these the pieces show worn edges, while others contain pieces only with sharp edges and corners, indicating their connection with an amygdaloid bed at the place which is otherwise covered. Frequently these broken amygdaloid pieces contain small chips of native copper in the amygdules.

The matrix of the amygdaloid is dense and shows usually signs of alteration in various stages of progression from comparatively fresh to completely altered to epidote. In some places the alteration has proceeded to such an extent that only a crumbling mass remains with harder portions of epidote. Such is the case at Burnt creek where an amygdaloid of this character was found, containing chips and flakes of native copper in the altered rock, and at Copper creek, where an amygdaloid outcrops, which shows prominently as a reddish mass with intermixed epidote. Some native copper was found in this bed also. The amygdules are filled with calcite, zeolites, epidote, chlorite, quartz, a red mineral which probably is secondary orthoclase, and native copper, one or more of these minerals filling the cavity. The amygdules show some variation in size and form. They are usually small, although amygdules measuring more than 6 inches were observed in one place. At north shore of Dismal lake an amygdaloid with elongated compressed amygdules, suggesting a viscous flow, occurs.

In places, small fissures penetrate the beds, forming sometimes a network of small seams, traversing the shattered rock. They are filled principally with calcite, sometimes containing chalcocite. Fissures of this kind were observed striking nearly north-south and east-west. The conglomerate beds, which occur interstratified with the basalt beds, consist of pebbles of basic rock, pebbles with amygdaloidal development predominating. The matrix is apparently of the same material and is frequently permeated by calcite.

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[1]The strata do not, as Dr. Sandberg thought, extend eastward to connect with the area of similar rocks about Bathurst inlet; but, somewhere, less than 75 miles to the east of Coppermine river, terminate against a great area of Precambrian granitic rocks.

To the north of Copper mountain, a sandy shale overlies the basalt bed and is succeeded by fine to medium-grained sandstone, which continues north to the Bloody fall, a distance of about 30 miles. Both shale and sandstone are of dark red to brown colour. The sandstone consists of grains of quartz and feldspar, with a highly ferruginous matrix. The feldspar grains, which are smaller than the quartz grains, predominate. These sandstones are similar to the sandstônes in the "Nonesuch" group of the Keweenaw series. The deposition of the sandstone was interrupted at four different times by the eruption of basalt, which flowed over the floor and became interbedded in the sandstone. None of these flows attained more than a few hundred feet thickness. The rock shows a somewhat coarser crystalline texture than the basalt at Copper mountains and the amygdaloidal phase of the flow is either scantily developed or non-existent. Between the last two basalt ridges occur thin strata of a greenish gray slate, interbedded with the sandstone. Judging from their appearance, the islands in Coronation gulf beyond the mouth of Coppermine river and the capes on the west shore of the gulf are composed of basalt ridges.

Dykes

At the foot of Sandstone rapids a dyke, striking south 17 degrees east, crosses the river. The dyke, which stands perpendicular, measures 100 feet and consists of plagioclase feldspar and a ferro-magnesian mineral. It is possibly the source of the magma which formed the flows that are interbedded in the sandstone. The dyke shows cross-columnar jointing. The centre part is coarsely crystalline, gradually becoming finer in grain to glassy at the contact with the sandstone. The dyke-rock shows some copper-stain at the contact with the sandstone. The sandstone has been changed on both sides of the dyke, from the baking of the hot magma. The red colour is changed to grey. The comparatively soft sandstone has become hard and fissile at the contact with the dyke. The change is visible, gradually diminishing, to 150 feet from the contact, No data regarding the age of the Coppermine series were obtained. Petrographically they show great similarity to the Keweenawan series at Keweenaw Point.

Glacial Deposit and Glaciation

In the Copper mountains, evidence of ice action is everywhere present, in the form of bedrock scorings on the crests of the basalt ridges, which have been rounded off and polished. Occasionally a cliff shows scorings, indicating ice movement along the cliff. Glacial drift is to be seen all over the mountains. In the valley the lower bench and bedrock topography is in some places concealed by small terminal moraines and tillsheets, in no place reaching far up on the hillside. Most in evidence are the glacial deposits in the small basin around Tepee and Larrigan creeks and along the south shore of the Coppermine river on its northwest course through the mountains. The sandstone is covered by a thin sheet of till.

On the south side of the basalt ridge at Bloody fall, several hills of greyish white stratified clay lie against the basalt cliffs on both sides of the river. These hills, which are about 300 feet high, have very steep sides, intersected by ravines, and present a very striking appearance.

Copper Occurrences

It has long been known that copper in the native state existed in the northern part of Canada. It furnished the source of supply for the weapons and utensils of copper used by the Indians before they were supplied with iron from trading posts.

As early as 1771, Samuel Hearne on his journey to the Northern Sea established the fact that the Indians got their supply of copper from the Copper mountains. He describes the "mine" he visited as situated about 30 miles south-southeast from the mouth of Coppermine river. That would be in the upper part of the series of basalt beds constituting the Copper mountains, and would correspond to the eastward prolongation of the amygdaloid beds, which outcrop in the hill on the north side of Burnt creek.

Later, in 1821, the Copper mountains were visited by Sir John Franklin and Sir John Richardson. Their investigations were made on the north side of the big bend of Coppermine river around Stony, Glance and Big creeks. They found many evidences of native copper, but as Richardson states they "did not observe the vein in its original repository, nor does it appear that the Indians have found it." Recently, Hanbury observed the occurrence of native copper in basalt on the islands in Coronation gulf at Bathurst inlet. These islands are probably the eastward continuation of the Copper mountains.[1] Even to-day the Coronation Gulf Eskimos, or at least some of them, come to the Copper mountains for their supply of copper. These people do not possess tools for working rock and are restricted to digging in loose rock for pieces of copper, liberated through weathering and decomposition of the rock.

Judging from specimens in possession of Eskimos we met, the pieces usually found are comparatively small, although they occasionally find pieces large enough to beat out knives about 8 inches long and about 3 inches wide. In our search we did not find any large slabs of native copper. But in many places we observed small chips or flakes of native copper in the broken pieces of amygdaloid which forms small heaps in the flat soil-covered valleys on the

[1]The strata do not, as Dr. Sandberg thought, extend eastward to connect with the area of similar rocks about Bathurst Inlet; but, somewhere, less than 75 miles to the east of Coppermine river, terminate against a great area of Precambrian granitic rocks.

back slope of the ridges. Usually more or less of a green copper-stain indicates the presence of native copper. In two locations or horizons we found native copper in place in amygdaloid beds, viz., at the head of Copper creek and in the hill on the north side of Burnt creek.

At Copper creek, on the east side, well up on the hillside, an amygdaloid, showing an exposure of about 30 feet thickness, outcrops. The amygdaloid is much altered, presenting a reddish appearance, which is noticeable at a distance. Kidneys or irregular masses of epidote occur in the bed. The altered rock shows a copper stain on the outside, and, although not abundant, small chips of native copper were found in this amygdaloid. It is, however, common that the broken rock shows copper-stained amygdules. The dense, lower non-amygdaloidal portion contains tiny specks or shots of native copper. A short distance below this bed lies a conglom erate but no copper was observed in it. The most favourable locality for native copper, so far as our observation went, is at the north side of Burnt creek.

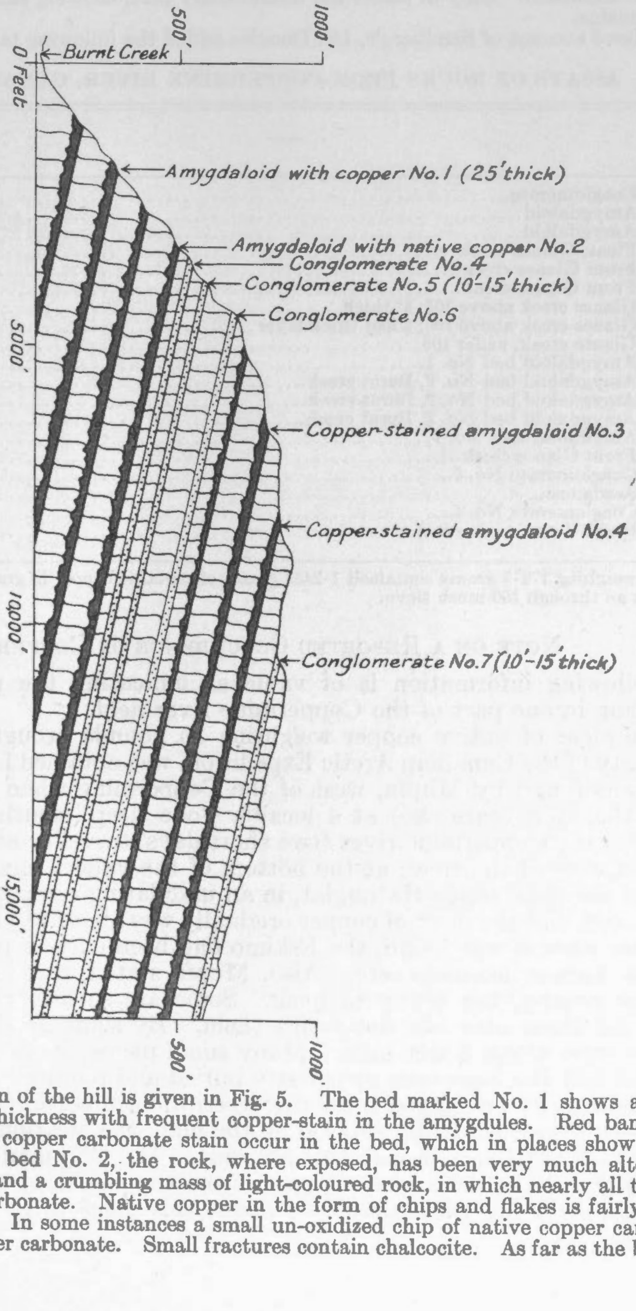

Figure 5. Section across hill of copper-bearing rocks at Burnt creek, west side of Coppermine river (after James Douglas).

A cross-section of the hill is given in Fig. 5. The bed marked No. 1 shows an exposure of about 25 feet in thickness with frequent copper-stain in the amygdules. Red bands of a much altered rock with copper carbonate stain occur in the bed, which in places show cleavage like stratification. In bed No. 2, the rock, where exposed, has been very much altered, in some places to epidote and a crumbling mass of light-coloured rock, in which nearly all the amygdules contain copper carbonate. Native copper in the form of chips and flakes is fairly abundant in this altered rock. In some instances a small un-oxidized chip of native copper can be observed enveloped in copper carbonate. Small fractures contain chalcocite. As far as the bed is exposed i' shows a depth of about 26 feet. Above this amygdaloid lie three conglomerate beds. Of these the two marked No. 5 and No. 7 show a thickness of 10 to 15 feet and contain some native copper in the amygdaloid pebbles. The bed marked No. 6 shows an exposure indicating a depth of 4 feet. The two amygdaloid beds marked No. 3 and No. 4, lying higher up, both show frequent copper stain, but no native copper was observed in them.

At Glance creek about a mile from its mouth, occurs what appears like a breccia but probably is the filling of a crack. It consists of altered basic rock, cemented together with quartz, calcite and chalcocite. It outcrops irregularly in the bottom of the creek and on the east bank of the creek, where in places the adjoining rock looks like sandstone, stained with copper carbonate. No native copper was found here, except as tiny shots in the hard basalt, a few hundred paces to the east. Similarly, at the mouth of Stony creek, the hard basalt shows native copper. Here, the amygdaloid phase of the flow has been eroded away and is covered by drift where it dips under the mountain. Only in places the intermediary part, showing scant development of amygdules remains.

To the above account of Sandberg's, Dr. Douglas added the following table of assays:—

ASSAYS OF ROCKS FROM COPPERMINE RIVER, CANADA

Specimen No.	—	Per Cent. Cu.
100	Conglomerate	0·09
102	Amygdaloid	·05
3	Amygdaloid	·12
10	Float, Glance creek	43·39
11	From Glance creek	1·78
13	From Glance creek	·86
106	Glance creek above 105; 4" thick	·44
107	Glance creek above 106; 3 feet thick layer	·15
108	Glance creek, under 105	·09
139 (c)	Amygdaloid bed No. 1	1·85
140 (a)	Amygdaloid bed No. 2, Burnt creek	·08
140 (b)	Amygdaloid bed No. 2, Burnt creek	·07
140 (c)	Amygdaloid bed No. 2, Burnt creek	7·77[1]
144	Amydaloid Bed No. 1	·19
105	From Glance creek	·008
143	Conglomerate No. 5	·084
130	Sandstone	·002
142	Conglomerate No. 4	0·16
149	Basalt (cont. native cu.)	·069

[1]A sample weighing 179·3 grams contained 1·2432 grams of metallic copper in grains of such size that they would not go through 100-mesh sieve.

Note on a Reported Occurrence of Copper

The following information is of value as indicating the possible copper values existing in one part of the Coppermine river field.

A large piece of native copper weighting 35 pounds brought back by the southern party of the Canadian Arctic Expedition, was obtained from an Eskimo. This piece was found by Mupfa, west of the Coppermine when he was a small boy (more than ten years ago) at a locality "one sleep" southwestward from Bloody fall on the Coppermine river (two short days' travel or about 20 miles). It was found west of the trees, at the bottom of the valley, immediately below and south of the peak called Hatungiat, in an undulating country.

Mupfa said that the piece of copper originally was about 2½ feet in diameter and that ever since it was found, the Eskimo had been cutting pieces from it to make spears, knives, ice-picks, etc. Also, Mupfa stated, many large pieces of copper occur nearby, too heavy to pack. Some are so heavy that it is just possible to roll them over but not to lift them. By signs he showed that the larger pieces were about 3 feet high. Many small pieces, it was said, stick out of the ground but the large ones are mostly buried and require to be dug out.

As near as could be judged from the description of several men, and from the location they independently showed on the map, the location of this deposit is in Lat. 67° 30′ north, and Long. 116° 30′ west. Mr. Chipman states that the Eskimo who in 1916 accompanied his party from the mouth of the Coppermine towards Great Bear lake, left the party about this place to go west to search for copper.

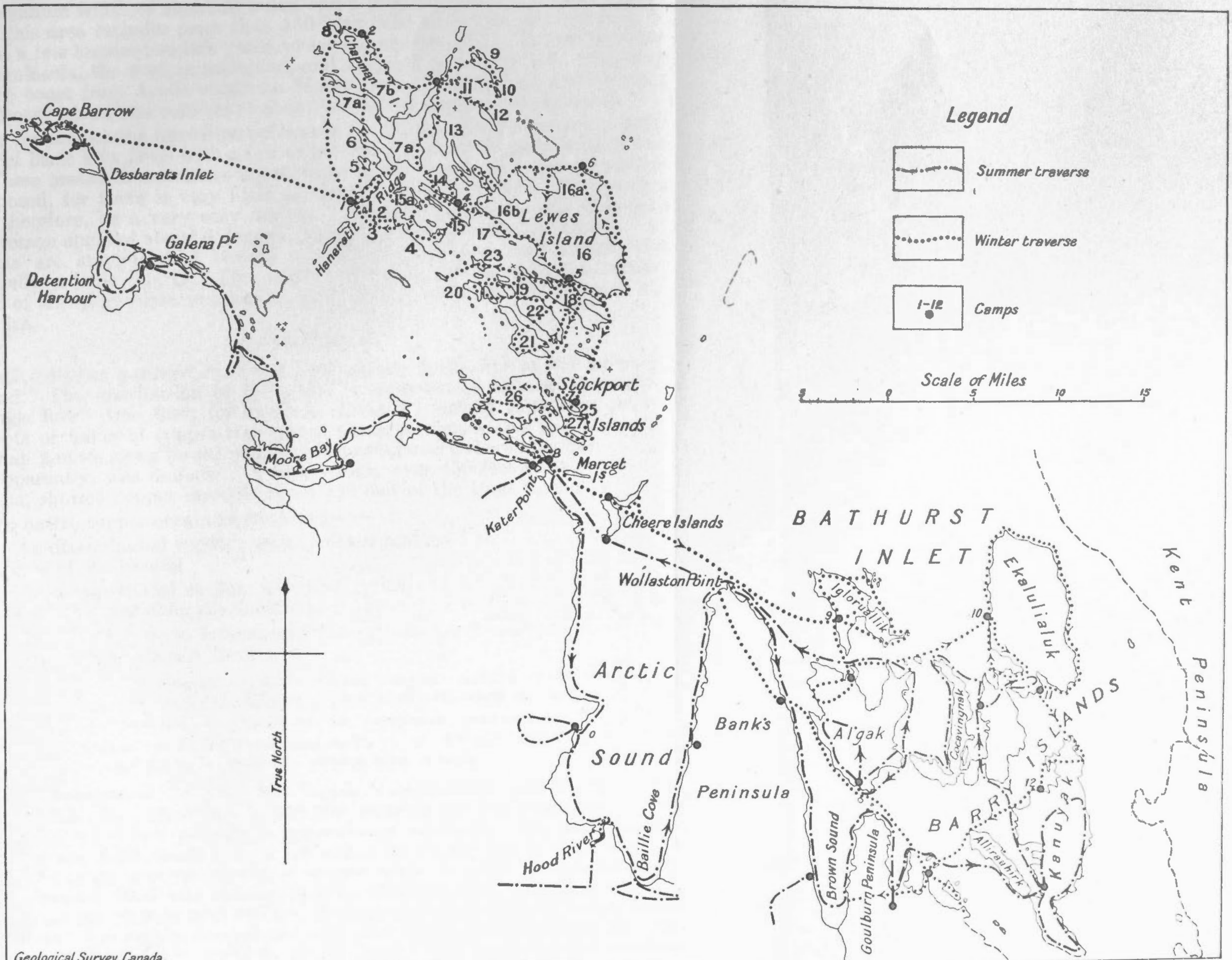

Figure 6. Map of islands in Bathurst inlet showing traverses made in examination of copper-bearing formation. The unnamed islands or parts of larger islands numbered 1 to 28 correspond to the numbers used in the tables in the report. The slightly smaller italic numbers accompanying the large black dots are numbers of Camps.

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Bathurst Inlet Area

GENERAL DESCRIPTION OF THE DEPOSITS

The copper-bearing rocks in Bathurst inlet apparently occupy an area separate from the Coppermine river area. The portion of the Bathurst inlet area examined is oval-shaped, extends about 50 miles northwest-southeast, and has a maximum width of about 25 miles, and a total area of about 1,000 square miles. This area includes more than 150 islands in Bathurst inlet, ranging in size from a few hundred square yards to several square miles. It also includes Banks peninsula, the western mainland, and a strip 5 or 6 miles wide extending along the coast from Arctic sound to Moore bay. The thickest section seen was on Barry island and consists of about 950 feet of basaltic amygdaloids.

The copper-bearing formation belongs to the Coppermine River series, and is a series of basic lava flows with a few thin beds of tuffaceous conglomerate and ash. These measures are the youngest rocks in the region, and are everywhere well exposed, for there is very little overburden of soil or drift. Prospecting would, therefore, be a very easy matter. The beds dip in various directions at an average angle of about 6 degrees, forming a shallow basin, or basins. All the lavas are amygdaloidal basalts containing plagioclase and augite with occasionally a little quartz. The only variations noted were in the relative amount of the plagioclase and augite, and in the nature of the filling of the amygdules.

Native Copper

Native copper was seen on almost every island in the area as well as on the mainland. The distribution of the metal is remarkably uniform throughout any single flow. One flow, for instance, about 75 feet in thickness, showed tiny shots or flakes of copper throughout the groundmass and was traced for more than 2 miles along Banks peninsula, showing everywhere a copper content that, apparently, was uniform. A rock section over 450 feet thick, on Banks peninsula, showed copper through about 350 feet of the total thickness.

The native copper occurs in three forms:—

(1) As disseminated copper; minute flakes scattered throughout the dense groundmass of the basalts.

(2) As amygdaloidal copper; irregular grains and small masses filling, or partly filling the branching gas-cavities near the surface of the basalt flows.

(3) As vein copper; in fissures and shatter-planes not confined to any particular horizon in the basalt flows.

(1) *Disseminated Copper.*—Disseminated copper occurs over the whole area of more than 1,000 square miles and practically through the whole exposed thickness of the formation. Analyses of forty-five representative samples show that the values range between $^1/_{100}$ and $\frac{1}{4}$ of one per cent. The copper is in the form of tiny flakes, commonly visible with a lens.

(2) *Amygdaloidal Copper.*—The highly amygdaloidal portion of a flow occurs near the top, where imprisoned and escaping gas left numerous cavities which permitted a free passage to mineralizing solutions. The amygdaloidal portions of the flows, range from a few inches to several feet in thickness and, in places, contain several percent of copper while in other places the amygdules are entirely filled with chlorite, epidote, prehnite, opal, agate, etc. Where a flow forms the present land surface, the amygdaloidal material, being rather easily eroded, has usually disappeared and, as a result, broad surfaces are composed of the dense lower portions of the flows. The amygdaloidal portions are commonly exposed only along cliffs, which, however, are in many places screened by talus. Under these conditions it was not possible, when merely conducting a reconnaissance, to judge of the relative extent and importance of the amygdaloidal copper.

(3) *Vein Copper.*—Copper occurring in veins is important in some areas where the basalts have been considerably shattered and are now traversed by a network of thin fissures, occupied by plates of native copper or by vein material containing a small amount of native copper. Vein copper occurs along the west side of Banks peninsula, on the west side of Kanuyak island, and on the many small islands between the Stockport islands and Lewes or Wilmot island.

The profitable development of the native copper ores of Bathurst inlet depends on the finding of amygdaloidal copper, or vein copper, or a combination of these two classes of ore, sufficiently developed to furnish a large tonnage of payable ore. There is little or no prospect of the disseminated copper ore of itself forming a deposit of economic importance; but, under certain conditions, richer portions of the disseminated ore might be profitably treated in conjunction with ores of the other types.

Sulphides of Copper

In addition to native copper, sulphides of copper occur in the district and appear to be worthy of investigation. The possibility should not be forgotten, that, in the Coppermine River region, important deposits of sulphides may also occur in the limestones or dolomites, which are there found below the amygdaloids. In Bathurst inlet, in the south and western portions of the region at least, a series of dolomites immediately underlies the copper-bearing basalts. The dolomites are exposed at several places in cliffs about the border of the area, and at three different localities, a few miles apart, sulphides of copper partly replace the dolomite for several feet below the contact with the overlying basalt. Some of the thin dolomite layers are completely replaced for several feet along the strike and others have masses of the sulphides scattered through them. The determination of the sulphide content with reasonable degree of accuracy would at least involve drilling. The sulphides of one layer, 6 inches in thickness, were examined by H. V. Ellsworth, and determined to be a mixture of 79 per cent chalcocite and 21 per cent covellite; and on analysis the material proved to contain 49·87 per cent copper.

Besides the sulphides which replace the dolomites, there is a considerable amount of chalcopyrite and some chalcocite, disseminated through some of the large sills or dykes of diabase which traverse the region. A grab-sample of one such occurrence, on a small island just northeast of Algak, was found by analysis to contain 1·18 per cent of copper. Similar sulphide occurrences are displayed all along the ridge of diabase passing through Hanerotit island about 16 miles eastward of cape Barrow, and in other places.

General Estimate

The area of rock carrying values in native copper, neglecting those parts of the mainland where sufficient information was not obtained, is roughly estimated to be about 60 square miles. Of this more than 10 square miles occurs on Banks peninsula, the remainder being represented by the islands. Assuming that one cubic yard of rock weighs 1 ton and that 90 feet is the average thickness of copper-bearing rock, the available tonnage would be about 6,000,000,000 tons carrying $^1/_{100}$ to $\frac{1}{4}$ of one per cent of disseminated native copper; and an unestimated amount of amygdaloidal material, which assays over one per cent of copper; as well as the copper of the veins, some of which are filled with thin sheets of native copper and others carry over $4\frac{1}{2}$ per cent of flake copper.

Assay Values of Copper-bearing Specimens

The results of a number of assays of copper-bearing specimens from Bathurst inlet are tabulated below. Forty-five assays of the dense part of the amygdaloids were made by M. F. Connor of the Mines Branch, Department of Mines, who reports his results as follows:—

Each separate sample was prepared for analysis as follows:—

After preliminary crushing, it was finely ground in a porcelain ballmill. As much as possible of the resulting powder was passed through a 100-mesh sieve, the portion so passing being designated "fines." The very small quantities remaining on the screen, which contained any flakes of metallic copper, are here called "scales."

The "fines" and "scales" were separately analyzed, and the results so obtained are shown both separately, and conjointly, below.

No. of Spec.	Wt. of Spec. in grammes	Copper, per cent		Total, per cent
		Fines	Scales	
217	380	0·028	0·00	0·028
221a	110	0·052	0·016	0·068
222	185	0·03	x	0·03
231	369	0·028	0·006	0·034
233	242	0·06	x	0·06
239	149	0·035	x	0·035
245	214	0·036	0·001	0·037
249	148	0·034	x	0·034
252	81	0·021	x	0·021
255	368	0·032	x	0·032
257	227	0·076	x	0·076
263	382	0·01	0·01	0·02
266	239	0·012	x	0·012
269	410	0·10	0·03	0·13
287a	84	0·07	0·005	0·075
288	161	0·006	x	0·006
301	253	0·135	0·015	0·15
302	268	0·036	x	0·036
303	393	0·066	0·015	0·081
308	398	0·028	0·025	0·053
309	284	0·034	0·002	0·036
320	387	0·10	x	0·10
329	154	0·042	x	0·042
340	150	0·08	x	0·08
350	200	0·082	x	0·082
355	178	0·036	x	0·036
360	520	0·19	0·005	0·195
371	320	0·09	0·005	0·095
379	272	0·235	0·05	0·24
389	563	0·032	0·005	0·037
393	268	0·11	x	0·11
395	118	0·042	x	0·042
398	166	0·059	0·001	0·060
436	338	0·045	0·003	0·048
453	165	0·055	x	0·055
455	344	0·025	x	0·025
458	250	0·01	0·00	0·01
460	177	0·014	x	0·014
462	344	0·184	x	0·018
465	169	0·025	x	0·025
466	332	0·06	lost	0·06
469	475	0·121	0·003	0·124
473	251	0·032	0·005	0·037
474	420	0·06	0·007	0·067
476	246	0·215	0·02	0·235

x Quantity less than 0·001 per cent.

A composite sample made up of equal weights taken from each of the 45 samples was assayed for gold with the result that that metal was found to be absent.

Four specimens were assayed by H. A. Leverin, of the Mines Branch, Department of Mines, who reports as follows:—

The results of the analysis of the several specimens were as follows:—

No. 180. Amygdaloidal basalt carrying a small quantity of native copper.

Total weight of sample.................................430·2 grammes.

(weight of copper scales included in the above 6·18 grammes).

It was found on analysis to contain:

Copper...1·44 p.c.

Silver...at the rate of 0·05 of an ounce Troy, to the ton of 2,000 lbs.

No. 184. Copper sulphide ore—designated by the sender as "a replacement of dolomite by sulphide of copper."

Weight of sample......................................193 grammes.
It contained:
Copper......................................49·87 p.c.
Silver......................................at the rate of 1·12 ounces, Troy, per ton of 2,000 lbs.

No. 192. "Sill of diabase impregnated with chalcopyrite."
Weight of sample......................................786·9 grammes.
It contained:
Copper......................................1·18 p.c.

No. 327. "Vein material carrying native copper."
Weight of sample......................................112·5 grammes.
(Weight of copper scales included in above 4·88 grammes).
It was found to contain:
Copper......................................4·56 p.c.

Origin of the Copper Deposits

Although a considerable proportion of the copper is epigenetic, that is, was deposited later than the rocks which now contain it, there are certain features which suggest a syngenetic origin for some of the copper, that is, seem to show that the copper was present in the rock at the time of its consolidation. The points which have a bearing on the origin of the copper are grouped below according as they favour a syngenetic or an epigenetic origin.

Facts Favouring a Syngenetic Origin

1. The apparently uniform distribution of native copper in individual flows of lava of large extent, and the occurrence of such flows throughout so extensive a district.

2. The copper is abundant in some flows and apparently absent from others.

3. The copper occurs minutely disseminated throughout the dense, massive part of the flows, as well as in the upper amygdaloidal parts.

4. In many places the rocks containing the copper are, apparently, fresh and unfissured.

5. In many instances copper occurs in the dense groundmass of a flow while apparently none occurs in the amygdaloidal portion of the same flow.

6. Copper sulphides occur disseminated through massive sills of diabase, which probably came from the same magma as did the surface flows.

7. No enrichment of native copper has occurred in flows cut by sills of diabase, although the flows contain native copper and the sills, sulphides of copper.

[1]8. On the Coppermine river, conglomerates interbedded with copper-bearing lava flows carry native copper in the contained pebbles, but copper was not observed in the matrix by the Douglas party. The copper therefore must have been in the amygdaloid before the immediately overlying conglomerates were deposited.

Facts Favouring an Epigenetic Origin

1. Specimens of the copper-bearing flows examined under the microscope show that minute grains of native copper replace the matrix or some of the minerals of the rock.

2. Native copper forms the outer edge and in some cases the centre of amygdules, and in some instances replaces other minerals of the amygdaloid filling.

[1]See also No. 7 under Facts favoring an Epigenetic origin.

3. In places native copper occurs in thin fissures and in veins in the flows and at some places the copper was found to be more abundant nearer minute fissures than through the rest of the rock.

4. Chalcocite occurs in some of the veins in the flows.

5. Dolomites immediately underlying the copper-bearing basalts in many places have been partly replaced by chalcocite. The chalcocite is intimately mixed with covellite so that it is probable that secondary enrichment has taken place to some extent.

6. At one place, on Iglor-u-allik island, copper occurs about the contact of two of the flows of basalt. The lower foot of the upper flow contains considerable native copper but no copper was seen throughout the rest of it.

7. A specimen of native copper in conglomerate was brought from the Coppermine River district to Dr. J. A. Allen of the University of Alberta. The writer was shown this specimen and was immediately struck with the fact that the native copper in this case had replaced most of the matrix around the pebbles of amygdaloid.

Detailed Descriptions of Copper Occurrences in the Bathurst Inlet Area

The following detailed descriptions of the copper-bearing and associated rocks of Bathurst inlet are presented for the most part in the order in which the various localities were examined in the field.

Archipelago North of Kater Point

The islands of the archipelago north of Kater point are formed almost entirely of fine-grained amygdaloidal basalt. The basalt forms thick flows which dip at low angles and are cut, in some localities, by vertical dykes and inclined sills of diabase. In the Cheere islands, at the southeastern edge of the archipelago, thinly bedded dolomites or limestones, cherts and variously coloured tuffs resembling shales and sandstones, outcrop in nearly horizontal beds, overlain by sills of diabase; but similar strata were seen nowhere else throughout the archipelago. On some of the islands lying immediately north of Kater point, the fact that the amygdaloidal basalt occurs in distinct, superimposed flows one of which measured about 90 feet in thickness, was clearly established.

The amygdaloidal basalts are fine-grained rocks, commonly porphyritic or with the feldspars tending to occur partly in larger, phenocryst-like individuals. The rock colour is usually purplish; in many places mottled greenish, or grey. Amygdules occur everywhere but vary much in size and relative amounts. At many localities the amygdules do not exceed a fraction of an inch in diameter and are rather widely scattered throughout the rock. In other places, they are much larger, in some instances 2 to 3 inches long, and are quite abundant. The amygdules are filled with quartz, jasper, variously coloured chert, zeolites, calcite, chlorite, etc., occurring in varying proportions from place to place. Frequently the rock shows an ellipsoidal structure indicated by narrow brown bands, usually two in number, enclosing ellipsoidal areas, which are commonly only a few inches, but in places several feet, in diameter.

Examined in thin sections, the amygdaloids are seen to vary chiefly in the relative proportions of augite and plagioclase. Quartz is present in many cases and iron ore is an abundant constituent.

Native copper and malachite derived from it are widely distributed throughout the amygdaloidal rocks of the islands. In some localities the copper appears to occur very sparingly or not at all; this appearance may be deceptive, for the rock in general is much weathered and it is difficult to detect any copper that may be present. Only on fresh rock surfaces is the copper readily visible and it is frequently difficult to break the rock so as to expose unweathered material.

The copper occurs as minute grains in the groundmass of the rock, as grains or tiny flakes in the amygdules, and as grains and small flakes in narrow seams and veins. Where the copper occurs disseminated through the groundmass of the rock, the minute grains are evenly distributed throughout, or they may tend to be segregated in small patches, or to occur grouped about the amygdules which in some such instances carry copper and in others do not. The amygdules at many localities are barren of copper, though the metal may be present throughout the groundmass of the surrounding rock. In places the amygdules may bear copper and the groundmass be barren. The copper-bearing veins or seams are developed at many places but are much more numerous and important in some localities than in others. The fissures seem to have developed in zones of shattering. In some places distinct veins of quartz, calcite or other minerals have resulted. These are seldom over a fraction of an inch in width, and either fade away in a short distance or are interrupted by cross fractures. In some places, the planes of fracture are only visible on close examination. In the veins and along the planes of fracture native copper occurs sparingly in minute flakes and in some instances the only indication of a shatter plane is the presence of minute plates of copper. The zones of fissures, in places, occur within the intrusive dykes and sills, and contain either native copper or chalcopyrite, but not both.

On island No. 20[1], southwest of Lewes island, a vein, not seen by the writer, was reported to be about 1½ inches wide where broadest, to be traceable for 6 feet and to be about one-third filled with copper. On other islands in this general vicinity veins are apparently numerous. Southeast of island No. 21, on several small islands, thin flakes of copper were seen in seams and veins, the largest of which measured one-half to three-fourth of an inch in width and extended for at least several hundred feet. On island No. 25, a thin vein carrying copper was traced for 60 feet. Smaller veins occur in the same vicinity and one of these having a width of one-quarter to one-half inch, was seen to hold grains and thin plates of native copper. In general the whole eastern part of island 25 carries much copper in the groundmass, in the amygdules and in veins. Numerous copper-bearing veins and seams occur on a small island northwest of the tip of island No. 25. Similar veins were noted to the east on island No. 26 and at both places the country rock appeared to be barren, as seemed to be the case over much of island No. 26.

A number of rock specimens of the copper-bearing rocks of the island were assayed for their copper contents. The results of these assays are given in the following table:—

Specimen Number	Copper content per cent	Locality	Remarks
217	0·028	Island No. 2	Grey amygdaloid; copper in groundmass.
222	0·03	Island No. 5	Grey amygdaloid; copper in groundmass.
257	0·076	Island 7a, east shore	Grey amygdaloid; copper in groundmass.
231	0·034	Island 7b, northwest part.	Purple amygdaloid; copper in groundmass.
233	0·06	Island 7b, northwest part.	Purple amygdaloid, copper in groundmass.
239	0·035	Island 7b, northeast shore.	Purple amygdaloid; copper in groundmass.
245	0·037	Island No. 9	Purple amygdaloid; copper in groundmass.
249	0·034	Island No. 9	Purple amygdaloid; copper in groundmass.
252	0·021	Island No. 10	Purple amygdaloid; copper in groundmass.
255	0·032	Island No. 13	Brown colored band, encircling ellipsoids.
266	0·012	Island No. 15a	Copper disseminated in rock traversed by mineralized fissures.
221a	0·068	Island No. 4	Copper disseminated in rock traversed by mineralized fissures.
263	0·02	Island No. 14	Copper in groundmass.
269	0·13	Island No. 14	Copper in groundmass, in grey amygdaloid. Amygdules bear copper also.
287a	0·075	Lewes island, west part of south shore.	Copper disseminated in rock.

[1]For convenience, the islands are designated in the text by numbers and these numbers appear on the accompanying map.

Specimen Number	Copper content per cent	Locality	Remarks
301	0·15	Lewes island, interior of..	Copper disseminated in rock.
302	0·036	Lewes island, interior of...	Copper disseminated in rock.
303	0·081	Lewes island, east part of south shore.	Copper disseminated in rock.
288	0·006	Island No. 17............	Copper disseminated in rock.
308	0·053	Island No. 20............	Copper disseminated in rock.
309	0·036	Island No. 20............	Copper disseminated in rock.
320	0·10	Island No. 18, north side.	Copper disseminated in rock.
329	0·042	Island 26, northeast shore.	Copper in amygdules and in groundmass.
355	0·036	Island 26, south part......	No copper visible in rock.
340	0·08	Island 25, east part.......	Disseminated through rock cut by many copper-bearing fissures.
350	0·082	Island, 25, east part.......	Disseminated through rock cut by many copper-bearing fissures.
360	0·195	Small island, south of island 26.	Copper in amygdules and in groundmass.

Iglor-u-allik Island

Iglor-u-allik is a large island lying east of cape Wollaston, the north point of Banks peninsula. The island is composed chiefly of a succession of amygdaloidal flows, cut by a broad sill of diabase. The flows dip at low angles to the southwest and rest on metamorphosed limestone outcropping at the southeast end of the island.

A general section of the rocks of the island, arranged in descending order, is as follows:—

Descending Order		Thickness in feet
373–375	Dark grey amygdaloid, with small individuals of a pink mineral in the groundmass. Native copper occurs disseminated through the groundmass and at one locality flake copper occurs in veins of milky quartz, calcite and sericite. The veins ¼ to ⅜ inch wide were traceable for 35 feet. Thickness unknown..	–
	Dark grey amygdaloid, with small individuals of a pink mineral in the groundmass. Small grains and flakes of copper occur in the groundmass. In several places the rock is shattered and stained with malachite. Thickness about..	50
371	Dark grey, in part purplish amygdaloid; with numerous amygdules of calcite and chlorite. Copper occurs in grains grouped about the borders of the amygdules and in aggregates in the groundmass. Specimen (No. 371) assayed 0·195 per cent copper. Thickness about........................	30
	Purplish amygdaloid, the amygdules measuring ¼ to ⅜ inch in diameter and filled with calcite and chlorite. Minute grains of copper occur through the groundmass. Thickness about................................	30
369	Grey amygdaloid with grains of copper in the amygdules and flakes of copper scattered through the groundmass. Thickness about....................	30
368 379	Fine-grained, purple amygdaloid, with phenocrysts of feldspar, small scattered amygdules, and red-brown bands. Some copper in small grains. The lower 1-foot is a dense amygdaloid carrying numerous minute amygdules of chlorite and, less abundantly, larger ones (⅛ to ¾ inches in diameter) of quartz, calcite, and native copper. A specimen (No. 379) from the lower 1 foot assayed 0·24 per cent copper. Thickness about........................	75
	Fine-grained, purple amygdaloid with numerous amygdules filled with calcite, quartz and chlorite; no copper visible. Thickness about................	20
	Fine-grained amygdaloid with fragments of other amygdaloids; no copper visible. Thickness about..	30
384	Fine-grained, purple amygdaloid with numerous amygdules of calcite, quartz and chlorite; no copper visible. Thickness about......................	20
385	Mottled brown and grey amygdaloid containing rounded fragments of other amygdaloids; amygdules abundant; no copper seen. Thickness about......	30
386	Dark greenish grey, fine-grained amygdaloid with large amygdules of quartz, agate, calcite, prehnite, epidote and chlorite. The rock is cut by several veins mainly of quartz, calcite and a green mineral. No copper was seen in the rocks or veins. Thickness about................................	30
	Gap in section. Thickness unknown..	–
	Metamorphosed limestone containing forsterite surrounded by serpentine. Thickness unknown..	–

At a horizon in the above section about 100 feet below the summit, an 18-inch bed of ash occurs between two amygdaloids. The ash rock has a red-brown base in which lie numerous small angular pieces of quartz and feldspar. The whole is veined and partly replaced by carbonate.

Algak Island

Algak island lies north of Goulburn peninsula and faces Banks peninsula. Cliffs of thin-bedded dolomite occur along the east coast, dipping westerly beneath a broad band of diabase. West of the diabase, forming the western two-thirds of the island, occur successive flows of amygdaloid dipping at very low angles towards the west. What appears to be the lowest flow, outcrops on the point forming the west shore of the large bay on the north side of the island. A section, as measured from this point westward along the north shore to the northwest point of the island, is as follows, given in ascending order, commencing with lowest flow observed.

	Thickness in feet
Medium-grained, purplish amygdaloid. Amygdules are few; no copper seen. Thickness unknown...	–
Gap in section; no exposures for one-half mile; concealed thickness unknown...	–
Fine-grained, dark grey amydaloid with scattered small amygdules of calcite and chlorite carrying a little copper. Thickness, about...	40
Purple, green mottled amygdaloid. Amygdules measure about $\frac{3}{8}$ inch and are composed of chlorite and calcite. Native copper occurs in the rock about the amygdules and in thin seams. A specimen (No. 389) assayed 0·037 per cent copper. Thickness about...	30
Fine-grained, dark amygdaoid. Copper occurs in the groundmass and in the amygdules. Thickness, about...	15
Gap in section; no exposures for 800 feet; concealed thickness unknown...	–
Dark amygdaloid; abundant minute amygdules of calcite and chlorite with copper, and larger amygdules of quartz, agate and calcite, stained with malachite. Thickness about	30
Dark greenish grey amygdaloid; abundant amygdules, $\frac{1}{2}$ to 3 inches in diameter, most of the larger ones filled with quartz, agate and calcite, the remainder with calcite and chlorite. Most of the amygdules carry copper. Thickness, about...	40
Fine-grained, purplish grey amygdaloid; amygdules abundant, $\frac{1}{4}$ to 1 inch in diameter, filled with calcite and chlorite and in some cases with quartz and agate. Native copper occurs in nearly all the amygdules and largely fills many of them, copper occurs also in thin seams and in flakes through the groundmass. A specimen (No. 393) of the rock not including any seams or larger flakes of copper, assayed 0·11 per cent copper. Thickness, about....	50
Mottled green and purple amygdaloid; numerous small amygdules filled with chlorite and calcite. Copper occurs in many of the amygdules and through the groundmass of the rock. Thickness, about...	40
Gap in section; no exposures for 500 feet; concealed thickness unknown...	
Mottled green and purple amygdaloid; numerous small amygdules. Minute grains and occasional flakes of copper occur in the rock. A specimen (No. 395) assayed 0·042 per cent copper. Thickness, about...	25
Fine-grained, dark grey, greenish grey spotted amygdaloid. Scattered flakes of copper. A specimen (No. 398) assayed 0·060 per cent copper. Thickness, about...	50
Fine-grained, dark greenish grey amygdaloid. Many of the smaller amygdules carry grains of copper of about the size of a grain of wheat, the larger amygdules hold smaller grains of copper and scattered grains of copper occur through the groundmass of the rock. Thickness, about...	30

Occasional exposures of amygdaloid occur along the southern shores of the island and in places are traversed by seams bearing a little native copper.

The same general assemblage is displayed along the west coast of the island. A specimen (No. 453), from a 50-foot cliff section of dark grey amygdaloid, assayed 0·055 per cent copper. In another cliff, about 60 feet high, the dark grey amygdaloid shows malachite along numerous seams. One vein was seen composed of calcite and quartz carrying native copper in plates 1/16-inch thick and occasionally as thick as $\frac{3}{8}$ inch. A specimen (455) of the country rock assayed 0·025 per cent copper. A purplish amygdaloid showing disseminated copper, occurring in another cliff, assayed (specimen No. 458) 0·01 per cent copper, and another specimen (No. 460) from another locality, assayed 0·014 per cent copper.

Kokavingnak Island

On the extreme north point of Kokavingnak island and, in places, along the east shore are exposures of coarse pink quartzite with occasional layers of pink and white sandstone and dark shale. The sediments are thinly bedded and dip westerly under diabase, apparently a sill, which occupies the rest of the island. Several small islands lying northwest of Kokavingnak island are formed of the diabase. The rock on one island is traversed by a network of thin quartz veins and bears a black metallic mineral weathering to malachite. A specimen (No. 192) of this rock in which no native copper was visible, assayed 1·18 per cent copper.

Barry or Ekallulialuk Island

Barry island was visited by Hanbury who reported the abundant occurrence of native copper on the beaches and along the cliffs on the west side of the island. The present writer traversed the shores of the island, and nowhere saw any native copper although staining by malachite was noted at several localities. The central part of the island is largely occupied by flows of amygdaloid such as occur elsewhere in Bathurst inlet, at least two of which contain copper. They dip westerly at low angles and near the west coast are capped by a broad sill of diabase. Along the east shore are exposures of sediments, apparently underlying the amygdaloidal flows.

Kanuyak Island

Kanuyak island is occupied by westerly dipping amygdaloidal flows, except along the east coast, where underlying sediments outcrop. The amygdaloids of the north part of the island in places carry disseminated copper and one specimen (No. 436) from this area assayed 0·048 per cent copper. On the west coast of the island, at several localities, the rock carries copper in the amygdules or through the groundmass. Elsewhere no copper was seen.

The sediments outcropping along the eastern side of the island consist of dolomites overlain by sandstone and shale. A short distance inland the sediments are overlain by the amygdaloids and, where these rest directly on the dolomite, that rock at most places is replaced by a mixture of chalcocite and covellite. At one such locality near the northern end of the island, the upper layers of the dolomite are highly impregnated with the sulphides, especially within 3 feet of the contact. An analysis of a specimen of one of these layers which showed a complete replacement of a bed 6 inches thick, indicated the presence of 49·87 per cent copper and 1·12 ozs. of silver per ton.

Alirhowik Island

Alirhowik island is apparently occupied by amygdaloidal flows. No copper was seen at any place on the island but malachite was noted at several places along fracture planes.

Banks Peninsula

Banks peninsula is occupied by amygdaloidal flows, except along the southern part of the east side. The rocks along the coast were examined at only a few localities. At one such locality on the west shore, copper stain and small pieces of native copper occur in veins in the amygdaloid and grains of copper border the amygdules. A second somewhat similar occurrence was noted on the west shore, and a third one mile south of the north point of the peninsula. A line of section was examined commencing on the east coast about 5 miles south from the end of the peninsula and extending northwesterly towards cape

Wollaston. The flows dip at low angles to the west, and this line appears to traverse all that are exposed on the peninsula. Arranged in descending order, the strata met with are as follows:—

Descending Order	Thickness in feet
Dark, purple-grey amygdaloid, with much finely disseminated native copper. A specimen (No. 474) assayed 0·067 per cent copper. A second specimen (No. 476) from the prolongation of this flow along the strike on a small island west of cape Wollaston assayed 0·235 per cent copper. Thickness, about	40
Fine-grained, dark grey amydaloid. Some copper occurs in the groundmass and many of the amygdules hold copper. Thickness, about	40
Dark, purplish-grey amygdaloid. Copper occurs through the ground and in the amygdules Thickness about	30
A flow like the above. A specimen (No. 469) assayed 0·124 per cent copper. Thickness, about	40
A flow like the two above. Thickness, about	60
Fine-grained, dark grey amygdaloid with small amygdules. Copper occurs through the groundmass and along thin seams. Thickness, about	40
Dense, mottled amygdaloid; copper in grains and small flakes in the groundmass. A specimen (No. 466) assayed 0·06 per cent copper. Thickness about	40
Fine-grained, grey amygdaloid with copper about the amygdules and through the groundmass. A specimen (No. 465) assayed 0·025 per cent copper. Thickness, about	60
Medium-grained, purple amygdaloid; no copper seen, Thickness, about	30
Coarse, purple amygdaloid with copper through the groundmass. Thickness unknown; only partly exposed	–
Gap in section; no exposures. Concealed thickness	100
Dark, purple-gray amygdaloid with a little disseminated copper. A specimen (No. 462) assayed 0·018 per cent copper. Thickness, about	50
Coarse, purple amygdaloid. Copper occurs in most of the amygdules. Thickness unknown	–

Summary of Conclusions

In general, then, there is in Bathurst inlet a series of copper-bearing amygdaloidal basalts, light grey, dark grey, green-grey, purple or mottled green and purple, in colour, that have a total thickness of something over 850 feet.

It is not known to what depth the deposits have been eroded in this district; it may have been very great, for the large sills of diabase, which carry copper and were presumably of about the same age as the flows, were possibly feeders for higher flows, and stand at least two hundred feet above the highest flows in the district.

Individual flows are seldom more than 75 feet in thickness, and the amygdaloidal portions as a rule, have been either eroded or were originally poorly developed. In places the amygdules are found scattered through the upper few feet of the flow and only in a few flows were they seen to average more than an inch in diameter or to occupy as much as 50 per cent of the amygdaloidal portion of the rock. The flows are all made up of plagioclase and augite, often in about equal amounts, but in different flows one or other somewhat preponderates. The only other primary minerals observed in a rather cursory examination of about 350 sections were quartz, in small amounts observed in a few sections, and black iron ore which is very abundant in some of the flows and is often bordered by leucoxene.

Practically all of the flows have been altered to some extent, and in general the main products of alteration have been chlorite and sericite with some calcite. The iron ore is in places altered to limonite, and there are distinct brown bands in a few flows which owe their brown colour to limonite.

The amygdaloidal fillings are for the most part of chlorite quartz, clear and amethystine, agate and opaline quartz, and calcite. Epidote is locally abundant in the groundmass as well as in amygdules, but as far as observed zeolites are not nearly as abundant as the common minerals.

No fixed rule can be stated as to the association of native copper with any particular flows or with any particular mineral as an indicator as its distribution is practically universal. It apparently occurs in all the flows and in all parts of the flows, but not in uniform percentages. Minute flakes of copper occur disseminated in apparently fresh, unfissured, massive portions of flows, as well as in and about the amygdaloidal portions, but it is quite clear that the richest parts are those in which there are abundant minute fissures or seams. In some of the amygdules the copper forms the outer layer of the filling, and quartz, chlorite or calcite forms the centre, or the positions may be reversed. Usually there is no enrichment in the rock bordering the amygdules but in a few cases abundant flake-copper was noticed in this position. The copper in the groundmass is always in minute flakes, but there is often a tendency to a grouping in small areas with barren patches between.

In the veins the copper occurs in plates or in irregular pieces, usually in a gangue of quartz or calcite. Few veins larger than three inches in width were seen, but there is a large mass of copper on the northeast end of the island south of Lewes island, apparently at the intersection of two veins; the veins were seen on the island striking to intersect under the water at the place where the Eskimos said this copper occurs, but the exact spot is just below water-level and was covered with ice when the writer visited it. No large pieces of copper were seen by the writer, in Bathurst inlet, although the Eskimos reported one other occurrence found long ago on an island south of Barry island.

No exact evidence was obtained in Bathurst inlet as to the period or periods of mineralization, but it seems quite clear that a large part of the copper was introduced into the rocks after they were solidified and fissured. The warping of these rocks has been so gentle that no definite shoots along beds are to be expected, except those related to fissures which traverse right through the series of flows. There are no shoots comparable to these formed in the more steeply dipping deposits in Michigan. Replacement or disseminated deposits bordering fissures in areas of considerable fissuring, taken together with the copper in the fissures themselves, may render large tonnages workable, and two or three such areas were noted. There may be enough copper in the surface amygdaloidal portions of some of the flows to produce a paying blanket deposit (the exposure of these portions was very limited, for reasons stated before, but in some places they contained three or four per cent or more along exposures of several feet). The chalcopyrite deposits in large sills of diabase especially in areas of considerable fissuring, may prove to be of importance. The replacement deposits of chalcocite and covellite in dolomite were very rich where exposed, but there was no means of telling their horizontal extent. The vertical range of the replacement was less than 8 feet where observed immediately below flows of basalt. Because of their close association with alteration minerals which are characteristic of high temperature, the main native copper deposits of Bathurst inlet are thought to have been formed by hot, ascending solutions. Apparently there has been very little leaching of copper, even from the amygdaloidal portions of the flows.

The general conclusion is that the Bathurst inlet deposits probably form an important reserve of copper ore but that it is not sufficiently attractive under present conditions of accessibility, transportation, demand, etc., to warrant the large expense necessary to prove and develop the deposits.

The conditions in the Coppermine River district are decidedly different. There, the flows are not comparatively flat, and are not all piled one immediately on top of the other, but are separated by occasional conglomerates or sandstones, and have a general dip of about 12 degrees. The amygdaloidal portions are apparently much better developed than in Bathurst inlet, and some of them at least carry important percentages of copper. It is also certain that the matrix of some of the conglomerates has been replaced by native copper, and a specimen obtained of this is very rich. It is also known that numerous large masses of copper occur in the drift immediately north of the copper-bearing rocks west of Coppermine river; so that it seems highly probable that parts of this district contain workable and even rich deposits. The district is easily reached from Great Bear lake and transportation could be arranged *via* the Mackenzie river valley.

Conditions Governing Prospecting and Mining

Climate

The Eskimos divide the year into five parts and conduct their movements accordingly. A decided break from the grip of winter occurs about the middle of April, and by the end of May all the snow has disappeared from the land except where large drifts remain along the cliffs. The sun is quite hot in April, the seals come out on the ice and the caribou begin their migration to the northern islands. In May, the wild-fowl arrive and after them the small birds; the sun shines for twenty-four hours and the vegetation responds rapidly so that by the middle of June many wild flowers are in bloom, the slopes and valleys are green and small mammals are seen everywhere. At this time the flies begin to make their presence felt, and soon the mosquitoes are so numerous that one is reminded of summer in northern Ontario. Black flies are rare on the coast, but are too abundant for comfort along some of the rivers.

The rivers are usually free of ice early in June, and by July, most of the small lakes are open. Great Bear lake breaks up about June 20th and the ice in Coronation gulf at about the same time. The ice is then rapidly crushed into small pieces and disappears before August. Of all the ice on the Arctic coast, that which offers most obstruction to navigation is in Beaufort sea. This ice drifts around all summer and responds to all variations of wind and tide.

By September, the days are shortening and light snowstorms occur and, by October, all the small lakes are frozen. The swift rivers freeze before the middle of the month, the migratory birds depart for the south and, by the end of the month, the shore ice is thick enough to permit of travelling by sled. The sun disappears altogether in November; but, even in the middle of December, on clear days there is sufficient light for travelling for about five hours.

The mean temperature for the five months, November to March, inclusive, in the winters of 1914-15 and 1915-16, at Dolphin and Union strait was −15 degrees, F. The minimum was −49 degrees the first year, and −44 degrees the second. The total snow-fall does not exceed three feet and the wind keeps the islands and coast rather bare. During the summer, the ground thaws to a depth of about 21 inches but below this depth remains permanently frozen. In the summer, the maximum temperature recorded on the coast was above 60 degrees F. and the mean for the months June, July, August and September was above 32 degrees, F.

It may be seen, then, that as far as the climate is concerned, there is nothing to prohibit settlement. Game and fish abound and there should be little difficulty in establishing a mining industry if the mineral deposits prove to be valuable. Underground mining could be carried on throughout the whole year without much inconvenience.

Power and Fuel

Waterpower in abundance for mining operations and probably enough to take care of local transportation, is available from Coppermine, Tree and Hood rivers. Coppermine river, at Bloody fall, is sometimes open all winter.

Coal, which varies in character from lignite to bituminous, has been reported to occur on the north shore of Great Bear lake, on Horton river, on the northeast coast and in the central part of Banks island, and on the southern parts of the Parry islands. Oil is known to occur in seepages in the Mackenzie valley, as far north as Norman, and oil has already been obtained in important quantity by drilling.

Transportation

The main difficulty confronting the prospecting or developing of the deposits of copper in Arctic Canada, is, apparently, one of transportation. There are two large areas of copper-bearing rocks which require to be examined to determine if there is a tonnage of commercial ore sufficient to warrant the expenditure of the large capital required to place the district on a producing basis. To carry out this examination, using present means of transportation, those engaged in the work would have to spend at least one winter in the country, whether they went in by boat around the coast, or overland by way of the Mackenzie river route. A party could be placed on the ground in August, at the earliest, and would have about three months for work the same year before having to go into winter quarters. The next spring they could start work in May and work until the middle of August before returning. Thus, in a period of eighteen months, they could work six and a half months. The working time could be doubled by remaining another twelve months, that is, in thirty months, they could work about thirteen months. These figures are based on the assumption that the expedition would be well organized and managed.

By using aeroplanes, a party could spend between five and six months each year in actual work and it would not be necessary to keep the men in the north during the winter, thus affecting a considerable saving in wages, provisions and outfit. For the investigation of the native copper deposits by aeroplanes, the most suitable base, easily accessible to railway lines, would be on Great Slave lake. Fort Reliance at the east end of the lake would be the best base for operations in the Bathurst inlet region; and Rae, on the northern arm of the lake, would be best suited as a base for an investigation of the Coppermine river region. From either place the route to the north could pass along rivers and chains of lakes for most of the distance, and by the use of hydro-aeroplanes, intermediate bases could be established as desired.

The total distance from Fort Reliance to Bathurst inlet is only 260 miles; and, by using Aylmer lake and Beechey lake as intermediate bases, the route could be split into three parts, each one hundred miles in length. Practically the whole distance would be over water. The total distance, from Rae to Dismal lake in the centre of the Coppermine river district, is 315 miles in a straight line and this could be split up as desired by forming intermediate bases along the chain of large lakes which occur on this route. The trip could be accomplished in a few hours by air, though with present means of travel it requires two months and the expenditure of a great amount of energy.

Food Supply

All supplies, except fresh meat, have to be taken into the country. Caribou abound in the spring and in the fall during migration, and stocks could be obtained at such times, although the recent influx of traders and the supplying of the natives with firearms is said to have noticeably reduced the caribou in the past few years. Fish may be obtained in large quantities in most of the rivers at certain seasons and in the larger lakes, all the year round. They include Dolly Varden or salmon trout, and lake trout mostly, the latter attaining a large size in Great Bear lake. Reindeeer could be raised in herds sufficiently large to furnish a sure meat supply to any mining industry, that might be instituted.

PLATE II

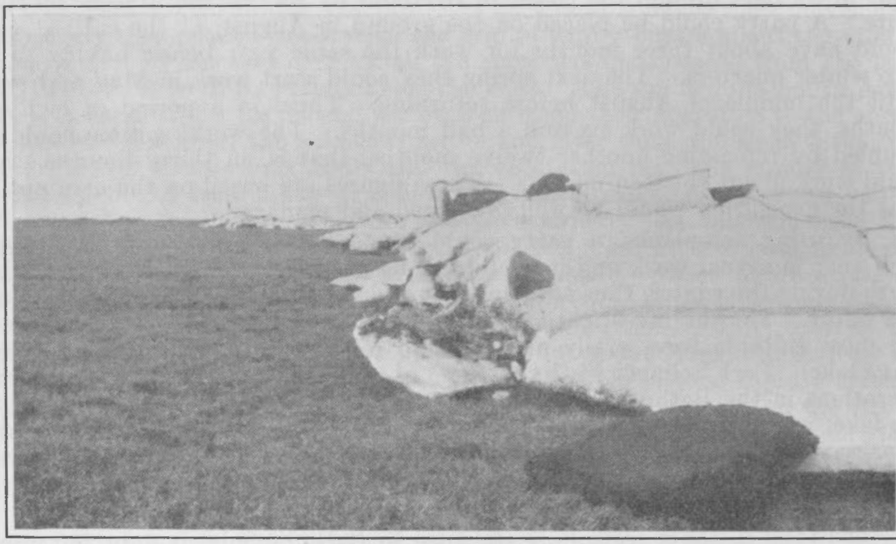


Fig.1. Sea ice being shoved up over low tundra shore, and carrying boulders and driftwood trunks with it. Camden bay, Alaska, July 3, 1914. Photo by R. M. Anderson.

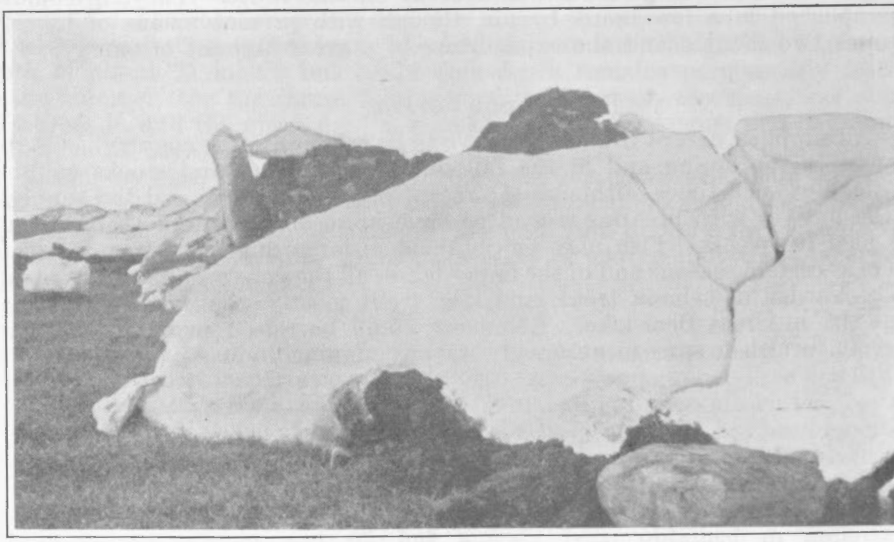


Fig. 2 Detail of sea ice overriding low coast. There is, as a rule, very little disturbance of the underlying material Camden bay, Alaska. Photo by R. M. Anderson.

PLATE III

Fig. 1. Valley of Firth river nine miles from the coast looking north. Cliffs are highly folded Jurassic sediments overlain by recent fluviatile deposits. March, 1914.

Fig. 2. Canyon of Firth river, about 30 miles from the coast looking south. March, 1914. Photo by J. R. Cox.

PLATE IV

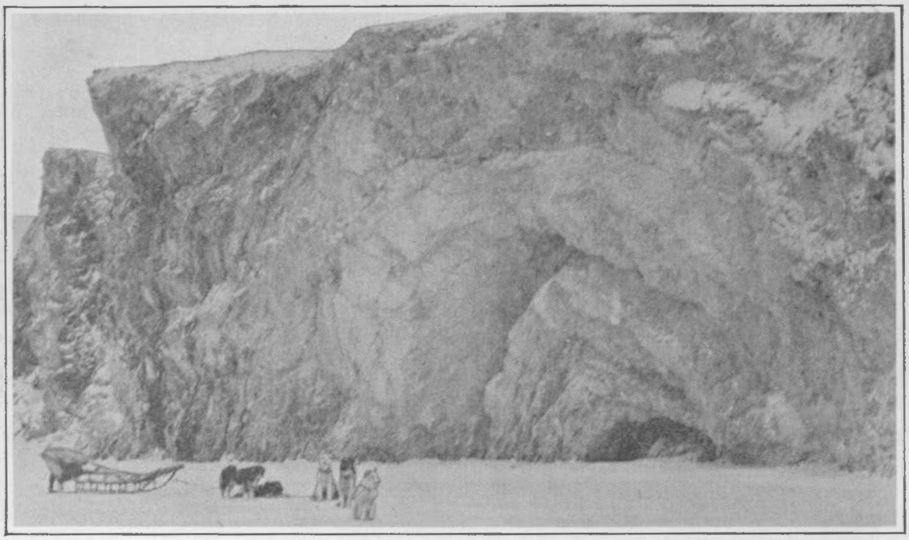


Fig. 1. Anticline in beds of massive limestone; oldest formation seen in Firth river section; about 40 miles from the Arctic coast.

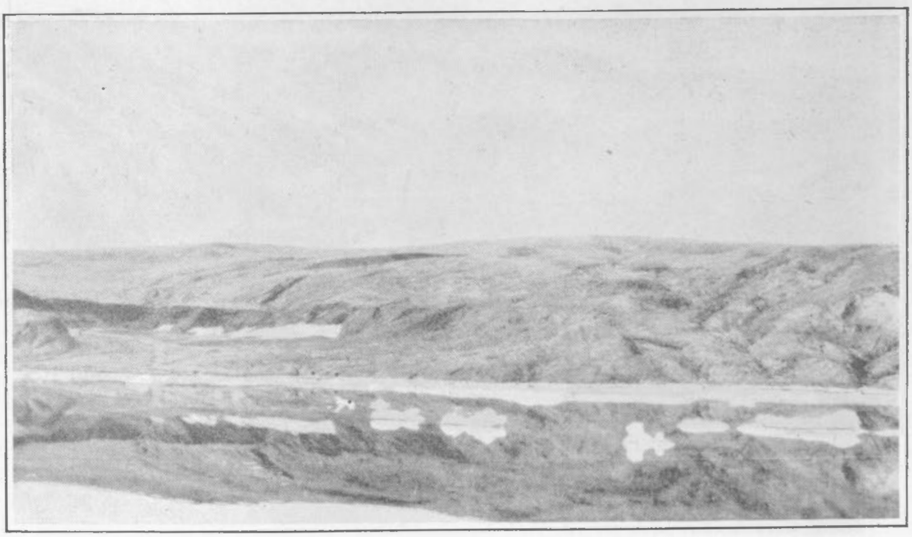


Fig. 2. East side of Kay point, Yukon Territory; shows rapid erosion of the marine Pleistocene formation by slumps and wave action. The lower part of picture is a reflection in the water.

PLATE V

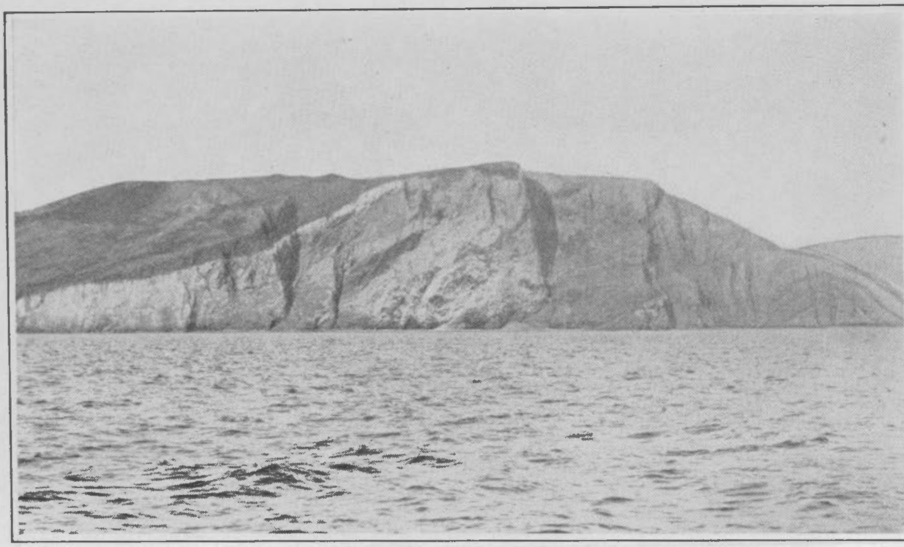


Fig. 1. Cliffs of silty mud, etc., on the north side of Herschel island have stratification and folding at this place; there is also a large lens of ice exposed in the cliffs.

Fig. 2. Northwest end of Herschel Island. Cliffs of marine, silty and sandy muds of Pleistocene age.

PLATE VI

Fig. 1. Looking south to the east branch of Mackenzie river. Latitude 68° 43′ 15″. (Place of section).

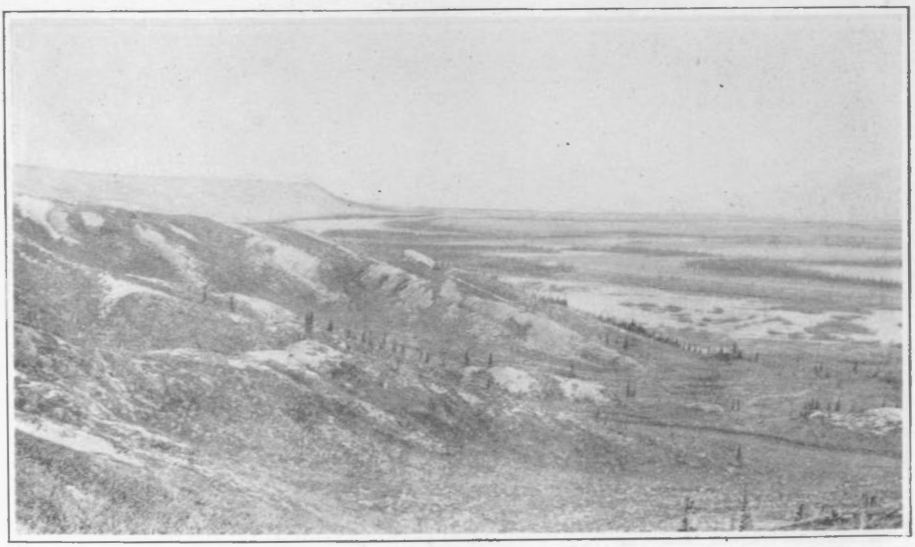


Fig. 2. Eastern border of Mackenzie river delta; typical erosion of the silt-sand-gravel formation.

PLATE VII

Fig. 1. West branch of Mackenzie river delta.

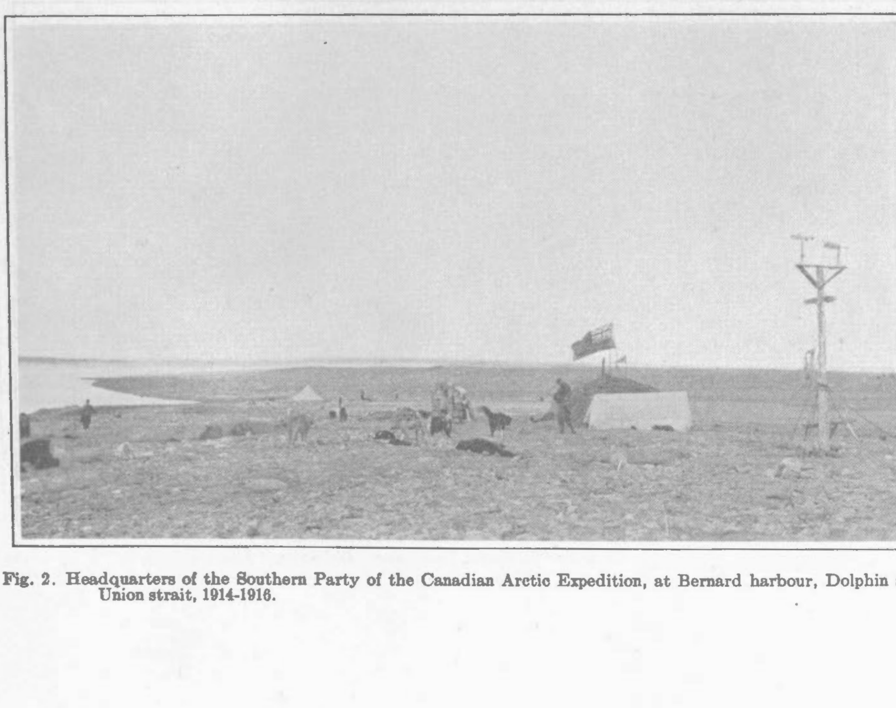


Fig. 2. Headquarters of the Southern Party of the Canadian Arctic Expedition, at Bernard harbour, Dolphin and Union strait, 1914-1916.

PLATE VIII

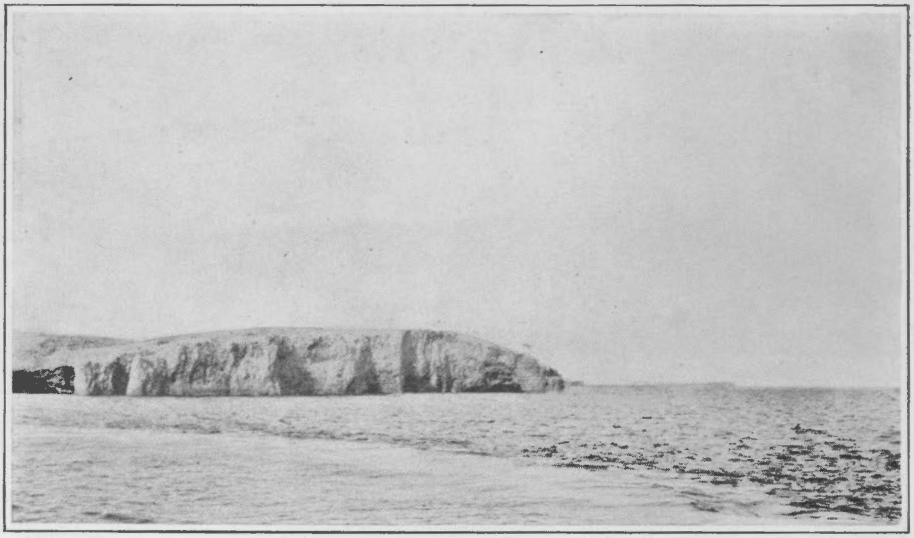


Fig. 1. Silurian dolomites at Cape Parry, Northwest Territories, July 24, 1916.

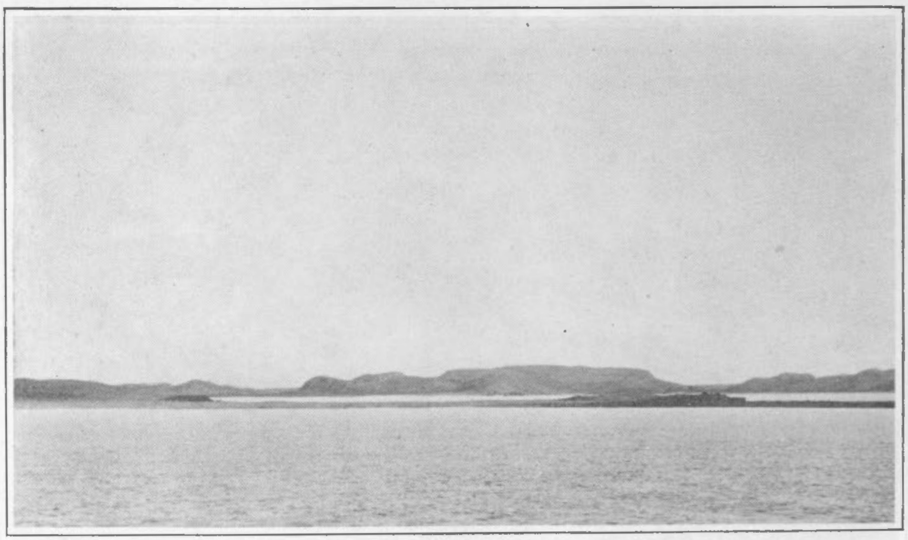


Fig. 2. Harbour on the east side of Pierce point, Northwest Territories. Old series of dolomites on point, cut by dykes of diabase. July 23, 1916.

PLATE IX

Fig. 1. Flood-plain of Brock river, north side near coast. The bank is of Eocene estuarine shales, overlain by Pleistocene sands, gravels, etc. April, 1915.

Fig. 2. Gravel topped hills about Brock river, 8 miles from the coast; gravels are of Pleistocene age. April, 1915.

PLATE X

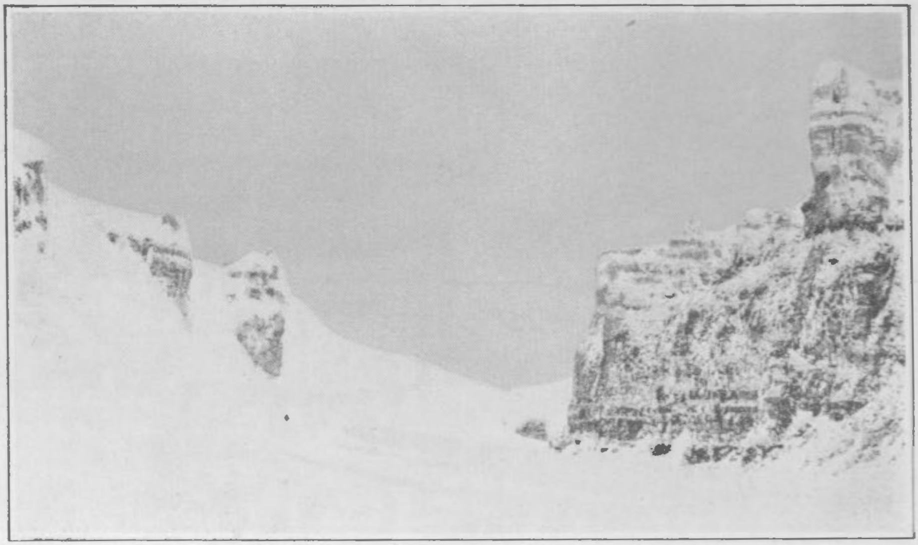


Fig. 1. In the canyon of Croker river, 15 miles from the coast of Amundsen gulf. Cliffs of dolomite with castellated fronts. March 18, 1916. Photo by R. M. Anderson.

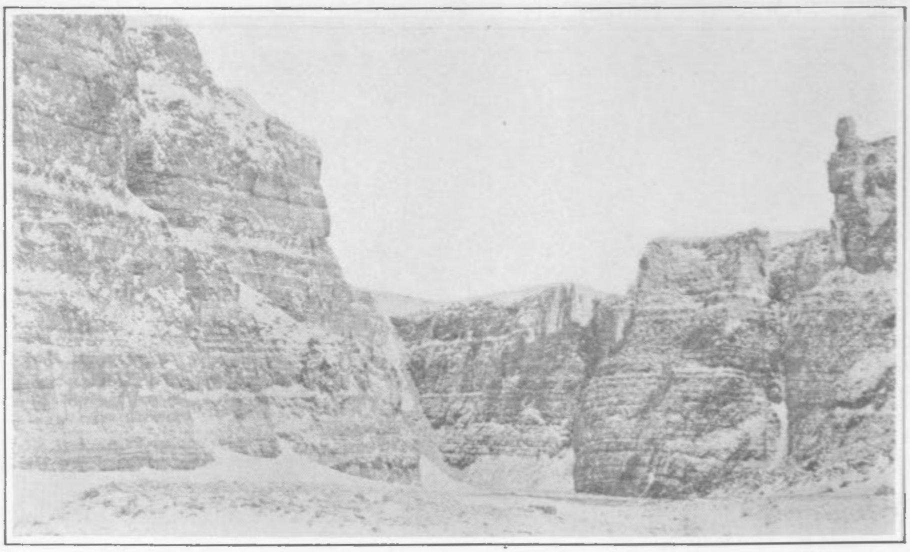


Fig. 2. In the canyon of Croker river, 20 miles from the coast. Cliffs of dolomite showing distinctive bedding. March 18, 1916. Photo by R. M. Anderson.

PLATE XI

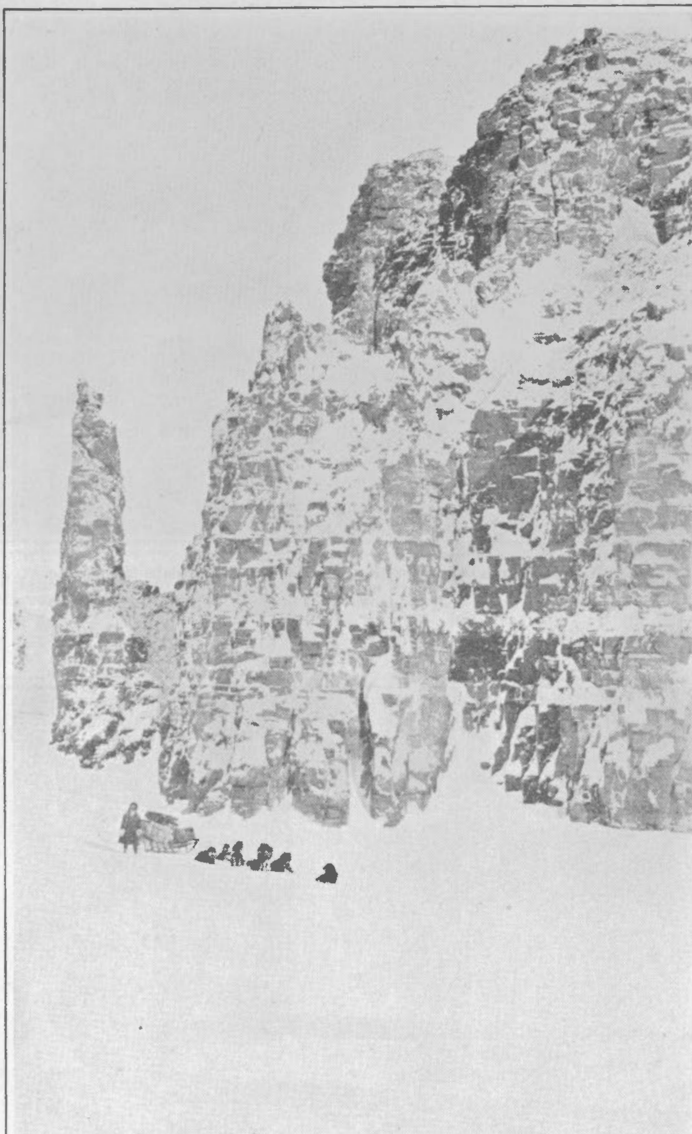


Fig. 1. Typical exposure of Silurian dolomite in the canyon of Croker river; pinnacles are apparently due to post-glacial erosion. March 18, 1916. Photo by K. G. Chipman.

PLATE XII

Fig. 1. Wise point from the east; typical beach covered with slabs of dolomite.

Fig. 2. Bernard harbour; Silurian dolomite at the beach covered by marine Pleistocene deposits. Liston and Sutton islands may be seen in the distance, near the left side of the photograph.

PLATE XIII

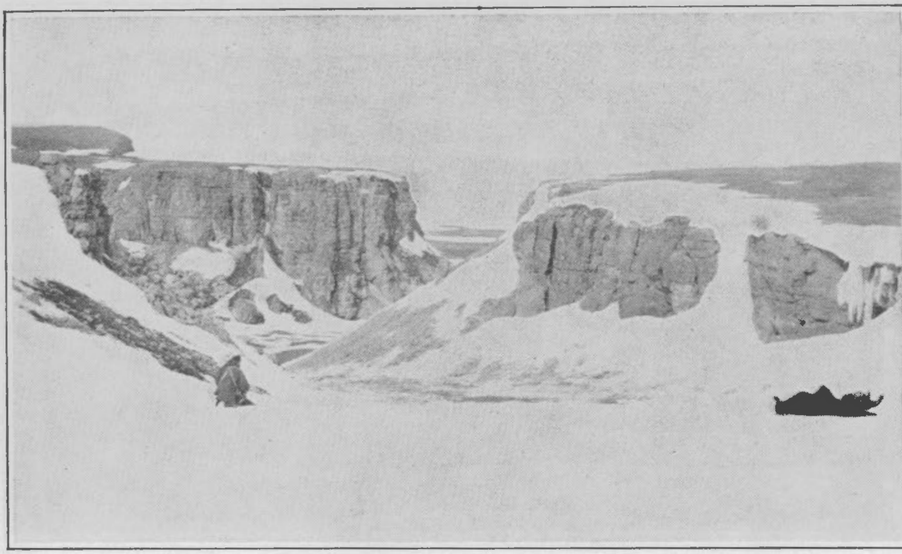


Fig. 1. Silurian dolomites overlain by Pleistocene formation near the mouth of Inman river; delta of the river may be seen through the cut in the cliffs, extending into Amundsen gulf. May 18, 1915.

Fig. 3. Cliff of dolomite at northeast end of Liston island, containing Silurian corals. April 1916. Photo by F. Johansen.

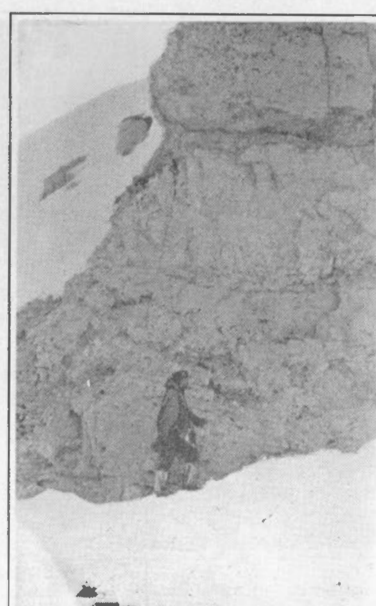


Fig. 2. Detail of dolomite near mouth of Inman river; massive brecciated bed under banded chert and dolomite.

PLATE XIV

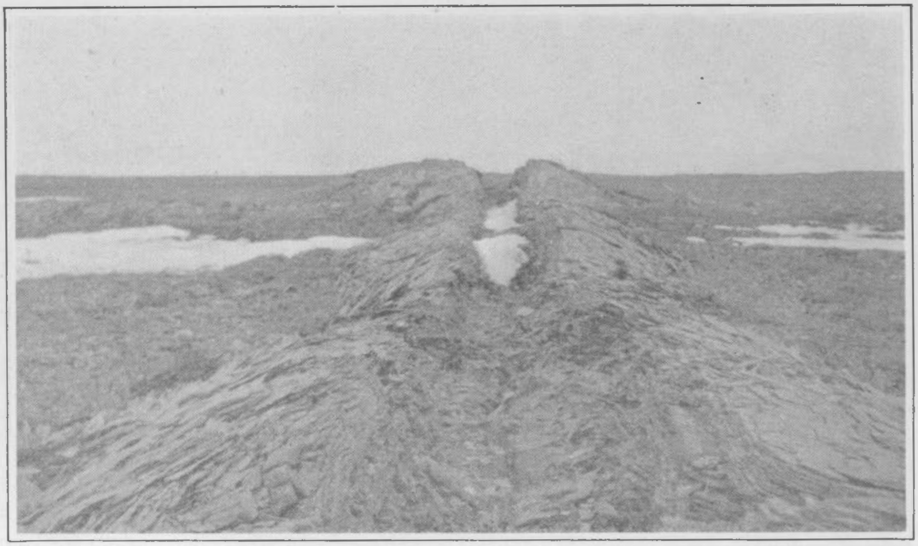


Fig. 1. Effect of frost action along the joint planes of flat-lying dolomites at Cape Hearne, Coronation gulf. The edges are flexed sharply upward, thus forming trenches 2′ to 4′ in width which intersect at right angles. June 3, 1916.

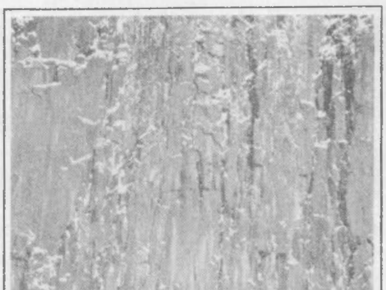


Fig. 2. South side of typical island in Coronation gulf. Columnar diabase overlying thin bedded sediments; in this case they are red sandstone of the Coppermine river series.

PLATE XV

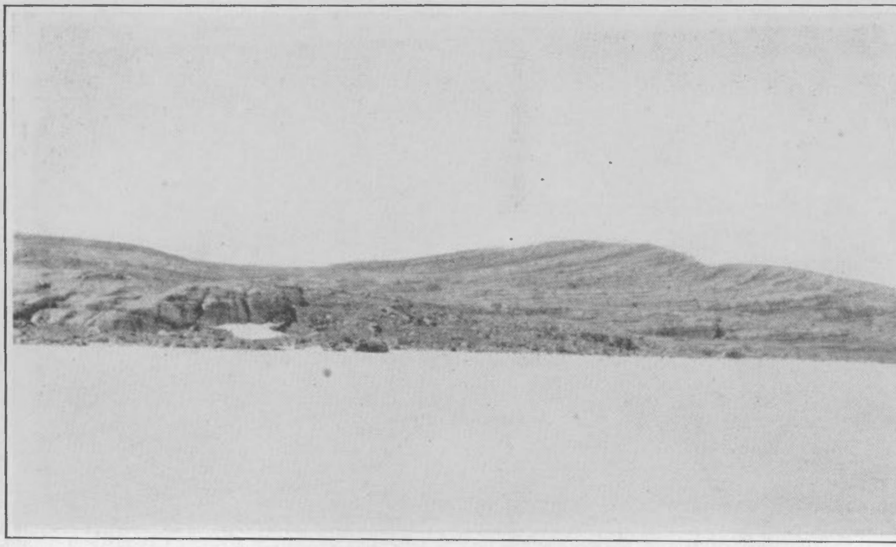


Fig. 1. Synclinorium of cherty dolomite at base of Port Epworth harbour, Coronation gulf.

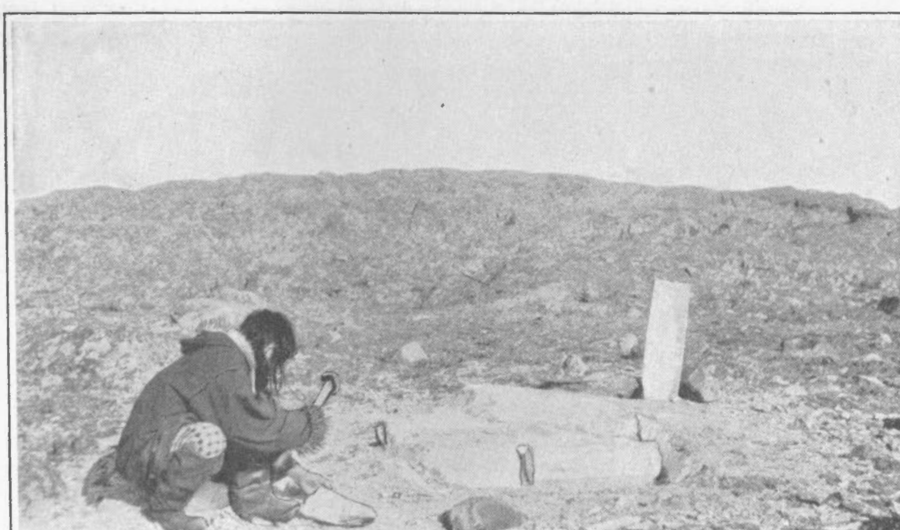


Fig. 2. Mupfa, a Copper Eskimo, cutting blocks of talc-chlorite schist to make pots and lamps from an inclusion in the Archaean granite on the east side of Port Epworth harbour. June, 1915. Photo by J. R. Cox.

PLATE XVI

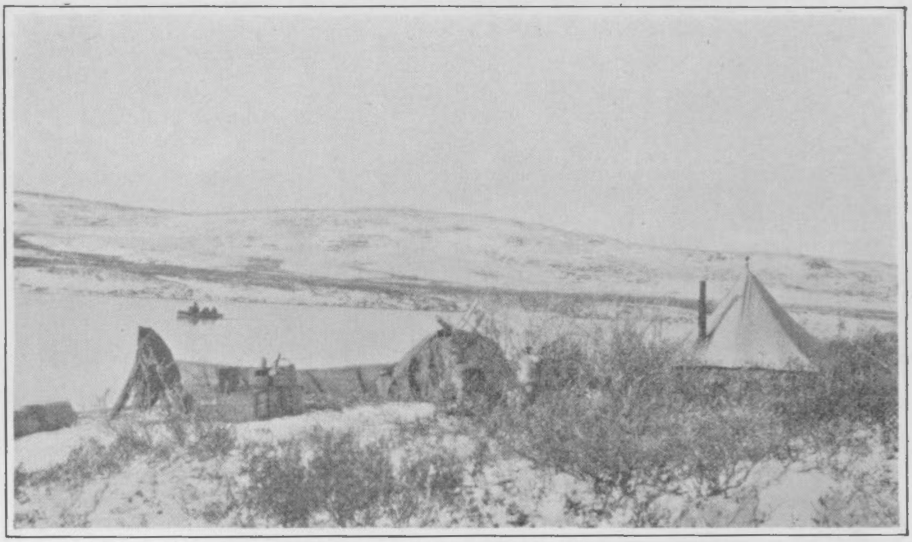


Fig. 1. Mouth of Tree river, Port Epworth harbour, Coronation gulf. October 4, 1915.

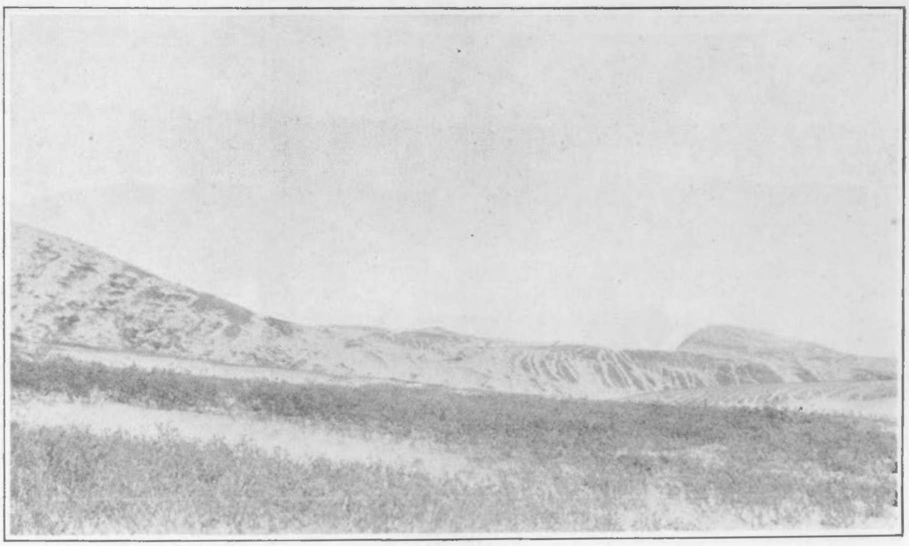


Fig. 2. Cliffs of Pleistocene marine silty mud, on east side of Tree river, five miles from the coast. 2′–3′ willows in foreground. October 4, 1915. Photo by R. M. Anderson.

PLATE XVII

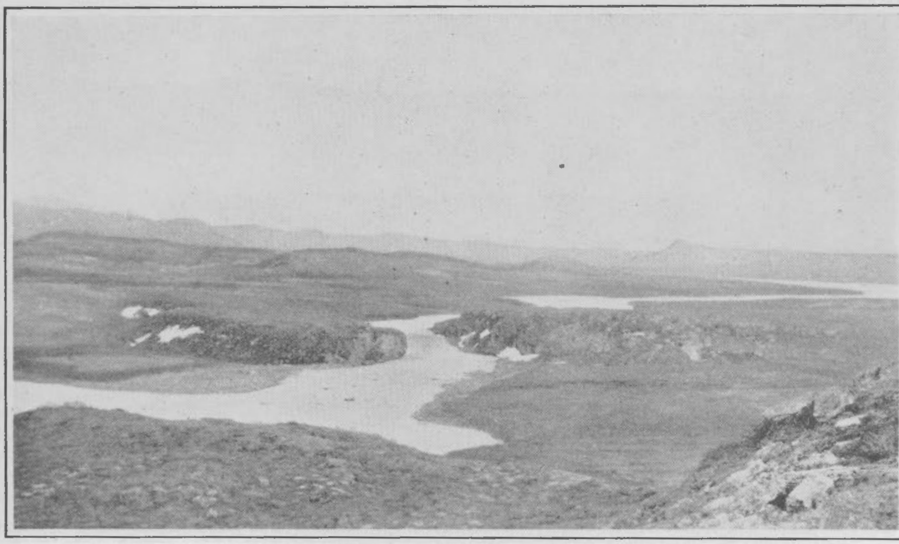


Fig. 1. Falls on Tree river six miles from coast; looking south up the valley. Granite hills to the left; dolomite across the valley.

Fig. 2. From 1,000 foot bluff of diabase on west side of Tree river, looking southeast across the valley to the granite hills in the distance. The central ridge separates the east from the west branch of the river, and is part of the dolomite formation.

PLATE XVIII

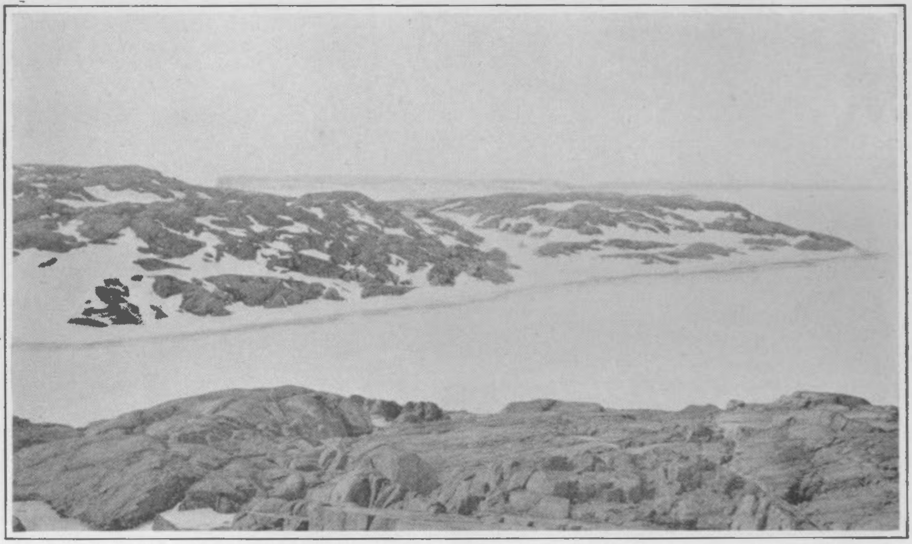


Fig. 1. Cape Barrow granites and the diabase-capped Jameson islands to the north.

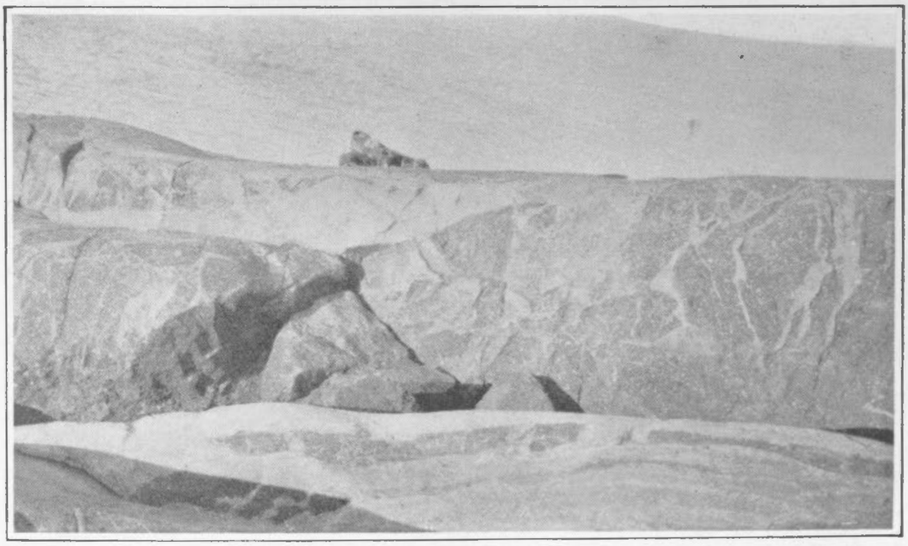


Fig. 2. Precambrian granite containing abundant inclusions; southeast end of Grays bay.

PLATE XIX

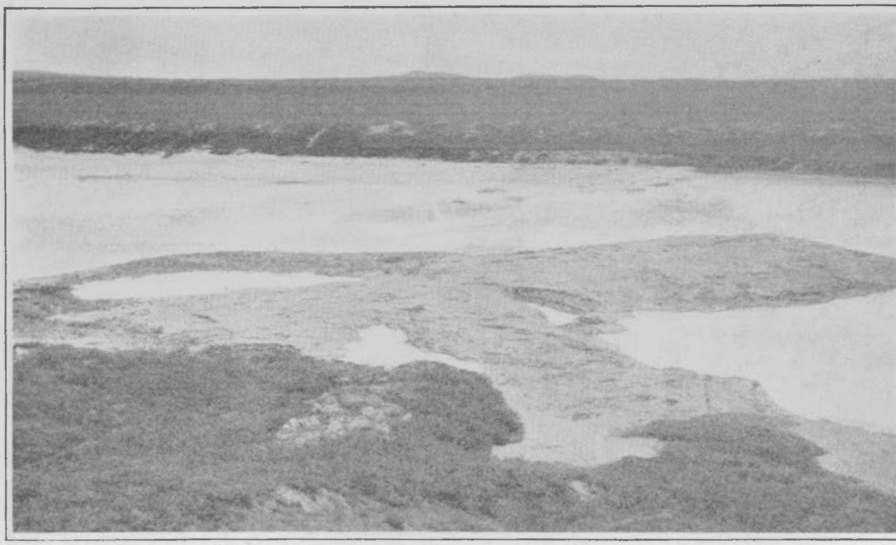


Fig. 1. Pink quartzite at first cascade on Hood river, about 6 miles from the mouth; looking east.

Fig. 2. Valley of Hood river above the first cascade; banks of marine Pleistocene silty muds; hills of granite in the distance.

PLATE XX

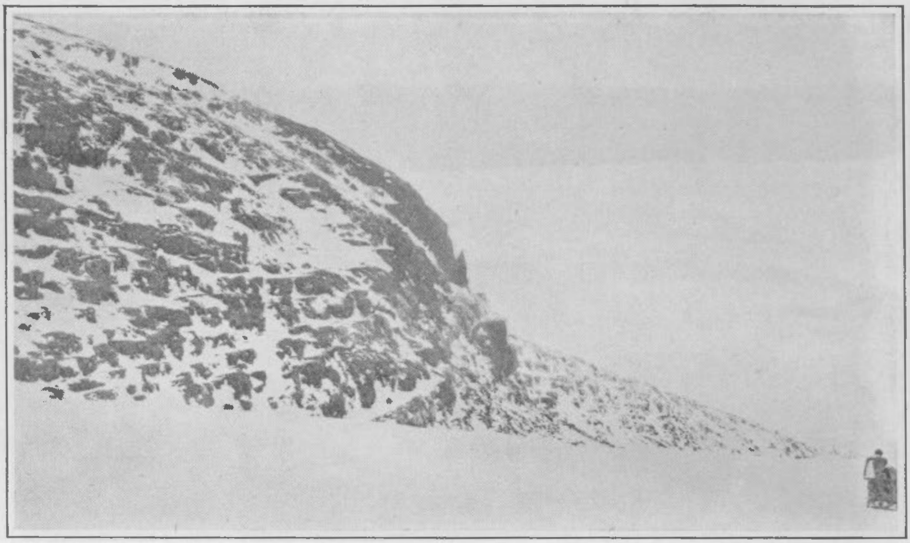


Fig. 1. Cliffs of massive Goulbourn quartzite-conglomerates and quartzites along north shore of Goulbourn peninsula.

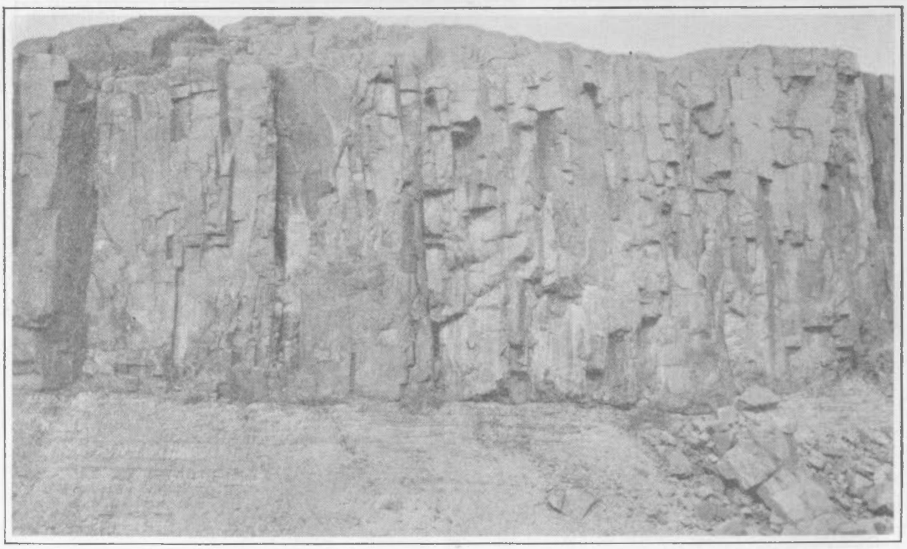


Fig. 2. Thin bedded upper part of the Goulbourn quartzite capped by sill of diabase on south side of Barry island.

PLATE XXI

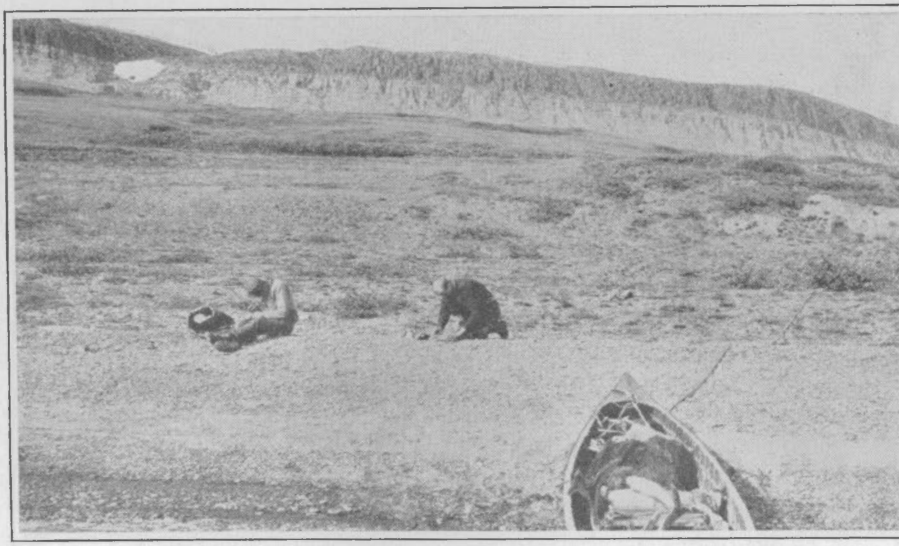


Fig. 1. East base of Banks peninsula; cliffs of cherty dolomite overlain by amygdaloid at 850 feet above sea-level. The lower slopes are of marine Pleistocene sands and gravels.

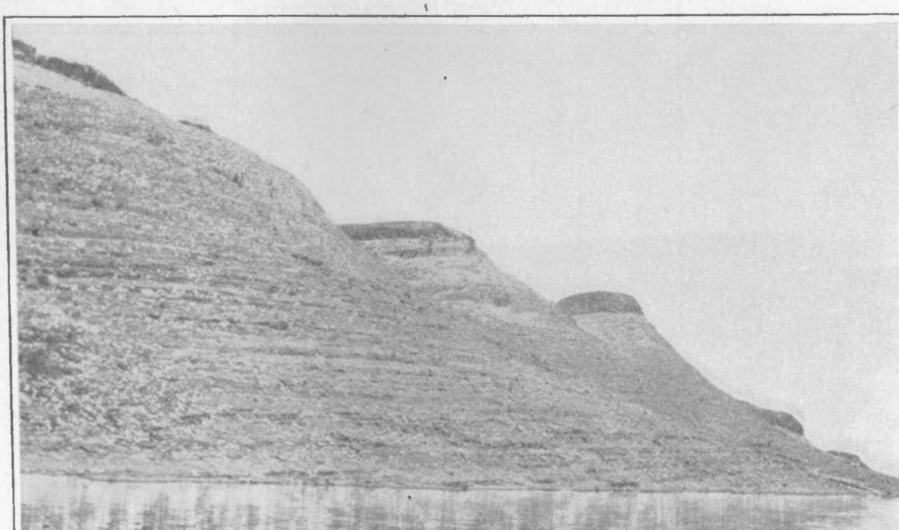


Fig. 2. Cherty dolomite capped by diabase on southeast side of Algak island; there is some replacement of the upper layers of the dolomites by chalcocite and covellite.

PLATE XXII

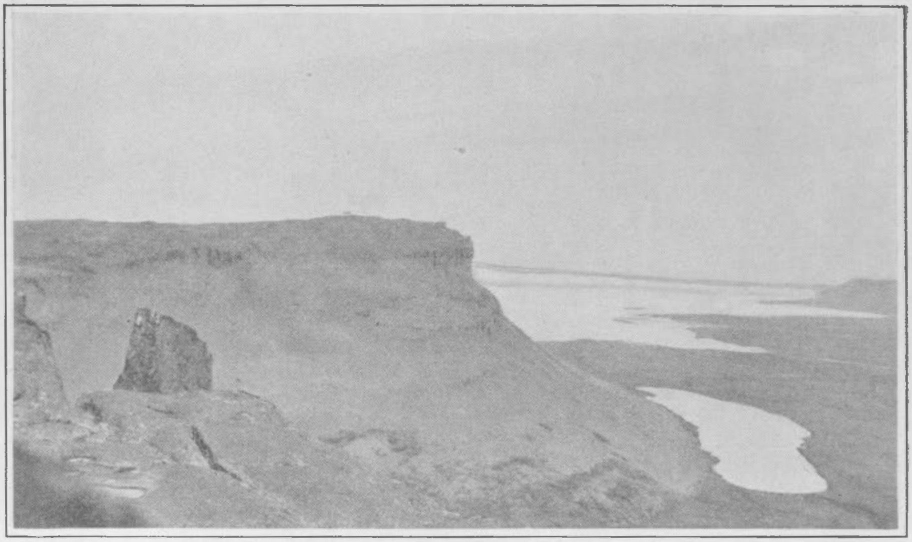


Fig. 1. Monadnock of quartzite on Barry island overlooking the amygdaloids of the central lowland; looking northeast along the coast.

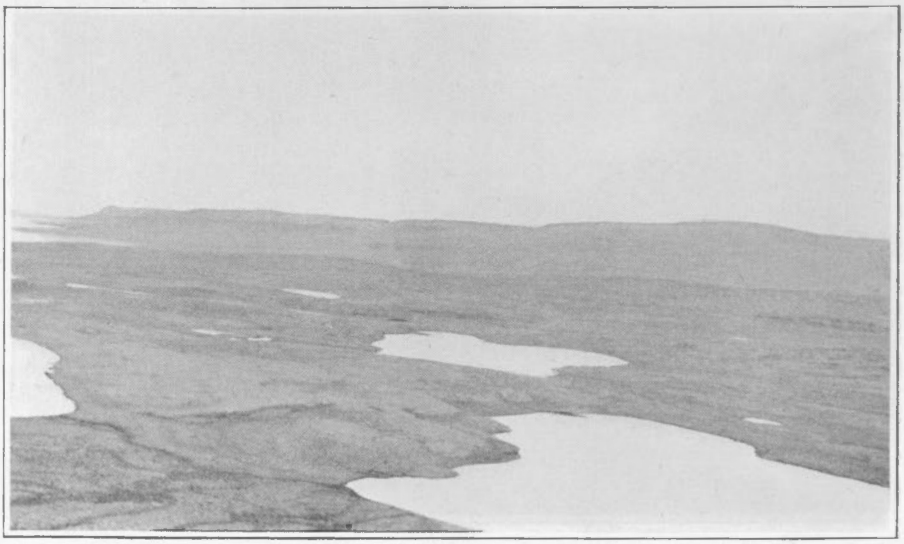


Fig. 2. Amygdaloids of the central lowland of Barry island.

PLATE XXIII

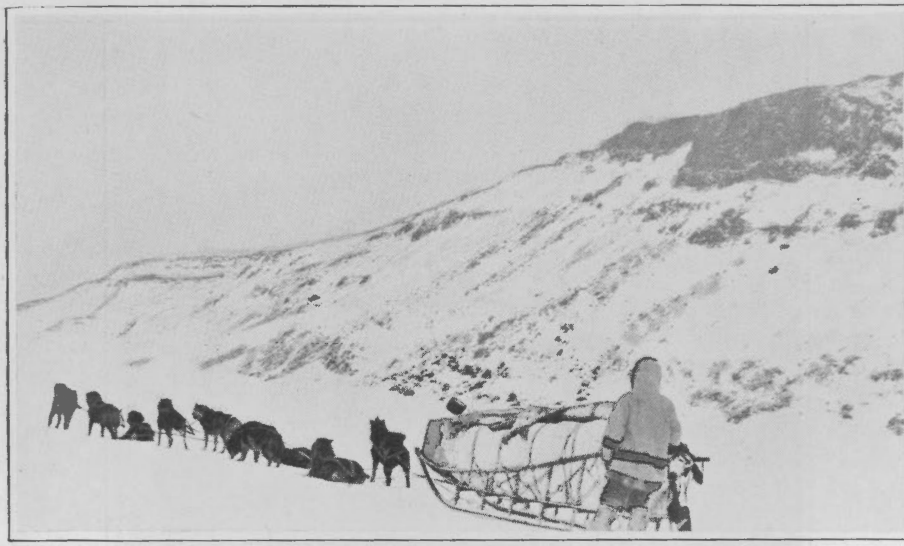


Fig. 1. Outcrops of basaltic amygdaloids along the eastern side of Barry island.

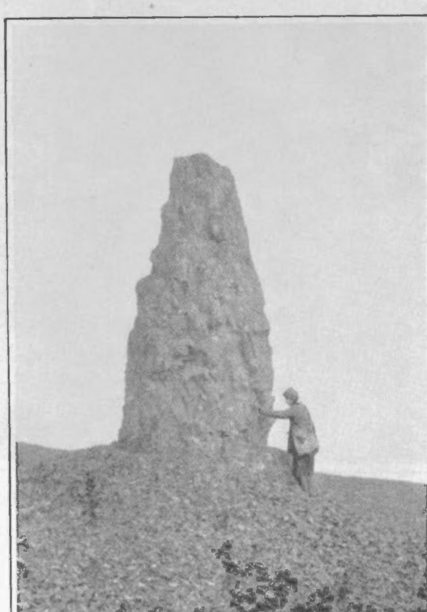


Fig. 2. Pillar of basaltic amygdaloid remaining on central lowlands of Barry island. Photo by R. M. Anderson.

PLATE XXIV

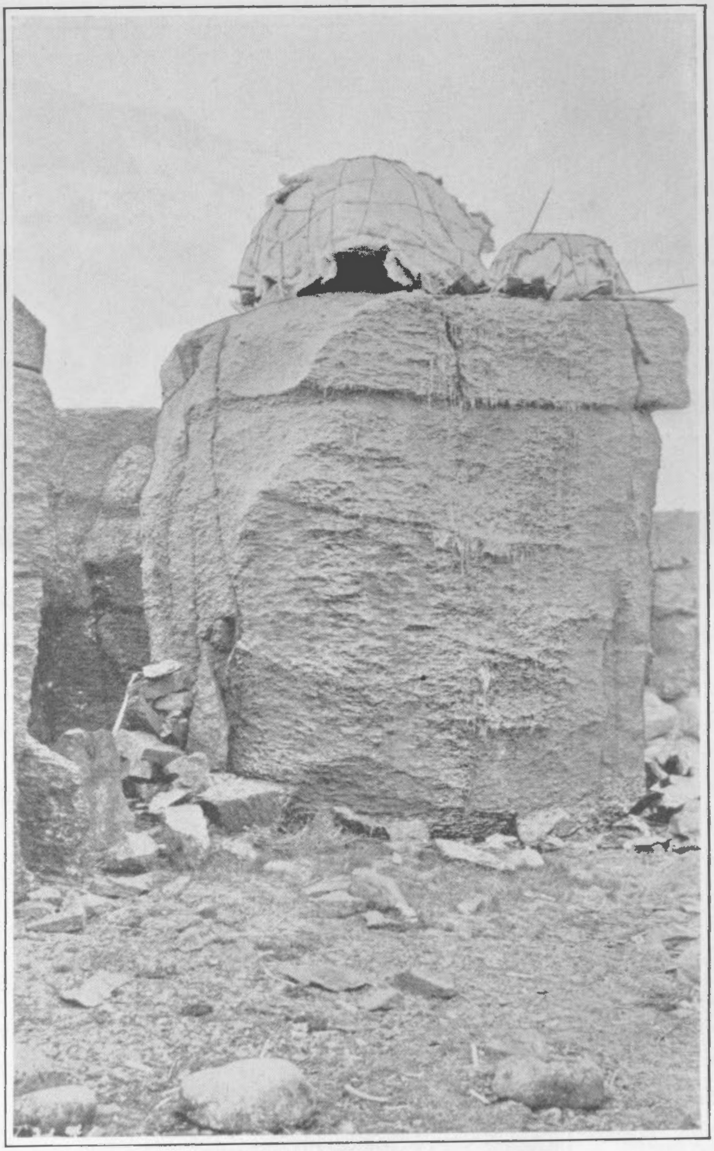


Fig. 1. Copper bearing basaltic amygdaloid at the northern end of Banks peninsula.

PLATE XXV

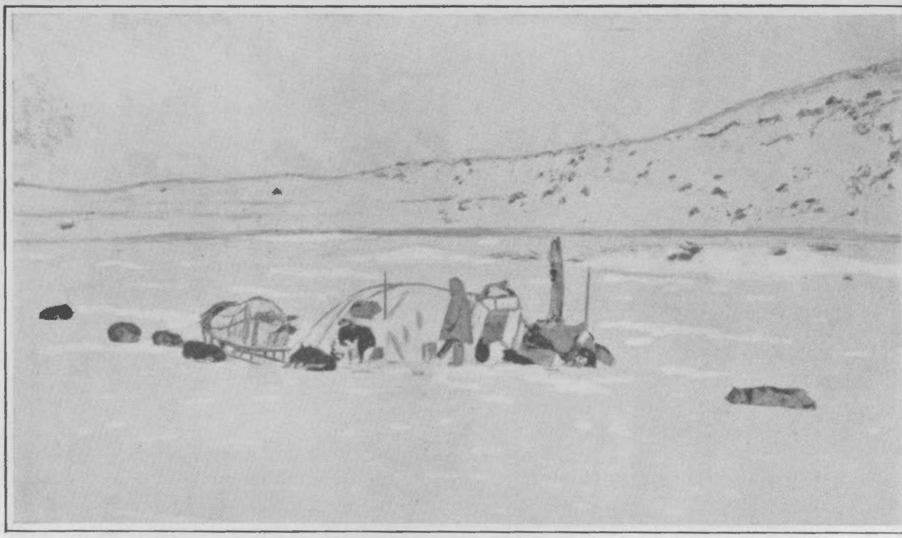


Fig. 1. Hanerotit ridge from the west, showing amygdaloids on the side of the main ridge of diabase.

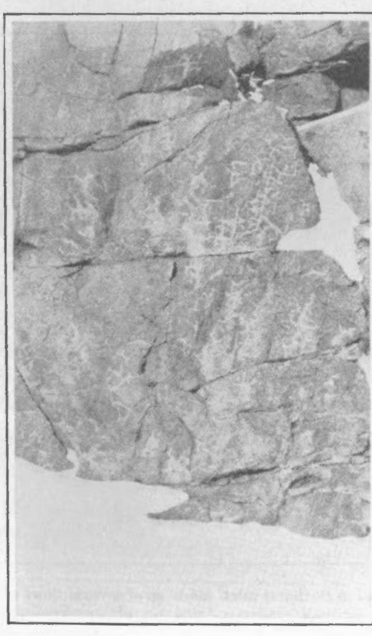


Fig. 2. Cliff of diabase on Hanerotit showing malachite stain about shatter-planes.

PLATE XXVI

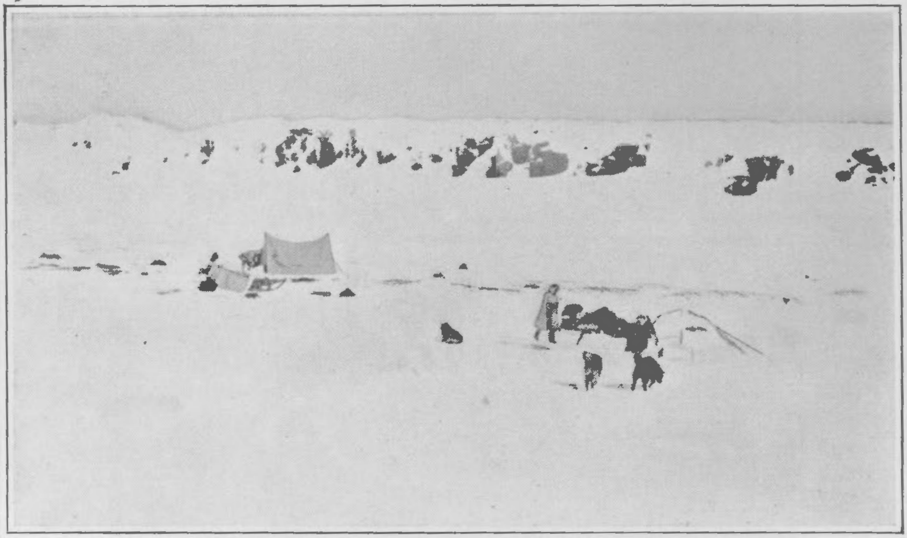


Fig. 1. Cliff of copper bearing basaltic amygdaloid on the south side of Lewes island. Bathurst inlet.

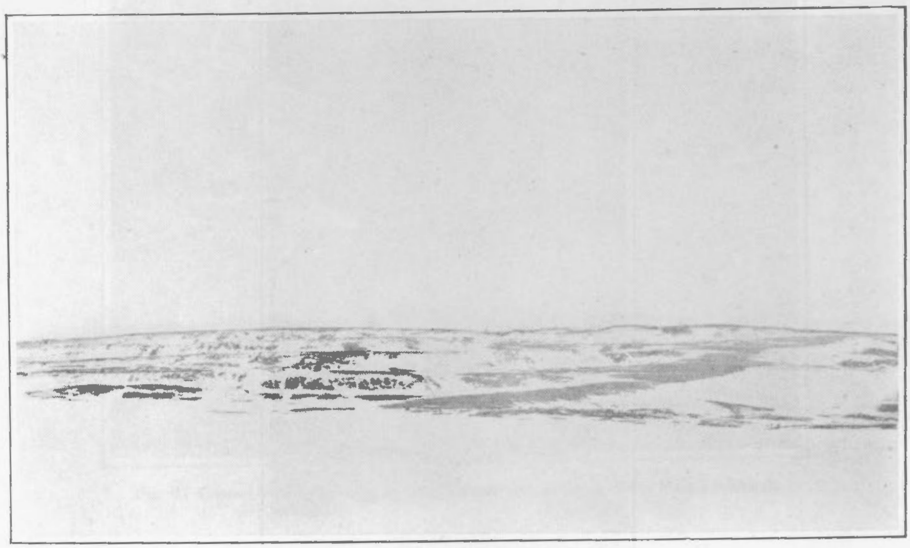


Fig. 2. Typical island in Bathurst inlet, made up of several flows of amygdaloidal basalt.

PLATE XXVII

Fig. 1. Falls over Silurian dolomite on Okauyarvik river, southwestern Victoria island (Wollaston peninsula), 2½ miles from the coast. October, 1914. Photo by D. Jenness.

Fig. 2. Diabase cutting and capping dolomite at Murray point, southern Victoria island. April, 1916. Photo by F Johansen.

PLATE XXVIII

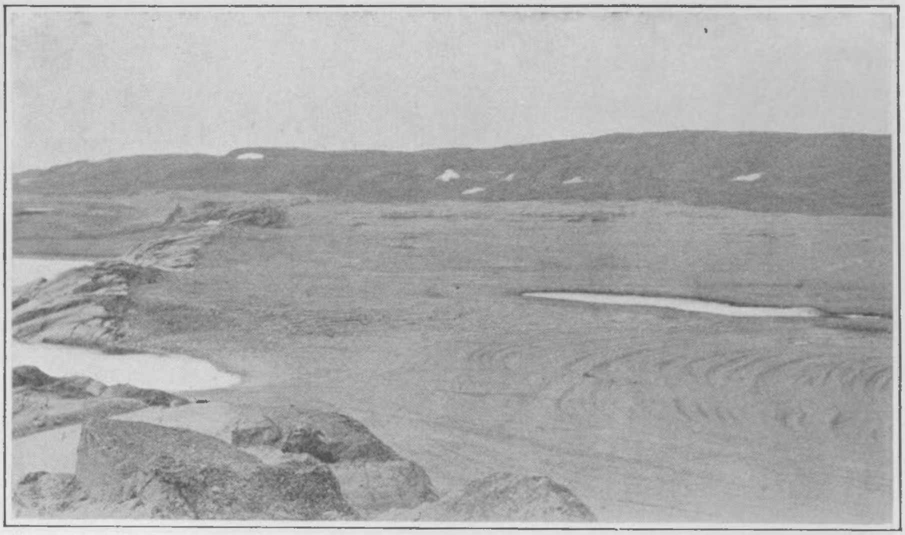


Fig. 1. West coast of Bathurst inlet near Moore bay. Hills of Precambrian granite faced by dolomite, which in turn is overlain by amygdaloids; all are cut by the diabase dyke at the left. August 18, 1915.

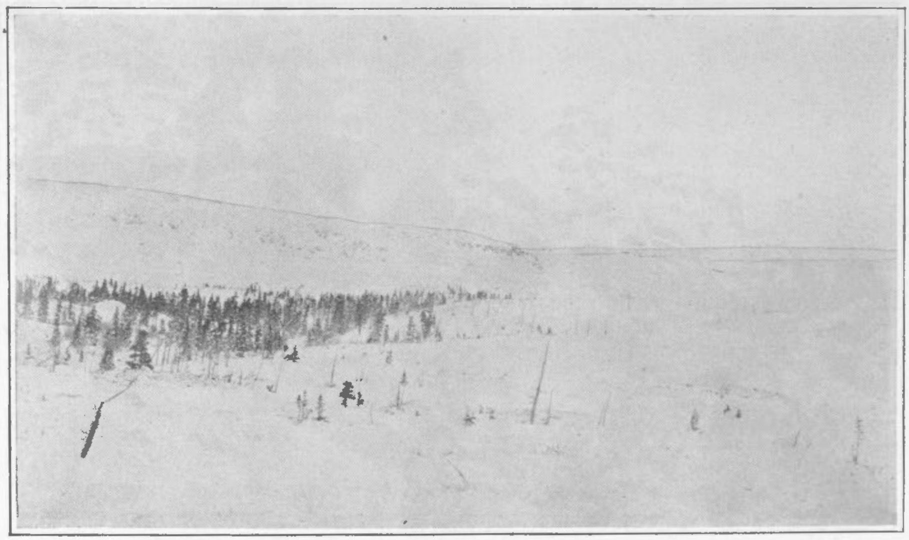


Fig. 2. General surface of the country northeast of Dismal lakes. Northern limit of trees. March 17, 1915. Photo by R. M. Anderson.

PLATE XXIX

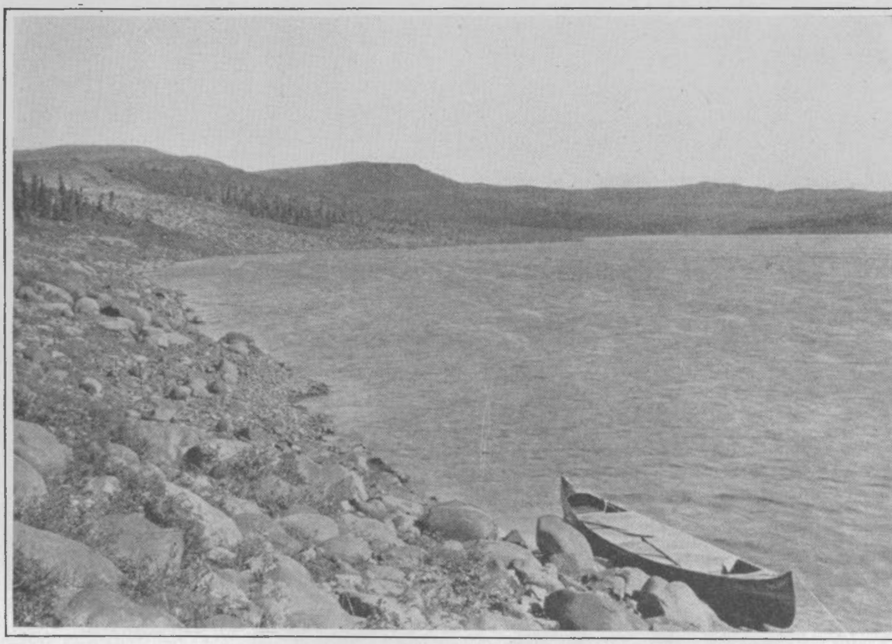


Fig. 1. View of Coppermine mountains looking north from near mouth of Kendall river. June, 1912. Photo by James Douglas.

PLATE XXX

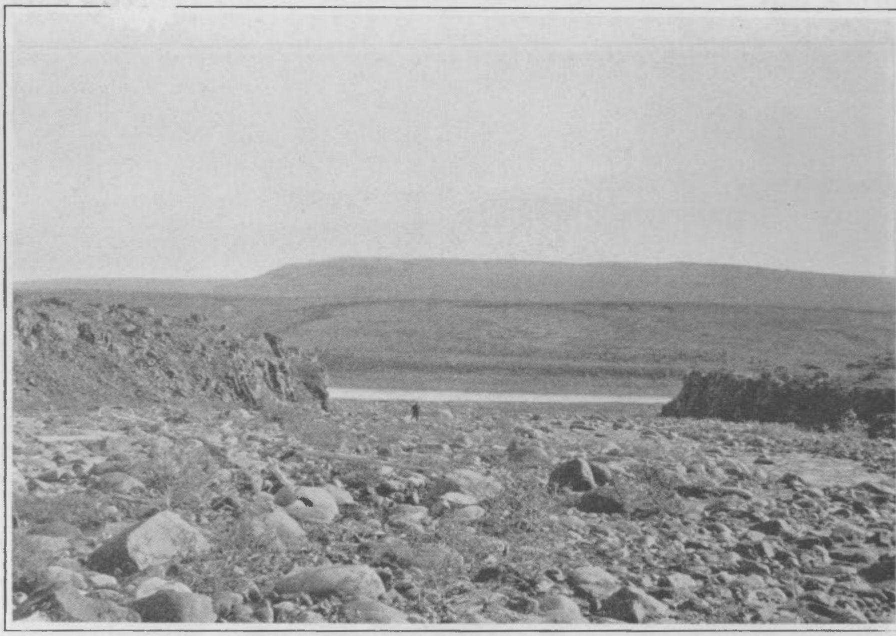


Fig. 1. Coppermine river, north of Stony creek. Hell Gate. Photo by James Douglas, 1912.

Fig. 2. Musk-ox rapid, Coppermine river. Photo by James Douglas, 1912.

PLATE XXXI

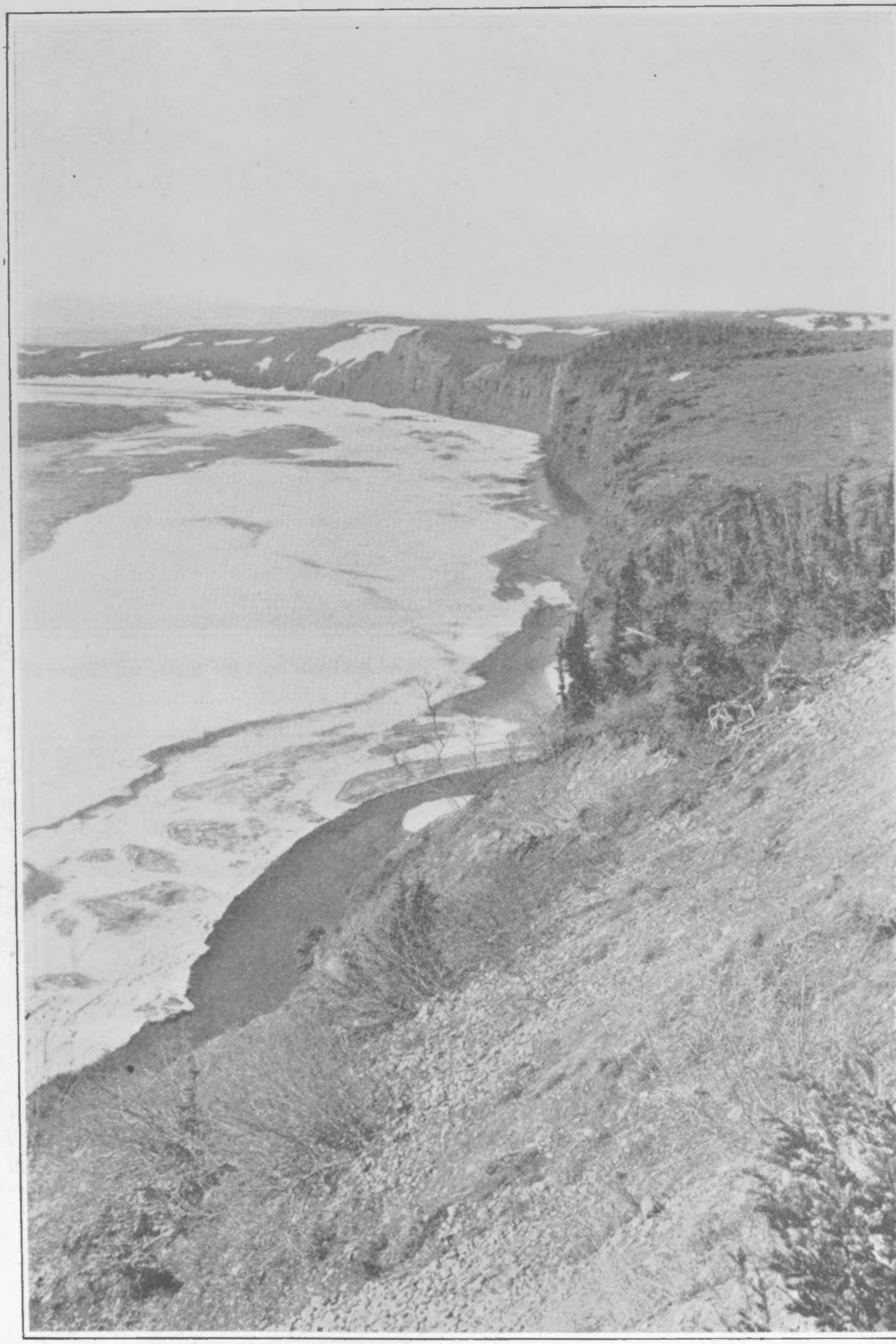


Fig. 1. Coppermine river. Character of river banks (red sandstone) above Sandstone rapid, looking south. Photo by James Douglas, 1912.

PLATE XXXII

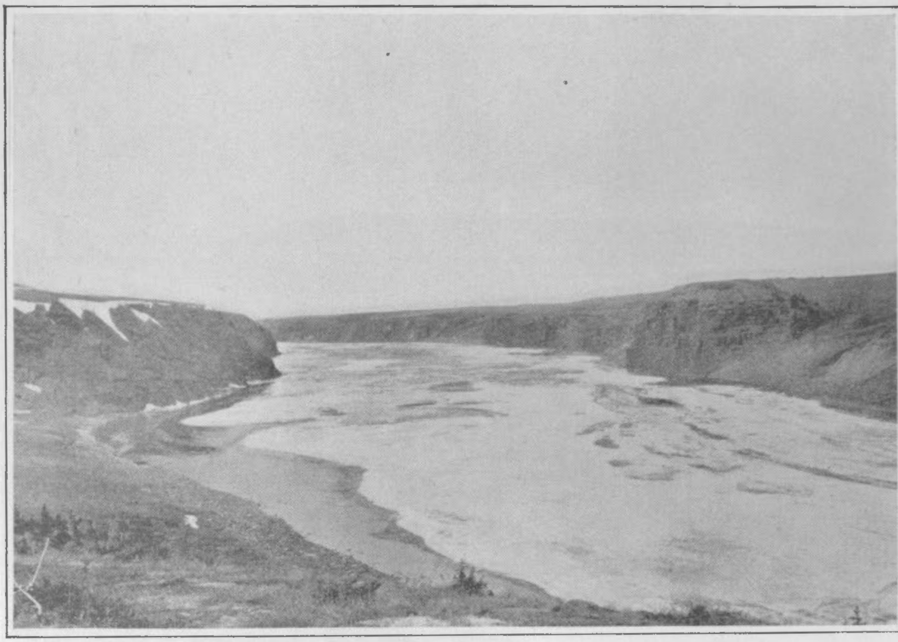


Fig. 1. Coppermine river. Characteristic sandstone banks between Sandstone rapid and Bloody fall. Photo by James Douglas, 1912.

Fig. 2. Coppermine river. Dyke of basalt, Sandstone rapid. Photo by James Douglas, 1912.

PLATE XXXIII

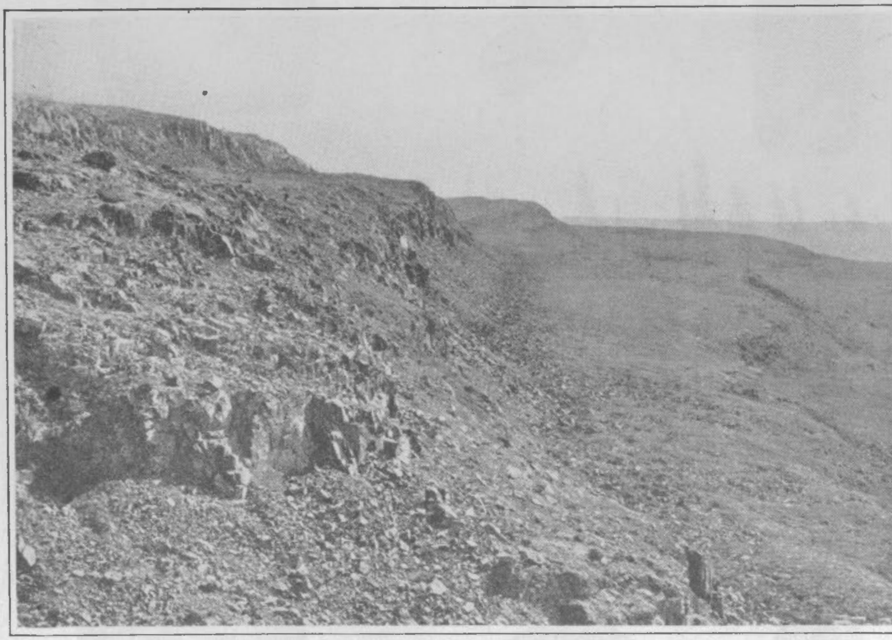


Fig. 1. Coppermine mountains. Characteristic terrace about 900 feet above river. Photo by James Douglas, 1912.

Fig. 2. Tailing dump camp, just above Bloody fall, Coppermine river, on west side of the river. Photo by James Douglas, 1912.

PLATE XXXIV

Fig. 1. Boulder bank on east shore of Coppermine river, just below Melville creek. March, 21, 1915. Photo by R. M. Anderson.

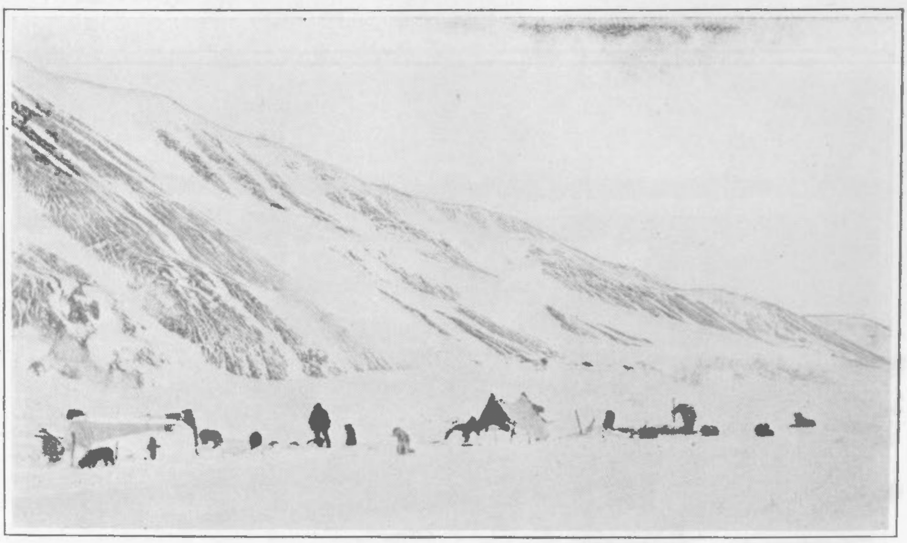
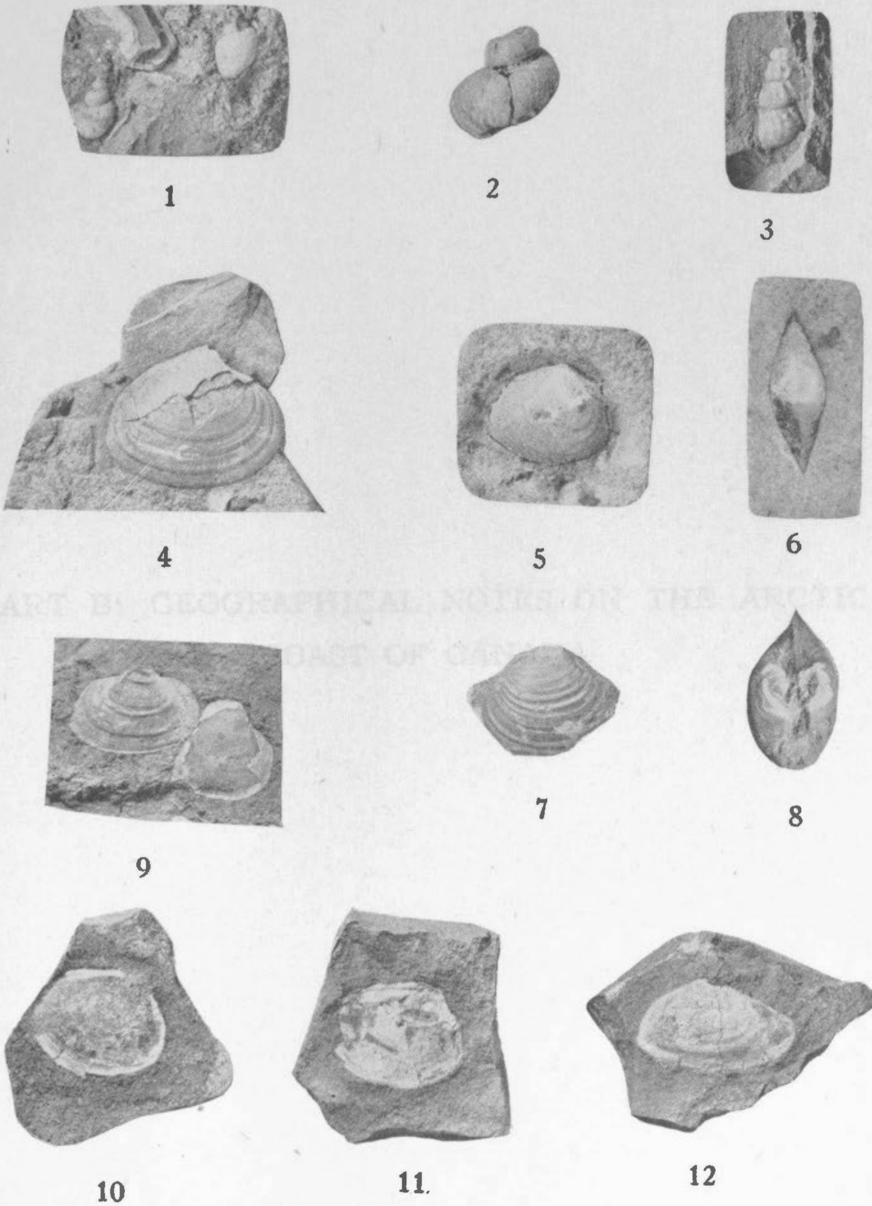


Fig. 2. Hills of silty mud cut by small stream, which enters Coppermine river a few miles above Bloody fall on the east side. February, 1916. Photo by W. V. Bruce, R.C.M.P.

PLATE XXXV



Explanation of Plate

TERTIARY FOSSILS FROM BROCK RIVER

Fig.	1.	*Lymnaea oneilli*, x 3,.................Can. Geol. Surv. Mus. No.	4339
"	2.	*Amnicola stefanssoni*, x 3............ " "	4341
"	3.	*Goniobasis borealis*, x 3.............. " "	4377
"	4.	*?Sphaerium aquilonarum*, x 2......... " "	4378
"	5–6.	*?Sphaerium gemma*, x 3.............. " "	4379
"	7–8.	*Sphaerium gemma*, x 3............. " "	4379a
"	9.	*Cymatocyclas diacis*, x 3............. " "	4380
"	10.	*Nucula johanseni*, nat. size........... " "	4381
"	11.	*Nucula johanseni*, nat. size.......... " "	4381a
"	12.	*Mactra? epidema*, nat. size.......... " "	4384

PART B: GEOGRAPHICAL NOTES ON THE ARCTIC COAST OF CANADA

GEOGRAPHICAL NOTES ON THE ARCTIC COAST OF CANADA

By Kenneth G. Chipman and John R. Cox

Issued July 8, 1924

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MAPS

GEOGRAPHICAL NOTES ON THE ARCTIC COAST OF CANADA.

By Kenneth G. Chipman and John R. Cox

CHAPTER I

Introduction

In March, 1913, the writers who were members of the Topographical Division of the Geological Survey of Canada, were asked by the Director and the Chief Topographer to undertake the geographical work in connexion with the southern party of the Canadian Arctic Expedition.

Our instructions covered the geographical mapping of the part of the Arctic coast of Canada in Coronation gulf and adjacent areas that included the copper bearing rocks. The work was to "be of a high order for this class of exploration and should mark a distinct advance over previous work. To secure such results the geological and topographical sub-parties should follow closely the regular scheme for field parties engaged on reconnaissance work adopted by the Geological Survey."

Ice conditions on the Arctic coast of Alaska in the summer of 1913 delayed the party there until the summer of 1914. The loss of this year made it necessary to confine the work to the mainland coast from Darnley bay on the west to the foot of Bathurst inlet on the east, with more intensive work on the islands in Bathurst inlet where the geologist of the Southern Party desired to make more detailed investigations.

Narrative

The members of the Southern Party travelled to Nome, Alaska, on the *Karluk*, which was the boat of the Northern Party of the Expedition, and on one of the regular passenger steamers from Seattle. For transportation from Nome, two 65-foot power boats were provided, the *Alaska* and the *Mary Sachs*. We left Nome in July, 1913, and owing to unusual ice conditions were unable to proceed during that summer beyond Collinson point, on the north coast of Alaska. That coast had been recently well mapped by Mr. E. deK. Leffingwell[1] and it was not necessary for us to undertake extensive work in that district. A map was made, however, on the scale of 1/24 000, of the harbour at Collinson point and extended inland to include 10 square miles of tundra, with 20-foot contours; and the harbour was thoroughly sounded. During the winter a series of solar, stellar and lunar observations were taken for astronomical position, variation of compass, and chronometer ratings, as well as to make us familiar with the various methods and technique of making these observations at low temperatures. A tide gauge was set up and kept in operation during a portion of the winter by Mr. Cox, and the other meteorological work, so far as we could carry it out was divided among the members of the party. (Plates XXXVI-XXXVIII.)

During our enforced stay at Collinson point as much experience as possible was gained in the modes of work and travel and the clothing, food, etc., best adapted to conditions in the Arctic, in order to be prepared for the work in the Coronation Gulf country.

In March, 1914, the writers left Collinson point by dog team for work to the east of the Canada-Alaska boundary. Five days were spent at the boundary securing a series of time observations to tie our position at Collinson point

[1] The Canning River Region, Northern Alaska, by Ernest deK. Leffingwell, Professional Paper 109, U. S. G. S., Washington, 1919.

to the boundary and to check our watch ratings. Mr. Cox made a compass and pace traverse of Firth river from the coast to near the Alaska boundary. He also mapped in the same way the Arctic coast of Canada from the Alaska boundary to the mouth of Mackenzie river

After navigation opened on the Mackenzie as much work as was possible under the conditions was carried out in the delta. The west branch was mapped and much of the middle and east branches, with a number of cut-off channels and smaller channels used in winter for sleds, or in summer for travel by whale boat. The surveys were carried through to Arctic Red river and McPherson, and astronomical positions were determined at these places as well as at several points in the delta.

The establishment of the astronomical position of the coast line from the boundary east to the mouth of Mackenzie river and inland to McPherson and Arctic Red river furnishes a tie for the work of previous explorers in the lower Mackenzie and Peel river country.

Before leaving Collinson point, in March, we agreed to meet the steamer *Mackenzie River* at McPherson, on her annual trip down the Mackenzie, to arrange for the transportation to Herschel island of mail and freight which she was bringing for us. The steamer reached McPherson on July 15 and left on her return trip the following day. We left for Herschel island on the 18th, but delays incident to freighting, weather, and ice on the coast kept our boats as well as the others from the delta, from reaching Herschel island until the morning of August 6. The *Alaska* had reached there from the west a few hours previously.

We left Herschel island on the *Alaska* on August 17, 1914, and reached a small harbour in Dolphin and Union strait on August 24. To this small harbour we gave the name Bernard since it had been first used by Captain Joseph F. Bernard, of the trading schooner *Teddy Bear,* when he wintered there in 1912-13. Bernard harbour was our headquarters for the next two years. (Plate XXXVIII, fig. 1.)

For several reasons it was considered necessary for the *Alaska* to make a return trip to Baillie island or possibly to Herschel island. She left Bernard harbour on September 6 and reached Herschel island without difficulty, but when on her way east again was forced to go into winter quarters at Baillie island. There remained at Bernard harbour five members of the scientific staff and an Eskimo boy. We were so short handed that the autumn months were necessarily spent in building a house and shed, securing meat for ourselves and twenty-one dogs, and in getting everything ready for the winter. We were unable to undertake any geographical work along the coast, for the freeze-up was late and not until the middle of November was travel along the coast practicable. At that time of year the days are so short, the light so poor, and storms so frequent, that work at any distance from the base is not feasible.

The best season for geographical work along the Arctic coast is from March until June. Consequently, it was the following spring (1915) before we could undertake any extensive geographical work along the coast. Mr. Chipman, in company with Mr. O'Neill then went west about 250 miles to the foot of Darnley bay and worked back along the coast, making short trips inland where advisable from a geological view point. Mr. Cox worked east from Bernard harbour to the mouth of Rae river, up that river to its source, and thence overland to the foot of Stapylton bay. The two parties met at Young point and Mr. Cox carried the mapping east from there to Bernard harbour.

After the two parties had returned to Bernard harbour, sled travel over the ice was still good; so, on June 9, Mr. Cox and Mr. O'Neill went east, planning to go over the ice from cape Krusenstern to the mouth of Tree river. From there they intended to work inland as advisable and, when navigation opened, to continue along the coast to cape Barrow where they were to wait for the *North Star*. For the work along the coast they were provided with an Alaskan 30-foot umiak which had been fitted with an Evinrude motor.

The *North Star* was unable to get out of Bernard harbour until August 9 and then had much difficulty with the ice until she was out of Dolphin and Union strait, on August 10. On the 12th the *North Star* reached cape Barrow and left Mr. R. M. Anderson and Mr. Chipman there with Mr. Cox and Mr. O'Neill. With a 20-foot launch and the umiak with Evinrude attachment, work was then started and carried eastward from cape Barrow into Bathurst inlet and among the islands there, until it was necessary to start back in order to reach Bernard harbour, if possible, before the freeze-up. We reached port Epworth late in the evening of September 30 and were forced to wait there for the freeze-up.

Mr. Cox and Mr. O'Neill had left their sled and dogs at port Epworth in care of the Eskimos, and using these, we started on October 27, when the ice of Coronation gulf was strong enough for sled travel and reached Bernard harbour on November 9.

Field work was resumed early in March (1916), when Mr. Chipman went west to Croker river in order to map the river and secure a geological section for Mr. O'Neill. Messrs. Cox and O'Neill left Bernard harbour about the middle of March and spent the spring in work among the islands of Bathurst inlet, where a special study of the copper bearing rocks was required. After mapping Croker river Mr. Chipman spent the balance of the spring in completing the coast line from the mouth of Rae river to cape Barrow. Leaving the mouth of Coppermine river on June 1st he came out to civilization overland, *via* Coppermine river to Fort Norman on Mackenzie river. Ottawa was reached on September 2. Mr. Cox returned to Bernard harbour and came out with the others of the Southern Party on the *Alaska, via* Herschel island and Nome.

Methods of Survey

All map construction is based on a system of control usually expressed by the latitude and longitude of a number of points. For ordinary mapping in areas in which civilization is established, this control is best, and is usually, secured by triangulation from known positions. In the Arctic there are few accurately known positions and triangulation is usually not feasible. The latitude and longitude of the control points therefore, must be independently secured.

Latitude observations are comparatively simple and the method usually used is the circummeridian altitude of the sun, or some star, commonly Polaris. The latitude depends solely on the observed altitude so that the accuracy of the determination depends on the accuracy of the instrument and the skill and care of the observer.

Accurate longitude determinations are complicated by the necessity of having Greenwich Mean Time (commonly abbreviated to G.M.T.) which must be transferred by chronometers. Longitude is the distance east or west of Greenwich expressed in time or arc. Local Mean Time is readily secured by observation and the difference between it and Greenwich Mean Time is the longitude. The necessary and difficult thing is to have accurate Greenwich Mean Time. Longitude may be directly determined by occultation of a star, or by moon culminations; but neither of these methods is comparable in accuracy to longitude by the correct transfer of time. Furthermore, occultations are not always observable with the instruments usually used. With an ordinary surveyors' transit, stars with a less magnitude than about 3 are not clearly visible for such an observation. In the winter 1913-14 which we spent on the Alaskan coast, a series of perhaps a dozen occultations were visible each month during the winter; whereas, during the two following winters none could be secured. Usually, several occultations of the stars in one constellation occur on the same night, and if the sky is cloudy the whole opportunity is lost. Moon culminations give unsatisfactory results and that method is rarely used now although it was the most common method of early explorers.

When starting out to map our area, the first essential was to establish the position of some point in the area. The natural choice for such a position was our base, or headquarters, to which we went first in the country, and from which we carried on our work. This base was also the point from which we could most readily check back our position. The triangulation points on the Arctic coast of the Canada-Alaska Boundary Survey furnished us with a very convenient basis from which to transfer the geographical position. Having established the position of Bernard harbour, all work during the two years was referred to it, and at the end of that time, the position of the harbour was checked back to the boundary.

The accurate transfer of G.M.T. being the most important element in the transfer of the geographical position every precaution was taken to know the exact rate of the chronometers, and to ensure that, so far as possible, the rate during the transfer was carefully preserved. For good results the chronometers should be carefully rated before and after the transfer and there should be several instruments with dependable ratings so that the mean may be taken. The rating of the chronometers consists in observing for Local Mean Time (commonly abbreviated to L.M.T.) at the same place, with an interval of several days between the observations. The longitude of the place must be approximately known in order to correct the right ascension and declination. If the rate of the chronometers were zero, the difference between the chronometer time and L.M.T. would be the same on different days; the change in this difference divided by the number of days gives the rate. The observations must be several days apart in order to give a good mean rating.

The object in using chronometers is to carry G.M.T. Having rated them at a known point, and knowing their error on G.M.T., it is simple to calculate the G.M.T. on any given day. An observation is made for L.M.T. and the difference between this and G.M.T. is the longitude. The rating, however, must be checked by further observations and adjustment of the position made if necessary. The rate should be checked regularly at the base, and at every opportunity when away from the base, and a record kept.

The longitude of Bernard harbour was determined by chronometer difference and time observations on east and west stars at approximately the same altitude. An 8″ Berger transit was used for these observations. East and west stars were also used for chronometer ratings at the base. When we were away from the base it was usually more convenient to use the sun than stars and most of our positions along the coast were determined by sun observations. When away from the base we were usually forced to travel, going and coming, along the same coast, and ratings were secured by observing for L.M.T. at the same points when going and coming. Watches were also rated during the entire time we were away and at the beginning and end of whatever work we were doing. It was necessary to check up ratings whenever and wherever possible, for, often, the rates were found to change without apparent reason. When travelling along the coast the usual method of observing for time was used, *i.e.*, time by the altitude of the sun, a series being observed and the mean taken.

The latitude of Bernard harbour was determined by several series of altitudes of Polaris at culmination. When travelling, the usual method was by circummeridian altitudes of the sun, or by a single meridian altitude.

Declination in the area varied more than 10 degrees (45° to 56° E.) and was usually determined by the sun. When using a transit this observation could be taken at any time in connexion with L.M.T.; but when using a sextant the compass direction of the sun when on the meridian was observed. (Plate XXXVII, fig. 2.)

The latitude and longitude of points every 50 miles—in most cases much less—was established. Between these points the detail was filled in either by compass and pace traverse or by compass and boat-log. Most of the filling in was done in the season between early March and June and consequently was done by pacing and compass. The shore line was everywhere carefully followed.

For the detailed map of Bernard harbour, plane-table and stadia was used. Soundings were made by Mr. F. Johansen and were taken through the young ice in the fall. This map was controlled by a local triangulation.

For the map of the Mackenzie delta, part of the traversing was done by pace-compass, in the season between March and June when travel was by sled, and the balance by compass and boat log after the ice went out. On this map it was necessary to increase greatly the number of control positions in order to be able to take into account the effect of the current on the boat log.

During the winters all observations were computed and the positions plotted on a polyconic projection. This projection was plotted on a scale of ten miles to one inch and was developed on the backs of 10″ by 12″ protractor plotting sheets in order to keep the work in units of convenient size. All work was plotted in statute miles, and unless otherwise stated, statute miles are used throughout this report. All traverses were plotted and adjusted to the fixed positions.

On our return to Ottawa final computations and adjustments were made and the work assembled in one manuscript, from which the accompanying map has been prepared.

Notes on Observing at Low Temperatures

Making observations at low temperatures involves a somewhat special technique, and a few brief notes on our experiences may be of benefit to others who may have to undertake similar work. Our experience included observations at temperatures down to $-44°$ F.

Lubricating oil thickens in the cold, and if it is used the instruments will either work stiffly or not at all. For use at low temperatures therefore, instruments must be completely taken to pieces and all oil thoroughly cleaned off. At these temperatures kerosene oil will not evaporate appreciably and a little may be rubbed with a feather on the bearing surfaces. If powdered graphite of sufficient fineness can be obtained it is an excellent lubricant and, of course, will not thicken. Unoiled surfaces are liable to corrosion and during the warmer months the instruments should be oiled to guard against this.

This treatment applies to such things as gun springs as well as to instruments. Parts of the gun mechanism that are not easily gotten at may be soaked in gasoline to remove the oil.

The alternate heat and cold in the field usage of Brunton compasses spoiled the silvering on the backs of the mirrors. Frost seemed to get behind the glass and crack and peel off the silvering. To keep the compass as far as possible at a uniform temperature seems to be the only way to overcome this difficulty.

Instruments should be equipped with cross-hairs ruled on glass rather than spiders' webs which break or buckle in the cold. Manipulation of the instruments is necessarily with the bare fingers, and all parts which have to be touched should be wrapped with surgeon's tape.

An observatory of some sort is a necessity, principally to protect the observer from the wind. A square or round snow-wall is simply and easily constructed and the materials are readily available. At Collinson point our snow-house was 7′ by 7′ inside and about 5½′ high—just high enough to act as a windbreak. The door was to the south where the azimuth mark was to be, and also because the prevailing winds were east and west and the snow would blow past the door. A log just high enough for comfortable observation at the instrument was put in the centre and frozen down with snow and water. On top of this the tripod head was placed and frozen to the log. (Plate XXXVII, fig. 1.)

At Bernard harbour the natives built for us a round house. This was built with very little labour, but it did not stand up as well as the more heavily constructed square house. Neither kind will collect snow during the storms of winter.

In both cases the instrument was fastened to the tripod head and left out all winter, with simply a cover over it. It was thus adjusted to the position and to the cold and was ready for use at any time. Adjustment to the cold is a big factor at low temperatures.

When observations are to be made at night, the instrument should be tested during the day to see that it is in adjustment and working readily. If this is done there will be little delay at the time of observation. The discomfort of making observations at temperatures of 20 to 40 degrees below zero, F., can be greatly lessened if one is warmly dressed and all unnecessary delays are eliminated. Some observations can be prepared for in advance. For instance, if Polaris is to be observed for latitude, the approximate elevation may be calculated during the day in the warm house and the instrument set both in altitude and azimuth so that at the time of the observation the star will appear in the field of the telescope. If meridian passage of stars is to be observed, the instrument may be set on the meridian during the day.

Clothing should be warm and the person should be well warmed up before going out to observe. The feet should be especially well protected. The most satisfactory covering for the hands is a pair of fingerless mittens which come well up on the arms. These cover the wrist and upper hand and thus afford a certain amount of protection while leaving the fingers uncovered. A pair of large and heavily furred caribou skin mittens with the fur inside, should be hung around the neck so that the hands may be easily thrust into them. If the hands are cold it is difficult to make neat entries in a notebook and we found it more satisfactory to record the observations on a large scratch pad, or on a sheet of paper fastened to a board, and later to copy the data into a book.

Perhaps the greatest of all difficulties is that due to the lenses fogging and freezing. The breath must be kept very carefully from all lenses and care must be taken to hold a bare and warm hand over a lens rather than under it, as the moisture rising from the hand condenses on the lens. A little experience and care will overcome this difficulty.

Previous Exploration

Of the area mapped in detail by the present writers, the part east of Coppermine river was first mapped by Captain (afterwards Sir John) Franklin, in 1821; the part west of the Coppermine by Doctor (afterwards Sir John) Richardson and Lieutenant E. N. Kendall, R.N., in the *Dolphin* and *Union*, in 1826; and several later expeditions have made corrections and additions.

Samuel Hearne.—The first visit of a white man to this part of the Arctic coast was that made by Samuel Hearne in 1771. Leaving Fort Prince of Wales (now Churchill) on December 7, 1770, he reached Coppermine river near Sandstone rapids on July 14, 1771, and on the 17th continued his survey to the mouth of the river.[1] Of his geographical position at the mouth of the Coppermine river, Hearne says (p. 163, Dublin edition): "I did not think it worth while to wait for fair weather to determine the latitude exactly by an observation; but by the extraordinary care I took in observing the courses and distances when I walked from Congecathawhachaga where I had two good observations, the latitude may be depended upon within 20 miles at the utmost." His map, facing page 164, gives the mouth of the river as, latitude, 71°-54′ N., longitude 120°-30′ W. The position as determined by us was latitude 67°-50 N. and longitude 115°-06′ W. Hearne's position is far to the west and north of the true location.

This error is due largely to the overestimation of distances which is apparent and easy to account for when one considers the conditions under which he travelled. He says on page 164 that he first came to the Coppermine "about

[1]A Journey from Prince of Wales Fort in Hudson's Bay to the Northern Ocean undertaken by order of the Hudson's Bay Company for the Discovery of Copper Mines, A Northwest Passage, etc., in the years 1769, 1770, 1771, and 1772, by Samuel Hearne, Dublin, 1796; or New Edition with Introduction, Notes and Illustrations by J. B. Tyrrell, M.A., Toronto, The Champlain Society, 1911.

40 miles from the mouth." This place appears to have been in the vicinity of Sandstone rapids[1] and is about 28 miles from the mouth of the river. Again, on page 164 he refers to the most northerly clump of trees on the river as "about 30 miles from the mouth." This is actually 17 miles. Also (page 162) he says that the sea was 8 miles from Bloody fall, whereas it is only 7 miles.

Little mention is made of the use of the compass and it is evident that Hearne took little care in correcting for local attraction, or change in magnetic declination. This factor together with the over-estimation of distances would throw his position by dead reckoning far to the north and west of his true position. It should be remembered, also, that his scientific equipment was very inadequate, his only instrument for observations being "an old Elton quadrant which had been upwards of thirty years at the Fort." (Preface p. v). Hearne's trip was a most remarkable and wonderful one, but the greatest value of his results is other than geographical.

Sir John Franklin,—Franklin's expedition of 1819-22 was equipped by His Majesty's Government, "to explore the northern coast of America, from the mouth of the Coppermine river to the eastward." Accompanying Franklin were, Doctor John Richardson, a surgeon in the Royal Navy, Mr. George Back, and Mr. Robert Hood, two Admiralty midshipmen. Leaving England on May 23, 1819, they arrived at York Factory, Hudson Bay, on August 30. The following winter was spent at Cumberland House on the Saskatchewan, and the next summer the journey was continued to Fort Enterprise, 175 miles north of Great Slave lake, where winter quarters were established. From Fort Enterprise, in the spring of 1821, the canoes and baggage were dragged over the snow and ice for 117 miles and the canoes launched on Coppermine river on July 1 a few miles below Red Rock lake. The mouth of the Coppermine was reached on July 18.

On July 21, they started eastward from the mouth of the Coppermine and mapped the coast as far as point Turnagain, from the vicinity of which they turned back on August 22. Franklin states that although point Turnagain is only some 175 miles east of the Coppermine, they sailed 640 miles in following the deeply indented coast. From the mouth of Hood river the party travelled overland and reached Fort Enterprise on October 12, and Old Fort Providence and provisions on December 11. The return trip was full of hardships and many died on the way.[2]

In Appendix No. IV of Franklin's book, p. 638, is given the following list of positions:—

Place	Latitude North			Longitude West			Variation East		
	°	′	″	°	′	″	°	′	″
Mouth Coppermine	67	47	50	115	36	49	46	25	52
Port Epworth	67	42	15	112	30	00	47	37	42
Detention Harbour	67	53	45	110	41	20	40	49	00
Galena Point	67	53	12						
On west side Arctic Sound	67	30	12						
Lower Rapid in Hood's river	67	19	23	109	44	30	41	43	22
A point near to Pt. Turnagain	68	15	50	110	05	15*	44	15	46

*On the return to Hood's river the chronometers were found to have altered their rates considerably after our departure from Arctic Sound, giving the longitude too far west; and in consequence of this change the coast from Bathurst's Inlet to Point Turnagain by the course and distance daily given, and the spot, is placed in Longitude 109–25–00.

With regard to his sextant he says (page 632):—

We found the errors of the sextant materially changed, that the glasses had lost their parallelism, and the graduated arches of the sextants were warped, owing to the contraction of the brass during the intense frosts of the winter.

When the results of Franklin are compared with ours the striking difference is in longitude. His position at the mouth of the Coppermine river is 30′ (13·1 statute miles) west of ours. At Detention harbour his position is 39′ (16·9 miles) west, and in Bathurst inlet this has increased to 47′ (20·7 miles). Between

[1]Narrative of Discoveries, Thomas Simpson, p. 261.

[2]Narrative of A Journey to the Shores of the Polar Sea, in the years 1819, 20, 21 and 22. John Franklin, Captain R.N. London 1823, p. 387.

the Coppermine and Hood river he had no opportunity to test the rate of his chronometers, and it would seem that the rate was then changing—as he afterward found to be the case—and his positions are consequently too far west.

In latitude his positions are very little different from ours. Such differences as there are may be accounted for, in part at least, by the difficulty of knowing just where his observations were made. For example, at Port Epworth we found the island at the mouth of the harbour to be in latitude 67°-46′-05″, and the mouth of Tree river at the south end of the harbour to be in 67°-41′-10″. Franklin gives the latitude of port Epworth as 67°-42′-15″ and does not state in what part of the harbour his observation was taken. Some part of the difference may be due to the instruments, but, aside from the above note, there is no data on which to account for such difference.

Franklin, Sir John—Second Expedition.—Richardson and Kendall.—In 1823, Captain Franklin placed before His Majesty's Government "a plan for an expedition overland to the mouth of the Mackenzie river, and thence, by sea, to the northwestern extremity of America, with the combined object, also, of surveying the coast between the Mackenzie and Coppermine rivers." Lieutenant George Back was appointed to accompany Franklin, as well as Dr. John Richardson and Mr. E. N. Kendall, Admiralty Mate, the latter two undertaking the survey of the coast between the Mackenzie and Coppermine rivers.

Three light boats with men and stores were despatched from England to York Factory in June, 1824, and the officers of the expedition left England in February, 1825, and proceeded by way of New York and Canada. The parties were united in June, 1825, on the Methye river and together proceeded down the Mackenzie. Winter quarters were established at Fort Franklin at the west end of Great Bear lake.

Leaving Fort Franklin in June, 1826, the two parties travelled together as far as point Separation, at the head of the Mackenzie Delta, where they separated on July 4. Franklin and Back, in the two boats, *Lion* and *Reliance*, followed the west channel of the delta, while Richardson and Kendall, in the *Dolphin* and *Union*, took the east channel.

Travelling down the east channel and along the coast, cape Parry was reached on July 23 and the mouth of Coppermine river on August 8. The boats were left at Bloody fall and the party went overland to Great Bear lake where they were met and taken by boat to Fort Franklin.

It has been pointed out that the mouth of Coppermine river as determined by Franklin in 1821 was 13·1 miles west of its position as determined by us, and that as he went east his error increased and placed his positions more and more to the west. The positions of Richardson and Kendall in 1826 are all east of ours. The map prepared by Franklin's Second Expedition covers the Arctic coast from Return reef in Alaska to the mouth of the Coppermine and affords an opportunity to make a more comprehensive comparison.

TABLE SHOWING MAP LOCATIONS, FRANKLIN'S SECOND EXPEDITION AS COMPARED WITH RECENT INFORMATION

Location	Authority	Latitude N.	Diff. in statute miles	Longitude W.	Diff. in statute miles
Mouth Clarence river	Franklin	69-36	....	140-43	....
	Bound. Sur.	69-38	− 2·3	140-50	− 2·8
Arctic Red river	Franklin	67-26	....	133-29	....
	C.A.E.	67-27	− 1·15	133-46	− 7·2
Cape Bathurst	Franklin	70-36	....	127-40	....
	C.A.E.	70-35	+ 1·15	128-05	− 9·7
Cape Parry	Franklin	70-05	....	123-34	....
	C.A.E.	70-05	± 0·00	124-37	− 24·9
Cape Lyon	Franklin	69-46	....	122-51	....
	C.A.E.	69-46	± 0·00	123-08	− 6·8
Between points Tinney and Croker	Franklin	69-17	....	119-28	....
	C.A.E.	69-19	− 2·3	119-38	− 4·1
Mouth Coppermine river	Franklin	67-48	....	115-36	....
	C.A.E.	67-50	− 2·3	115-06	+ 13·1

Regarding the instrumental equipment of Richardson and Kendall, Franklin says:—

[1]The only cause of regret I had respecting the equipment of the eastern party was my being unable to provide Dr. Richardson with a chronometer, the main-springs of two out of three chronometers furnished to us having been broken. I borrowed however, from Mr. Dease, a watch, made by Barraud, to enable Mr. Kendall to obtain the longitudes by lunar distances. They were likewise provided with that excellent instrument, Massey's Log; and knowing Mr. Kendall's intimate acquaintance with marine surveying, I had no doubt of his being able to make a correct survey of the coast.

In July, on this part of the coast, daylight is continuous and lunar observations are not easy to obtain. Richardson and Kendall give a few longitudes (see Appendix, p. cxxxiv), but they evidently relied mostly on the boat log and computed the positions by dead reckoning.

The error in the position of cape Parry is not easy to account for. One longitude position is given on the west side near the tip of the cape, and two on the east side. Richardson and Kendall sailed well down into both Franklin and Darnley bays and it would seem that they must have realized that the distance across Darnley bay is greater than they have shown it to be. The apparent discrepancy was noticed by members of the Canadian Arctic Expedition when they first crossed the bay. There is nothing in Franklin's account of the voyage which would indicate how the error occurred.

Nor is there any explanation of the loss of 17·2 miles between the observed position of a point between Tinney point and Croker river, and Coppermine river. Of their tie to the Coppermine, Richardson says (p. 261):—

The correctness of Mr. Kendall's reckoning was another source of pleasure. Having been deprived of the aid of chronometers, by the breaking of the two intended for the eastern detachment of the Expedition, during the intense winter cold, our only resource for correcting the dead reckoning was lunar observations, made as frequently as opportunities offered; yet when we approached the Coppermine river, Mr. Kendall's reckoning differed from the position of that place, as ascertained on Captain Franklin's former Expedition, only twenty seconds of time, or about two and a half miles of distance, which is a very trifling difference when the length of the voyage and the other circumstances are taken into consideration.

It is interesting to note that Captain Collinson who sailed along this coast in 1853, makes the following comment on the position of cape Parry:[2]—

By my observations the cape is nearly a degree (of longitude) or 18 miles too far to the east upon the charts; which error probably arose during the circumnavigation of Franklin bay, and Sir J. Richardson not having a chronometer with him, had no means to correct his reckoning.

If, as seems reasonable, the 18 miles are geographical miles, they would be equal to 20·7 statute miles.

Dease and Simpson.—To the Hudson's Bay Company, Canada is indebted for a great deal of exploration in the far north. Peter Warren Dease and Thomas Simpson, two officers of the company, spent the years 1837-38-39 in surveying previously unmapped portions of the Arctic coast. In 1837, they closed the gap on the Alaskan coast between Return reef of Franklin, 1826, and point Barrow, which Beechey in 1826 reached from the Pacific. They returned to Fort Confidence, at the east end of Great Bear lake, where they spent the winter of 1837-38. In June, 1838, they left Fort Confidence to connect point Turnagain, of Franklin, 1821, with point Ogle, of Back, 1834. They did not reach point Turnagain by boat, but Simpson went 100 miles beyond it on foot. They returned to Fort Confidence to winter and, in 1839, successfully connected the two points.

Of the area east of the Coppermine covered by Dease and Simpson, only the part between the Coppermine and Bathurst inlet concerns this report. This portion had been mapped by Franklin in 1821, and Dease and Simpson

[1]Narrative of a Second Expedition to the Shores of the Polar Sea, in the Years 1825, 1826, 1827, John Franklin, Captain, R.N., London, 1828, p. 94.
[2]Journal of H.M.S. Enterprise 1850-55, Captain Richard Collinson, London, 1889, p. 296.

made no attempt to alter the map. They observed for position at the mouth of the Coppermine river and also at Cape Barrow. The former position agrees very closely with that of Franklin. Of this Simpson says[1]:—

I obtained an excellent series of solar altitudes and lunar distances, which place the mouth of the Coppermine in lat. 68-48-27 N., long. 115-31-15 W.; being 37 seconds to the northward, 5′-34″, or about two miles, to the eastward of the position determined by Sir John Franklin; but he was encamped on the west, and we on the east side of the river.

As already pointed out this position is 13·1 miles west of its position as determined by us. The only other position determined in the area is cape Barrow. Franklin gives no position there, but Simpson's determination and ours are:—

		Lat. N.	Long. W.
Cape Barrow.	D. & S.	68-04	110-59
	C. A. E.	68-01	110-09

The position of Dease and Simpson is 50′, or 21·7 miles too far west.

The above expeditions were essentially for exploration, and mapping and other scientific work was consistently carried on. They were followed by a group of expeditions known as the Franklin Search Expeditions, whose essential purpose was the search for any information that might reveal the fate of Sir John Franklin and his companions. In the area of our work, where the coast line had already been mapped, little attention was paid to changes or additions that might have been made.

Richardson and Rae.—In 1848 Sir John Richardson, accompanied by John Rae, an officer of the Hudson's Bay Company, went down Mackenzie river and searched the coast eastward to Coppermine river.[2] It was their intention to search a portion of the southern coast of Victoria island, but the ice in Dolphin and Union strait, and Coronation gulf did not permit them to cross.

In 1849 Rae spent from July 30 until August 23 at cape Krusenstern from where he expected to cross to Victoria island; but the ice never opened and he was forced to return to Fort Confidence.

John Rae.—In May, 1851, Rae covered the southern coast of Victoria island from cape Louis Philippe (Dease and Simpson 1837-38) to cape Baring on foot. He then returned to the Coppermine and when navigation opened went east and explored a further considerable portion of the southeast coast of Victoria island.[3]

Captain Richard Collinson.—In August, 1851, Collinson in the *Enterprise* reached the coast of Banks island, and after cruising about for a time went into winter quarters at Walker bay, Victoria island.[4] In 1852 he surveyed Prince Albert sound and then turned south and east along the coast and spent the following winter in Cambridge bay. From there, he turned westward in 1853. In Coronation gulf he did not land on the mainland, and did no new mapping but made soundings and some notes on the geographical positions

After Collinson, there is no record of any expedition having visited Coronation gulf until Hanbury went along the coast by sled and canoe from May to July, 1902.[5] In 1905, Amundsen sailed through in the *Gjöa* and successfully completed the Northwest Passage from east to west.[6] In 1910 and 1911, V. Stefansson and R. M. Anderson spent some time in the Coronation gulf country and have made many geographical contributions and added, as well, extensive

[1]Narrative of the Discoveries on the North Coast of America, Thomas Simpson. London, 1843, p. 267.

[2]Journal of a Boat Voyage through Rupert's Land and the Arctic Sea, in Search of the Discovery Ships under the Command of Sir John Franklin, Sir John Richardson, London, 1851.

[3]Journey from Great Bear Lake to Wollaston Land; and, Recent Explorations along the South and East Coast of Victoria Land, Dr. John Rae, Journal of the Royal Geographical Society, vol. 22, 1852, p. 73 *et seq.*

[4]Journal of H. M. S. Enterprise, 1850-55, Capt. Richard Collinson, London, 1889.

[5]Sport and Travel in the Northland of Canada, David T. Hanbury, London, 1904.

[6]The North West Passage, Roald Amundsen, Vol. II, London, 1908.

information in other branches of science.[1] Captain Joseph F. Bernard, a trader, in the schooner *Teddy Bear*, wintered 1910-11 at the mouth of the Kugaryuak, a small river 18 miles east of the Coppermine, and 1912-13 at the harbour in Dolphin and Union strait, where the southern party of the Canadian Arctic Expedition spent the winters 1914-15 and 1915-16, and to which they have given his name. In 1912, the Douglas party who had wintered at the east end of Great Bear lake went down the Coppermine to the mouth and mapped the country between Great Bear lake and the mouth of the Coppermine.[2] In 1912 Harry V. Radford and George Street, reached Bathurst inlet from Hudson bay and were killed by Eskimos. In 1913 two Roman Catholic priests, Rouvier and Le Roux, from Great Bear lake reached the mouth of the Coppermine and when on their way back up the Coppermine were killed by Eskimos.

Franklin must be given the credit for mapping in 1821 the southern coast of Coronation gulf, east from the mouth of Coppermine river. To Richardson and Kendall, in 1826, as an eastern detachment of Franklin's second expedition, belongs the credit for the mapping of the mainland coast west of the Coppermine to the Mackenzie. Later expeditions had other objects and beyond making some criticisms and suggesting a few changes did not alter the work of Franklin's two expeditions. These criticisms and suggestions usually applied to isolated and individual points and without comprehensive control it was difficult to apply them to previous work. It remained for the southern party of the Canadian Arctic Expedition to fix more accurately the control positions for this area, and to map the detail carefully.

When one considers the methods used and the circumstances under which this early exploration was made, the existing map is a tribute to the men who did the work. They worked long distances (especially in time) from their bases, and even under the best of circumstances it was difficult to obtain accurate control. The geographers of the Canadian Arctic Expedition had the distinct advantage in establishing their control in the Coronation Gulf country, that they could, in a comparatively short time, carry the control from the positions of the Alaska-Canada boundary survey to the base; and then check that position back to the boundary. With the position of the base established, it was not difficult to extend the control.

Detail in the early maps is meagre, chiefly because of the circumstances under which the work was done. It was necessary for Franklin's parties to travel fast and it was more important to obtain a quantity of general outline than to map all the details. In following a coast line they travelled from point to point wherever possible and in this way missed many of the smaller details of the bays. When seen from some distance off shore, the land may not appear in its proper perspective; for example, high land with low land on either side appears as a point, and the converse may be the case. At the time of the early expeditions full details were not essential, but with public attention recently directed toward the Coronation gulf country, it was necessary for us to map them.

[1]My Life with the Eskimo, Vilhjalmur Stefansson, New York, 1914, pp. 1-435. (Report on the Natural History Collections of the expedition, by Rudolph Martin Anderson, pp. 436-527).
[2]Lands Forlorn, George M. Douglas, New York, 1914.

CHAPTER II

GENERAL CHARACTER OF THE ARCTIC COAST REGION

Mackenzie Delta

The Mackenzie delta forms a huge triangle, about 100 miles wide at the base and with approximately the same height. The base of the triangle is formed by the Arctic coast and the apex is at point Separation, 20 miles below Arctic Red river. On the east of the delta, south of Richards island, are the so-called Caribou hills. These hills are rolling and grass covered on top, and rise from 500 to 700 feet above the delta. Farther south, the land to the east is not visible for any considerable distance, but the grass-covered hills apparently give way to tree covered ones, south of the valley leading to the Eskimo lakes. On the west side of the delta, at McPherson, the mountains are not far distant, and on Husky river they approach close to the river. Farther north, they give way to rolling foothill country, which continues to the coast.

The delta itself is a maze of islands, lakes and channels. There are apparently three main channels, West, East and Middle. These split up into various smaller channels and the country between is covered with lakes and drainage ways. At times of high water the direction of flow in the small channels is reversed and water pours from the main channels into the lakes, flooding the lower parts of the delta. During the spring the writers were in the delta, the water rose about 14 feet before the ice went out of the main channels and with so much water backing up into the lakes, the character of the whole delta seemed to be altered. Channels everywhere were full and overflowing their banks; in the small channels the water was flowing away from the main channels; small lakes grew large, meadows became large lakes, and the highest parts of the delta were very little above water level.

The greater part of the delta is wooded. Willow and alder bushes begin within a few miles of the coast and a few more miles farther south they grow so large and close together as to be almost impenetrable. Spruce trees reach 68°-54′ N. latitude on the east branch and 68°-38′ on the west. Birch is not plentiful and occurs mostly on the east side. On the same side poplar grows as far north as 68°-32′. (See Part A, Plates VI and VII.)

Channels.—There are three main channels of the Mackenzie delta, the West, East and Middle branches. The largest flow of water goes down the Middle branch.

Trouble in navigation comes at the coast, where the water spreads out, the current slackens, and the immense quantities of mud carried by the water are deposited. In the middle branch, the natives are said to know a channel through which they can take their whale boats, drawing perhaps a couple of feet of water. This channel (in 1914) was not known to any white man and was said to be uncertain at best. It is quite certain that there is no deeper channel to the sea. The east branch has probably a six-foot channel. Captain James McKenna in the schooner *Charles Hansen*, drawing eight feet, came some way up this channel to Tuktuyaktok, about ten miles below Kittigazuit, and wintered in 1905-06. In 1916 the Hudson's Bay Company's schooner, *Fort McPherson*, drawing perhaps six feet, went up to Arctic Red river and McPherson. She had considerable trouble outside Kittigazuit but this seemed largely due to lack of knowledge on the part of her pilot. The channel is said to be long, tortuous and shifting. It is quite safe to say that above the vicinity of the coast, there is twenty feet draught for boats.

The Middle branch, where the Aklavik leaves it, is between two and three miles wide with a current of from two to three miles per hour. Soundings in the channel gave five fathoms and no bottom; but there are sand bars, and shoal spots on which there may be less water, though a boat should always be able to find twenty feet or more.

The name West branch is applied to the forty-mile stretch from Sinik to the most northerly spruce trees. The principal channels which come together to form the West branch at its southern end are Husky river on the west, Middle Peel river, on the east and an unnamed river between the two. These three come together about twelve miles above Sinik to form a river about half a mile wide. At Sinik, the river widens considerably and two miles below Sinik it is joined by the Aklavik which is a channel from the Middle branch. The West branch, there, is about a mile wide and continues fairly uniform to the most northerly trees on the branch, where it splits up into smaller channels which run out to the sea. The current in the West branch is between two and three miles per hour.

Leaving the coast for Arctic Red river or McPherson, boats may travel either by Moose river, Ministikug[1], or the channel which has been mapped east of Ministikug.

On June 19, 1914, the depth of water over the bar at the mouth of Moose river was four feet. Inside the bar there was plenty of water for the most part, although there were a few shoal spots, particularly at its junction with Ministikug. These shoal areas are said to vary from year to year and even within one season.

The Ministikug is a channel about 400 feet wide, with a current of nearly two miles an hour.

A channel frequently taken by the whale boats and small schooners of the Eskimos comes to the sea about ten miles east of Tent island and leaves the West branch about two and a half miles below the junction of Moose river and Ministikug with the West branch. The southern part of this channel is very narrow; but, on July 31, 1914, it carried a depth of nine to ten feet throughout. About ten miles from its southern end it is joined from the southeast by a large channel and, a short distance below, runs out to sea. Over this last stretch and for a mile out to sea the water is shoal, and in some places we could not find a depth of more than four feet.

The usual route with sailing boats is up the West branch and through the Aklavik into the Middle branch. This is somewhat longer but offers better opportunities for sailing. The Aklavik has a good depth of water throughout and a current of one and a half to two miles per hour. It has an average width of about a quarter of a mile.

Husky river, the most westerly channel of the Mackenzie through the delta, is excessively winding and crooked, averages 250 feet in width, with a fairly uniform depth of fifteen feet (July 1, 1914) and has a current of about two miles per hour.

As is usual in rivers of this kind, the channel meanders, producing high cut banks where erosion is going on, with sand spits and mud flats, willow-covered on their higher parts, on the side of the shallow water. The current hugs the concave side of the curves.

Firth River

The mouth of Firth river lies about fifteen miles to the west of Herschel island harbour, and from the coast up to the foothills of the British mountains its course is split up into a large number of small channels, which spread over a considerable area.

After the foothills are reached the river narrows, and for many miles it runs in a gorge about 150 feet wide with walls from 100 to 200 feet in height. This is a secondary canyon cut in a much broader valley, which shows well developed river terraces. (Plates III and IV.)

[1]A recently coined Eskimo barbarism meaning "Minister's or missionary's *Kug* (river)."

The first stunted spruce trees appear in a striking U-shaped bend in the canyon about eighteen miles up the river. About thirteen miles above this bend a good sized stream (Mungitkug) joins the river from the west through very pretty, open country, with plenty of scattered spruce trees. White mountain sheep (*Ovis dalli*) are often shot in this neighbourhood. About five miles up this creek there is said to be a low divide, passable by sleds, to Yoyak creek to the west, though the usual portage out of Yoyak creek is by a small creek, a few miles farther to the southwest, which enters Firth river at "The Blowhole".

Above Mungitkug, the river enters the main range of the British mountains and cuts through them in a narrow and tortuous passage with an increased gradient. The ice in this part of the river is generally swept smooth by the strong winds for which the gorge acts as a funnel, and travellers sometimes find it impossible to make headway over the smooth glare ice. This pass is justly named "The Blowhole." The writer found a pair of steel crampons most useful in crossing several wind swept stretches of the lower river. The mountains on each side are bare of trees and for this reason it is difficult to make an estimate of their height. They probably do not exceed 5,000 feet.

In about seven miles the river rises into open, partly wooded country with low grassy slopes to the sides of the valley and an easy gradient. South of the mountains one is at once struck with the change from the coastal to the interior climate. The furious gales of the coast are left behind, and instead of the windswept glare ice on the river and marble-hard drifts on the land, there is everywhere the deep soft snow of a less stern climate.

From there on, sleds are at a disadvantage and snow-shoes and toboggans are a necessity.

A few miles south of "The Blowhole", the river takes a north by west course and a large branch enters from the southwest, coming through low, open country from a range of high mountains. The main river continues through another low range of mountains, and thence through low open country for many miles to an upstanding limestone bluff named Ikthout, where it makes a sharp bend to the west and heads off in the direction of the international boundary. There is a large lake a few miles above this point. At the date of our visit (April 10, 1914) the water had begun to run out from this lake over the top of the ice and the river was flooded from bank to bank by the rapidly advancing stream, forcing us to turn on our tracks.

Just north of Ikthout there is a small creek coming in from a range of hills to the southeast. This creek is frequently travelled in the late spring when the water has begun to run on Firth river. An easy portage from the north fork of this creek leads into a creek which brings one out on the coast at the Kay point lagoon. This creek is usually a week or two later in breaking up.

Just above Ikthout is another larger fork coming from a southerly direction. About eight miles up this stream there is said to be an easy toboggan portage (one day without wood) to a branch of Old Crow river, which has a fairly large lake at its head.

Darnley Bay to Coppermine River

At the foot of Darnley bay the coast is low, with mud flats and shallow water for some distance from shore. Inland, however, the country rises rapidly to the Melville hills which are sufficiently dissected to give the country a broken appearance. Both Hornaday and Brock rivers, which come to the coast at the bottom of the bay, have cut fairly deep canyons through these hills. (Plate IX, figs. 1–2.)

On the east side of the bay there is a lagoon about three miles long and a mile wide, where Charles Klengenberg had his boat in 1915. The lagoon is very shallow and Klengenberg had some difficulty in reaching the north end where he wintered.

The country on the east side of the bay is rolling, with gentle, even slopes, usually grass covered. Ridges of diabase running northwest and southeast come to the coast at a small point about half way up the east side and at cape

Lyon. A portage was made from the foot of the bay west of Pierce point, overland to Darnley bay a short distance north of the lagoon. This portage was paced and found to be fifteen miles long. It crosses one lake about four miles and another about one mile in length. The divides are low and grades easy and the two diabase ridges are low. (Plate VIII, fig. 2.)

Eastward from Darnley bay along the coast, cliffs of varied heights alternate with gravel beaches. Inland the country is rolling and rises gradually to the Melville hills. From cape Lyon to Deas Thompson point the diabase ridges, which extend northwest and southeast, produce hills which are more barren and rugged than is usually characteristic of the country. Cape Lyon is 50 feet high; Pierce point is 150 feet, with diabase hills 240 feet at the inner end; the sharp, unnamed point, ten miles east of Pierce point, is 135 feet high; and the cliffs from Keats point to Deas Thompson point are usually from 30 to 50 feet.

Keats point is roughly T-shaped, the top of the T being about one and a half miles long, and behind the whole of the T there is a fresh water lake. In winter travel the rough ice which usually accumulates against the cliffs on the outside may be avoided with advantage by crossing this lake. The portage continues to the west over low tundra and ponds for about two and a half miles of good going, coming to the coast again in a small bay.

From Deas Thompson point to Wise point, with the exception of Clinton point, the beaches are everywhere of gravel. The shore line is very regular, as might be expected where there are few areas of outcropping rock, and where the general character of the country is uniform, and there are very few features that call for special mention.

About half-way between Deas Thompson point and Clinton point a table-topped hill 245 feet high, forms a prominent land mark from both directions. The cliffs of Clinton point are 100 feet high and rise in less than a mile inland to 250 feet. The mouth of Buchanan river is marked on the west side of its delta by a high cut-bank, which has been much dissected.

Deas Thompson point appears from the east as a prominent point; but, in reality, it is hardly a point at all and does not produce nearly as much change in the direction of the coast as does the point a short distance eastward. On the map the latter has been called Deas Thompson point. What has been called the point on previous maps is in reality a cliff with low land on each side. The cliff appears from the water to be a point; but, actually, it is not. This feature of the early mapping is discussed elsewhere and the above remarks apply particularly to Deas Thompson, Clinton and Wise points.

Clerk Island.—The island was named by Richardson and Kendall in 1826. Of the days travel from a camp three miles west of Croker river Richardson says, "A light westerly wind having opened up a channel between the ice and the shore, we embarked early in the morning of August 1..... Further on we had a view of a high island lying ten or twelve miles from the shore, which received the appellation of Sir George Clerk's island.,,[1]

Rae and Richardson, in 1848, do not mention the island.

Collinson, in 1853, sailed close to the so-called island without seeing it.[2]

Mr. Stefansson crossed from cape Kendall on Victoria island to point Tinney on the mainland and saw no island. Dr. Anderson, with Capt. Bernard in the *Teddy Bear*, spent some time cruising around its supposed location in August, 1911, looking for it, and failed to find it. Captain Amundsen says he passed near its supposed location in clear weather and did not see it. Mr. Jenness, from an elevation behind cape Kendall, had a clear view of Amundsen gulf and the mainland shore and could see no sign of the island. The Rev. H. Girling states that from behind Clifton point he had the reverse view on a clear

[1]Narrative of a Second Expedition to the Shores of the Polar Sea in the years 1825, 1826, 1827, Sir John Franklin, London, 1828, p. 247.

[2]Journal of H.M.S. Enterprise, 1850-55, Captain Richard Collinson, London, 1889, p. 296.

day and could see no sign of the island. No member of the Expedition in several trips along the coast by sled in the winter, or by boat in the summer, saw it, although, had it been there, we almost certainly would have seen it.

On the other hand, Captain S. F. Cottle, one of the most experienced of the whaling captains, says that not only is the island there, but that he has landed on it.

The weight of evidence seems to be that the island is non-existent and should be omitted from the maps. Richardson mentions ice in the vicinity when he saw and named the island and it is quite probable that he saw dirty ice and mistook it for an island—a mistake easily made.

The 220-foot dolomite cliffs of Wise point are a prominent feature and a landmark for miles along the coast in both directions. There are two of these cliffs, one just east of Hoppner river and the other about thirteen miles to the west. The westerly one has been called Wise point, for it was from the west that the mapping was done. But at this western cliff there is no change in direction of the coast line, whereas at the eastern point there is a noticeable change. The name has consequently been transferred to the eastern cliff. (Plate XII, fig. 1.)

A traverse was carried from the source of Rae river, overland to the south side of Stapylton bay. From Rae river this traverse runs for thirty-five miles through a gently rising grass country with only one low dolomite ridge. Thence to the coast the country, though still for the most part grassy, is rather more uneven and the traverse crossed three sets of low hills formed of mud and gravel, between which lie one or two very small lakes. No large lakes were seen from the head of Rae river to the coast, nor any very striking topographical features. The height of land between Rae river and the coast has an elevation of about 1,000 feet.

The above traverse was begun from the head of Rae river on May 8. At that time the snow was melting fast and during the next few days considerable difficulty was experienced in finding enough snow for the sled. Nearer the coast there was much less difficulty.

From Stapylton bay to cape Krusenstern the country is rather lower than farther west but of the same general character. Hills of mud and gravel succeed one another inland, gradually rising to a height of several hundred feet. The slopes are gentle and uniform and usually more or less grass covered. Lakes and swampy ground are usual between the hills. Dolomite cliffs, usually not more than 50 feet in height, occur near the coast at Hope point, on the shore line at cape Lambert, and scattered through the inland country. A good idea of the inland country may be had from the detailed map of Bernard harbour which is published as an inset on the coast map.

Cape Krusenstern is a nearly barren rocky promontory with low dolomite cliffs at its extremities. A little farther to the west the cliffs rise to a height of about 100 feet. There is a little driftwood on the tip of the point, and a considerable amount in the bays on the south side. In winter travel it is usual to go down into the bay west of the point and portage across the neck of land, about a mile in width, to the shore on the south of cape Krusenstern. There is also a good portage sometimes used by the Eskimos that leads from the foot of the above bay, behind Barrow mountain (hill), and straight south through a wide low valley, coming to the coast again southwest of Locker point. The valley has an even easy grade and is commonly travelled by the caribou on their migrations. Barrow hill rises to an elevation of 220 feet and is a conspicuous land mark.

A few miles west of cape Krusenstern (Plate VII, Fig. 1) the country is for the most part grass covered and far more pleasant to the eye than the desolate coast of Dolphin and Union strait. From the high land west of Locker point, one may look inland for many miles over a vast grass land, broken only by a ridge of low cliffs which extend from the first bay north of Basil bay to cape Lambert.

The same type of country continues to Basil bay, a narrow inlet with shores from 50 to 300 feet in height, which extends northwesterly for about eight miles from the small island at the mouth of the inlet. This island is a mile long and nowhere more than forty feet high, though Richardson speaks of it as being several hundred feet in height. The low, grassy hills at the foot of the inlet are said to be one of the best places for caribou in the summer time.

The south shore of Basil bay runs out to form the low shingly promontory of cape Hearne. About three miles back from the cape there is a fine series of cliffs which rise to a height of 205 feet. The coast to the southwest of cape Hearne is low and grassy as far as the foot of the next bay, where, apparently, a small river enters the sea between sand banks about eight feet high.

The shore continues low until cape Kendall is reached, though some miles north of there, and a mile inland there is a low range of rocky hills rising to an estimated height of 600 feet.

At cape Kendall there is a marked change in the topography, due to the dolomite giving way to the more resistant basalts and massive sandstones. Cape Kendall is a fine, bold, rocky promontory, the diabase cliffs being in places 200 feet high. From these cliffs a fine view can be had over the groups of islands in this part of Coronation gulf, and of the country in the direction of Coppermine river.

From cape Kendall to a point 20 miles up Rae river, there is an almost continuous series of fine bluffs which average about 180 feet in height.

As has been pointed out elsewhere, Rae river comes to the coast in a low, swampy flat. In the southeast corner of the same flat, Richardson river, coming from the south and southwest, also reaches the sea. The latter is much smaller than the Rae and, a few miles inland, seems to divide into two branches with valleys of about equal size. Diabase ridges are prominent features in this vicinity. As elsewhere throughout Coronation gulf, these ridges have steep (commonly vertical) faces to the south and even slopes to the north. Between the ridges are valleys which usually have uniform grass covered slopes and commonly contain lakes and marshy ground. Mackenzie point, ten miles east of the mouth of Rae river is the eastern end of one of these ridges.

None of the rivers coming to the coast from Darnley bay east to Coronation gulf seems to extend any great distance inland, for the valleys are all small and both valleys and beds indicate a heavy run-off in a short time. The Croker is the largest river. Its delta is built out a short distance from the general line of the coast, is four miles wide and extends inland for four and a half miles. The river spreads out over this delta and none of the channels are very definite, although most of the water seems to come out on the east side. The bed of the Croker is composed of heavy boulders, and a quick run-off is further evidenced by a continuous sand and gravel bar built across the mouth when the water is low in summer and autumn.

Croker river.—At the head of its delta, the Croker comes from a box canyon which continues upstream for about ten miles. At its lower end this canyon has walls about 40 feet high which increase, until, five or six miles up from the delta, they reach 300 feet and over. The walls are sheer and consist of nearly flat lying dolomite, and on top of the higher walls there is 40′ or more of gravel. There are no places where a sled could be got out and very few where a man could climb out. In width, the river varies from 70 yards at the lower end of the canyon to about 40 yards three or four miles up. In one place it narrows to 15 feet, in another 30 feet and is less than 50 feet for half a mile, while in another there is only 6 feet between the sheer walls. It is probable that there are falls in at least the last mentioned place but the snow was packed in too tightly for us to be sure of this.

The canyon ends almost abruptly and for about 1,000 feet there is a flat which very likely contains a lake. Above, the river issues from another canyon with walls of about 50 feet decreasing to 10 feet. The dolomite continues for about a mile and is succeeded by walls of partly consolidated conglomerates. From there south, the banks of the river are gravels or muds sloping to the river. The valley cut by the river continues to the southwest in a broad plain which is very little lower than the general level. It narrows rapidly and apparently ends within fifteen or twenty miles. (Plates X and XI.)

Inman River.—Next to the Croker, the Inman is the most definite river on this part of the coast. It is well defined right to the beach line, and about half a mile inland passes between a prominent bluff on the east and a hill on the west. From there it has a well-defined bed and gradually sloping walls rising 200-250 feet above the river-bed. The bed is full of boulders and in flood time the river spreads to some extent over the valley bottom. It is not navigable by canoe. The walls of the canyon are of mud and gravel with an occasional outcrop of dolomite. Like most of the rivers on this part of the coast there is a lagoon behind the gravel and sand bar at the mouth.

Buchanan river has a delta about three miles wide and nearly four miles deep. Inman river has a fairly large, low lying area about the mouth but, at the time of our visit, the surface was covered with snow and its character could not be seen. (Plate XIII, figs. 1–2.)

Rae river.—Rae river flows into Back inlet in Coronation gulf, through a low, swampy flat, several miles wide. The main mouth is in the middle of this flat and is three-quarters mile wide, with low grassy banks. There is another, smaller mouth at the northwest corner of the bay. At four miles up, the river narrows to 1,200 feet, with mud banks 30 feet high and a ridge of red sandstone 150 feet high a few hundred feet back from the north shore.

About half a mile above the first small island in the river there is a gully on the north side which is filled with willows from six to ten feet high. The first falls, mentioned by Rae, are ten miles from the mouth and are possibly ten feet in height. The river narrows to from 200 to 300 feet for some distance above and below the falls. These falls are said to be a favourite fishing place for the Eskimo in the summertime. Above the falls, rapids are numerous though there are some long stretches, with enlarged channels, that are probably long narrow lakes in the summertime. The series of bluffs on the north bank continues for many miles, whereas the country on the south is lower and runs back to grassy plains, from which rise occasional isolated basalt bluffs. The first narrow lake is about 18 miles long and the country on each side is for the most part open, grassy and rolling, with occasional isolated diabase buttes. About two miles to the south the surface drops several hundred feet to very rough and rugged country. At the western end of the lake, the river passes through a series of low diabase hills for several miles. West of these hills the river again expands into a long narrow lake in open grassy country and about ten miles above breaks up into four small branches, which appear to be practically the head of the river. In this part willows are plentiful and large, growing up to fifteen or twenty feet in height. Elsewhere on the river, willows are scarce and small, with the exception of two small willow covered islands in the first lake.

The traverse of Rae river was made late in April and early in May, 1915. The river being frozen, apparently, to the bed, a large part of the way, it was difficult to make any estimate of its volume but it is probably small. A good deal of trouble was experienced with the soft snow which in places covered the ice for miles at a stretch to a depth of two feet or more. Snowshoes and toboggan would be the best equipment for travelling up the river. Willows cannot be relied on for fuel. At this time of year we found caribou fairly plentiful in small bands which were working their way north, and there was no difficulty in getting all the dog food we needed.

Melville Range.—To what appears on maps and in books as the Melville mountains, Richardson, in 1826, gave the name Melville range and he always refers to them, collectively or individually, as hills.[1] They were described as extending from the foot of Franklin bay to east of Croker river. We went into them by ascending Brock river at the southeast corner of Darnley bay, and up Croker river, near their eastern termination. In both places they have distinctly the character and appearance of hills rather than mountains. Stefansson says of them at the foot of Darnley bay: "At Langton Bay the Melville mountains, about a thousand feet high, are three miles inland. They are really the sea-front of a plateau that slopes almost imperceptibly south from their crest to Horton river, ten miles further inland."[2]

They approach nearest to the coast at the foot of Franklin and Darnley bays and seem to be more dissected there; and in Darnley bay from off-shore they appear rugged and mountainous. But the dissection is not enough to give them the characteristics of mountains, and no mountain range structure is to be found.

Climbing out of the box canyon about fifteen miles up Brock river we found about 250 feet of rock with 300 feet or more of gravels on top of it. What are apparently old terraces extend nearly to the top of the hills. The hills are everywhere flat on top, with gently rounded slopes. They rise little above the general level, which gradually increases in height to the south and, apparently, are all of gravel. The general level of the hills is 700-900 feet above the sea.

From Pierce point and from a sharp point about ten miles east of it, there is no hill visible that should be called a mountain. The inland country rises gradually to summits that are uniformly low and rounded, and apparently not even in definite ridges. The distance to the sky line was difficult to estimate but it was perhaps five to eight miles away and in elevation it was not more than 1,000 feet and probably only 600-800. From Keats point, however, can be seen a double topped hill which rises perhaps 200-300 feet above the general level within ten miles of the coast. The shape of these hills and the character of the country between them and the coast indicate that they are probably gravel hills and ridges like those seen on Brock river.

At several places, notably in the vicinity of Roscoe river and at Tinney point, hills are visible within four or five miles of the coast. They do not appear to be more than 500-600 feet high and are of the same character as those above described. It is probable that the country continues to rise behind these hills.

Richardson speaks of a hill to which he gave the name Davy as, "the last part we saw of the Melville Chain." It is the most easterly distinctive hill that can be seen when travelling along the coast and may be considered as the end of the Melville range. Mount Davy, as it is called on the charts, is about twenty-three miles from the coast at the mouth of Croker river and about seven from the end of the canyon on that river. In the last named stretch, no rock in place was seen. Mount Davy, although conspicuous from the coast, rises only 200 feet above the surrounding country and is composed entirely of glacial gravels. In shape it is like an inverted cup and is evidently of the same origin as the numerous small hills in the vicinity. These hills are sufficiently numerous to give the country a broken appearance, although nowhere is there any justification for speaking of a mountain range.

As seen from mount Davy, the country from east to southeast has many hills similar to that mountain but somewhat lower. To the south the country rises with uniform slopes and in a few miles attains the same elevation as mount Davy. The Croker river valley runs to the southwest and is in a broad plain, very little lower than the general level. From west to northwest there are many small ridges and hills as far as Croker river. From northwest to north to east there is an unbroken plain sloping uniformly to the coast.

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[1]Franklin, Second Expedition, 1825-27, p. 240 *et seq.*
[2]My Life with the Eskimo, V. Stefansson, p. 126.

From the evidence that we could gather the name Melville range seems to have been applied to the summits of gravel ridges and hills which are visible from the coast. There is certainly no mountain range. The whole country is rolling and rises gradually from the coast. No hills that we saw rise more than 200-300 feet above the surrounding country; but they are succeeded inland by higher rolling country.

Coppermine River

The Coppermine reaches the coast through two mouths which enclose a large, low island, grass covered except for two diabase hills on the northern end. This island is a well-known fall gathering place for the Eskimos. It is a good fishing ground, and when we were there in the spring, herds of caribou were continually visible.

Inland from the mouth of the Coppermine, the country is generally tundra, rising evenly and with scattered lakes in the small valleys. Not far above the mouth, the river contracts to about half a mile in width and has steeply sloping alluvial cut banks.

The generally preferred route of travel on the Coppermine is up the west side of the river for some indefinite distance, usually twenty to forty miles, thence southwest to Dismal lakes, and thence south to lake Rouvier and west to Great Bear lake. The Eskimos who spend the summer in searching for copper in this area, follow this route for ten miles or more up the Coppermine and then strike to the west. These Eskimos stated that after picking up the required copper they would swing east and south to the northwest corner of Dismal lakes where they would rejoin the others who had been securing wood during the summer. (Plate XXXIX, figs. 1–2.)

The route up the west side of the Coppermine is one of easy travel. Long gentle, grassy tundra slopes to low rolling country offer no difficulties either to packing with dogs or to travel with toboggans. The usual line of travel is some distance back from the river, and before one strikes towards Dismal lakes no creeks or steep gullies are met. Travelling toward Dismal lakes, the country is level with a good deal of swampy tundra until one commences to climb the long slopes of the so-called Copper mountains. These mountains, which attain an elevation of probably not more than 1,500 feet, are in reality a series of long basalt terraces. Since they occupy a belt about fifteen miles wide and the terraces are numerous and low, the general effect is of a long gentle slope to the north with a somewhat steeper and more irregular slope to the south. Dismal lakes lie just south of the ridge.

From Dismal lakes to lake Rouvier, the country is more rugged, and there are at least two recognized routes, both of which follow the gently sloping valleys of creeks in which are numerous lakes. These valleys offer good feeding and hunting grounds for caribou and the lakes probably contain fish.

Lake Rouvier, known to the Copper Eskimos as *Immaernirk*, is the source of the east branch of Dease river. The route crosses the lake, and thence cuts west over a low and gently sloping ridge of tundra hills to the south side of the valley of the main Dease river. It follows the main river to the Garche hills, crossing the southeast branch at Big Stick island, and from the Garche hills, which are about fifteen miles east of Great Bear lake, the route goes through wooded land to the lake.

The trip across the above route should occupy ten or twelve days. The whole Coppermine valley to the mouth seems to be good caribou country, but within two or three days of the coast, the Eskimos do not seem to rely on finding them. When we made the trip in June, 1916, except for three on the east side of the river, where we could not get at them, we saw none until we had left the Coppermine; but from there on we always had plenty without going out of our way to find them and had no need to consider fish or other sources of food supply. In both Dismal lake and lake Rouvier, however, fish are known to be plentiful and the Eskimos say that the many small lakes which abound throughout the gently rolling tundra country are full of fish. Ducks, loons, bears, etc., are not numerous, but are sometimes used by the natives as food.

Big Stick island, about thirty-five miles east of Great Bear lake on the southeast branch of Dease river, is an area of several hundred acres covered with trees suitable for timber. It is surrounded by the Barren lands and is recognized as a good hunting ground both by the Eskimos and the Indians of Great Bear lake. When the Indians are hunting, after their return from the summer trips to the trading posts, the two peoples meet at this island. The camps of the Eskimos here, as elsewhere, are not made immediately on the river or in the valley, but somewhere on or among the surrounding hills.

On the Coppermine itself trees extend to within twenty miles of the mouth, but they are small and stunted. From thence, upstream, trees are frequently met with and in places they attain considerable size. In the valley of Kendall river, which connects Dismal lake with the Coppermine, trees are abundant, and at the east and west ends of Dismal lake there are a few. The balance of the shore of Dismal lake is said to be destitute of trees except for a small clump in a cirque-like basin near the Narrows. Lake Rouvier is well forested on the north side. It was there that the Fathers Le Roux and Rouvier had their house. The main valley of the Dease also is well forested, especially as Great Bear lake is approached. In all of this country the trees are confined to the immediate vicinity of the river or lake valleys and the surrounding hills and plains are part of the "Barren lands." (Plates XXVIII to XXXIV.)

Of the spring breaking up of the ice on Great Bear lake, on July 13, 1838, Thomas Simpson says[1]:—

> At this date I find by Ritche's journal (Ritche was left in charge at Fort Confidence) that the ice on Great Bear lake was still perfectly solid and continued unbroken till the beginning of August, which may be considered the average term of its disruption.

In 1916, on June 29, one of the writers, in company with Mr. D'Arcy Arden, a well known traveller in the north, tried to cross on the ice from cape McDonnel (locally known as Caribou point) to Gros cap (locally known as Big point). At that time the ice was badly broken up and we were unable to make the crossing. On July 6 we made the crossing by York boat without any difficulty. The summer season that year was said to be a month ahead of 1915.[2]

Mr. Arden informed us that for eight years over which he had information it had been perfectly safe to make the above crossing up to July 10. This crossing is the usual one when travelling by sled in the winter from the east end of Great Bear lake.

Coppermine River to Bathurst Inlet

About ten miles east of the Coppermine there is a small river which flows from the forested land and is said to have plenty of fish. Eight miles farther east the western Kugaryuak reaches the coast through a wide grass flat. Captain Joseph F. Bernard wintered in the mouth of this river in 1910-11. The country from there to the eastern Kugaryuak (28 miles) is broken and rough—typical diabase country. The eastern Kugaryuak is a fair-sized stream and has plenty of willows about its mouth. About ten miles farther east a wide steep-sided, grassy valley comes down out of the diabase opposite a group of four large islands with striking bluffs. This place is known as Sallik and is said to be a very good hunting ground for caribou in the spring-time. Immediately to the east granite takes the place of diabase on the coast and continues to within about ten miles west of port Epworth. Along this stretch of coast, which is rough and barren, gravel beaches are common and alternate with rocky shores. Inland, the country rises gradually to barren granite hills. There is considerable vegetation in the valleys and small ponds and lakes are numerous. Small low islands close to shore along this part of the coast offer good shelter for small boats.

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[1]Discoveries on the North Coast of America, 1836-39, Thomas Simpson, London, 1843.
[2]The same relative conditions prevailed on Dolphin and Union strait in 1915 and 1916.

From the bottom of the grassy bay about twelve miles west of port Epworth a portage of about two miles leads to a lake about seven miles long. This lake parallels the coast and its eastern end in within a third of a mile of the southwest corner of port Epworth. This short cut is frequently used in winter. There are willows on the shore and the lake contains plenty of fish.

On the east side of the above bay, the diabase comes in again, and from there to Grays bay the coast is bleak and desolate and the grassy slopes and valleys which are common in many parts of the coast are absent. The shore line throughout a greater part of this distance is of rock and there are few gravel or boulder beaches. Shelter for boats may be had in many places.

The coast about the entrance to port Epworth is of black, barren and forbidding diabase. the bluffs a little back from the shore reaching an elevation of 400 to 500 feet. A granite mountain on the east side of the harbour, known as Kittirigaluk, has an elevation, by aneroid, of 1,090 feet.

Tree river runs into the southeast corner of port Epworth between a range of rough granite hills on the east and a range of slightly lower dolomitic hills on the west. It has a considerable volume of water and is navigable for small schooners for a few miles inside the mouth. The first rapids are six miles from the mouth, and a short distance above them there is a fine fall of about sixteen feet. Below this fall is a favourite fishing place of the Eskimos. There are plenty of willows up to three inches in diameter for fuel. Ten miles above the mouth the river forks into two branches of about equal size. Not much is known of the east branch, though according to the Eskimos it has its source in a lake which is also the source of the Hood river, or of a branch of it. They also say that both branches of the Tree river run into forest land about five sleeps up (*i.e.*, sixty to seventy miles). (Plates XVI–XVII.)

The western branch runs for about twenty-five miles through a narrow, grassy valley, with steep ridges on each side. Rapids are fairly numerous. The surrounding country is full of lakes, most of which are said to have fish. About twenty-five miles up, the river expands into an L-shaped lake three or four miles long around the L. The main valley continues for some miles to the south before swinging off to the southwest. A deep but narrower valley heads north northwest from the short arm of the L, and has two or three small brooks flowing into it from fairly large lakes. Near the corner of the L on the east leg a striking canyon cuts through the range of hills (about 1,000 feet high) which forms the eastern side of the main valley. The main river appears to run through this canyon out of a big lake that was just visible from the high hills on the western side of the valley. The walls of the canyon appear to be practically vertical from 700 to 800 feet high, and not more than 200 feet apart. The country to the south of this point, so far as it was visible, was very rough and full of lakes which, on July 10, 1915, were covered with ice. The ridge on the east side of the river appears to be dolomite and seems to have an elevation of 2,000 feet above sea-level.

In connexion with equipment and as a sidelight on travelling conditions, the following extracts from the diary of one of the topographers on the trip up Tree river, may be of interest:—

July 9, 1915. The walking up the valley is very poor for a man with a load; it consists chiefly of niggerhead tundra; i.e., a watery marsh with tufts of dry grass sticking out of it. After one has succeeded in falling off these tufts up to the knees in mud and water about four hundred times, and the dogs have jumped each other at least a score of times, losing their loads in the process; after the sun has almost turned one into steam and the mosquitoes have collected so thickly as to almost hide the scenery, and one feels that in another minute he will be choked; then it is that one begins to feel slightly out of humour with the country and that its beauties do not appeal as they might under other conditions. Northern Canada is cursed, not by its interminable distances, its vast stretches of swamp and muskeg, its isolation or the bitter cold of its winters; all these one can, with a certain amount of determination triumph over and acquire a fair degree of satisfaction in doing so. It is the astounding atmosphere of mosquitoes that envelops the whole face of the country in the summer time that is the real curse. At times it adds the last touch of exasperation to make one completely disgruntled with existence, and does more to dampen one's enthusiasm and to lower the quality of the work done, than any other factor.

For this reason the best possible protection against mosquitoes is of great importance. A good mosquito tent, veils, gloves and dope are often worth their weight in gold.

The western branch of Tree river is said to pass very close to the Coppermine and the natives often make the portage across.

From the foot of Grays bay the coast runs northeasterly to cape Barrow and is of granite throughout. Three rivers of nearly equal size empty in this stretch; the Anialik at the southwestern corner of Grays bay; the Kogluktuaryuk opposite the south end, and the Utkusikkalluk opposite the north end of Hepburn island. In the country between the Kogluktuaryuk and the Utkusikkalluk, musk-oxen are still to be found in small numbers. The natives were hunting them near the mouth of the Kogluktuaryuk as we passed there in the spring of 1916. About the Kogluktuaryuk, the coast and the country for a mile or two inland are low and grassy, but elsewhere the granite comes to the coast and the country is rough. Nevertheless, in the small valleys there is considerable feed and caribou are plentiful from March onwards in the spring.

From the foot of the north arm of Inman harbour there is a short portage into Desbarats inlet. This route is usually taken by the Eskimos in winter.

At cape Barrow there is a sharp change in the general trend of the coast line. It there strikes to the south and east into Bathurst inlet. Cape Barrow is a fine bold headland of red and dark granite, the highest point near the cape being 340 feet above sea-level. In many places the shores drop off sheer into the sea. There are two harbours at the tip of the cape, and about one and a quarter miles to the southeast of the cape in a small bay, good water can be obtained from a small brook. (Plate XL, figs. 1–2.)

From cape Barrow to Detention harbour the shores are for the most part precipitous and from 200 to 400 feet high. In Detention harbour the shores are lower and more grassy. Galena point is rough and granitic until Moore bay is reached, where the first amygdaloids and dolomites are found. Moore bay is composed of two smaller bays and at the west end of the larger and more southerly one there is a range of granite hills 300 to 500 feet high. A narrow channel about a mile long and apparently tidal, runs from this bay to a sound to the south, into which, at its southeast end, a fair sized river appears to flow. In the main bay there are several small basaltic islands. (Plate XVIII, fig. 1.)

Kater point is high and rocky and is separated from the Marcet islands by a narrow channel. The country to the west of Kater point is for the most part low and grassy, and is a good feeding ground for caribou. For six miles south of Kater point the shore is paralleled by a series of small islands. There is no further shelter down into Arctic sound, the shores being precipitous and rocky as far as a low sandy point about five miles from the mouth of Hood river. Beyond that point the country is low and grassy for many miles. (Plate IX, fig. 1)

Hood river flows into the southwest side of Arctic sound. The mouth is hidden by a number of low, sandy islands and flats which make a delta about one and a half miles wide. The main channel seems to be the second mouth from the south side of the delta, but only three feet of water was found over the bar. On the lower reaches of the river the western shores are low, whereas there are high mud banks along the eastern shores. At the first rock exposure, about five miles above the mouth, the river is 200 yards wide and carries a good volume of water. (August, 1915). There are many shoals and sandbars but the main channel carries about ten feet of water. The first rapids are about seven miles up from the mouth. Plenty of willows were found, up to eight feet in height. (Plate XIX, figs. 1–2.)

The country to the south of Baillie cove[1] for a few miles is very low and grassy, with two small creeks flowing through it. The east side of Arctic sound is in general rocky and rather high.

[1] Name given by Franklin to bay at southern tip of Arctic sound. See Fig. 6, opposite page 61 A.

Wollaston point, at the tip of Banks peninsula, is barren and rocky and rises to a height of 100 feet about half a mile from the tip. On the east side of Banks peninsula the coast is mostly formed of cliffs about 100 feet high for about nine miles where the dolomite appears under the trap rocks and the coast becomes low and gravelly in places. (Plate XXIV.)

At about seventeen miles south of Wollaston point one reaches the bottom of a deep bay with a small river flowing into it from a wide low marshy valley. Steep mud slopes run down to the water's edge on the western side of the bay. They rise 500 feet and are surmounted by a beautiful range of dolomite cliffs capped with trap, which rise to 900 feet above sea-level. The east side of the bay is low and rocky to the south, but rises to a fine, red quartzite bluff 200 feet high at the northern end (Goulburn point). (Plate XXI, fig. 1.)

At the foot of the next bay to the south of Goulburn point, a shoal channel leads into a landlocked lagoon of considerable extent. Goulburn island is really part of the mainland, Franklin having been deceived by the low nature of the land at the foot of the bay between Banks peninsula and the land to the east. This bay is shown on the Admiralty chart as Brown's channel. (Plate XX.)

All but four of the islands in Bathurst inlet that were visited by us are so barren and rocky that they are not much visited by caribou. These four islands are the two named Kanuyak, Algak, and Ekalulialuk.

Kanuyak island, lying about four miles southeast of Goulburn point, is a large irregular mass to the east and south of a small island from which it is separated by a narrow channel carrying ten feet of water. The main island is ten to twelve miles long and from one to four miles wide. It has an elevation of 400 feet in parts. and is quite hilly. There is a considerable growth of dwarf birch, willow and blueberry bushes.

The Barry islands lie a mile and a half to the north of Kanuyak island. Their fine basalt cliffs (200 feet) drop sheer into the sea, make an imposing barrier as seen from the south. Franklin, coming from the northeast in his canoes, found a break in these cliffs with only a small gravel bar about fifty yards wide separating the inlet to the south from the landlocked stretch of water to the north. He portaged this and mapped the two most western islands as one. Had he gone a mile and a half to the east he would have found the channel, 100 yards wide between high cliffs, through which we passed in our launch. This channel separates Barry island into two parts. The northeastern part of the eastern half is low, with two deep bights which almost cut through the island. (Plates XXII–XXIII.)

Ekalulialuk, the easternmost of the Barry islands, is also the largest and highest. It is separated from the mainland to the east (Umingmuktor) by a strait about two miles wide. The centre of the north end of the island has considerable grass land upon which caribou were seen in April, 1915. A large lake runs almost across the island near the northern end. A range of hills running east and west across the island rise to an estimated height of 1,000 feet.

On the mainland opposite the northeast end of Ekalulialuk, there appears to be a large river flowing into Bathurst inlet from the southeast.

Algak, the island immediately to the west of the Barry islands has a striking horn-shaped hill at its northern end, which is a useful landmark. A wide low grassy valley runs down the centre of Algak, with high hills on each side. (Plate XXI.)

Iglor-u-allik lies to the north of Algak and has two fine 300 foot cliffs on the east side.

The Cheere islands lying to the southeast of Kater point are two barren ridges of diabase separated by a narrow gap. There is a fine small-boat harbour in the southwest tip of the most westerly island.

Travelling north from this little harbour one gets into a maze of islands which are shown on the Admiralty chart as Marcet, Lewes, and Chapman islands. It is not surprising that Franklin mapped them as single islands, for, at a little distance they so merge into each other that one would never suspect the immense number that is revealed upon closer inspection. They range in size from a few yards to several miles in diameter and are all very similar in character. In general they are low and rocky and support very little vegetation. The most striking are the Chapman islands, to the north, where a dyke of hard trap rock withstanding erosion better than the rest, and rising to a height of 300 feet in places, forms the backbone of a string of islands.

GENERAL NOTES

Harbours

From Darnley bay eastward to Coronation gulf, harbours are very scarce. The coast is regular, with a shore line of gravel terraces; and the points and bays are rounded and offer little or no protection. Until Bernard harbour in Dolphin and Union strait is reached, islands, with the shelter which they offer, are extremely few and are generally of gravel, low lying, and with shallow water behind them. The river mouths, which might be expected to offer harbours, do not do so. At their mouths they spread out over a delta from one to five miles wide, making entrance to them impossible. In the season of high water it is quite possible that there are lagoons at the mouths of some of the rivers, which boats of shallow draught might enter, but as the high water goes down the ocean piles up bars of sand and gravel and the entrances are closed.

The yawl *Argo* wintered, 1914-15, in a shallow bay in the southwest corner of Darnley bay. This offers only partial protection and is difficult to approach, the bottom or south end of Darnley bay being generally shallow; and shoals and mud flats are said to be common.

Charles Klengenberg sailed from the Mackenzie with a scow in 1911 and wintered, 1914-15, in a lagoon on the east side of Darnley bay. This lagoon is very shallow and could not be considered for a boat drawing over four feet of water.

There is a good harbour for boats of any draught one mile east of Pierce point. Floating ice in the harbour in 1915 indicated twenty-five to thirty feet or more of water at the entrance and in the harbour itself; and protection from any wind can be easily secured. This harbour is most appropriately called Pierce point harbour.

From Pierce point to Bernard harbour in Dolphin and Union strait there is no harbour and the only shelter is afforded by the rounded points or the lagoons at the mouth of some of the rivers. The latter cannot be relied on, as a place which gave shelter at one time might not do so at another. Richardson and Kendall in 1826 took their light draught river boats into a lagoon at the mouth of Roscoe river; as did also Richardson and Rae in 1848; but we could see no indication that such a lagoon is available now. Partial shelter is afforded at the first point east of Pierce point and also at Keats point. Young point has a hook on the west side which offers good shelter from north and east winds.

There are dangerous shoals close to cape Bexley and it should be given a fairly wide berth.

Bernard harbour is about seven miles east of Cockburn point and southwest of Liston and Sutton islands. (Plates VII, fig. 2 and XXXVIII, fig. 1.) The outer harbour is formed by Chantry and another smaller, unnamed island extending nearly across the mouth of a shallow bay, from which extend several small bights. Vessels of light draught find good shelter in these bights and vessels of nearly any draught would find good shelter in the outer harbour. The small bight we used is completely sheltered and has a very narrow entrance with twelve feet of water. The entrance to this harbour, on the west end of the small unnamed island, is a false entrance and has only three feet of water. The true entrance lies between Chantry island and the unnamed island and along the south side of the latter. This harbour was first used by Captain Joseph F. Bernard, who wintered there, 1912-13, in the small trading schooner *Teddy Bear*. Consequently, we have given to it the name, Bernard harbour.

From Bernard harbour east to cape Krusenstern there are no good harbours for small boats although the bay just west of cape Krusenstern, and Lambert, Liston and Sutton islands offer reasonable protection. They are however poor places in which to get caught in a suddenly rising wind, especially since, in a great many places, the water near shore is shallow and the bottom foul.

Rae river was visited only in the spring before the break up and it is uncertain whether or not boats could get in. There is no wood; it is not a good place for seals; it is not a central place for the Eskimos; and there are better places for hunting caribou, so it can hardly be considered a good place to winter.

The mouth of the Coppermine has many advantages. It is perhaps the most central place for the Eskimos, for whom it is a regular gathering ground in spring and fall; it is an excellent hunting ground; because it is used by the Eskimos as a fishing place, it is probably a good fishing ground; there is considerable wood scattered along the coast in its vicinity; it is within twenty miles of the first trees on the river and within forty miles of good timber for building or other purposes; and it is the best starting point if one wants to travel. The depth of the channel, however, is uncertain. Hanbury says that in going up the east branch by canoe he had to wade and drag the canoe. Numerous mud flats are just above the surface at the mouth of the west branch, and it seems probable that this branch also is shallow. There may be a channel and if so, it is probably near the island at the mouth. A boat should keep well offshore until past the mud flats near the mainland and then come in.

About eighteen miles east of the Coppermine, in a bay behind a group of islands, the mouth of the Kugaryuak was used by Captain Joseph F. Bernard as a wintering place in 1910-11. The bay has deep water and is well protected and Bernard took his light draught schooner some distance up the creek. He secured wood in the fall with his schooner from the vicinity of the mouth of the Coppermine. This is a good fishing and hunting place and opens early in the spring. The islands lying off this creek are gathering places in spring and fall for the Eskimos.

Port Epworth is at the mouth of Tree river, the Eskimos' name for which is Kogluktualuk. The harbour is about five miles deep and is well protected. Our launch ran up the river for five miles and it is probable that a boat drawing six feet could do the same. Care is necessary however as the water off the mouth of the river is very shallow in places. This is the home of a group of natives who in winter hunt seals offshore, cache their winter outfit at the mouth of the harbour, and spend the summer a few miles up the river where they live mostly by fishing in the rapids. Nearby is the source of the potstone from which they make their pots and lamps. The fishing is good but the hunting is only fair as most of the caribou cross farther to the west. There is little wood. A post of the Hudson Bay Company and of the Royal Canadian Mounted Police was established here in 1917. (Plate XVI, fig. 1.)

There appears to be a good harbour a short distance east of port Epworth. Between port Epworth and Grays bay there are several places where shelter could be had by small boats. There are, however, several dangerous shoals and rocks lying off-shore for which a careful lookout must be kept. A small but good harbour, located about eighteen miles east of port Epworth, is the most easterly one, with a fair supply of driftwood, that we saw. This harbour lies behind a small island about two miles west of the western point of Grays bay. The island is hard to see until close to it for there are high cliffs on the mainland just behind it. The entrance is around the southwest corner of the island and has plenty of water. Inside there is a depth of eight feet.

Grays bay has several small islands at its foot which would give good shelter.

Wentzel river has a good volume of water and empties by two mouths. The northernmost mouth is the larger and has four feet of water over the bar. The river is 200 feet wide just inside the mouth.

The Kogluktuaryuk, which has several mouths, is probably a little larger than the Wentzel. We entered the second mouth from the north and found three feet of water over the bar.

Neither of these rivers could be considered as other than very temporary shelter, for there is no wood and the caribou hunting is said to be better farther to the west, and east. Fishing is said to be good and there are usually natives in the vicinity. The difficulty in getting into both rivers is due to the shoal, formed of mud deposited from the river water as the current slackens.

Between Wentzel river and cape Barrow there is plenty of shelter to be found behind small islands.

Inman harbour is large but is open to northerly winds.

At the tip of cape Barrow there are two good harbours. The better one is near the east side of the tip and is circular and about 1,000 feet in diameter, with a fine steep sandy beach on the eastern side. About a hundred yards back from this beach there is a fresh water lake and there is ample water for any ship in the harbour and entrance. When entering, a boat should stand in from the west, about 150 feet from the shore, keeping a sharp lookout for a rock just awash, about 500 feet off the main mouth of the harbour. The harbour is a little to the west of the main group of islands about the tip of the cape. (Plate XL, figs. 1–2.)

The second harbour is a little to the west of the one just described. It is larger; but is probably shoal in spots.

About a mile and a quarter southeast of the tip of cape Barrow there is a small bay with a good fresh water creek running into it. Fresh water may also be obtained from many little lake basins in the granite.

Throughout Coronation gulf, islands are so numerous that one can usually find shelter. On the north side of the islands it is not unusual to find reefs or dangerous shoals, but on the south side the water is usually deep. Harbours are common among the islands. In all navigation in Coronation gulf a careful lookout must be kept, for shoals, reefs, and small islands are common in unexpected places.

After leaving cape Barrow for Bathurst inlet, the next good harbour is Detention harbour, which Franklin has described. It is a fine large harbour with entrance on the west side of the island at its mouth. About its southern and eastern sides, extensive grass lands offer splendid feeding grounds for caribou in spring and fall.

Between Detention harbour and Kater point shelter can be had in many places amongst the islands close to shore. At Kater point there is a very fine harbour which Franklin found and named Snug harbour. It has a narrow entrance just west of the strait between Marcet island and Kater point. It is well protected by the high diabase bluff of the point, and has plenty of water for good sized ships. The channel between Marcet island and Kater point is narrow and probably carries only three fathoms of water.

There is a small but good harbour on the southwest tip of the Cheere islands.

From Kater point to the foot of Arctic sound there is no harbour, though a little shelter can be had from northerly winds behind the low sandy point on the west side of the sound. All the west side of the sound south of this point is shoal. The mouth of Hood river is hidden by low sand bars; but there are several outlets, all apparently shoal. We entered the river through the second mouth from the south side of the delta. This appeared to be the main channel but there was barely three feet of water over the bar. Once inside, the channel carries nine or ten feet for several miles up the river.

Good shelter can be had on the tip of Wollaston point, behind a small island near the eastern side of the tip.

Amongst the Barry islands good shelter can be had almost anywhere, and there is a good hook on the south end of Ekalulialuk.

Climate

The Arctic coast region is subject to fewer extremes of temperature than is northern Ontario or the prairie provinces. During three years on the Arctic coast we had no temperature lower than −50° F. in the winter, nor can the writers recall any above 76° F. in the summer.

The cold is by no means extreme in Coronation gulf, but a penetrating wind blows almost continuously. We have seen dogs from the interior, accustomed to a dry windless temperature of 60 to 70 degrees below zero, that were miserably cold in zero weather on the coast. The gulf is completely frozen over during the winter and the cold is accompanied by less humidity than in other parts of the Arctic, where there is open water during this season. Blizzards are common, but are neither as frequent nor as severe as in a more mountainous country, or one with more open water; and, generally, air conditions are much more stable.

In Coronation gulf there is continuous daylight for more than two and a half months in the summer, from May 10 to August 1. For about one and three-quarter months of this time the sun is continuously above the horizon. On the other hand, during December and January the sun does not appear above the horizon for over a month. This period is not entirely dark for there are from four to five hours a day of very fair light.

Precipitation is very light. The snowfall in winter does not exceed two feet, and in summer there is seldom heavy rain. The ground is usually free from snow except in an occasional gully, for three or four months during the year.

There is little doubt that fur clothing is best suited to the country. It is lighter, more comfortable, and warmer than any white man's clothing that could be taken in. That worn by the Eskimos of Coronation gulf, however, is not very satisfactory for the use of white men. Anyone with experience could have suitable clothing made in the district but the maximum comfort can be secured from the clothing made by the Alaskan or Mackenzie Delta Eskimos. They select and dress the skins more carefully; the clothing is better made; and the design and fit are, in every way, more satisfactory for the use of the white man. The skin used for clothing is almost invariably that of the caribou killed in the early fall before the hair has grown too long.

A sleeping bag made from long-haired winter caribou skin is lighter, warmer, and more comfortable than either woolen blankets or eiderdown. A sleeping bag, weighing nine pounds, with a light canvas cover (weighing three pounds) to keep out the snow, is comfortable at any temperature.

For use in the summer, the clothing of the white man is better than that of the Eskimos; but for the greater part of the year, native clothing is to be preferred.

Wood

From Darnley bay to Bernard harbour driftwood is relatively plentiful. We travelled this coast several times in winter and spring and had no difficulty in finding plenty for camping purposes. There are stretches where there is little or no wood, and some where the wood is generally drifted over with snow, but one can always find plenty for camping, although, doubtless, more may be found in summer than in winter. There are many places, notably at and near the mouth of Croker river, where wood for building, spars, etc., is plentiful and of good quality. The Rev. H. Girling, G. Eldon Merritt, and W. H. B. Hoare wintered with the missionary schooner *Atkoon* in 1915-16, about twelve miles east of Croker river. They built a small house and used wood for fuel and for various purposes about the boat.

In the bottom of Darnley bay wood is not plentiful. There is a good supply on a sandspit near the southwest corner of the bay, but the quality is not good.

The shores of Dolphin and Union strait carry quite a sprinkling of driftwood, and during the two years that the expedition had its headquarters at Bernard harbour, we were able to pick up a considerable quantity within six or eight miles of our house. At the end of our stay, however, we had swept the coast clean within these limits. Apparently the amount of fresh driftwood coming in in any one year is not large. The traders and missionaries who have since wintered in this vicinity have had still more difficulty in finding wood and have had to depend largely on imported coal and fuel oil.

From Bernard harbour east there is much less wood. From the harbour to Richardson bay there are small quantities in the summer but these places are usually drifted over in the winter and the traveller cannot rely on finding enough even for camping. On a gravel beach, about five miles south of cape Krusenstern (about two miles south of the short portage), there is a good supply of wood, with clear spruce up to twelve or fifteen feet long, but in winter this beach was completely drifted over.

The Coppermine river brings down a limited quantity of wood and good wood for camping may be picked up for several miles on each side of its mouth. Generally this wood is of twisted, stunted growth, but near the mouth of the river occasional pieces twenty feet or longer may be picked up. This was the only locality in Coronation gulf where, in April and early May we found plenty for camping. The first standing trees are 18 miles up the river.

From the Coppermine eastward along the south side of Coronation gulf to cape Barrow all the gravel beaches have enough wood for camping in summer or early fall, but they are practically all drifted over in the winter. In April and May we had to rely almost entirely on the Primus stove, although we searched carefully for wood. In one or two places, notably about eighteen miles east of port Epworth, where behind a small island there is an excellent harbour for small boats, there is enough wood to build a small house and provide fuel for the winter. East and south of cape Barrow the supply on the mainland is extremely small. Many of the islands have some wood but this cannot be relied on in winter. More can be found on the islands in Coronation gulf than on those in Bathurst inlet, although even there a considerable quantity may be picked up in the summer. In general, more wood is found on the north and west sides of bays and islands than elsewhere.

Except for small quantities from the Coppermine most of the driftwood comes from the Mackenzie.

Many of the rivers coming to the Arctic coast have willows growing in their valleys and these bushes are often an important factor from a fuel viewpoint. They vary greatly in size from scrub varieties which reach only a few inches above the ground to some in sheltered valleys that grow to ten or twelve feet in height.

At Darnley bay, Hornaday and Brock rivers have willows at the mouth. There is considerable drift willow at the mouth of the Hornaday and it is probable that there are willows up the river for some distance. This is borne out by the reports of Messrs. C. Klengenberg and S. MacIntyre. On Brock river our party found willows for about fifteen miles; but Patsy Klengenberg told us, there are none beyond that point.

We found no willows on Croker river and saw no driftwood. We ascended the Inman for only a few miles but saw no willows. It seems doubtful if there are any on the rivers between Pierce point and Coronation gulf.

We found willows in small quantities but of good size on Rae river and, in April, 1916, used willows for two days from a clump about three miles from the mouth of the river. There is considerable small driftwood at the mouth of Richardson river, but we saw none of good size.

Commencing twenty miles up the Coppermine, there is plenty of spruce, and there are large willows on a creek which comes from the west at Bloody fall, eight miles up the river.

East of the Coppermine most of the creeks seem to have willows. At the mouths of several of them we used willows for camping and at the mouth of Tree river we lived for several weeks, using willows for fuel. The Niparktoktuak has spruce as well. Five miles up Tree river there are willows several inches in diameter. There are also willows at the first rapids on Hood river, in Arctic sound; and on some of the islands in Bathurst inlet, there are both dwarf willows and dwarf birches.

For winter travel in Coronation gulf or Bathurst inlet, a Primus stove and fuel, or seal oil and proper lamps for burning it, should be carried. In summer small amounts of wood may usually be picked up. Willows or dwarf birch, or even heather may be used if necessary.

Transportation

No one familiar with ice conditions in the Arctic will make a positive statement as to what can be done in a season; but it is a fairly reasonable statement that in an average season a ship can be taken from the Pacific into Coronation gulf; but it is doubtful if the return trip could be made in the same season. In 1913, it was impossible to get in or out past the Alaskan coast. Six ships tried to get in and failed, and two failed to get out. In 1914, one ship with inexperienced ice navigators, failed to get in, while another with experienced men, got in and out. In 1914, we went from Herschel island to our headquarters on August 24, without any difficulty. In 1915, we could not get out of Bernard harbour to go west until August 12, but during the latter part of August and all through September navigation was open. In 1916 our boat got out in July, and had little difficulty in steaming to the west. (Plate I, Figs. 1-2.)

So far as is known, ships can usually reach Herschel island from the west about August 10, although there are some years on record when ships could neither get in nor out. Experienced ice navigators have gone in or out, however, when inexperienced men have failed. Dolphin and Union strait is not free of ice by the above date, but it is almost certain to be free by the end of August or early in September. Coronation gulf is free of ice before this date, but after a ship has arrived in Coronation gulf and has been unloaded, it is doubtful if she could return to the Pacific in the same season. In the gulf the ice breaks up in the latter part of July, and disappears in a very few days, and the harbours and sheltered water freeze up early in October. Open water may be relied on only through August and September, but during these two months one can go anywhere with any available kind of boat.

Dog Teams.—For perhaps a month before the break up and for a month after the freeze up the ice is not safe. During the remainder of the winter season, travelling is done by dog team. (Plate XLI.) Dogs and dog teams form a never ending topic of conversation and argument in the north. Dogs, sleds, harness, methods of hitching, feed, etc., vary in different parts of the Arctic and are all quite different from those which give the best results in a wooded country. Dogs from the interior want fish for food and will not at first eat seal meat, whereas those from the coast want seal meat only. The toboggan used in the interior is of little use on the coast. Sleds vary in type from the toboggan of the interior to the heavy, unwieldy but easy sliding, ice-runnered, native sled of Coronation gulf; the Point Barrow or Alaskan native type which has little to commend it; and the Nome sled or basket sleigh, which is a native model, adapted and improved by the white man. Dogs vary from the long legged, spare-framed, short-haired dog of the interior (adapted and trained for speed, lighter hauls, and soft snow) to the long-haired, short-legged, broad-chested, heavy-framed animal of the coast, adapted for heavier and slower hauling where the snow is not soft and living conditions are more severe.

Any white man going into the country will probably find that a sled of the Nome type is the most suitable. This sled will carry more and stand up better than any other kind; also, it can be handled more easily and, generally, is well suited to the country. Generally, a team will haul 100 pounds to each dog with a Nome sled, although in our experience it was usual to start out for long trips with as much as 150 pounds per dog. We found that a seven-dog team, with the Nome sled and Nome harness,[1] gave the best and most economical results.

[1] Harness with fitted leather collars, double traces, singletree for each dog, and dogs hitched in pairs to a central towline, with single leader in front.

For inland travel in the summertime, packing by dogs and men is the only method. Good dogs will pack about forty pounds. (Plates XXXIX, fig. 1, XLII, fig. 2.)

Seasons and Conditions for Work

For mapping in the Arctic, conditions of light and travel are the two factors of greatest importance. The best season is from the early part of March until about the middle of June. It is at this time of year that the two conditions, considered together, are at their best. The cold is still severe, but is not a drawback to the work. Rather, it is an advantage, for the cold weather is usually clear while fog and storms come with the warmer days. During this time the days are lengthening to continuous daylight; the ice is in good condition for sled travel; the light is good; the caribou are coming north; and, in April, the seals are coming to the top of the ice and may be secured by natives or experienced white hunters.

The next best season is that of open water. This varies from year to year for the individual season regulates the breakup and after that the winds may either drive the ice offshore or hold it on the shore. But, in general, August and September may be relied on fairly well. On the open coast, ice may be on the shore at any time, and for any length of time; but in sheltered areas such as Coronation gulf, in a normal season, the ice has cleared out and working conditions are good soon after the first of August. In 1915, at Bernard harbour travel along that part of the coast was not feasible until the middle of August; but, in 1916, conditions were fair soon after the middle of July.

The harbours and sheltered bays freeze soon after the first of October and the open coast freezes a few weeks later. In 1913, at Collinson point, the ocean as far out as we could see, froze over on the night of September 12 and did not again open; but that was an exceptional year. In 1914, Bernard harbour froze over on October 16, although Dolphin and Union strait was not frozen along the shore until after the first of November, and travel along the coast was not possible until the middle of the month. In 1915, at port Epworth, the harbour was partly frozen over on October 5 and on the 27th we were able to travel along the coast without difficulty.

The amount of work that may be accomplished after the freeze-up, varies from year to year; but not a great deal can be done any year and it is wiser to attempt only work that is within a reasonable distance of the base camp. The days are short and growing shorter; light is poor and grows poorer up to the disappearance of the sun early in December (a variable date depending on the latitude); and storms are frequent and may break up the ice, which is still thin, and carry it away from the shore.

The season while the sun is hidden and until the early part of March is best occupied in the computations and compilations which are always an essential part of mapping.

Working conditions must be distinguished from conditions for travel. It is usually possible to travel during any month in the year but work may be at a very low degree of efficiency. From about the middle of June until the ice has broken up and cleared away, considerable travelling may be accomplished but it is not always possible to go where the work may require one to go. There is usually open water near the shore and it may be impossible to reach the shore when it is necessary; the points of land may have ice on them while the bays may be largely open and their entire extent have to be traversed along the shore, which is frequently prevented by the rivers which have broken out and cannot be crossed; or open leads may have developed which force the traverseman to follow them until he comes to some place where they may be crossed. Also during the darker time of the winter it is quite possible to undertake any journey, but the days are so short, the light so poor, and storms so frequent that it is impracticable to undertake any other than the most general work. Work in any detail or degree of refinement is not possible.

APPENDIX

Geographical Positions

REFERENCE POSITIONS

—	Latitude N.	Longitude W.	Variation E.
No. 1 Monument. International Boundary Survey	69 38 45	141 00 00	
Herschel island, R.C.M.P. Barracks	69 34 11	138 54 31	
Cape Bathurst, N. tip of sandspit	70 35 06	128 05 09	54 15
Cape Parry. Cairn 0·4 miles S. of N.E. tip	70 04 30	124 36 33	
Bernard harbour, C.A.E. station 1914-16	68 46 55	114 50 27	52 46

The position of Bernard Harbour is derived from No. 1 Monument of the International (Canada-Alaska) Boundary Survey. All the following positions are referred through Bernard Harbour to the 141st meridian of the International Boundary Survey.

POSITIONS IN AMUNDSEN GULF

—	Latitude N.	Longitude W.	Variation E.
Argo bay. Small bay in S. W. corner Darnley bay	69 22 28	124 40 21	49 37
Wicksuaks. Eskimos camp on E. side Darnley bay	69 22 23		
Klengenberg's. N. side lagoon, E. side Darnley bay	69 32 25	123 06 07	51 29
Patsy Klengenberg's house. Foot of bay W. Pierce point	69 48 22	122 46 21	
Roscoe. One mile west mouth Roscoe river	69 41 51	121 07 32	55 30
Clinton. Camp at break in cliffs, Clinton point	69 29 48	120 30 58	
Clifton point. East side	69 12 40	118 40 16	55 22
Young point	68 57 22	117 06 21	53 07
Stapylton bay. Mouth creek 5 miles W. x N. from foot	68 49 10	116 09 03	51 00
Young point. Twelve miles E.S.E	68 52 34		

POSITIONS IN DOLPHIN AND UNION STRAIT

Hope point. 2½ miles S.E	68 56 05		
Cockburn point. 8 miles N.W	68 55 29		
Bernard harbour. C.A.E. station 1914-16	68 46 55	114 50 27	52 46
Cape Lambert. Small spit S. end cliffs	68 29 05	114 10 00	

POSITIONS IN CORONATION GULF

Locker point. Camp on sea ice about 5 miles north of cape	68 17 34	114 00 21	55 00
Locker point. Camp about 11 miles west of cape	68 14 03	114 29 54	55 30
Cape Kendall. Camp on small point 8 miles N. x W. from cape	68 07 37	115 19 47	50 30
Rae river. Mouth	67 56 13	115 38 28	52 00
Rae river. Station No. 197	....	116 35 42	
Rae river. Station No. 203	67 56 30	....	51 30
Rae river. Willow covered island, first lake	67 57 50	117 03 38	
Rae river. Station No. 266, forks near head	68 04 56	117 52 14	50 30
Overland portage from Rae river to Stapylton bay. Station 5	....	117 08 53	
Overland portage from Rae river to Stapylton bay. Sta. 5 plus	68 24 51	....	53 30
Coppermine river. Island in mouth	67 50 25	115 06 10	54 15
Island. S.W. of Hadlirk, 25 miles W. of port Epworth	67 42 03	112 59 15	
Port Epworth. Island in mouth	67 46 05	111 59 27	53 37
Port Epworth. Fishing camp ½ mile N. of mouth Tree river	67 41 10	....	51 30
Kogluktualuk (Tree river). At Upper falls	67 27 33		
Port Epworth. 14 miles east of port, E. side small harbour	67 49 48	111 23 28	
Cape Barrow. Harbour at tip of point	68 00 36	110 08 32	52 55
Cape Barrow. Umiak camp 1·2 miles S.E. of tip	67 59 32	110 06 15	52 15
Galena point. About 7 miles S. of point	67 49 37		
Kater point. Straits	67 44 20	109 04 03	53 36
Chapman island. W. Igloo, near W. end Hannerotit	67 57 16	109 32 36	56 00
Hannerotit. Near sta. No. 22, E. end Hannerotit	67 56 46	109 14 24	
Marcet islands. Camp sta. No. 90	67 46 53	109 00 33	

POSITIONS IN BATHURST INLET

	Latitude N.	Longitude W.	Variation E.
Sta. No. 28	67 36 50		
Sta. No. 32. Foot of Brown channel	67 21 48		49 00
Sta. No. 37		108 25 55	
Station 47		108 09 51	
Sta. No. 64. Barry island	67 31 37	108 18 39	45 00
Desolation camp. Station No. 77	67 27 36		
Kanuyak island. N. Straits, W. end ridge	67 53 27	109 01 06	49 00
Iglor-u-allik. Island in bay W. side	67 36 28	108 26 01	52 00
Ekallulialuk. Under bluffs W. side, sta. No. 152	67 35 35	108 04 52	48 00
Hanneracherk. Sta. No. 182	67 22 57	108 10 52	45 43
Tikiraryuak. Wollaston point N.W. tip	67 38 19	108 40 04	
Sta. No. 192 plus 18	67 46 41		49 30

POSITIONS FROM INTERNATIONAL BOUNDARY ALONG COAST TO THE EAST AND IN MACKENZIE DELTA

No. 1 Monument. International Boundary Survey	69 38 45	141 00 00	
Herschel Island, R.C.M.P. Barracks	69 34 11	138 54 31	
King point, Spit near W. end of harbour	69 06 05	138 0 07	
Akpagviatsiak, N. Point of delta	68 57 50	137 10 00	
Roxy's cache. Near mouth Moose R	68 53 04	136 4 28	
Ministikug and west branch Junction	68 38 55	135 48 57	
Iglukitaktok	68 20 30	135 3 25	43 47
West branch and Aklavik	68 15 32	135 01 28	
Aklavik and cut off to Middle branch	68 07 58	134 39 06	
N. entrance Aklavik and Middle branch	68 03 58	134 28 25	
Peel river and Middle branch	67 41 17	134 27 54	
Station No. 387	67 50 11	135 3 40	
East branch. Point No. 31	68 43 18	134 3 34	44 16
Nanereak	69 00 54	134 37 55	42 44
East branch. June 21	68 14 17		
Arctic Red river	67 27 20	133 3 43	44 42
McPherson	67 26 58	134 48 30	44 17

POSITIONS ON FIRTH RIVER

Camp No. 1		139 5 03	
Camp No. 2 Big Bend	69 12 35	139 55 31	
Camp No. 3	69 08 35	140 08 31	
Station 31-32	68 57 07		
Camp No. 5 1½ miles below Ikthout		140 5 51	

ESKIMO PLACE NAMES*

CORONATION GULF

TIKIRAK: *Locker point.* (The forefinger.)

KIKIGARNAK: Hill with stone house on top, west of Locker point.

PAUNERAKTOK: First islands south of Locker point. ("It has berries.")

NAUYAT: Island south of Locker point. ("Sea gulls.")

KULLIKSHAK: Second island south of Locker point. ("Stone for making lamps.")

INYUERNERIT: First island south of Locker point. ("A place formerly inhabited now uninhabited.")

NUVUK: *Cape Krusenstern.* ("Point of promontory.")

ANGOYARVIK: Second point south of cape Krusenstern. ("Rather big.")

SATUALIK: Small island about 17 miles southeast of cape Krusenstern.

NANUKTOK: Group of islands to the northeast of Satualik ("Place where a polar bear was killed.")

*Translation and etymology of Eskimo names verified by Mr. D. Jenness, ethnologist of the expedition.

Names printed in italics are as approved by the Geographic Board of Canada and printed on accompanying maps.

EPEAVIKSUAK: Island to the east of Satualik. ("A hitching post" so named from its appearance at a distance.)

AKUVILLIK: Group of three small islands about 14 miles northwest port Epworth. ("Place where a whale carcass was found.")

KINGAK ("nose") and TOKINGEYOK, two islands of Akuvillik group.

CORONATION GULF. 2.

IMILIGARYUITKUT: Island south of Locker point.

ULUGVIK: Cliff behind *Cape Hearne.*

IMNALUGYUAT: *Cape Kendall.* ("Big cliff.")

PALLIRK: *Rae River.* ("Dead willow twigs.")

NIAKONGUAK: *Richardson river.* ("Little head.")

KUGNAHIRK: *Richardson river.* ("A mere river.")

KOGLUKTOK: *Coppermine river.* ("Big river.")

HAGAVAKTOK: *Bloody fall.* ("Cascade, tide-rip, current.")

NIPARKTOKTUOK: First small river east of the Coppermine. ("It has spruce trees").

KUGARYUAK: Second small river east of the Coppermine. ("River, not very large, not very small.") This is a common name and is also applied to the next small river to the east. It was in the mouth of this river that Jos. Bernard wintered 1910-11. ("Joe's river.")

MALIGUN: Cliffs about 2 miles west above Kugaryuak. ("The place one follows along.")

AKLAKTOK: Island about 20 miles east above Kugaryuak. "(Place where a brown bear was killed.")

ONIKTITOK: Island off Maligun. ("The place which one passes beyond.")

ITUKSIORVIK: Bight between Basil bay and cape Kendall.

SALLIK: 10 miles east of eastern Kugaryuak. Grassy valley on mainland opposite 4 large islands with striking bluffs.

CORONATION GULF. 3.

OKRUHIVIK: Long low island about 15 miles east Kugaryuak ("Joe's"). ("Place where blubber was cached.")

KUGARYUAK: The easterly Kugaryuak. (See "Joe's" ditto.)

OKSHOKTUOYUAK: Island some distance off shore, and several miles west of above Kugaryuak. ("Place where seal blubber was obtained.")

KAIAKTILIK: Long low island a short distance off shore about two miles east above Kugaryuak. ("The place where kayaks or skin canoes were used.")

ILUITKALUK: The point of high land about 6 miles west of Hadlirk.

OMUNOK: Eastern island of group near shore about 28 miles west port Epworth. ("Heart.") So-called from its apparent shape.

HADLIRK: The two large centre islands of above group, close in shore, having high cliffs.

IHUITKALUK: Low grassy mainland between Hadlirk and (eastern) Kugaryuak.

AUNIRK: Two low islands about seven miles west port Epworth, and two miles off-shore.

KITAGUNAK: Country east side port Epworth.

NENNITAK: Country west port Epworth.

PINGANGNĄKTOK: Country south and east port Epworth. ("The country towards the south.")

CORONATION GULF. 4.

KOGLUKTUALUK: *Tree river.* ("The river with falls or big rapids.")

KITTIRIGALUK: Granite peak 1,900 feet high, on east side Tree river and about five miles up.

KONGIYUALUK: Island at entrance port Epworth.

IHYORKTUAK: Large lake in valley south of diabase ridge to northwest port Epworth.
IMUKUTALUK: Large L shaped lake five miles above second falls on west branch Tree river.
UTKUSIVIK: First lake through canyon to east of Imukutaluk. ("The place for lamps.")
EKKALUITTUYAK: Second lake to east through canyon. ("Not much fish.")
IKIAROTIT: Prominent hill (diabase) at the south end of range on west branch overlooking Imukutaluk. Small cairn built here. ("Place where things are cached.")
KAIATILIK: Fishing lake to the west of the diabase range on the west side of the west branch of the Tree river (from the second cataract). ("The place where kayaks are used.")
TARIONAK: Lake to the northwest of Imukutalik. ("Only sea or salt water.")

CORONATION GULF. 5.

AGIAK: Cliffs extending west from *Grays bay.* ("Whetstone.")
IGLUHUGYUK: *Hepburn island.* ("Big house.")
ANIALIK: River in southwestern corner Grays bay. ("Place where fish go out to the sea.")
KOGLUKTUARYUK: River on east side Grays bay of Franklin. 1821. ("River with rapids.")
UTKUSIKKALUK: River on east side of Grays bay. North of above. Probably the *Wentzel river* ("Potstone place.")
HULUKTOK: Two most westerly of the *Jameson islands.* ("Wing.")
IMNAHUGYUK: The one of the *Jameson islands* third from the west with a big cliff. ("Big cliff."
TUPIRIUIT: Fourth from the west of the Jameson islands. ("Tents.")
AUKPILAIRTUT: Fifth from the west of the Jameson islands. ("Red foxes.")
IKIERIT: Sixth from the west of the Jameson islands. ("Cliffs with talus slope at the foot.")
NUVUKSHAK: Northeast point of Ikierit. ("Point.")
MANILLEROK: Land northeast of Anialik. ("Rough.")
NANITAK: Country south of Utkusikkaluk.

CORONATION GULF. 6.

AMAROALLIGIT: *Inman Harbour.* ("Plenty wolf cubs.")
KINGAK: Large island 20-30 miles north port Epworth. ("Nose.")
KONGLYUALUK: West entrance port Epworth. This is a common name for any sharp bend in the coast.
KITAGONAT: Two small islands in bay west Agiak. ("Steep.")
YOKINGEYAK: Long low islands southeast Nanoktuk. ("Stretched out.")
KABVERAVIK: Island between Paneraktok and Nanoktuk. ("Place the wolverines have left.")
SHUKARUN: Northern one of Paneraktok group. ("Support for a lamp table.")

DOLPHIN AND UNION STRAIT

INEKSHARVIK: *Cape Bexley.* ("The place where they finish up their clothes.")
AKULLIAKATTAK: The fishing lake back of cape Bexley giving to the tribe its name. ("Short portage.")
AKUNNIK: Land to the south of cape Bexley and Stapylton bay.
SIORAK: Creek at the foot of Souths bay. ("Sand.")
AIYEYAK: *Cockburn point.* ("The place to which (the caribou) always return in the summer when driven by the mosquitoes.")
PIYUMALEKSIAKUK: Two islands off *Cockburn point.* ["The places they (ducks?) love to frequent."]

UGYUKSIORVIK: *Bernard harbour.* ("The place where bearded seals abound.") Strictly, this is the bay on the east side of the Expedition station at Bernard harbour.
KIKIAKTARYUAK: *Chantry island.* ("Big island.")
HUNGAGNAK: Small island off the west end Chantry island.
NULAHUGYUK: Fishing creek four miles southeast Bernard harbour. ("The place with a covering of snow or ice.")
HINGITTOK: Fishing lake about 6 miles south of Bernard harbour. (From *hinnik* = the fur fringe on clothing.)
UKULIT: *Liston and Sutton islands.* Collective name. ("Arctic hare.")
NOAHOGNIK: District of the triangular peninsula with apex at Locker point.

DOLPHIN AND UNION STRAIT. 2.

PUTULIK: The northern island. ("The place with a hole," because there is said to be a hole under the island.)
ILLUVILLIK: The southwestern island. ("The place with graves.")
AHUNGAHUNGAK: The southern island.
IMNEYUKAT: *Cape Lambert.* ("Cliff.")
KAUWAKTUAK: *Lambert islands.* Name for both islands. ("The place gleams in the light.")
IGAKTORLIGYUAK: *Lambert island.* Western island. ("The large island to which men cross.")
IGAKTORLINNUAK: *Lambert island.* Eastern island. ("The small island to which men cross.")
UVAIYU: *Mount Barrow.*
IMNELIGARYUK: Hill or cliff about half way across the long portage over cape Krusenstern. Has small lake at east foot. ("The place with a cliff.")
KEAHOTIVIK: *Hope point* region.
AKIOHUARYUK: Bay at east side of short portage over cape Krusenstern.
TULUGAK. Cliffs north side of portage bay. ("The raven." A nesting place.)
AKULLIAKATTUK. Short portage over cape Krusenstern.

VICTORIA ISLAND

IKPIGYUAK: *Cape Baring*? ("Big cliff or hill.")
SINIELUK: *Pullen point* (*cape Kendall*). ("Old beach.")
KIKIAKTARYUAK: *Bell Island.* ("Island.")
NAUYAT: Northwest of cape Kendall. ("Sea gulls.")
ANNORIDLIT: *mount Arrowsmith*? ("The windy place.")
MISUMEOK: *Cape Hamilton.*
NIAHOGNARYUK: *point Williams.*
KINARUK: Cape 4 miles east of point Williams.
TULUGAK: Cape 20 miles east of cape Hamilton. ("Raven.")
INGNERIT: Place marked, "Cliffs about 80 feet" on Rae's map. ("Pyrite" because pyrite, used for striking fire, is found here.)
TIPFIKTOK: Hill on coast 20 miles east of Ingnerit.
OKAUYARVIK: Point marked "18th May" on Rae's map. ("The place where the plant *Dryas integrifolia* is found.")
KINGAUTAK: Centre peak of the Colville mountains. ("Big nose" or big hill.)
KINGMIKTORVIK: Peak beside mount Arrowsmith. (to the west of Annoridlit which is the smaller). ("The place where caches of fish were made.")
ATTAUTSIKKIAK
KUGALUK } two creeks flowing into *Penny bay.*
HANERAK: A district on north side of Dolphin and Union strait, around cape Hamilton.
PUIVLIK: District bordering on Hanerak.
TAHIRYUAK: Lake 10 miles N.N.W. of Wivyuarun.

EPIULLIK: Creek with outlet N.E. of Reid island.
KIGIAKTALLIK: Lake, head of Okauyarvik creek.
OKAUYARVIK: Creek east of Epiullik.
KIMILYUAK: Creek coming into Forsyth bay.
KOGLUKTOK: River south of above. Comes out just below Clouston bay.
NUVUK: Point where Victoria island approaches nearest to Liston and Sutton islands. ("A cape.")
WIVYAURUN: Highest peak of the *Museum range.*

BATHURST INLET

HANNINIRK: *Cape Barrow.*
AKEAHUGYUK: *Detention harbour.* ("Big stomach") from its shape.
NAUCHEAKAVIK: *Kater point.*
KATTIMANIK: *Hood river.*
KILUSIKTOK: Country about the western and southern side *Arctic sound.* ("The place that lies behind or inland.")
Also the name of a small river which flows into the bottom of Arctic sound east of the Hood river.
KINGAUK: Small river 4 or 5 miles north of the Hood river. ("Nose.")
TIKIRARUAK: *Banks peninsula.* ("The forefinger.")
EKALLULIALUK: East *Barry island.* ("Plenty fish.")
KOKAVINGNAK: West *Barry island.* ("A chamber-pot.")
ALGAK: Island between Kokavingnak and Banks peninsula. ("Hand.")
IGLORUALLIK: Island north of Algak. ("The place which has old houses." Eskimo always come here in the fall.)
KANNUAK *or* KANUYAK: Island south of Barry island. ("Copper.")

BATHURST INLET. 2.

ALLIRAUHIRK: Smaller island to the west of Kanuyak. ("A part of the stomach used as blood-bag.")
KOGSUIT: A meeting-place on the mainland near Igloruallik.
KONGIRKSHURRYUAK: Creek from southwest, south of *Stockport island.*
SANINGAYOK: Country south of the foot of Bathurst Inlet. ("The country where one skirts along the side, i.e., of the river.")
UMINGMUKTOK: Country east side Bathurst inlet. ("The musk-ox country.")
KEGLINGOYAK: *Kent peninsula.* Country on top of land.
HANNEROTIT: *Chapman island* and the small island to the west.
NUAHONGNAT: Big island southeast *Galena point.* ("Protuberance.")
OKALLIRKTOK: Island between Nuahongnat and Hannerotit. ("No Arctic hares.")
KANUYAK: *Lewes island.* ("Copper.")
TATIGIRNAK: Three small islands north Lewes island. ("Caribou horn hook for paddle on kayak used to stop capsizing when spearing caribou.")
KELIRKTINGUALIK: Blockhouse hill on *Marcet island.* ("A bundle.")
NAKAHONGNAKTUAYÚTT: Island northwest above. ("Big calf muscles.")

BATHURST INLET. 3

ITIGUGUIT. Island northwest above. ("Big feet.")
EKALULIALUK: Island east above. ("Plenty fish.")
KITAGONAK: *Cheere islands.* ("Steep.")
KARITANGNAK: Island with caves on it, close to Kater point. Like Brains.
SHATUK: Island to north east in *Wilmot group.* ("Flat.")
KALUHARVIK: Island northeast above.
ONGAEVIK: Conspicuous horn on island northeast Shatuk.
UMINGMAKTOK. East side Bathurst inlet.
KIGLINGUYAK. Kent peninsula to the north.

GENERAL

KIKIAKTARYUAK: *Herschel island.* ("Island.")
NUVUGYUK: *Baillie island.* ("Point.")
UTKULLUK: *Cape Bathurst.* The people of cape Bathurst are Utkullugmiut not Avvagmiut as Stefansson calls them.
AVVAK: Cliffs about a mile east of cape Bathurst.
NUVUGYUK: Small sandspit on the west side Langton bay where there are a number of whale skulls.
AKILLINAK: Point opposite Nuvugyuk on the east side Langton bay.
IGLULUALUIT: Place at the mouth Horton river where F. Wolki and an Eskimo family lived. ("Many houses.")

IMARYUAK: *Great Bear lake.* ("Big water.")
TAHIERPIK: *Dismal lakes.*
IMARINIK: Source main branch Dease river. ("Empty place.") This is the lake Rouvier of "Lands Forlorn" by G. M. Douglas.

IKIERAHAK: General name for *channel.*
KONGIRCHUK: General name for *bay.*

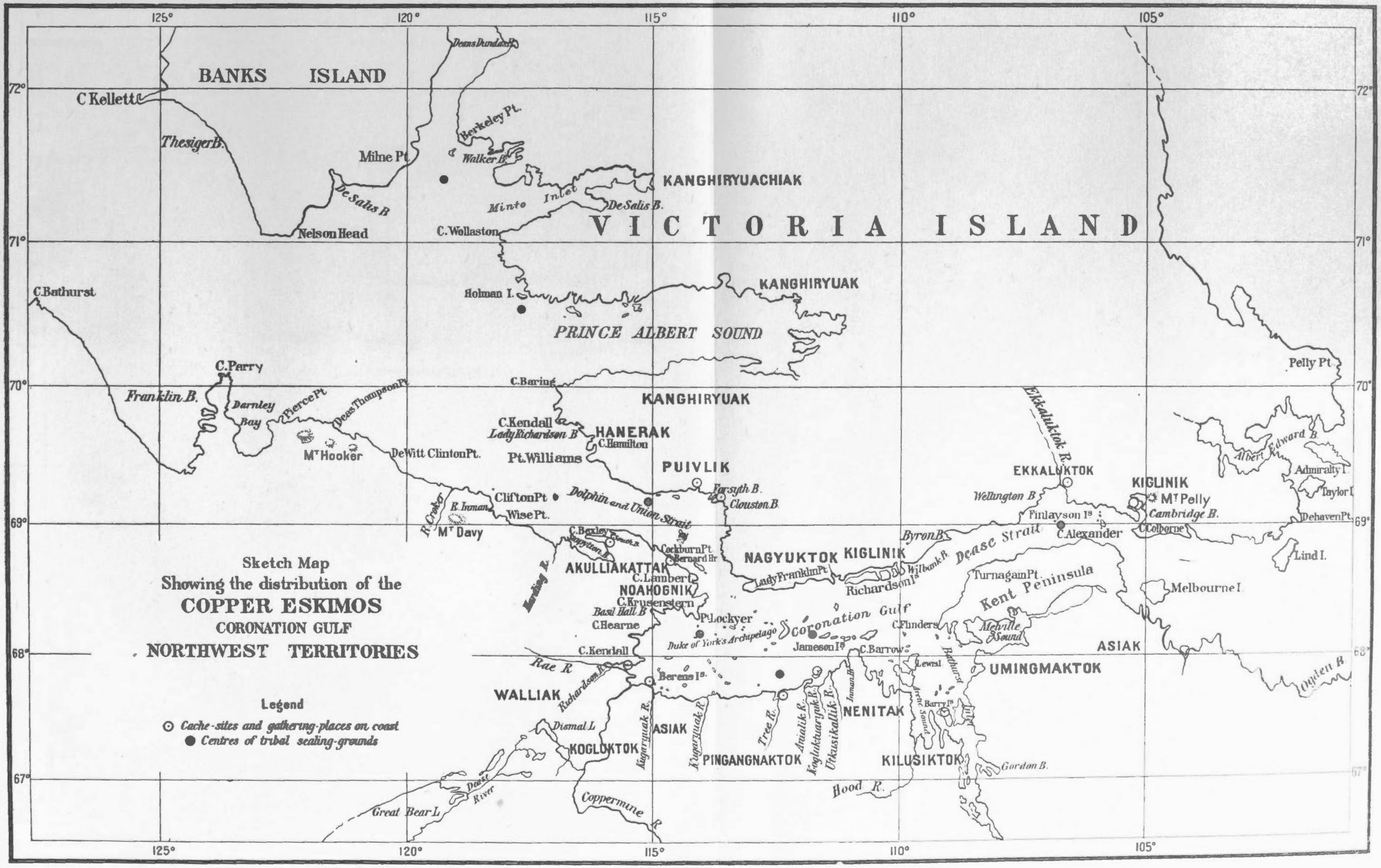

FIG. 7. Sketch map showing the distribution of the Copper Eskimos, Coronation Gulf region, Northwest Territories. (From Life of the Copper Eskimos, by D. Jenness, Vol. XII, Part A, 1922).

PLATE XXXVI

Fig. 1. Pack ice in Dolphin and Union Strait, July 29, 1915.

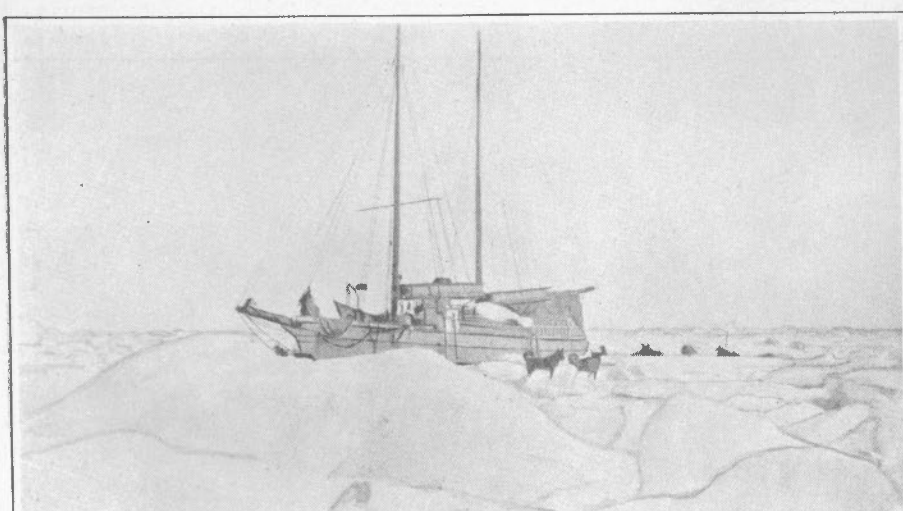

Fig. 2. Schooner *Mary Sachs* in ice, Camden bay, Alaska. August 29, 1913.

PLATE XXXVII

Fig. 1. Transit observations in snow house. Collinson point, Alaska, Winter of 1913-14.

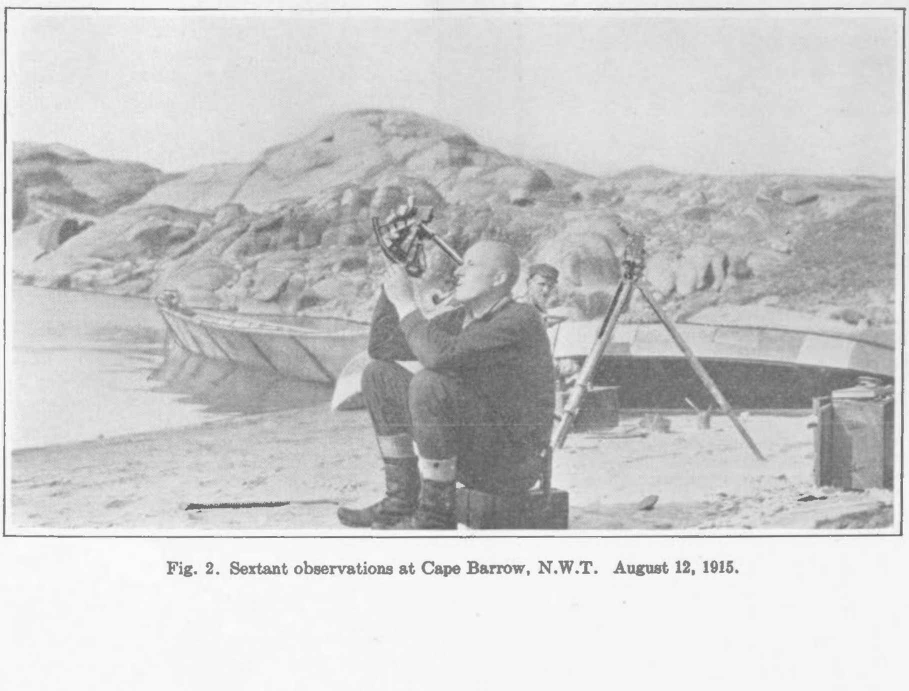

Fig. 2. Sextant observations at Cape Barrow, N.W.T. August 12, 1915.

PLATE XXXVIII

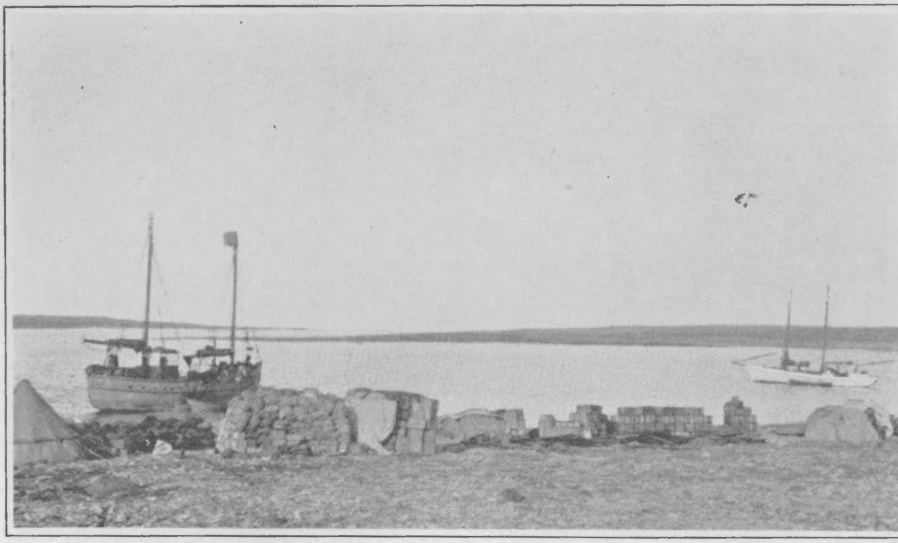

Fig. 1. Expedition boats *Alaska* and *North Star* unloading at Bernard harbour, Dolphin and Union strait. August, 1916.

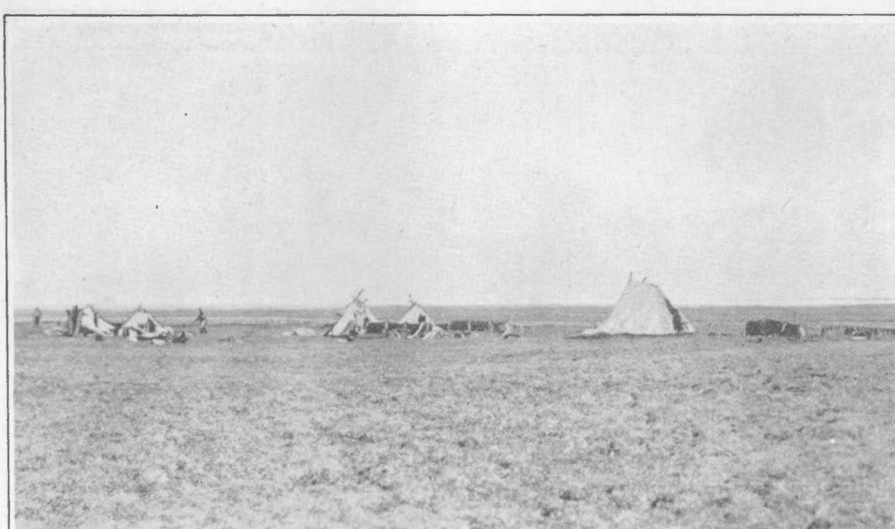

Fig. 2. Eskimo camp at Cape Krusenstern, Northwest Territories July, 1915. Photo by D. Jenness.

PLATE XXXIX

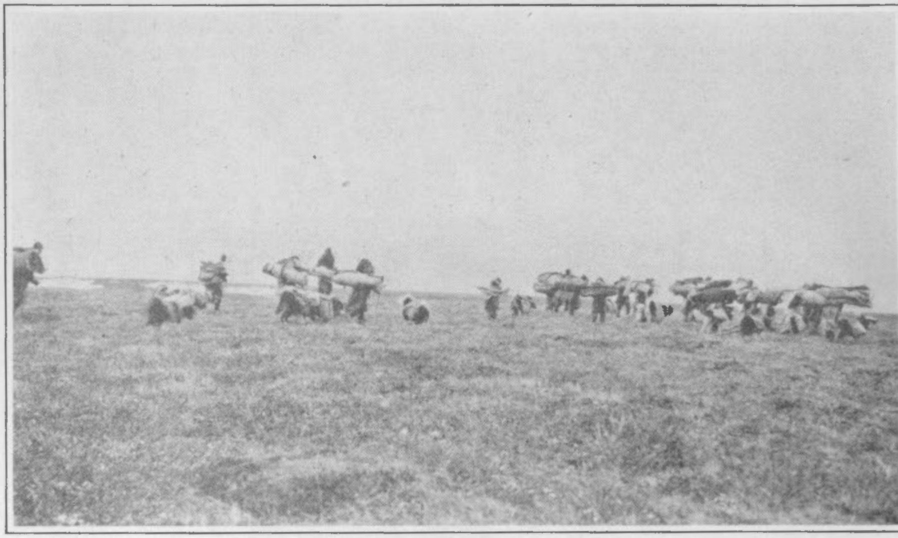

Fig. 1. Copper Eskimos packing on summer inland migration. Coppermine river. June, 1916.

Fig. 2. West bank of Coppermine river, 20 miles from mouth. June, 1916.

PLATE XL

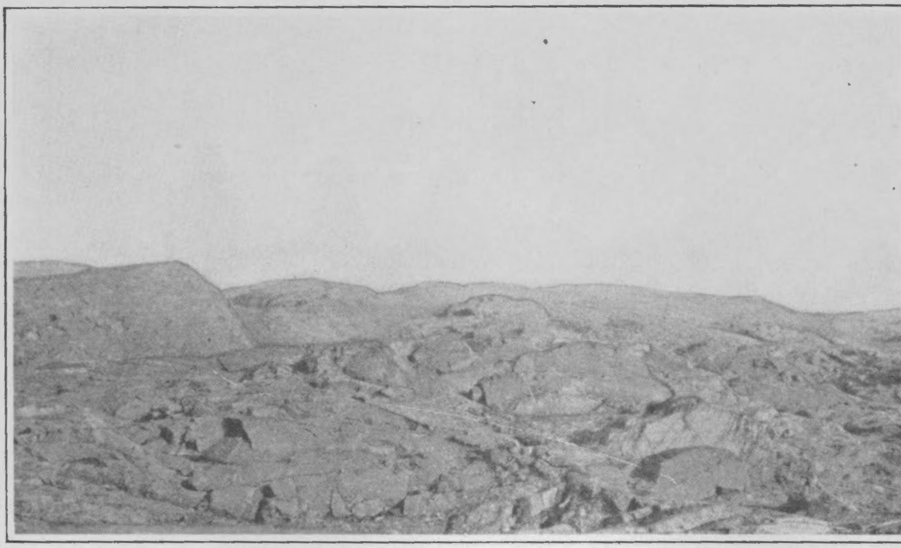

Fig. 1. Topography of Cape Barrow, Bathurst inlet. Precambrian granite. The proportion covered by any kind of vegetation is very limited, August, 1915.

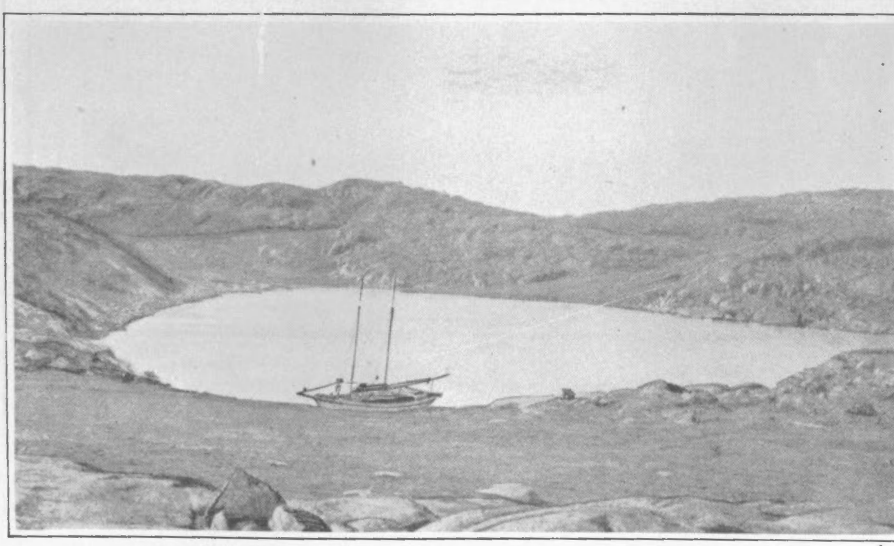

Fig. 2. Schooner *North Star* in small deep harbour at Cape Barrow ,Northwest Territories ,August 12, 1915. Photo by G. H. Wilkins.

PLATE XLI

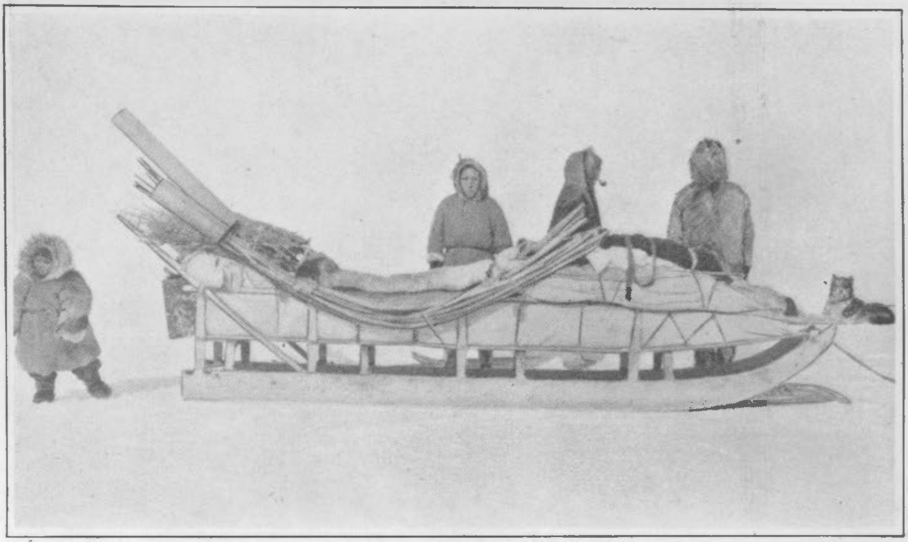

Fig. 1. Point Barrow, Alaska, sled, shod with bone. Photo by G. H. Wilkins, 1914.

Fig. 2. Nome basket sleigh with dog team hitched in Nome harness. Collinson point, Alaska. 1914.

PLATE XLII

Fig. 1. Copper Eskimo sled on the trail. Note dogs hitched with individual traces and mud runners shod with ice. Cape Krusenstern. Photo by D. Jenness.

Fig. 2. Eskimo dog with pack. Bernard harbour, June 29, 1915. Photo by G. H. Wilkins.

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