A GEOGRAPHICAL SURVEY OF THE SOUTH SHORE OF CORONATION GULF, BETWEEN 111°00' W. AND 115°45' W.

A Thesis Submitted to

the Faculty of Graduate Studies and Research

McGill University

In Partial Fulfilment

of the Requirements for the Degree

Master of Science

by

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July 3rd, 1956

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FOREWORD

This thesis is essentially the text of a report made for the Geographical Branch of the Department of Mines and Technical Surveys, Ottawa. The writer was sent by them to the Coppermine region in May, 1954 as part of a Programme of Research in Canadian Geography with two principal tasks. The first was the preparation of an Aerial Photographic Interpretation Key for as great an area of the region as could be conveniently and efficiently described in the time available. The second was to prepare a Geographical Report within the general limits described in the list of contents above. An introduction to the Report which deals with matters more administrative than Geographical has been omitted here and replaced by a new introduction and a short appendix describing equipment, food and techniques in the somewhat unusual conditions of the area.

My thanks are owed to the Geographical Branch for providing the opportunity for this work in its entirety and their permission to reproduce the material in this place. They must also go to my field companion George Falconer without whose companionship the field work would have been quite impossible and whose suggestions at many points helped me in my analysis; and to two other field companions, the Eskimos Jimmy Niptunatiak and Walter Bolt who acted at different times as guides in the field. I would like to thank the people of the settlement at Coppermine for their information and hospitality which was freely given. Finally I would wish to thank Professor J. B. Bird for advice and information before, during, and after the field work, without which many of my efforts would have proved fruitless.

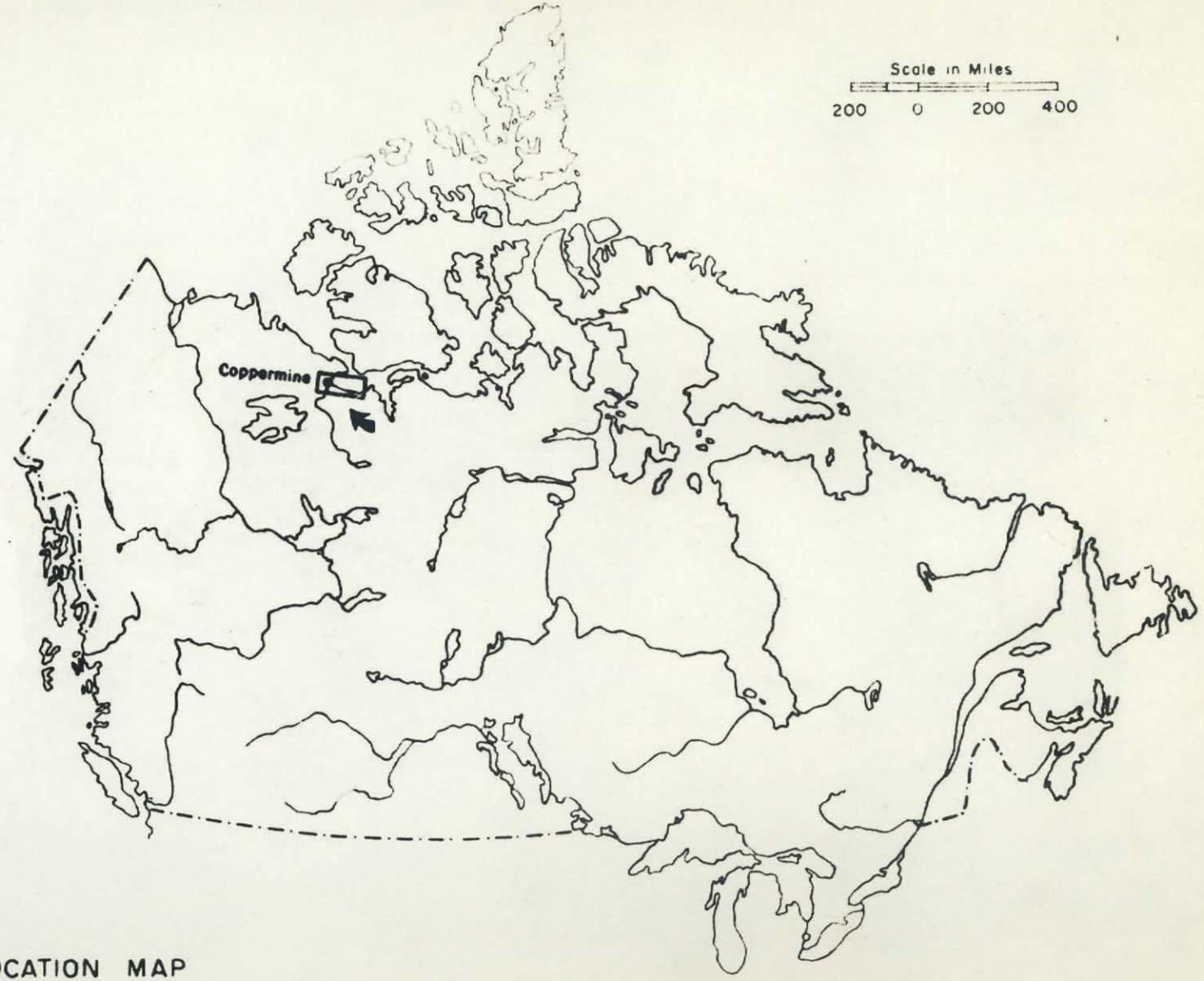
INTRODUCTION

1) Location map - Coppermine survey area 1954.

2) Investigations carried out by the Coppermine Survey.

3) Previous work in the Area.

4) Map illustrating routes travelled.



LOCATION MAP

Coppermine Survey Area 1954

INVESTIGATIONS CARRIED OUT BY THE COPPERMINE SURVEY, 1954.

The primary object of the survey was to provide a Photographic Terrain Interpretation Key, and the organisation of field work was directed to that end. As the terrain characteristics of the survey region had to be analysed during the preparation of the key it was also possible to prepare a geographical outline at the same time. Owing to the need for minute detail in the widespread photographs chosen for keying, a good deal of time was spent on purely photographic work at the expense of other aspects, notably the detailed geomorphology. However, a reconnaissance geomorphology was evolved, and the photographs taken should be of value in later evaluations in this field.

The survey area was found to have in it parts of six distinct morphological regions. The survey area contains only a part of each region, and the regions themselves extend for an unknown distance beyond the limits reached by the survey party. A map showing the regional boundaries within the survey area appears on Page 89 in the section entitled Geology and Geomorphology.

In order to organize the investigation of the whole area, the aerial photographs were made up into as complete a mosaic as they provided. The photographs which appeared most typical were set aside for the various regions. Search was then made for photographs showing atypical and unusual details within the main areas which had to be keyed for interpretation purposes. Making allowances for the fact that certain types and details were duplicated in different regions, it was decided that every type of terrain and most of the unusual features could be represented in 20 aerial photographs of sites distributed throughout the survey area. The provision of a key for these controlled all move-

ments in the field.

The work which provided a photographic interpretation Key for the selected aerial photographs also gave the detail for a systematic physical geography. The contact boundaries of the various geological series were plotted as precisely as possible, giving an improved generalised map of the geology.* Certain elements of the physiographic development were clear from the aerial photographs and the visits to the sites concerned revealed more detail. A past glaciation of the area was obvious from drumlinoids and eskers apparent in the photographs and some of the features were studied in the field. The drumlinoids gave the general direction in which glacial movement had taken place, and confirmation was obtained at numerous points during the journeys on foot, being taken from striae, chatter marks and plucking.

The probable limit of the postglacial sea was observed, together with raised beaches, depositional and erosional features and the various geomorphic processes.

The animal life of the area was recorded at all times. The writer was assisted by D. V. Ellis, a marine biologist working in Coppermine from May to August; and by R. Cruickshank, H. B. C. trader, a keen amateur ornithologist. The Eskimo provided data on number, habitat, variety and movement of animals.

The plant geography was more difficult to evaluate in the absence of specialized knowledge by either member of the party. Only an elementary

* The writer made only the broadest differentiation: as between the granitic rocks, the basaltic rocks of the Coppermine Series and the dolomitic Epworth Series.

division as to the ecology was possible: i.e., niggerhead; mosses; willow thicket; alder thicket; grasses, etc. The relationships of the broader basic types to the terrain and geology was most carefully recorded and successfully predicted from the photographs in the later work.

Only the most elementary climatic observations were made, since they could be no more satisfactory than those of the D.O.T. station in Coppermine, whilst the short relative range of the field party and the brief period of stay at any one point made field observations pointless. The D.O.T. records are included in this report.

A collection of information on physical environment required for evaluation for defense purposes was made at all times in the field in accordance with the prepared checklist DRB 35-390-367 (JIB).

The field work was interrupted by long periods, as during break-up, when the party was confined to Coppermine. The opportunity was then taken to obtain as much information as possible about the history and running of the Hudson's Bay post, the R.C.M.P., the Catholic Mission, the Anglican Mission, the D.O.T. stations, and the Eskimos.

A permafrost survey proved impossible as only in rare cases after mid-July was permafrost encountered at a depth that could be reached with the soil auger provided.

The tidal range was ascertained, but ocean currents were beyond the scope of the party. Some information on them has, however, been obtained from the literature.

The only major change in the project found necessary was the omission of a study and key for the palaeozoic area 20 miles west of Coppermine and north of the Rae River. The party was prevented from working there in the early days by bad weather; and in the closing week of the survey, when a second attempt was made, poor visibility and squalls made it unsafe for the party to proceed to the area.

PREVIOUS WORK IN THE AREA.

Previous work in the area can be divided into two main periods. In the earlier period there were purely exploratory parties whose objectives were new discoveries along the Coppermine River itself or along the mainland coastline to which the river provided a convenient routeway. The period ended with the passage of Stefansson in 1910. In the next period the first white settlement in the general area began, and work during this second period has been devoted to gaining more detailed and precise knowledge of the country and assessing the commercial possibilities of the geology. The whole subject is covered fully in the section entitled "History of Exploration" (P. 106). The following is a brief account of the various parties which have traversed the area, divided into the two main periods.

1771 - 1910: EXPLORATION.

The area was first visited by an explorer in 1771 when Samuel Hearne reached the ocean at the site of the present settlement of Coppermine. He had been sent to the area by the Hudson's Bay Company in search of the fabled copper mines which gave the river its name. It was not until 1820 that a white man visited the area again when (Sir) John Franklin and his party mapped the Arctic coastline eastward as far as Point Turnagain. Members of Franklin's second expedition, including (Sir) John Richardson and Kendall, passed through again in 1826 on their way back from charting the coastline between the Mackenzie and the Coppermine River mouth. In 1838 and 1839 Dease and Thomas Simpson used the river on their way to extending exploration of the Arctic coastline eastward to Castor and Pollux Bay. During the search for Franklin in 1857 Sir John Richardson sent Dr. John Rae

down the Coppermine River to search in the area north of the mainland, which he did without success, returning by the same route. There was then a long interval until 1902 when David Hanbury passed up the river at the end of the journey described in his book 'Sport and Travel in the Northland of Canada.' Finally there was the passage of Vilhjalmur Stefansson up the river in his early expedition inland, returning overland in 1910.

These last two men, Hanbury and Stefansson were not really explorers in the old sense. Although each contrived to cover a little new ground, their main contribution was to add more knowledge of the area. It was notable that the earlier explorers merely passed through the area. The later men marked the beginning of a period when more detailed scientific knowledge had to be accumulated and the accounts of Hanbury and Stefansson reflect the new attitude. The date of Stefansson's journey marks the beginning of real work in the survey area as outlined here. This work has gone on concurrently with settlement and has often been helped by it.

1910 to the present: Serious Scientific Investigation.

During 1911 and 1912 G. M. Douglas and a Swedish geologist, A. Sandberg undertook a journey to the mouth of the Coppermine River in the course of which Sandberg prepared the first reliable account of the Coppermine Series. It was 1913-1916 however that saw the greatest scientific activity throughout the area described and not merely along the Coppermine River. Those years saw the Southern Party of the Canadian Arctic Expedition based at Bernard Harbour and working parties travelled widely from there. The reports of the Expedition contain the greatest bulk of information on the area to this time. They include accounts of geology, geography, ethnology, anthropology, marine and mammal biology, etc., written by men including

R. M. Anderson, K. C. Chipman, J. R. Cox, D. Jenness and J. J. O'Neill.

The next scientist, as distinct from the settlers, was W. H. B. Hoare, a special investigator commissioned to carry out surveys affecting wild life and Eskimo in the area during 1924 and 1925. Coppermine settlement itself was begun shortly afterwards in 1927 and included by 1931 a meteorological station providing continuous data from then to the present time.

In 1929 and 1930 a geological exploration group called Dominion Exploration Ltd. carried out prospecting with the aid of aircraft, touching on the extreme south-west of the area under discussion, although the work was mainly concerned with the Great Bear Lake area. In 1930 another group of geologists under the name of Northern Aerial Mineral Exploration carried out mineral prospecting from aircraft actually based at Coppermine.

Since 1930 there have been many geological parties in the area, including independent prospectors. Their total number, date and locale are difficult to ascertain from published material but their presence in the area may be assumed to be almost a commonplace. Particularly strong groups worked in the south-west part of the area in 1943. Most of the search has been for copper, but there is no claim yet worked in the area. All the published accounts of work or visits to the area are included in the bibliography at the end of the report. C. P. Jenney has an excellent summary of the findings of the geological work in the "Proceedings of the Geological Society of Canada", Vol. 6, May, 1954.

The only previous geographical survey is that of Chipman and Cox of the Canadian Arctic Expedition 1913-18. (Vol. II) It is confined principally to a description of the area, and mainly the actual coast or the

Tree or Coppermine Rivers. There is no systematic physical geography or geomorphology. The human geography has changed considerably since that time and there is good reason to believe that the animal geography is doing so too. The climate has only been recorded since 1931.

Rae River
RICHARDSON BAY
COUPER ISLANDS
BERENS ISLANDS
LAWFORD ISLANDS
CORONATION GULF
Sir George Moore Islands
Hepburn Island
GRAYS BAY
Richardson R.
Coppermine
Bloody Falls
Nipparioktuak
Asiak
Kugaryuak R.
River
Anialik
Tree
Coppermine

Canoe and Foot.....

Sledge.....

Areas studied intensively over a period of time.....

ROUTES TRAVELLED BY COPPERMINE SURVEY - 1954.

Scale in Miles

8 4 0 8 16

GEOLOGY AND GEOMORPHOLOGY

1) Geology of the area.

2) Observations on the geology and structure affecting the physiography.

3) Features of the geology and structure affecting the physiography.

4) Evidences of Geomorphological Processes:
marine, river, glacial and minor modification processes.

5) Suggested geomorphological history.

6) Geology of the Area. (Map)

GEOLOGY OF THE AREA.

There is no accurate geological map of the survey area although there are a few generalised outlines prepared from the work of prospecting geologists. Since the only geological surveying has been in the search for minerals there has been no overall mapping, nor is there a published account showing full knowledge of the petrology or sequence. Many of the rocks are only vaguely named and their outcrop is not delimited.

Apart from casual accounts accompanying explorers' narratives, as in Franklin's and Hanbury's books, there are only ten published papers discussing the geology of the survey area. With the exception of one paper they describe the work of only five field parties, and two of those parties only touched on the south-west corner of the area. The one exception is a recent paper by C. P. Jenney in Vol. 6, Part II of the "Proceedings of the Geological Society of Canada" published in May 1954. This is the best description published up to this time and is a summary of information from all available sources, containing sketch maps. Its scope is restricted to an area between 114°W. and 117°W., but it contains references to areas lying further east. The title is 'The Coppermine River Area, N.W.T., Canada.' All the published papers are listed in the Bibliography.

From this and other papers it becomes clear that the survey area lies in the southern portion of a shallow structural basin more than 400 miles in diameter. In the western part particularly, north-east trending major tension faults have been traced over 50 miles, and the zone of faulting traced 100 miles south-west to Great Bear Lake.

There is widespread mineralisation, principally primary chalcocite and bornite, in the outcrop area of the basalts of the Lower Coppermine Series and this is closely associated with the faults.

The constant search for the copper of the area not only led to the exploratory journey of Hearne, but has been a constant attraction since that time for geologists. No deposit worth mining in the present undeveloped condition of the area has been traced, but there are numerous claims staked, mainly however southwest of the survey area proper.

In the summary of Jenney's paper is the following statement as to the sequence: "In the Coppermine, late Precambrian sediments and volcanics rest unconformably on a basal granite. The younger rocks are separated by a disconformity into an older series of sediments, predominantly dolomites and an overlying section of basalt and diabase flows with interbedded sandstones, shales and slates." (A table showing his version of the stratigraphical sequence is on page 14)

In the area about Coppermine settlement the Coppermine River series strike in a line some few degrees north of east, but the strike becomes more northerly in the eastern part of the area of the survey, until it becomes almost north-south. As a result of this alignment all the diabase scarps run out to the sea in Coronation Gulf. At a point just east of the large Kugaryuak River granite rocks appear on the coast, but at Epworth Harbour the sea coast is again of diabase. The Epworth Dolomite never reaches the sea, passing under the diabase at Port Epworth. Granitic rock east of the Tree River includes granites, syenites and gneisses. Jenney states that some part of the same area may in fact include gently rolling limestones.

TABLE I

STRATIGRAPHICAL SEQUENCE IN THE COPPERMINE RIVER AREA
(from: JENNEY. 1954)

Palaeozoic ..... Dolomites and Limestones.

Late Precambrian ..... Quartz carbonate veins.

Monzonite and acid dikes.

Coppermine River Series

Upper — Diabase flows and dikes with interbedded sandstones, shales and limestones ..... Approximately 15,000 feet.

Lower — Basalt flows with many interbedded sandstones and quartzites ..... Varying estimates - 3 - 13,000 feet. Thinly and evenly bedded.

Disconformity

Epworth Series

Dolomite and minor limestones.
3,800 - 4,900 feet.
Conglomerate.
Sandstones and Quartzites. 1,500 feet.

Unconformity

Teshierpi Granite.

OBSERVATIONS ON THE GEOLOGY MADE BY THE FIELD PARTY.

The work in the field revealed several important points about the geology. The map at the end of this section which has been prepared from aerial photographs and the field work shows the outcrop boundaries of the different rocks of the series. The different rock types were ascertained in the field and their boundaries precisely recorded on the sections traversed during the inland walks.

1) The Granitic Rocks. a) The granitic rocks were observed to be of great complexity and variety. Many varieties of colour and crystal size can be found within small areas in some places, as in the area west of Gray's Bay. Colouring varied from deep red through pinks to gray. There would appear to be many kinds of granite, with many intrusions and metamorphic rocks. Syenites were found, and some gneissic rock. There is a thick bed of what is apparently pink quartzite at the contact between the basalt flows and the granite at Gray's Bay, and as far west as 111°20' along the coast and inlets. It was not seen at the contact in Port Epworth harbour but may be hidden there by scree.

b) Large areas of gneiss were not seen, despite the reports of persons like Hanbury.[1] The only gneissic structures actually observed were in obvious fault gorges as at the Anialik River, where gneissic foliation may be observed in the rocks to a distance of a few yards only from the edge of the gorge. Gneissic structure was also seen at the edges of the valley running south from the coast at about 112°23' West.

[1] Hanbury, D. T. 'Sport and Travel in the Northland of Canada.' (1904) (P. 267)

c) The area of limestone suggested as being possible by Jenney[2] was not actually seen during the limited traverses of the party in the area.

2) The Epworth Series. a) An outcrop of an unmapped rock was found ten miles inland at an area about 113°50' West. This a fine-grained sandstone, and its observed outcrop of about five miles square appeared to be a sharply folded anticline although this was not proven. This sandstone has been associated tentatively with the dolomite which outcrops east and west of it. The rock contains elongated cavities up to one inch long, which are tentatively ascribed to solution. If the structure of the outcrop is an anticline, the rock is probably one of the sandstones of the Lower Epworth Series. It is unlikely to be one of the sandstones of the Coppermine Series because it is folded unconformably to the diabase scarps, striking at a right-angle to them, i.e., north and south. The area of outcrop may extend some little distance west as its actual contact is masked by drift.

b) The Epworth Dolomite was traced much farther west than was previously mapped, as had been suggested would be the case. More important was the tracing of the dolomite outcrop much farther north than was expected. Westward to the Asiak River it is never more than 24 miles from the sea and at the most westerly outcrop reached by the party, only 16 miles. At a point 18 miles south of the Asiak River mouth and on that river the Epworth Dolomite outcrop boundary finally swings away southward. This is recorded upon the map. It is interrupted by the sandstone mentioned above.

c) Excellent examples of nodular concretions in the limestone were found on the hill above the site of the old trading post on a plint of land in Epworth Harbour.

[2]Jenney, C. P. 'The Coppermine River Area, N.W.T., Canada.' 1954.

d) The Epworth Dolomite has been extensively faulted, the faults in many cases carrying on across the granite where the two rocks lie side by side. There are examples of structural relief, i.e., synclinal valleys and anticlinal hills. The drainage system normally occupies the fault systems and in some places carries across limestone and granite alike.

3) The Coppermine Series. In the survey area the only part of the series encountered was the upper part, that is the thick diabase flows.*

a) Between the north bank of the Rae River and Coppermine settlement nine scarps of the diabase occur. This includes adjacent flows with separate scarp manifestation. Between Coppermine and the Asiak River there are believed to be five outcrops of the diabase but there may be only four. Between the Asiak and the larger Kugaryuak River only two scarps come to the sea. All the basaltic caps east of the Kugaryuak River appear to be isolated pieces of the thick-bedded flow which makes an uninterrupted scarp reaching the sea at that river. Since this flow was found to lie directly upon the Epworth sandstone mentioned above, and directly upon the Epworth Dolomite, and directly upon the granitic rock it is clearly the lowest or earliest flow of the series. There is no trace of the exceedingly numerous and notably even and thin beds of the Lower Coppermine Series. The limited banding of the lowest strata of the basaltic rocks in Gray's Bay bears no relation to the numerous beds, totalling at the very least 3,000 feet in thickness found in the section down the Coppermine River, even allowing for the drastic thinning at 114°W. mentioned by Jenney.[3] The diabase scarp which outcrops at the Kugaryuak River was traced along its full length to the Coppermine River and was found to cross there

* Op. Cit. Jenney (1954)

at Escape Rapids. South of the scarp, as far west as the Asiak, are to be found granites, dolomites and sandstone in turn, but no basalt flows.

From this fact and the aerial photographs (Plate 1) the following deduction was made. Between the Coppermine River and 114°50' W., in the area of Escape Rapids, there shows a fan shaped area of parallel relief forms of no great height. There is only the vaguest of indications on one or two of these that they in fact have a rock core, since the greatest number of them are blanketed by resorted glacial material. The lineation* is consistent over as great an area to the south as could be studied from available photos. These linears reach the major diabase scarp and end abruptly.

It becomes reasonable to suppose, in the absence of proof to the contrary, that these lines are minor scarps of the thin-bedded Lower Coppermine Series which are in fact traversed by the Coppermine River a few miles to the west. Since in plan view they pass under the beds of the Upper Coppermine Series at a distinct angle (approximately 30°) it follows that there must be an angular unconformity. This nonconformity implies a long period of erosion between the depositing of the two parts of the series, and therefore the present version of the stratigraphy requires slight modification.

b) The islands of Coronation Gulf are continuations of the scarped outcrops which reach the sea between the Rae River and the Kugaryuak, but in the one island inspected closely the following observations were made. What had been presumed to be a basaltic cap lay on a thick bed of shales. Above the shales were two beds of igneous material. The bedding was parallel and the dip uniform. The rock which formed the top of the island was

* 'Topographic forms of marked linearity'. See: Lahee 'Field Geology' McGraw Hill Book Co. Inc., New York, 1952. P. 7. (Quotes Cloos, E. and Wilson, J. Tuzo).

however a coarse gabbro, an intrusive rock. It lay upon a more normal diabase with its fine crystallisation, representing a flow rock. Presumably an accident of erosion has left a former sill as the cap rock, but it is clear that the flows of the Coppermine Series must include sills and other intrusive features.

FEATURES OF THE GEOLOGY AND STRUCTURE AFFECTING THE PHYSIOGRAPHY.

The igneous rocks, and specifically the granitic rocks of the eastern part of the area resist erosion except along joints and faults, and by lateral planation, as of the sea. The result is a rectangular drainage pattern with a relief consisting of steep slopes to river gorges in a flat upper surface. The stage is not sufficiently mature to be termed a Laurentide topography.

A clear drainage pattern rarely develops on the surface of the diabase, possibly because of the limited catchment area of the outcropcrop for any one flow. The stream channels, if any, are entirely consequent, following the dip to the plain or the sea. The shortage of regular stream channels in many areas suggests that sheet run-off must take place. The streams are rarely deeply incised, except with a few notable exceptions for the main rivers, which may in fact be superimposed, or more probably exploit fault lines. There are indications that most river gaps in the diabase scarps are in fact along fault lines. The scarps persistently disrupt what would have been the general drainage pattern by diverting the consequent streams running down the regional slope to the sea. Only the Tree River is an exception, occupying as it does a contact between granite and limestone and therefore a presumed line of weakness. The Coppermine, the Richardson, the Niparktoktuak and the Kugaryuak all exhibit, as even an eight mile map will show, considerable redirection of their flow by scarps. The diabase also resists marine erosion, with its gentle seaward dip slope and homogeneous structure. The only sea cliffs in the basaltic material occur where faults, or faults occupied by rivers, breach the coastal scarp dip-slope.

The Epworth Dolomite is extremely resistant to erosion except along faults, which are numerous. The bedding shows extreme contortion and, where this approximately parallels the surface, sometimes controls local relief. It nowhere meets the sea, so nowhere shows the effects of marine erosion.

A sandstone, tentatively ascribed to the Epworth series is bedded in such a way as to have only one possible surface manifestation. It is apparently a sharply folded anticline running north-south, which has at some time been peneplained. As a result of this the rock now shows as low parallel ridges with sharp ridge tops, running in straight lines. Present erosional forces are unlikely to modify this form, as it conforms to the drainage pattern. It also conformed in the past to the direction of glaciation. It has no contact with the sea at the present time.

EVIDENCES OF GEOMORPHOLOGICAL PROCESSES:

MARINE. (Plates 2,3)

Along the whole coast the only present day sea cliffs are at breach points in the diabase material which can be assigned to causes other than marine erosion. At all other points there is a complete absence of even a notch to indicate a contemporary wave-cut platform. Present day beaches are few, and narrow in the few examples. They were only formed where there was a supply of unconsolidated materials from other sources, as in the river outflow areas and on the resorted glacial materials of the area about Coppermine. It can be assumed that the present shore line is not an old one and probably not yet stable.

The only destructional marine feature to be seen is an abandoned sea-cut cliff running westward from the Portage Lake area as far as the first diabase flow on the coast east of the Kugaryuak. It is too irregular to be a fault scarp or a fault-line scarp and has several hanging valleys along its seaward face. These are floored at a height of 350 feet and have debris cones and cascades running down to a rock knob coastal plain at 220 feet. Although the height of the hanging valley coincides roughly with the height of the maximum marine transgression recorded elsewhere in this section as occurring post glacially, it is unlikely to be the same one, since the cut bench, i.e., the area between 220 feet and the sea, has numerous striations, plucked rocks and other evidences of glaciation which could not exist on the floor of a bench cut after glaciation. The bench is therefore preglacial. The period of still stand required for the cutting of this bench was presumably considerable, as it cuts back two miles at its maximum. It is not clear how the striae survived the post glacial rise of the sea, but in this connection it must be said that striae

consistent with the general direction of glaciation can be found on parts of the coast almost awash at the present normal high tide.

Marine constructional features are much more common, and indeed are typical of the western part of the area with its unconsolidated materials. Most strandlines are gentle ridge forms, typical of those thrown up on a gently shelving coastline. The strandlines however are only seen in numbers in the areas of unconsolidated deposits. For example they are seen literally in hundreds on the Asiak alluvial plain. They also occur in great numbers on the alluvial plain of the Kugaryuak River mouth, and along the coastal plain between Coppermine settlement and Cape Hearne. The only other areas with such great numbers of strandlines are a cleft running up the south-facing scarp of the diabase above Portage Lake near Port Epworth, and the coarse shingle deposits on the point opposite the mouth of the Anialik River in Gray's Bay.

Where the strandlines do occur they generally have certain consistent characteristics. They parallel each other and follow without interruption one upon the other. Those in the fine unconsolidated sediments are seen to run without interruption to a height of over 100 feet. They are all on areas of exceedingly gentle slope. However there are a few marked exceptions. The strandlines in Portage Lake and Gray's Bay are on steep slopes of coarse material and appear at greater heights. In Gray's Bay they were estimated to occur at a height of over 200 feet. The Port Epworth strandlines may reach 300 feet.

Elsewhere along the coast strandlines are not always visible. There are reasons for this which show consistently. On the dip-slope of the diabase there is generally no material with which to construct beaches. The same is true to a lesser extent of the granite coastlines. Therefore

they rarely exhibit strandlines except near rivermouths, or in places where drumlinoids have been left on the coastal areas, providing materials for the process of beach formation. An example is shown in plate 4 and many other examples were observed. Due to the scarcity of material, the record except in alluvial rivermouth plains, is frequently patchy and localised.

In contrast to these constructional forms there is evidence of a limited number of small cut beaches in the unconsolidated materials. These show as cliffed banks about two feet high facing the sea and running parallel to it for some hundreds of yards. They never extend far at any one point, but similar sections of beach may be observed at points as far as 50 miles apart. There are generally two notches, but in some places there are three, or even four. There are two height ranges of approximately 25 feet and 50 feet, but when precisely measured the beaches did not seem to be consistent in height above the sea. They could be assumed to represent temporary still stands of the sea during continued uplift if a correlation could be made, but since this is not proved they are more probably storm cut.

The strandlines were not shown to be made of sands and gravels in all cases. For example, the lower strandlines at Coppermine and the Kugaryuak River are made of sand and gravel but excavation at the higher levels revealed only vegetation roots, peat and sometimes clayey sand. However the following section, made at the Kugaryuak River, may be presumed typical. Mosses and grasses with willow had grown on a thin layer of peaty soil. This lies on sand which becomes very pebbly about four feet down. This deposit was probably the original beach construction. It in turn lay on a material consisting mainly of pebbles and larger stones, thinly coated with sands and clay. This was also a basic material of the clay floor to

the river plain, as could be seen above the strandlines.

Strandlines can only be observed in those areas which have been exposed to the sea's direct action in the past. Strandlines did not form inside the small scarp south of Coppermine settlement or on the large plain of the Rae-Richardson rivers, although both these areas were covered by the sea during the last major transgression. Similarly they did not form in the clay plains between the first and second scarps east of the Asiak River mouth. Plainly they must result from direct wave action in the open sea.

The present day continuation of the same process can be seen on the shore just east of Coppermine. Here the sea, using material from the deposition of the Coppermine River, has built a marked shoreline bar which is now the easiest way of walking along the shore. It is continuous and stands about 5 feet high over high tide mark. It encloses a lagoon system of brackish waters. The strandlines rise in concentric lines from the back of the lagoons to about 110 feet on the scarp dip slope, disappearing at the rock outcrop.

One extremely significant old beach line is presumed to mark the extreme limit of the postglacial sea. It is distinguishable as an old shoreline only by the presence of sea shells. There is no visible topographic feature but there is a zone at a height of approximately 310 feet where shells may be found, always associated with sands. The occurrence of these was recorded as 310 feet, plus or minus the altimeter error, in all cases but one. This was east of Bloody Falls on the Coppermine River where shells were found at 285 feet. The position of the deposit was such that there is a possibility the materials had slumped. The heights of 310 feet were recorded as far apart as sixty miles, i.e., from the esker south-east of the Asiak River mouth to the esker just west of the Tree River. The inclusion of the Coppermine river shells would put

the range of this level at eighty miles. This old beach line was the only one found to have shells.

Despite the occurrence of a limited number of strandlines of coarse shingle in a gully near the top of the scarp on the eastern side of Port Epworth at a height of 460 feet, the line of beach material with shells at 310 feet is thought to mark the limit of postglacial marine transgression.

Shells are associated with materials at the lower margins of multiple type eskers at two points: above Portage Lake at 112°12' west and at a point three miles inland at 114°15' west. Both eskers show distinct ice contact forms. Similarly, shells near Bloody Falls are closely associated with a lobate sand plain standing at 315 feet which is clearly an old delta form despite the absence of proof as to its bedding. (Plate 5) This structure which is postglacial for the area, since it stands on 300 feet of material over striated bedrock, is also plainly associated with the same period which produced the sands and shells, which occur at the same height in all parts of the region. It is probably a delta formed in the sea because it has a lobate rim (associated with rougher water conditions) and stands on apparently unvarved clays which would therefore appear to have been deposited in salt water which causes flocculation and unvarved deposition. When the two types of feature are considered; one of them a feature formed in a postglacial sea, and the others englacial, it becomes clear that no advance of the sea beyond that height can have occurred since glacial times, since all ice contact features would have been destroyed. The creation of the delta form at that height suggests a significant period of stillstand, and its unique nature suggests that the stillstand was also unique in the recent geomorphology. The longest

period of stillstand would be that immediately following the retreat of the glaciers from this area, when the sea returned but before the earth's crust, relieved of its burden, had begun its slow return to normal level. The argument for this 310 foot maximum for the advance of the postglacial sea still applies even if the delta form and the eskers and the associated esker deltas were laid in preglacial lakes. The glacial period ice-contact features have survived the postglacial rise of the sea. The feature at Portage Lake would have been fully exposed to the erosive power of the sea in any rise of the sea.

It will be observed that all evidence for this maximum of the advance of the postglacial sea is of a negative type. Areas east and west have been claimed to show advances of the sea up to a height of six hundred feet and more.[4,5] However as the illustrations show, there is good evidence for a much lower limit in this area.

[4] O'Neill, J. J. Report of the Canadian Arctic Expedition 1913-18, Vol. XI, 'Part A: The geology of the Arctic coast of Canada, west of the Kent Peninsula.' P. 33A.

[5] Anderson, R. M. 'Recent Exploration on the Canadian Arctic Coast.' The Geographical Review, Vol. IV, No. 4. P. 258.

EVIDENCES OF GEOMORPHOLOGICAL PROCESSES:

RIVERS. (Plates 6, 7 and 8)

Taking the survey area and the country lying to the south of it as a whole, the following generalisations may be made about the rivers.

The drainage pattern appears to radiate from a centre lying well to the south on longitude 113°30' west. The rivers near the coast at that longitude run north and south. To the east they trend eastward and to the west westward. The rivers are remarkable for having few tributaries and none of any size, however great their length.

In the western part of the survey area the drainage trends west of north. This trend increases westward. The lower course only of the Coppermine River is a notable exception. The trend conforms to the general direction of glaciation as shown by drumlinoids and striae. The drainage has undoubtedly been a little modified by the glaciation. Drumlins have prevented, or even wiped out, tributary streams, and have accentuated the linear pattern. The streams however are not completely controlled by the glacial features since some have shallow gorges in bed-rock and penetrate the basaltic scarps. While the smaller cuts in the scarps may have been cut in glacial times as is shown by the present dry form and associated multiple type eskers, the major breaches are probably preglacial. The Coppermine, Niparktoktuak and Asiak rivers all have large breaches in the scarps. That these breaches are not glacial in age is inferred from evidence seen in the field. An example is the large esker form on the Asiak River. This form which presumably followed the sub-glacial preferred drainage does not pass through the present river-gap but runs in a line due north from a major bend in the river, over a ridge of bed-rock and down to a narrow fault gap now occupied by a different and minor stream. The present river-gap lies four miles to the west, and is therefore not due to the

glaciation. Since the present river cuts through the ridge which the esker runs over, being apparently superimposed upon it, and does not conform to the drumlinoids among which it runs, it is clearly a preglacial stream which has reasserted itself. The drainage pattern cuts the scarps and ignores the bedding of the Epworth series and would therefore seem to be a superimposed drainage pattern with a typical early consequent form. The consequence was presumably on the slopes of the upper trap rocks or a conforming later series, and conforms to the regional structure.

In the central part of the area, the alignment is north-south. The lakes show the same trend. The glacial deposits in the area are more thin than to the west but there are still small modifications of the pattern by it. To the east of this part the drainage pattern becomes more obviously influenced by joint control. The Kugaryuak River, although cutting a major gorge in the Epworth Dolomite is diverted by the 800 foot diabase scarp to its present mouth. There is a considerable wind gap in the scarp at the point where the diversion occurs. All north-south streams in this part are diverted by the major diabase scarp running from Escape Rapids to the Kugaryuak mouth.

In the eastern part of the area, drainage is fault or joint controlled. The main drainage lines in the dolomite are seen clearly to follow faulting, and in many cases the lineation is carried over the granite at the contact. In the granites and associated rocks, the drainage is along masterjoints, joints and faults. The main drainage is aligned in a direction east of north along the line of faults, and the rivers are deeply incised. The rectangular drainage pattern of the upland surfaces is highly developed but very shallowly incised, often only tens of feet. Where the joint streams systems join the master rivers in the faults there are generally cascades running to the lower level. The controlling faults may be seen in some cases to pass through the basaltic areas near the coast, but the rivers do

not cut through with them.

The Tree River in its lower course seems to have been guided along the contact of the granite and the limestone, but does not follow it precisely at the present. This river has two breaches in the diabase at the coast, one through which the present river makes an exit and another four miles east, now dry.

It should be noted that esker forms reported along the upper Tree River, well south of the survey area, lie at right angles to the river and conform in direction to the general glaciation and the regional slope. Because of the block nature of the granitic complex there was no proof observed of any kind of superimposition of drainage.

The erosion of these rivers cannot be said to have had any great effect upon the present physiography for the following reasons.

In the west of the area the rivers pass through basaltic scarps and large plains of unconsolidated deposits. These deposits are glacial or postglacial and were probably deposited by the present river system or a broadly similar one. The scarps are cut by gorges and the scarps to either side of these cuts are unmodified by streams. The cutting in the alluvial plains has been gully-like, even the largest rivers typically having cliffed clay banks, thirty to eighty feet high. Old beds of the Coppermine River and terraces upon the present river show similar characteristics. The nature of the material and the arid erosion characteristics of the arctic climate inhibit the development of normal valley forms. Hence the effects of river erosion are confined to a narrow belt about the actual river courses. There is considerable gullying in the clays going on at the present.

In the area about 114° west the rivers do not have these unconsolidated deposits to work upon, but exhibit similar characteristics. They have narrow valleys and where they penetrate scarps or ridges do so in narrow gorges. Only the Tree River has any appreciable valley plain before

reaching the coast. Lateral corrasion is at a minimum because of the slow continual rejuvenation which appears to be taking place.

In the east of the survey area there is deep cutting everywhere, but only along apparent fault lines. The major part of the surface has poorly developed streams, with a rectangular drainage pattern. Their cutting is not deep. The drainage pattern lies upon a surface clearly peneplained at just over 1,000 feet but is not itself obviously responsible for the peneplanation. The fault valleys contain trains of erratic boulders and would seem to have had a considerably greater flow of water in early postglacial times.

Many rivers which pass to the sea through gorges exhibit a blockage of sand, gravel and boulder fills, in which the present river is deeply entrenched. The hills lie at varying heights and usually have flat tops. Some exhibit ice-contact features. They seem to have been formed as a result of ice blocking the gorges on their downstream, or northward side. This ice would seem to have been the stagnant ice left during the decay of the ice sheet. There are signs that this was left in large quantities between the scarps of the Coppermine series and on the seaward slope of the region, as well as in the major river gaps to the sea, causing these depositional features which are typical of the area.

All rivers and streams show that they are in a process of rejuvenation either by exhibiting terraces, or convex slope of their banks in the case of small rivulets. The lower reaches of the Coppermine and Anialik plainly show non-matching meander terraces. These resemble meander scar terraces in form and show continuous excavation during restrained down cutting (See Cotton 'Landscape', pages 193 to 200). They show the last 100 feet of uplift to have been continuous and fairly even. The upper portions of the rivers exhibit terraces of an 'inset' type, and show erratic uplift and rejuvenation prior to the more recent and gentle uplift.

EVIDENCES OF GEOMORPHOLOGICAL PROCESSES:

GLACIATION. (Plates 9, 10, 11 and 12)

There are two types of evidence for past glaciation in the survey area: erosional evidence including mammillated surfaces, striations and plucked surfaces: and constructional evidence which includes ground moraine, eskers and drumlinoids. Large areas of clay and sand deposition are also the direct result of glaciation.

Striae were observed in most areas, and there was a general agreement of direction within a few degrees. Excluding two sets of striae running east-west on beach rock exposures which are ascribed to ice rafted agents, the striae showed a variation between N 12° E, and N 39° W. The great majority were aligned at about N 30° W. The differences in the direction did not change consistently east or west, and were clearly due to localised topographic influence.

Plucked rocks in many places indicate the direction of flow to be as indicated and not to the southward. This was further confirmed by the location of Epworth Dolomite erratics north of the dolomite outcrop.

Mammillation of the surface rock is a common feature in the area. The top rim of many of the scarps show this feature while the upper surface of most of the granites show glacial smoothing. The dolomite alone was not observed to have these features.

Of constructional features the most striking is the large swarm of drumlinoid features extending westward from 113°30' to at least 115°, and possibly further. This swarm reaches the sea between the Asiak and Kugaryuak river mouths, and extends southward to a distance not known to the survey, but certainly in excess of 25 miles. The drumlinoids are to be numbered in hundreds and show varying degrees of perfection in form.

All the drumlinoids are aligned at approximately N 38° W. Near the sea they have been reduced or modified considerably by the postglacial advance of the sea. Some of the smaller points and headlands between the Asiak and Kugaryuak are drumlinoid forms, passing into the sea and somewhat modified by it. The drumlinoid swarm matches in alignment with a large swarm covering the land west of Cape Krusenstern which was seen in a flight to Read Island. In the survey area the features fade away eastward in the area of increasing relief, a condition presumed to have inhibited their formation.

The drumlins examined varied in height from 80 to 180 feet in these forms unmodified by marine action. Their length was never less than half a mile, and was more frequently about two miles. Some are more than four miles in length. The width is fairly consistent at about 600 yards. The slope was invariably convex. They were well vegetated with moss and lichen ecologies, willows and grasses being confined to the small vales between the ridges. Clay and small pebbles with occasional cobbles and small boulders seemed to be the main materials from which they were made up, although this material was only observed on the higher parts of the slope. Lower down, the ridges appeared to be composed entirely of cobbles and boulders. The vales between the drumlins were invariably narrow, v-shaped and wet, and were frequently occupied by boulder stripes through which ran small clear streams. The streams may have washed out the clays giving an impression of different materials on the lower slope, or the structure may in fact change at the lower level. The stones and boulders were not observed to be faceted in any way, but were in most cases roughly rounded. There was no smooth rounding suggestive of prolonged water action.

In one area the drumlins lay in and among low rock ridges of broadly similar height and alignment. Their own alignment was unaffected by the ridges nor did they show consistent relationships of any kind to the rock ridges. Eskers within the drumlin swarm were all of a similar type and possessed braided outwash deltas which were confined by drumlins and sometimes included drumlin remnants in their area. The eskers stood higher than the drumlins in some places but deltas were invariably lower than the drumlins. The eskers were of different materials to the drumlins.

The drumlins reworked by the sea were recognisable only by their general shape, the features being subdued. Their composition was apparently different, consisting of sands, gravels and clays, but this was assumed to be the result of marine reworking and deposit, and to be superficial only.

There are a considerable number of eskers in the area. Seven were positively identified in the field, and four more are inferred from aerial photographs.

These eskers with the exception of two, are of the type known as multiple eskers or Irish eskers (Cotton, 'Climatic Accidents.' Pages 340-342). They consist of erratically continuous embankments with associated knob and kettle areas, and broad flat-topped delta areas, sometimes with kettle holes.

These features are associated by most writers with stagnant ice conditions, and their siting in this area falls in with such a supposition. No less than eight of the eskers lie in the area of low relief just south of the high scarp running from the Kugaryuak river mouth to Escape Rapids.

The eskers have an association with the present drainage system, and in most cases follow the present rivers closely. Where they do not,

they follow the present rivers in part and are then aligned with a wind gap or exit to the sea, following a course to the sea which is always more direct. Most eskers exist on one-way slopes and have delta forms in their lower parts, but that along the Asiak River is a notable exception. This leaves the Asiak at a bend at 114° 20' west and runs true north. It runs up slope for two miles, becoming gradually lower until it disappears at a non-scarped basaltic outcrop. On the further side of the outcrop the esker resumes, rising gradually from zero height to 150 feet above the surface as it descends the slope. It ends upon some three miles of broad flat-topped masses of deltaic form. On both sides of the ridges it has a similar topographic expression, i.e., chains of mounds and narrow embankments, but the material is vastly different. South of the ridge, on the slope to the river, it is made up purely of sands and gravels. North of the ridge, running down to the scarp, it is made up of regular sized 'cobbles' - rounded boulders about seven inches across. Even the ponds in the kettle holes and lakes are floored only with these, and have no sands or gravels at all. The delta forms near the scarp are capped with sands and gravels, but the lake floors are composed of the same cobbles. Other eskers encountered were made of the more conventional sands and gravels. The ponds in the Asiak River esker had all shrunk, and some had dried completely when visited in August 1954, as shown by water marking and the aerial photographs of July 1949.

Continuations of the esker line down slope or along rivers consistently revealed a form not described in the textbooks. This is best described as an elongated delta form with a braided upper surface. It resembles a valley train of fine materials, except that there are no existing confining walls of any height. The edges lie against drumlins or

may have a steeply sloping perimeter up to sixty feet in height above the surrounding terrain with a form resembling an ice contact, as if stagnant ice had formed the 'valley' walls which previously confined the train. The surface has ponds, some of which resemble kettle-holes, while others resemble meander cut-off pools.

Ground moraine apart from these eskers and drumlinoids is strikingly rare. Apart from one feature discussed below, nothing resembling an end moraine was found in the area. This, taken with the positive fact of drumlins right upon the sea; when drumlins are taken to emerge from beneath stagnant ice, indicates that the glaciation completely covered the area at its height, and that deglaciation was by decay.

The one example of morainic end-form was encountered at a point 5 miles inland at 113° 45'. Here, in an embayment cutting northward into the scarp there is a considerable amount of rock agglomeration. Apart from an unusually large amount of scree debris there is a ridge of debris about 300 yards long and 100 feet high which stands across the scarp-foot stream, and at right angles to the scarp. A short distance east there is a small arcuate ridge of debris which stands about 35 feet high and is about 150 yards across (See photographs).

These features have no clear origin. The arcuate ridge for example stands on and in massive rock debris, and blocks what is clearly an old stream exit. It faces toward the scarp. It lies between, and is lower than, some cut and reworked drumlinoids. All the field evidence shows that it cannot be a glacial end moraine. One mile east, features were observed which closely resembled "rock glaciers" (Cotton "Climatic Accidents" - P. 319. Lahee "Field Geology" - P. 363 and Flint "Glacial Geology and the Pleistocene Epoch" - Pp. 131-132). The features des-

cribed above are probably of similar origin. The arcuate ridge is possibly the result of a landslide deposit upon a lobe of ice left facing down stream.

For the most part there is a notable absence of surface debris throughout the area. The dip slope of the diabase is conspicuously bare of debris except in frost shattered basins upon its surface, where the debris was seen to be derived from the bedrock of the site, and in most cases to be still in situ. Erratic blocks were found but did not abound. Upon the granite the same is true except that there is less frost heaving of blocks. Erratics there were conspicuous, but small in total and bulk. The greatest number of erratics were found in the stream beds of the gorges, and were probably stream deposited by the vigorous outwash streams.

Finally in the evidence of glaciation comes the matter of the large deposits of sands and clays.

These deposits are small and rare in the eastern part of the survey area and no clays at all were found in the survey area east of Port Epworth, although some were seen by binoculars to lie about ten miles east of the farthest east reached by the party. In the west of the area however there is a large area of clay deposition extending over hundreds of square miles. This clay almost buries the low-lying scarps of the Coppermine Series in that area. It was never found to occur at a height of much more than 300 feet. Its contacts with the sea are usually masked by sands, probably marine deposits made since the clay deposition, because the sand cover does not extend inland beyond the observed limit of strandlines. There is a large area of sands about Bloody Falls with an unmistakeable old delta form, and this makes a cap of sand about sixty feet thick and with a distinct perimeter. Some sands are to

be found at different places along the coast, and there is another large area of sands at the Asiak coastal plain, reaching the sea; and off the mouth of the Niparktoktuak River. Small areas were seen at other places, at a height of about 300 feet and generally near esker forms.

The clay in the Bloody Falls area is in an advanced stage of gully erosion, and in one gully which had cut down to bedrock, striations were observed. These had a bearing of N 20° E which differs but slightly from the general direction of the last glaciation as inferred from other striae, drumlins, etc. If the striae are of the last glaciation, then clearly the clay deposits are postglacial. It seems probable that they are the outwash of the decaying ice and the subsequent washing out of ground moraine by the postglacial river system. No varves were observed in any clays north of Bloody Falls, or between the scarps, and this would imply deposition in salt water, although there is no reason why there should not have been glacial ponding by stagnant ice.

GEOMORPHOLOGICAL PROCESSES:

MINOR MODIFICATION PROCESSES.

Gravity and Frost. The scarp fronts are rarely fresh, being covered with lichens or orange fungi which indicates little current scree accumulation. The scree materials have remained sharply angular and seem unmodified by weathering.

Frost Heave. Many examples of frost heave can be seen in the diabase where large blocks up to ten feet square were seen to be lifted out of holes into which their shape keyed and which was clearly their former resting place. (Plate 13)

Snowpatch Erosion. Gullies in the clay material often have blunt back walls, and these are frequently occupied, even in August, by small patches of snow. The melt water from the snowpatches appeared to be the only source of the streams which had caused the erosion, and was in some cases observed to be active at that time. Similar features were observed in the sands of the delta form north of Bloody Falls, but it was remarkable there that the gullies only cut down to the clay, and there had flat floors which emerged on the river as hanging valleys. Clearly the stream over the clay is ineffectual, whereas the snow patch, once established in the sand had eaten its way back considerably. Gully erosion in the esker delta at Portage Lake was also headed by snowpatches. (Plate 14)

Thermokarst. In the plain of clay deposition about the mouths of the Rae, Richardson and Coppermine Rivers there are numerous large round lakes. Some have edges which are collapsing at the present time, since fresh vegetation was observed to be submerged during July and August, and cracks

along the shore line can be clearly seen. These lakes would seem to be thermokarst phenomena in which melting down into the permafrost table is providing basins of accumulation. The lakes could be kettle hole forms, but if so, are still expanding at the present. Some lakes are in the line of old dry riverbeds, and these might have provided the original cutting necessary for the commencement of thermokarstic action. (Plates 15, 16)

In the same region a peculiarity of some streams is ascribed to thermokarstic action. Ordinary small streams in the unconsolidated material, some only inches deep, have in their courses deep pools which are up to eight feet deep and have abrupt vertical edges both upstream and down. Downstream the stream retains the same shallowness. The surface is smooth and the water not necessarily moving very fast. These pools resemble nothing so much as large bathtubs let into the floor of the stream. They cannot be water cut and are therefore probably due to a penetration and melting out of ice lenses in the permafrost profile.

Chemical Weathering. Chemical weathering is not important in the area but there are examples to be found. The basaltic boulders in esker trains seem peculiarly liable to rotting from the interior outward, so that hallow shells of boulders are left. A mass of red granitic rock found just west of Gray's Bay could be crumbled in the fingers. This is ascribed to chemical weathering. A sandstone found had cavities which may well be solution hollows.

Ice Rafting. Only rarely are boulders of any size to be seen in the clay deposits about Coppermine settlement. These few are presumed to be ice rafted materials. Many erratic pebbles and cobbles above the gorge of

Bloody Falls are probably ice rafted from a great distance upstream, being completely exotic to the area.

Striae observed on the basaltic rocks of the large promontory at Port Epworth did not agree with the general direction of glaciation as inferred elsewhere. The striae crossed, and ran approximately east-west, paralleling the coast. They may have been caused by ice rafted debris being driven along the coast on ice floes. Some of the materials found on the islands of Coronation Gulf are completely exotic to the area. Their source is unknown, but their presence can be ascribed to ice-rafting.

Erosion of unconsolidated materials by river-ice. It was observed that during the spring break-up of the river ice, large pieces of ice were left adhering to the river banks. These in due course fell into the river when its water level declined and the blocks were no longer buoyed up. They took with them large sections of the clay banks. Most of the muddying of the rivers in the spring is due to this, and the tearing of the soft banks by stream-carried floes.

Wind Action. Actual erosion by wind was not shown at any point. It may assist gully erosion by causing the snow drifts which are the only source of moving water for most of these features. Nowhere are the sands loose enough to be attacked by wind.

Patterned Ground. Patterned ground features were observed throughout the area, but never in large quantities. The classification used here is Washburn's as outlined in "Patterned Ground" from 'Revue Canadienne de Geographie' - Vol. IV, Number 3-4, July - October 1950, Pp. 5-54.

Non-sorted circles. By far the greatest majority of patterns observed

were non-sorted circles in clay-silt materials. They varied little from a standard size of about one foot diameter. They occur in groups or singly, generally on fairly flat as to be more properly described as nets of vegetation upon a clay-silt ground. (Plate 17)

Non-sorted polygons were observed in an old lake floor in an esker. The material was cobbles of about seven inches diameter. Other non-sorted polygons were common in areas of unvegetated clay. In these a polygonal pattern of fissures covered the surface. They were clearly cracks due to drying. The material was colloidal. Both the clay forms of unsorted polygons and circles were common in the alluvial plains about the mouths of the Rae, Richardson and Coppermine Rivers. In some instances they were observed on distinctly sloping ground. They were also to be seen in the clay plain at the Tree River mouth and in the clay areas between the scarps from the Asiak River to the Kugaryuak River. On the Asiak these features were observed to exist side by side, that is, an area of mud-boils in vegetated parts might be near unvegetated areas, or areas where the niggerhead was just beginning colonisation, and there the expanses of clay possessed polygonal fissures.

Sorted circles. Sorted circles were observed in small numbers on the flat tops of the esker delta forms. There they were about one foot in diameter and were made of small angular fragments of about one inch diameter or less, lying on sand or silt. The area between circles was vegetated, but was made up of fines. The circles were completely barren. They were sparsely scattered over the surface.

Sorted Polygons. Only one series of sorted polygons was observed. This was at a point where the Asiak esker crosses a ridge of bed-rock. Poorly developed polygons had formed in coarse debris. The walls were of larger

rock fragments. The centres were fragments, not fines. The smaller pieces were about two to three inches across, the larger were up to one foot across, but generally smaller. Only half a dozen of the features were at all well formed.

Nonsorted Stripes. Nonsorted stripes are common features at the foot of the scarps in areas of unconsolidated deposit. They are not true patterned ground phenomena, as the appearance is due to differences of vegetation on the fluves and interfluves of very shallow drainage depressions. Since these lines are always consequent upon their slopes they are probably run-off gullies of poor development, their appearance emphasised by vegetation.

Sorted Stripes. (Plate 18) Trains of boulders of various sizes from several inches up to two and three feet in diameter, were observed to run down the areas between drumlin forms. They were probably sorted by water rushing down the natural courses provided by these intervals. Some stood higher than the surrounding ground immediately to either side, but could still be the result of sorting of the material of the area.

Other sorted stripes were observed on the sides of the esker delta form near Portage Lake. These consisted of stripes of angular fragments lying on fines. The interval was generally vegetated. The stripes in at least one instance ended in a drainage depression.

Two other pattern features not classified by Washburn are left to describe. The phenomena named terracettes by Wilson and others was seen to occur on the steep slopes of the west bank of the Kugaryuak River and also at a point where the drumlins meet the basalt scarp. Concentric garlands of vegetation, broadly parallel to the slope but drooping down it, suggestive of slumping of the whole form, these patterns covered the

entire slope in both cases. The other pattern was a large polygon formation visible in aerial views and lying on a low natural causeway crossing a large lake just south and west of Bloody Falls. On investigation the following observations were made. The polygon form was not obvious on the ground. The causeway stood only inches above the water line. The floors of the polygons were made of wet spongy peat, principally vegetable roots, and the walls were made of ridges of a different vegetation. The walls appeared to have no solid basis of soil or anything but the plants and their root systems. The walls enclosed areas about 24 feet across, but the size varied considerably.

SUGGESTED GEOMORPHOLOGICAL HISTORY.

The structure of the survey area is of Precambrian and Palaeozoic rocks in the form of the south western portion of a basin, with its centre lying north-west of Coppermine settlement. The basin's rim lies against the ancient block of Teshierpi granite on the south, and the contact is marked by an unconformity. The Epworth series which make up the basin's rim are considerably contorted and yet their contact with the late Precambrian Coppermine flows represent a nearly plane surface. It would seem that the Epworth series had an almost level erosion surface on which the basaltic flows formed. Then the area of down warping to the N.W. tilted the surface to the north-west. The Upper Coppermine series lie non-conformably on the lower Series and dip more to the north than north-west. Yet again the line of contact for the bottom flow of the diabase is a uniformly straight line over both the Lower Coppermine series and the Epworth series. The implication is that the Lower Coppermine series and the Epworth surface had again been peneplained before the addition of the Upper Coppermine series. The Upper Coppermine series of the area have in turn been tilted to the north and north-west by the sinking of the centre of the basin.

The present erosional surface has a regional slope northward to the Arctic Ocean. Its top surface stands at just over 1,000 feet, but its relief varies with the geology. The diabase and basalt scarps are retreating by normal scarp erosion process. The areas of ground between the most southerly diabase scarp's foot and the 1,000 foot top surface, are exhumed surfaces, a fact which is shown best by the Epworth Dolomite which has a truncated top surface and shows anticlinal hills and synclinal valleys at lower levels. Twenty miles and more inland the dolomite has

caps of diabase which have a very gentle dip north, and a level contact at their base. The surface round these areas can only be an exhumed surface. A surface of fine sandstone believed to be a basal sandstone of the Epworth series outcrops 114° W and 10 miles inland. Its structure is a truncated anticline and its present surface dips north to the diabase floor at about the same dip as the flow. Its relief is only 30 to 50 feet. It too is clearly an exhumed surface to where it reaches a height of 1,000 feet.

All the rivers of the area except the Rae and the Richardson drain down the regional slope and cut across the Coppermine Scarps. They are clearly superimposed. Taking into account that the Palaeozoic limestones N.W. of Coppermine were laid down in sea water it becomes clear that the superimposition dates from that time when the flows were submerged. Drainage from the Continental Shield has cut its way through the Coppermine series as the sea level declined. Smaller streams have not done this, and are diverted by the scarps.

The upper surface at just over 1,000 feet is remarkably level and is in fact a dissected peneplain. Lower ground extending up the Coppermine River to the Coppermine Mountains (2,000 feet), makes an embayment into this surface. The embayment is a lower flat surfaced plain of clay, silt and mud deposits laid in water and rising gently from 0 to 350 feet. Small scarps of the Coppermine series stand above its surface.

The area has been glaciated by ice moving in a generally northerly direction. All upper surfaces and rock exposures are polished and striated, and so too are some of the gorges in the granite, showing them to be pre-glacial. Striations on a marine cut platform in the granite coast between the Kugaryuak River and Port Epworth show that it too is pre-glacial. The glaciation has left a large field of drumlins, covering hundreds of

square miles of ground between 113°30' W. and the Coppermine River. These drumlins all trend west of north. They incompletely mask the surface and have a uniform summit accordance, rising with the rock surface. Some of these drumlins lie near the coast and have been modified by the postglacial advance of the sea. Some points, extending into the sea along the coast between the Asiak and Kugaryuak Rivers are drumlins which have been considerably modified by sea action. There are twelve eskers or esker fragments in the survey area, ten of which are the Irish multiple esker type believed to form in stagnant ice. At least four of the eskers have delta end forms indicating a termination in water south of the diabase scarps. Two more end on the coastal plain and have deltas standing, one at 300 feet and the other higher still above the sea. A ridge on the eastern side of the Tree River and forming a bank to it below the first falls, is probably a reworked esker.

The glaciation passed completely over the area leaving no terminal moraines unless some are buried by drift in the Coppermine-Rae-Richardson clay-silt plain. It retreated by stagnation. The scarp nature of the topography broke up the stagnant residual ice so that ice sheets lay immediately south of the diabase area, between its scarps in the dip slope valleys, and on the seaward slope of the scarp nearest the sea. This ice dammed the north flowing streams so that in many cases the valleys cutting the flows or running to the scarp (as in Gray's Bay) were filled with alluvium. The present streams now cut down through these, but the fills remain, usually with a razor-edged slope feature to the north indicating a possible ice contact.

The stagnant ice also caused minor lakes at higher levels in many places. It possibly accounts for the bifurcated river east of the Asiak River and various other features. Ice marginal streams along the dia-

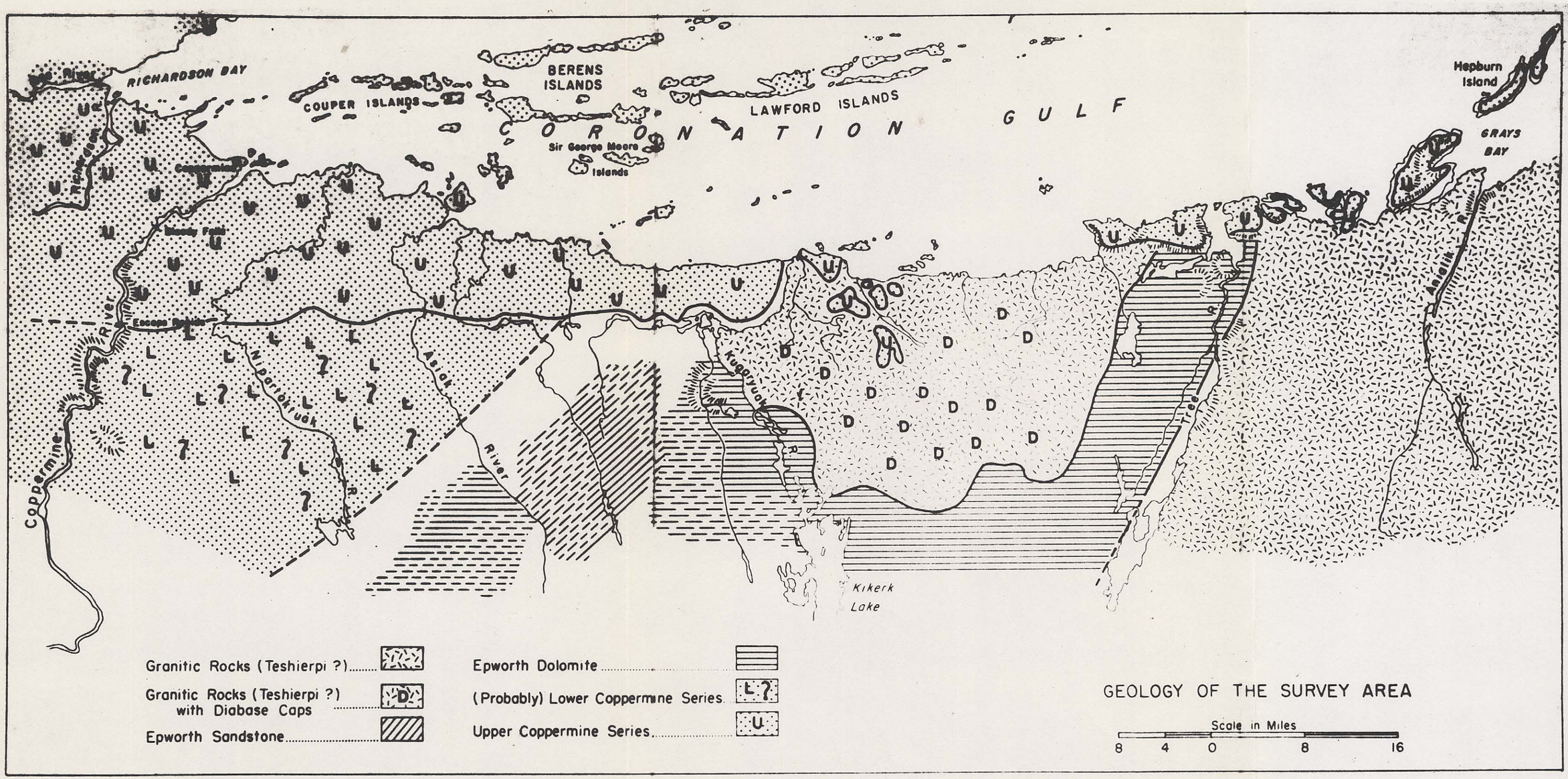
base scarp cut a section between the drift and the cliff so that today there is a drainage line of rivers and lakes running east-west south of the scarp.

The height of the post-glacial rise of the sea is debatable. Areas east and west of the region are reliably stated to have strandlines or marine fossils at heights up to 600 feet. J. J. O'Neill claims to have found marine shells at 500 feet in Tree River, and the 1954 survey found shingle ridges facing south on the basalt at Tree River at 460 feet, which might be lake strandlines, ice push ridges or marine beaches, although no shells were found in them. Elsewhere in the survey area nothing like a strandline was ever encountered at over 320 feet, even on continuous sections running to 500 feet as with the shingle ridges at Gray's Bay. Shells were only found at 310 feet, associated with sands. No clay or silt was found at a height much above 320 feet although this is a post-glacial deposit as is shown by the exposure near Bloody Falls of striated bed-rock at the bottom of a gully in the clay. The clay-silts may have been outwash during the stagnant decay of the ice sheet. The most important features are shells found in sands at the foot of the esker delta forms. These eskers must have been formed in the glaciers, probably in stagnant ice. They have ice contact features and are exceedingly fragile, being made of sands and gravels. Yet they are unmodified at the height above 310 feet. Marine action would surely have greatly modified these forms and they very strongly suggest that the post-glacial rise of the sea has not in fact much exceeded 300 feet. This agrees with the clay-silt deposits upper level, and the large pure sand delta form standing on the clays at Bloody Falls with a top surface at 310-320 feet.

Since the post-glacial advance the sea level has continually

declined. River terraces above 100 feet indicate jerky movement, but the last 100 feet has been remarkably slow and even, as shown by non-matching meander terraces on the Anialik, Kugaryuak and Coppermine Rivers, and the continuous evenly spaced strandlines on unconsolidated materials running from sea-level to 100 feet and more. The present streams show traces of having been gently rejuvenated, possessing incised channels with convex valley slopes on a small scale.

There is a great deal of gully erosion in the unconsolidated materials, generally caused by snow melt. There are indications of a relaxation in the permafrost regime shown by a great number of thermokerst lakes and depressions in the western plains, some of which have vegetated banks collapsing at the present time.


RICHARDSON BAY
COUPER ISLANDS
BERENS ISLANDS
LAWFORD ISLANDS
CORONATION GULF
Sir George Moore Islands
Hepburn Island
GRAYS BAY
Coppermine River
Kugaryuak River
Kikerk Lake
Granitic Rocks (Teshierpi ?)
Granitic Rocks (Teshierpi ?) with Diabase Caps
Epworth Sandstone
Epworth Dolomite
(Probably) Lower Coppermine Series
Upper Coppermine Series
GEOLOGY OF THE SURVEY AREA
Scale in Miles
8 4 0 8 16

BIOGEOGRAPHY OF THE SURVEY AREA

1) Plant Geography

2) Animal Geography

3) General Summary

Biogeography of the Survey Area.

PLANT GEOGRAPHY.

Plant geography has little human importance in the survey area now that the indigenous population no longer depends upon caribou for its existence. Since trapping is also poor the Eskimo is little concerned with vegetation even as the habitat of animals.

Vegetables, including lettuce, cabbage and radish have been grown in Coppermine settlement by nursing the seed and seedlings indoors and planting out in mid-July, but no serious farming is at present possible or likely. The Eskimo apparently does not collect or eat any of the various edible plants, even the berries which are numerous in the fall. The older Eskimo talk a good deal about certain vegetable foods and recipes, but are rarely seen to actually use them. There is at least one edible fungus found in the area.

From the scientific point of view no systematic collection has been made in the area.

As part of the animal ecology the plant life of the area has considerable importance. It is probable that many animals are located by vegetational factors. The smaller birds which migrate to the area in summer site their nesting areas by vegetational factors and their predators are in turn limited to a similar area. It is probable that the greatest number of water birds are vegetarian too, and locate their nesting sites accordingly, although a good number are fish-eaters. Caribou when they move in the area confine themselves to certain vegetation types, and they in turn are followed by the wolves.

The various vegetational associations described by Porsild in "Plant Life in the Arctic" (Canadian Geographical Journal, March 1951)

are nearly all to be found in the area. Their location is obvious in the naming of the association, but the following notes list Porsild's associations briefly, describes their nature and indicates their rough location and extent in the survey area. The headings are from page 12 of his paper.

ROCK DESERT OR FELL-FIELD COMMUNITIES

Rocky barrens having so little vegetation as to be incompletely covered. This includes bedrock exposures, screes, frost shatter debris areas, and river flats and fans, where made of pebbles or stones. The plants are mainly lichens but there are a great number of small flowering plants which either favour crevices or have a tussock form. They are listed in Porsild's paper and include the broad leaved willow-herb, mountain avens, crowberry, arctic poppy and the moss pink, to name a distinctive few. One lichen, Caloplaca elegans is worth mention because its distinctive orange colouring is a sure sign of animal life in some form. It is a dung-loving lichen and is found only at sites where animals have some permanent sort of a station.

In the survey area these associations were found on all the uplands east of the Kugaryuak River. West of that river these associations were confined to, and were distinctive of, the diabase scarps of the Coppermine series. Much modified forms appeared in the valley trains of the Epworth Dolomite and the granitic areas in the east.

TUNDRA COMMUNITIES

Tundra communities form a continuous cover to the ground, and usually have some kind of a soil formation below. In the survey area such communities are confined to the alluviated valleys and flats which are small in area in the east, but exceedingly large in the west. West of the Asiak

the area of unconsolidated deposits with tundra vegetation begins to greatly exceed the area of rock exposure, until in the plain of the Rae-Richardson rivers the area of rock exposure is very small compared with the tundra covered alluvium. Porsild divides the tundra communities as follows:

Dwarf-shrub heath: covering the greatest part of the surface, this is made up of sedges and grasses, principally the cotton-grass "niggerheads" which make walking so difficult in the area, and having also rhododendron, bearberry, white heather, fern weeds and lupins. In the survey area willows and alders are also thinly distributed on such a vegetation. This sort of association accounts for the greatest part of the surface of the clay-silt plains in the west, but in the east was only found in relatively small areas, as in alluviated valleys and coastal plains. It is usually a fairly wet association.

Lichen and Moss heath: this is to be found in the better drained parts of the alluviated plains. It lacks the sedges and grasses and is typically a smooth surface, pleasant to walk upon. Principally composed of lichens, there are also mosses and a few widespaced willows and odd shrubs and herbs. It was found typically in two sorts of location; on well drained sands, giving small areas only, and on the upper levels of old river terraces, as near Bloody Falls. It occurs locally in small areas or narrow strips on the edge of old beaches, or thaw sink depressions' edges, where minute areas of locally better drainage conditions obtain. The total area is small compared to dwarf-shrub heath. It is more often found on the higher levels of the unconsolidated materials in the west but can be found

locally throughout the area. It is the typical vegetation of eskers.

Grasslands: as cited by Porsild these grasslands occupy old alluvial flats, probably glacial lake floors. In the Coppermine area grasslands of any extent were only found in the thaw-sink depressions so common in the unconsolidated materials west of Coppermine settlement. These distinctive thermokarst lake basins are in many cases now drained or drying out, and the alluvial floors provide the same conditions described by Porsild. However, unlike Porsild's examples, a great number of these small grassland areas have been invaded by willows so that up to 40% of the depressions may be covered by willow thicket. The total area of such associations is small, being only a matter of hundreds of yards square in every instance. Small freak areas of grasses or sedge occur throughout the survey area.

Willow and Alder thicket: thickets of willow are common throughout the area. They are plants requiring an abundance of water during the summer and consequently their location is often governed by this factor. Whilst individual plants are quite ubiquitous, there are concentrations in damper depressions, on lake shores, along river banks, in gullies and similar locations, and even in drier parts of river boulder trains. Sometimes the depression they occupy is barely visible to human eyes, as for example the run-off gullies on many slopes which support willow stripes. In terms of area covered, the willow thickets are far more common west of the Asiak River mouth, but they are by no means uncommon features east of that point in alluvial pockets in the granitic rocks, or dolomites; and between drumlinoids, or along the alluviated valleys and on the coastal plains everywhere. With the thickets may be found other plants, of which distinctive species recognizable by anyone are the fireweed and

buttercup.

Marsh and Wet tundra: a vegetation associated with flat ill-drained areas anywhere, it could be found with all the other associations. In the Coppermine area it resembled a much impoverished dwarf-shrub heath association, with greater or lesser areas of sedge separating "niggerheads." Some areas would be all sedge, others all "niggerheads" of cotton grass.

Snowflush herb mats: were not recognized anywhere during the survey.

STRAND COMMUNITIES.

Lagoons and Salt Marshes: the only true lagoons are those in the bay immediately west of Coppermine settlement, but the sand spit at the Kugaryuak River furnished further examples of this association.

Strand vegetation for sandy shores and rocky shores: were not recognized but undoubtedly exist in the appropriate locations.

VEGETATION OF FRESH WATERS.

Ponds and Lakes: actual plants were rarely observed in the lakes. A black lichen appeared to be associated with ephemeral pools on basaltic rocks. A submerged moss appearing rather like sand was found in some lakes in all areas, specifically in joint crossing lakes in the granite and in some lakes on the clay-plain of the Coppermine-Rae-Richardson river mouth area. Some pools in the Bloody Falls area had a rich vegetation but the plants were all apparently submerged land plants. No pond weeds were observed at all.

Brooks and Rivers: no weeds were seen in any moving water, but commonly in stony-bedded streams there were lichens and/or mosses above the water line, and green and brown algae covering most of the stones of the bed. Stones in streams through the basalt and elsewhere, commonly had a brown slime attached, the exact nature of which is unknown to the writer.

Biogeography of the Survey Area.

ANIMAL GEOGRAPHY.

A survey party of this type cannot make any detailed numbering or distribution survey of animals in so large an area. This section therefore merely lists the mammals, birds and fishes encountered, with brief notes on their location, occurrence and economic importance. The section closes with a general statement formed after correlation of the written material available, together with the verbal accounts of white settlers and Eskimos and the observations of the Survey. Specialists in any field are advised to look at the lists of zoological collections made by the Canadian Arctic Expedition 1913-18. It is the only detailed and specialized list available for this area at present.

Mammals. The following mammals were encountered by the survey either alive or immediately after being killed by Eskimos. Only those positively identified are listed. The standard text used was Burt and Grossenheider's "A Field Guide to the Mammals" in the Petersen Field Guide series, published in 1952.

Shorttail Weasel - these are most common on the rocky areas outcropping from the alluvial deposits in the west, where small birds and game are more plentiful. Their skins are used by the Eskimo as decorations for drum dancing costumes, and occasionally for decoration of parkas.

Wolverine - common throughout the region, their tracks can be seen everywhere. Some furs are traded at the H.B.C. and they are highly prized by the natives for the fur surround on parka hoods, because breath vapour does not readily freeze on it.

Arctic Fox - fairly common all over the area, but relatively few are actually traded. Even allowing that the natives of Coppermine settlement are not very active trappers, there appear to be far fewer foxes in the area than on Victoria Island for example or to the east. The H.B.C. post is for this reason not a good fur trading post.

Red Fox - a few furs at the post, and a live fox was seen on an esker near the Tree River.

Gray Wolf - common throughout the area, but apparently more common about the Tree River. In 1954 wolves were seen in the Coppermine settlement and one was shot there. Tracks of wolf were seen on islands in the Gulf in May before the sea ice broke up. Their number is said to have declined with the failure of the caribou, but there are no facts on the subject.

Seals - trouble was experienced in identifying seals since none fitted the guide book. However, bearded and ring seal were identified and it is believed there are others. The bearded seal is shot away out in the Gulf, usually at sealing camps on the ice by open water. Its hide is held to be the best for the soles of boots, line, etc. The other seals are shot on the ice, or in the open water during summer, mainly in the area about the settlement. It was the experience of the survey that seals seemed especially common on that part of the coast immediately offshore from the Tree River promontory and for some ten miles to the west, but this may have been accidental. The natives no longer depend on seal so much as they did. Blubber lamps are never seen to be used today, although blubber is occasionally burned in stoves made from old gasoline cans. The Copper Eskimo at Minto Inlet

are said to depend on the seal in the same manner as of old, but the Coppermine native is not now an enthusiastic seal hunter. This is hardly because of shortage, but rather because of an easier life, and one of the duties of the police is to actively promote sealing to supplement the economy. Mukluks are the only articles still regularly made from sealskins. Many hunters nowadays having got the seal meat, usually for their dogs, allow the skin to spoil, which it does in a few hours if not carefully treated. The Eskimos assert that sealing improves the further north one gets from Coppermine.

Arctic Ground Squirrel - this little animal is exceedingly prolific in the area. Being a burrowing creature, its habitat is confined to areas of unconsolidated deposit, but it can also be found along the beaches of the rock areas. A very tame and inquisitive animal it can be trapped or killed with gun, trap, and even bows and arrows, stones, or the bare hand. It can be eaten but is regarded as second rate food by the natives being used only when food is scarce, or by such people as old women left guarding a camp. Its fur is occasionally made into a soft dress parka which is almost purely decorative, and as trimming on slippers and parka covers.

Lemmings - three types of lemming were found in Coppermine settlement. The Brown Lemming, the (Greenland) Collared Lemming and the Least Collared Lemming. The last was identified by a visiting biologist and is not in the Field Guide. The lemmings were observed in great numbers about the Coppermine River and some on the Richardson River, but they were never actually seen elsewhere. Presumably this is an accident of non-observation, since they must form the basic food of foxes, owls and some hawks.

Voles - tundra voles were common in the immediate vicinity of the settlement.

Muskrat - muskrats are fairly common in some lakes five miles south-west of Coppermine. Certainly they were observed every time the area was visited. Although the skins have a trading value, none was ever traded in the Coppermine store that could be traced. Their location seems to be quite limited, but little is known of the territory south and east again of the lake system they occupy. Most are to be found in pools which lie in a former bed of the Coppermine River, but one was seen in a pool on the upper surface of the plain. The entire population would probably be numbered in dozens and if it really is an isolated community might easily be wiped out.

Arctic Hare - seen in numbers on the islands in the Gulf in May. Not seen on the mainland but reported there by Eskimos. There is no obvious reason why the distribution should be limited to the islands, unless by choice of the animal, for some were seen on islands only a mile or so from the mainland and the sea is of course frozen in winter.

Moose - a moose was killed by Eskimo at the first big bend of the Richardson River in July 1954. This, together with the fact that the Eskimo concerned were not at all surprised, and indeed were familiar with moose meat, suggests that the area is within the range of this animal, normally described as a woodland creature and assigned a distribution accordingly.

Barren Ground Caribou - none were actually seen by the survey members in 1954, but caribou are common to the area. The Indian name for the Barren Grounds south of Coppermine means "the Caribou land" and at one time caribou roamed the area in enormous numbers. Caribou formed the basis of the Copper Eskimo economy, giving most of the food and furnishing clothing, tents and bedding. This is clear

from the accounts of D. Jenness in the report of the Canadian Arctic Expedition. The Copper Eskimo was known as an "inlander", a group who spent the summers inland, hunting and living off the caribou, getting skins and drying meat. Only the sick stayed at the coast to fish. Today, forty years later, the position is very different.

In a "Report of Investigations affecting Eskimo and Wild Life in the District of Mackenzie, 1924-1926", W. H. B. Hoare, a special investigator, made some of the following observations.

Caribou formerly migrated northward over the sea ice in about mid-April, fawning far to the north about June, and beginning their return about September. They crossed the sea when it froze in mid-November and went on south to the wintering areas.

Bernard Harbour was near one of the sites for such crossings. The presence of the Canadian Arctic Expedition in 1915 for their first year did not change this, but in 1916 the numbers making the crossing declined. The settlement expanded in 1917 and the numbers of caribou crossing declined notably, while "enormous" numbers were reported to be crossing near the Coppermine River. From 1919 no crossings were made near Bernard Harbour and only a few stray caribou were ever seen.

With the establishment of settlements at Tree River and Coppermine, the numbers crossing at those places also declined until all crossings were discontinued in 1921; although large numbers were still crossing to the east of the area. A crossing at the Kent peninsula was discontinued after a H.B.C. store was established there.[7]

[7] Hoare, W. H. B. 'Report of Investigations affecting Eskimo and Wild Life in the District of Mackenzie, 1924-26.' Pp. 35-36-37.

Canada. Dept. Interior. Mimeographed report.

Hoare relates the failure of migrations specifically to the presence of coal burning settlements; whether correctly or not is not known. However since some of these settlements have now been long abandoned and the remainder use oil fuels, whilst the migrations have not resumed, his second reason may be nearer the truth. He mentions the need for restraining the Eskimo from wasteful slaughter with their newly acquired rifles, and describes the Eskimos as forming an almost impenetrable line along the coast, taking immense toll of the caribou and discouraging migration.

Today caribou are erratic in their appearance and numbers. They appear to be more scarce than even in Hoare's time and cannot be relied upon to appear at all. This has cut the number of 'inlanders' drastically in the last decade. In 1949 the police discontinued the inland patrol as a waste of time, there being too few Eskimo to merit the patrol. In 1953 the very last family gave up the habit of summer hunting in the barren grounds as being too uncertain a living.

The hardships of the 1953-54 winter in Coppermine settlement were due to the failure of the inlanders to procure enough caribou in the summer to see them through the winter. They lived upon the fish harvested by the settlement people and as a result both groups were short of dog food and even human food. Yet only a year before the caribou had stayed for some time in the area actually about the settlement, and had been slaughtered in wasteful numbers. Skins abandoned to rot were encountered in walks about the settlement, and rotting hides and meat had been a nuisance in the settlement during the summer of 1953 while caribou was hard to find, and meat was scarce. During the summer of 1954 the survey members heard positively of only

three caribou being killed and one moose. A native family at Tree River killed only one caribou in the period before August. Caribou seemed to be genuinely scarce even though the small number shot may have been due to the failure of the Eskimo to hunt them in 1954.

Whatever the cause it is clear that caribou are no longer as common as they were fifty or even twenty-five years ago. They are still common and appear regularly to the east of the survey area about Bathurst Inlet.

The following mammals are listed as being possibly found in the area although not physically encountered. The reason for the inclusion is given.

Black Bear - some skins of the ordinary black bear were in the fur store at Coppermine, but where they were killed is not known. The Eskimo are familiar with bears, but they are always described as being fairly small and are probably not the Barren Ground Grizzly on that account. Tracks of a bear were seen in snow at the Tree River in May. The animal was apparently fairly small and therefore not the Grizzly. In two cases excavations of unknown age were found. They were about five feet across and two feet deep and are believed to have been made by bears burrowing for ground squirrel or the squirrel's food store.

Barren Ground Grizzly - claimed to have been seen by an Associated Airways pilot on a flight from Bathurst to Coppermine in early August 1954.

Least Weasel - a Least Weasel was found dead among supplies which had been landed from a H.B.C. supply boat one year previously. It probably died at the site, but may have been imported as a body.

Mink - a few skins in the H.B.C. fur store, but source unknown. A domestic cat in the settlement was one day mistaken by an Eskimo at a hundred yards for a mink, the point being that the Eskimo was familiar with the idea of mink.

Otter - a "seal" which ascended the Coppermine River in early June before the ice cleared was claimed by a dozen Eskimo to be an otter. Five white men who saw it all claimed it was a seal.

Muskox - the Eskimo claim that they are to be seen very occasionally. This is probably not true today, although formerly it was so. Franklin mentions musk oxen and so do many others. W. H. B. Hoare found a muskox carcass at an Eskimo camp and confiscated it in 1924. The survey members saw muskox horn at Eskimo camps in a form used for pounding blubber for oil lamps. This indicates they were older relics rather than recently acquired objects. The nearest certain occurrence is well outside the area, at Bathurst Inlet.

Whale - an old clean segment of a whale's backbone was found on an Eskimo campsite at the Kugaryuak River mouth. The Eskimos tell stories about whales, but if they do appear they are rare and accidental.

Of the above the muskox has probably disappeared from the area, like the polar bear which is never seen there now, although both were common in 1916. The whales are probably freak occurrences.

Birds: The following list includes all positively identified birds seen in the course of the survey. There are many others which were not identified. The text used was Petersen's "Field Guide to the Birds" published in 1947.

Pacific Loon - common everywhere along coast. Young broods were encountered.

Red-throated Loon - common along coast, and the lakes in the eastern alluvial plains. Young broods encountered.

Whistling Swan - many pairs on lakes of western alluvial areas. Not seen elsewhere and no young seen.

Canada Goose - Canada Geese passed over Tree River and Coronation Gulf going north in large numbers in May. A few were seen during July and August on lakes by the Richardson River and the Asiak River.

Snow Goose - a pair was seen in company with Canada Geese during the passage of the spring migration at Tree River.

Pintail Duck - very common along coast.

Old Squaw Duck - very common along coast and on some lakes by Bloody Falls. 130 were seen in one group near the mouth of the Asiak River in late August. Their young were frequently seen.

Common Eider - seen in June near Coppermine settlement.

King Eider - seen in June near Coppermine settlement.

Rough-legged Hawk - nested on cliffs of scarps around Coppermine River.

Duck Hawk - seen on the cliffs around Coppermine, islands of Coronation Gulf, and at Tree River. Some of these "Duck-hawks" were believed to be Gyrfalcons, especially on the islands but it was not proven. Seen nesting.

Willow Ptarmigan - exceedingly common all along the coast of the survey area and plains of the interior. Becomes more scarce only on the barren uplands.

Rock Ptarmigan - common in the area. Its habitat could not be distinguished from that of the Willow Ptarmigan.

Sandhill Crane - half a dozen pairs were encountered, all on separate lakes in the flats about the Richardson River in July. They were not proved to be nesting and no young were seen.

Semi-palmated Plover - fairly common about Coppermine settlement.

Golden Plover - this and the Black-bellied Plover were both positively identified.

Black-bellied Plover - one pair seen near Bloody Falls.

Sandpipers - a great many of these confusing birds were seen and the following listed by a visiting biologist. Pectoral, White-rumped, Least, Stilt, and Semi-palmated. There are probably others. They were common in the settlement, on the lagoons to the west, and the islands to the east. Some were seen about the Asiak river plain.

Red Phalarope - fairly common about the lagoons.

A Jaeger - Jaegers were seen in Black Inlet, but the exact species could not be ascertained.

Gulls - Glaucous and Herring gulls only were positively identified. There are undoubtedly others. Gulls were seen along all coasts and rivers. Nests were seen singly all along the coast and there is a large nesting area on a diabase cliff between Hepburn Island and Port Epworth. Gulls nest on the sand bar offshore from Coppermine settlement. A congregation of 170 gulls was seen in flight at the Asiak River in mid August, and was believed to be the beginning of a migration.

Snowy Owl - a Snowy Owl was seen at a point just west of Portage Lake.

Horned Lark - common on the low plains about the lower Coppermine and Richardson Rivers. Nesting.

Cliff Swallow - encountered only about Bloody Falls, where there is a nesting cliff south of the gorge on the western side.

Raven - Ravens were seen singly or in pairs, and were seen everywhere in the region. Although widespread in distribution they cannot be in too great a number.

Robin - a pair of robins nested in the settlement.

American pipit - fairly common on the alluvial plains of the west.

Redpoll - fairly numerous around Coppermine and Tree River.

Sparrows - these confusing birds are difficult to differentiate in most cases. The following were positively identified: Tree, Chipping, White-crowned and White-throated. There are probably others. Most were seen in the area about the settlement and the lower reaches of the Richardson and Coppermine Rivers. Numerous. All nesting.

Lapland Longspur - common on lowland everywhere, but especially about the settlement and the lower Richardson River. All nesting.

Smiths Longspur - half a dozen only were actually seen. On the lower Coppermine River.

Chestnut-collared Longspur - nearly as common as the Lapland with precisely the same distribution.

Snow Bunting - seen in numbers at the beginning of June but rarely thereafter.

The low vegetated plains of unconsolidated deposits are infinitely more rich in bird life than the areas of rock outcrop. Birds are much more numerous and appear in more variety in the west, and specifically in the plain between the Coppermine River and the Rae River. The barren uplands were devoid of bird-life except for ranging ravens. There was some life, notably ptarmigan, in the lower parts of the uplands, and quite a number and variety of birds in the large valleys and coastal plains.

There is a considerably greater variety of ducks and water birds than is here positively identified.

The only birds important to the human economy are the larger birds which the Eskimos eat when other food is scarce. There is no reliance on birds for food, although the ptarmigan is a regular item in the Eskimo diet.

Ptarmigan skins are used as towels. A very few Eskimos have made themselves down sleeping-robes. The down comes from a variety of birds.

Fishes

Neither member of the survey had any knowledge of fishes, and there is no appropriate text book available, therefore only the broadest general observations are possible.

Arctic Char - a salmon-like fish called char is very common in the area. It is a principal food of the Eskimos living in the Coppermine settlement area. It is caught in great numbers at the Rae-Richardson river mouths, the Coppermine River, the Tree River and the rivers of Gray's Bay. It is most prolific in numbers at the Coppermine River, which has been a famed fishing area for the Eskimo since before Hearne's arrival in 1771. The bringing of nets to the people who previously had to jig for, or spear the fish, has increased the fishing potential, and the Copper Eskimo today shows a greater dependence on fish than ever before. Previously only those who could travel inland after caribou would fish during the summer. Now that caribou are no longer hunted, fishing is the sole occupation during the summer, especially since seal shot at that time in the open sea usually sink. Thus the Copper Eskimos of the survey area now live almost wholly on fish and seal and are distinguished from the eastern Copper Eskimo around Bathurst, who live principally on caribou with some seals and fish, as they all used to formerly; and from the Copper Eskimo to the north who lives mainly on seals and whatever he buys as a result of his trapping. The main run is in the spring but the char are always about.

White Fish - a small percentage of the fish netted are White Fish. The White Fish arrive in runs. There may be several kinds. They are usually 18 inches to 2 feet long and weight 3 to 6 pounds. Larger ones are not uncommon. They have no special significance to the Eskimo who catch and use them along with the Char.

Tom Cod - a number of tom cod were washed ashore by a storm but they did not seem to be common.

Sucker Fish - Sucker fish were often included in the net catches and were invariably returned to the sea unless the dogs were hungry.

Starry Flounder - twice during the season these distinctive flounders are known to have been caught. They are possibly fairly common. They are not eaten, even by the dogs.

A Sculpin - at least one of these was known to have been caught. They are possibly common. They are not eaten.

Sticklebacks - abundant in pools near Bloody Falls.

Other fishes were seen but were not identified. The lakes of the eastern part of the survey were commonly observed to have fish which were some species of trout, since they had the distinctive trout fin arrangement. They were never seen to be larger than 18 inches in length but the Eskimo claimed that large lake trout up to 4 feet in length can be caught. No fish but Sticklebacks were seen in the lakes of the clay plains in the west, and the greatest number seemed devoid of fishes, but on the other hand some lakes had nesting loons which probably live upon small fish.

Marine Animals

The seashore between the tidal limits had very little life of any form. Only two fragments of seaweed were seen during the summer and these were drifting. Of animals only the following evidences were seen.

Isopods - isopods up to 2" long were seen in numbers at the Asiak River mouth and in the bays west of Hepburn Island.

Sea Urchins - shells only of these creatures were found on the granite shores between the Kugaryuak and Port Epworth. The size varied. They were not seen alive nor were they found elsewhere.

Mussels - the only shells found (apart from mya truncata and saxicava arctica in the old beach sands at 310 feet), were a group on a low rock island 16 miles west of the Kugaryuak mouth. There were some hundreds, all dry shells only and lying several feet above the present high tide mark. They were mussels, a somewhat faded purple-blue in colour and up to two inches long.

No shellfish of any kind were ever observed alive in the area. A marine biologist working in the area failed to find shells in the crops of any water birds. The only shells common to the whole area are those in the old strandline.

Small moving creatures in tidal pools on rocky islets were thought to be fish larvae, but may have been some other form of life.

Insects

There is a great variety of insect life in the survey area. None is important in the human economy save possibly the mosquito which inhibits freedom and happiness even for the hardened Eskimo during late July and early August. Other insects include black fly, butterflies, bumble bees, some various flies including blue bottle in the settlement and some water beetles.

Bees - bees were seen frequently among the vegetation but are not truly numerous.

Blackfly - blackfly are not so numerous as mosquito but are more disliked by the Eskimo since time brings relative immunity to the mosquito bite whereas the blackfly draws blood.

Butterflies - the following butterflies were seen during the period of late July, early August. All were equally common but none were numerous. The families are certain - the actual species are open to doubt. Hanbury, from a collection made from a range which included the survey area, names a good many more. It is probable there are others.

Satyridae ..... probably Ceneis
Erebia

Nymphalidae ..... probably Bolorea

Lycaenine

Pierinea ..... probably Colias.

These last appeared in a wide range of colours which may have been a number of species, or broad variations of one species.

Flies - ordinary house flies and blue bottles were seen in the settlement area only.

Mosquito - Coppermine area is notorious for its mosquito and blackfly. The larvae may be observed in the stagnant pools in mid-July and the first mosquitoes appear quite suddenly with the first warm weather. They begin to abate in mid-August, and have almost disappeared by month end.

Stefansson mentions the mosquito and blackfly of this area as constituting the only suffering endured during his travels.[8] Whilst the humans tend to be only inconvenienced by the mosquito, animals, which have to live without the shelter of tents are seriously affected. The tethered dogs suffer severely and may go tempo-

[8] Stefansson, V. 'My Life with the Eskimo'. Pp. 213-4
New York. The MacMillan Company, 1913.

rarily blind because of the irritation about the soft parts of the eyes.

Moths - No moths were observed, but moths are included in the collections of Hanbury and the Canadian Arctic Expedition.

Water Beetles - a half dozen small brown water beetles were observed in pools, some of which were ephemeral, in the area just east of Bloody Falls.

Many other insects are probably to be found in the area. The only ones of importance to the human geography are the mosquitoes and they are also probably the prime source of food for certain birds. The bees may have some importance in the fertilization of plants in the area but in view of the asexual nature of the reproduction of most arctic plants this is doubtful.

Biogeography of the Survey Area.

GENERAL SUMMARY OF BIOGEOGRAPHY.

The region of the survey is sufficiently well vegetated to support animal life. There is a range of mammals from the lemming up to the caribou and possibly bear. Hunting and settlement have probably modified the number and distribution of the caribou, so that they can no longer be relied upon in the human economy of the area in contrast to 30 years ago when the human distribution depended upon the migrations of caribou. The survey area is not rich in those animals whose furs can be traded and the Eskimo has eliminated muskoxen and polar bears from the region. The Eskimos of the area who formerly lived mainly upon mammals do not now do so, although seals are still fairly important. To the north and beyond the survey area, seals are the basis of the economy, to the east the caribou. In the survey area proper, the most important factor in the economy is fish.

There is a variety of fishes, but char are predominant. Coppermine River mouth is a specially rich area. Char greatly outnumber all other fishes and are held to be most valuable by the Eskimo. They are caught by netting and very rarely by any other method. There is no sign of depletion of numbers as yet.

The clay-silt area in the west with its relatively rich vegetation also supports a greater variety and number of animals. Each animal has different vegetational associations; the lemming living among close-knit tundra plants; the ground squirrel preferring quite open ground in which it can burrow and over which it can see without obstruction; and the ptarmigan living in willow thickets or in boulder fields.

The small birds have two types of habitat, one group inhabiting thickets of willow and alder, the other living and nesting on open tundra dwarf-shrub heath. Their eggs and young and even themselves are always

the prey of the predator birds and also of the weasel and occasionally the fox.

The fox roams everywhere living upon ptarmigan, ground squirrel and lemming, all or one of which are common everywhere. Wolves in 1954 also roamed everywhere, even scavenging in the settlement. Presumably in better years they would follow the caribou herds.

All the birds are migratory and leave in winter except the ptarmigan. The mammals are divided; some migrate, some hibernate, some remain active all winter. Insects probably survive in egg or pupae form, buried in vegetation and snow.

Insects are not numerous, except for mosquito and blackfly, but these last are so numerous as to constitute a definite factor for consideration in human comfort although they probably have no economic effect.

No distribution maps now published have anything more than generalised limits in or near the survey area. Animals shown not to occur in the region may occasionally be found, others recorded as inhabiting the region probably do so no longer. No detailed study by any scientist is published for the area, although the Canadian Arctic Expedition made collections during their somewhat brief passage through the survey area itself, and their findings are included in the report of that party. A good deal remains to be done in reporting all the species to be found, let alone their precise distribution. American and Canadian wildlife experts have passed through the area. A marine biologist spent two months at Coppermine in 1954, but his findings are yet to be published. The best existing lists are those in the reports of the Canadian Arctic Expedition. All books and papers on the subject known to the writer are included in the bibliography.

CLIMATIC OBSERVATIONS

Climatic Observations.

STATION RECORDS.

Since the survey party was never in one area for any appreciable length of time, and since its travel extended over a considerable area it became pointless to record any but the most basic features of the weather. In point of fact the year proved to be quite unusual in that there was an unusually high incidence of clear weather and cloudless skies, a feature not usually associated with the particular area. An unusually high maximum summer temperature was also recorded. For all these reasons the records of the permanent meteorological station in Coppermine which has been operating since 1930, would be far more useful as an indicator of the climate and the records are accordingly reproduced here. The records for any particular year are available in the publications of the Department of Transport and any interested person is recommended to study their publications.

In addition to the tables presented overleaf there are some generalised comments upon the weather of the area, as distinct from climate, and the total effect upon human activity and communications in the area.

CLIMATIC SUMMARY.[8a] I — COPPERMINE, N.W.T.

Years Observed	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
MONTHLY AND ANNUAL AVERAGES OF DAILY MAXIMUM TEMPERATURE.													
13	-12	-12	-8	9	30	45	58	52	42	23	1	-9	18
MONTHLY AND ANNUAL AVERAGES OF DAILY MINIMUM TEMPERATURE.													
13	-26	-27	-23	-8	15	32	42	40	31	12	-13	-22	4
MONTHLY AND ANNUAL AVERAGES OF DAILY MEAN TEMPERATURE.													
13	-19	-19	-16	0	22	38	50	46	36	18	-6	-16	11
AVERAGE MONTHLY AND ANNUAL PRECIPITATION IN INCHES.													
13	0.57	0.44	0.63	0.84	0.55	0.84	1.33	1.86	1.03	1.16	0.84	0.63	10.72

[8a] The Climatic Summary on this and the following page is taken from 'Climatic Summaries for Selected Meteorological Stations in the Dominion of Canada.' Meteorological Division, Department of Transport - Canada.

Toronto,

CLIMATIC SUMMARY. II — COPPERMINE, N.W.T.

Years Observed	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
AVERAGE MONTHLY AND ANNUAL SNOWFALL IN INCHES													
13	5.7	4.4	6.3	5.2	4.9	1.8	Trace	0.2	3.9	9.9	8.4	6.3	57.0
AVERAGE MONTHLY AND ANNUAL NUMBER OF DAYS WITH MEASURABLE RAIN													
10	0	0	0	#	1	6	10	14	7	2	0	0	40
AVERAGE MONTHLY AND ANNUAL NUMBER OF DAYS WITH MEASURABLE SNOW													
10	8	6	7	5	7	1	#	#	3	9	10	8	64
AVERAGE MONTHLY AND ANNUAL NUMBER OF DAYS WITH MEASURABLE PRECIPITATION OF ANY SORT													
10	8	6	7	6	7	6	10	15	10	10	10	8	103

# Indicates a total of less than 5 days with measurable rain or snow during a ten year period.

Climatic Observations.

COMMENTS UPON THE CLIMATIC SUMMARIES.

There are several features about the Coppermine data which are of interest. The annual average daily maximum is the lowest of the given stations on the Canadian mainland, with the exception of Chesterfield Inlet, which shares with it the distinction of being near open sea. The annual average daily minimum is the lowest on the mainland, being equal to that at Chesterfield Inlet. The annual average daily mean is the lowest of the given stations. Clearly its site near the sea has a marked effect when taken in combination with the winter cold. In summer with the sea open and free from ice, a moderating influence is exerted, but in winter the sea freezes over and what should be a moderating influence in the winter is thereby eliminated. Its agreement with the Chesterfield Inlet records is significant in this respect.

The average annual precipitation is equal to the average for the cited stations in the N.W.T. and does not differ from them in any marked way as regards the monthly distribution, but the station is unusual as regards snowfall. Together with Chesterfield Inlet it has the highest snowfall on the mainland of the cited stations in N.W.T., but has a markedly more even distribution of snowfall over the months than Chesterfield Inlet. The annual number of days rain is almost exactly average for all the cited mainland stations, but the annual number of days snow is the highest in the list. In summary, the number of days with precipitation at Coppermine is high compared with most stations in the N.W.T., only being equalled at Chesterfield Inlet and Hay River, and exceeded at Fort Good Hope.

There are no sunshine duration records quoted, although these are now being recorded, nor does the summary include a table relating average and extreme values of dew point to corresponding values of air temperature at four fixed hours.

Climatic Observations.

EFFECTS OF CLIMATE ON HUMAN ACTIVITY.

Clearly in an area where the monthly average of the daily maximum falls below freezing in eight months of the year there are restrictions upon human activity of one sort or another. For example the area is one in which permafrost is the rule, and whilst it is true that there are signs in the thermokarst phenomena that the permafrost may be relaxing its hold somewhat the fact remains that effectively, as far as building construction, road building or farming would be concerned, all the problems of permafrost would have to be tackled. Farming in any conventional sense is impossible because of the short growing season, quite apart from the permafrost problem. Lettuces, radishes and cabbages have been grown in the Coppermine settlement by nursing seedlings indoors and planting out in the high summer, but this of course is not a very practical procedure.

As far as white settlement is concerned the rigorous climate means that buildings have to be well insulated and heated, with all the ensuing complications of construction in addition to the problem of foundations on permafrost. Things like food storage become a problem, for while some items can be readily stored in the natural cold, other items like vegetables, potatoes, fruit and canned milk are easily spoiled by frost and have to be assigned moderately heated storage space. Water supply also becomes a problem since heat is required to keep water liquid in its storage tanks.

Transport can be helped or hindered by these climatic conditions. Boats can only approach the area over a limited period of time during the summer, and navigation during the time of ice break-up can be tiresome if not actually dangerous. On the other hand the winter freeze-up of the ocean provides almost unlimited numbers of landing strips for aircraft, and

offers the advantage of easy unloading as compared with the difficulties usually encountered by a float-plane. There is the drawback however that since there are no air strips in the area, the aircraft are at the mercy of the climatic conditions and must change from floats in the summer to skis in the winter. The mere cost of these items is one handicap offered to the development of commercial flying, and there is the added difficulty of the period during break-up and freeze-up when neither skis nor floats can cope with conditions and there is a hiatus in the communications system.

To the well adapted Eskimo it is probable that the cold winter offers only advantages. The use of snow igloos means that in winter at least building materials are free and housing cost and house movement is no problem. The frozen sea offers unlimited routeways for sledge travel and considerable weights can be transported cheaply and easily. Sealing becomes relatively simple. He can above all travel inland over the snow with sledges, to or from areas which otherwise could only be reached by the tedious methods of back packing. The older generation of the Copper Eskimo indeed depended on this very fact for his existence, for he did all his summer hunting of the caribou on the Barren Grounds inland, and could not possibly have carried out his accumulated meat and hides without building sledges at the treeline and sledging back over snow, or down the frozen rivers. Even the white settler has learned to leave supplies left in the summer by the boats on the Coppermine foreshore until such time as snow allows the goods to be sledged up to the buildings as much as a ton at a time.

As a counter to the various advantages offered by the cold, there is the problem of providing adequate clothing for the winter cold, and such items as really waterproof sealskin boots for the wet break-up period.

The fact that there is a period of freeze-up and break-up every year is another great problem raised by the climatic conditions. Transport is almost completely stopped during these times as was mentioned above, but there are other problems, for example the supply of drinking water to the settlement. In summer water may be obtained at the Coppermine River. In winter the sea ice confines the fresh water so that it can be raised through holes maintained in the ice in front of the settlement. During break-up however, the river is muddied, and also fouled by the debris and refuse left upon the ice surface during the winter by Eskimo families. Water then has to be obtained from stored fresh water ice-blocks.

There are a number of associated problems like the starting of gas engines in the cold, freezing of radiators, suitable grades of oil for all mechanical lubrication, and many other details.

Winds, not mentioned in the summaries, are not remarkable enough to provide a problem, but are consistent enough to make it a worth while proceeding to have windchargers and a battery electrical system. Nearly every dwelling in Coppermine settlement had a windcharger in 1954.

TIDES AND CURRENTS

TIDES AND CURRENTS.

Tides in Coronation Gulf are exceedingly small. None of more than one foot was recorded during the summer of 1954 in the area traversed by the survey party. The period is normal.

An important effect of this is that there is no rough broken ice on the coast as there is elsewhere in the Eastern Arctic. Sledging conditions are always easy, and the form of sledge and the harnessing of dogs is accordingly different from those forms further east. For shallow draft boats the tide is sufficient to make a difference in crossing the shoals at the following areas. Richardson River mouth, Coppermine River mouth, Niparktoktuak River mouth and the bay about the Asiak River mouth. Entry to the Kugaryuak estuary by canoe is difficult at low tide. A rapid on the lower Richardson River was only visible at certain times and this was ascribed to tidal effect.

The party learned nothing about currents. They have no known important human effect within the survey area. However most of the spring sealing is carried out on open water, a great distance out in the Gulf, and the open water is called by Eskimo and white the "tide crack". Since it is nearly 25 miles from shore it is more likely to be water kept open by a current or a tidal race, than a true tide crack. The ice, after break-up in the spring always moves eastward out of the Gulf and this too indicates a strong permanent ocean current.

REGIONAL PHYSICAL GEOGRAPHY

1) General Statement.

2) Map showing regional divisions.

3) The regions described:

   a) Clay-Silt plain of the Coppermine-Richardson-Rae rivermouths.

   b) The Cuesta region.

   c) The drumlinised region.

   d) The dolomite limestone region.

   e) The rock-knob upland.

REGIONAL PHYSICAL GEOGRAPHY.

GENERAL STATEMENT.

The survey area as studied by the field party in 1954 was delimited as extending between longitudes 111° and 115°45' west, and roughly twenty miles inland from the coast. It was found in practice that this area contained regional differences which prohibit consideration of the area as a unit. The basis of differentiation is in all cases a physiographic one, with allied vegetational differences. In some instances the survey area included part only of a region. In this account some estimate is made of the extent of the region where a part only of the region was actually traversed.

The entire survey area falls within an Arctic classification whatever the criteria. It is north of the Arctic circle by about seventy miles, and is also north of the tree-line, although trees appear as near the coast as twenty-six miles on the Coppermine River. The vegetation is of an Arctic type, and the population, apart from the white settlement, is Eskimo.

The area is traversed by one river of national importance in size, the Coppermine River; and has seven other major rivers. From west to east these are the Rae River and the Richardson River, both flowing into Back's Inlet, the Niparktoktuak ten miles east of the Coppermine River, the Asiak River twelve miles east again. The Kugaryuak River flows to the sea at 113°8' west and the Tree River at about 111°50'. The Anialik River runs into Gray's Bay at the eastern limit of the survey area. All these rivers run very approximately northwards except the Rae and Richardson which run west to east along a structural line delimiting two geological series.

Apart from the clay plain which never rises high enough, the survey area as a whole has an upper erosional surface standing at just over 1,000 feet above sea level, and rising very gently southward. The height of 1,000 feet is reached twenty miles from the sea round about

Apart from the clay plain which never rises high enough, the survey area as a whole has an upper erosional surface standing at just over 1,000 feet above sea level, and rising very gently southward. The height of 1,000 feet is reached twenty miles from the sea round about 114° W, although a scarp reaches almost that height east and west of that longitude within eight miles of the sea. At the Kugaryuak River the 1,000 foot surface is reached only six miles from the sea and about Tree River and Gray's Bay the surface comes within three miles of the sea, although much interrupted.

This surface ignores the geology. Contained within the area there are two main areas of unconsolidated materials, a clay-silt plain on the west and a drumlinoid area between 113°40' and 115°10' west. There are also three distinct geological series. The oldest is a granitic block which accounts for most of the surface east of Tree River and a considerable area west of Tree River. Then there is a complex ribbon of dolomite limestone paralleling the sea from Tree River at Port Epworth to a point twenty-five miles inland on the Asiak River before swinging away southward. This area includes a few square miles of a basal sandstone to the same series. The remainder of the survey area, where it is not submerged by drift, is made up of the basaltic flows of the Coppermine Series. The area of flows makes a wedge with its point at the Asiak River mouth, broadening rapidly westward, until, where the dolomite turns south the wedge becomes the great Series in which the Coppermine River cuts a section for over 100 miles. The only part of the Series in the survey area is the Upper Coppermine Series which consists of diabase flows and sills. Further isolated areas of flow rocks lie unconformably on the granite and nonconformably on the limestone, forming mesas and scarps according to their position and erosion.

The entire area has been glaciated, including the diabase scarps which rise above the clay plain in the west. The clay plain itself is probably an outwash feature of glacial or postglacial time and does not seem to be merely reworked glacial till. There was a post-glacial rise of the sea which came up to at least 320 feet, at which height there are unmodified esker forms. There is a suggestion that the sea came higher, a maximum of 500 feet having been suggested. The sea certainly did not exceed 700 feet anywhere in the area.

The vegetation of the area is as might be expected, with no startling anomalies or variations. There is a rich and varied bird life, mainly concentrated on the richer vegetations of the western plains. There are many mammals, principally lemming, ground squirrel, weasel, fox, wolf and caribou. Caribou, once fabulously numerous in the area, are now few and erratic in appearance. If anything, they are more common in the eastern areas. Fish, especially Arctic Char, are numerous, the Char being especially numerous in the Coppermine River mouth area and to a lesser extent in the Rae-Richardson mouths.

The human population is confined principally to an area about Coppermine, with a half dozen families scattered along the coastline eastward to Gray's Bay. Their total number is about 200 and they are part of an Eskimo group of about 900 who live in an area extending north and east of the artificially limited survey area.

Rae River
RICHARDSON BAY
Richardson R.
COUPER ISLANDS
BERENS ISLANDS
LAWFORD ISLANDS
CORONATION GULF
Sir George Moore Islands
Hepburn Island
GRAYS BAY
Aniglik R.
Coppermine
Bloody Falls
Tree R.
Asiak River
Kugaryuak R.
Coppermine River
N. barlokfuak R.
I
II
IIa
III
IV
V

KEY

I	Clay-Silt Plain of the Rae-Richardson Coppermine River Mouths	III	The Drumlinised Region
II	Basaltic Flows of Upper Coppermine Series	IV	The Dolomite limestone region
IIa	Basaltic Flows of Lower Coppermine Series	V	Rock-knob Upland

The Cuesta Region

REGIONAL DIVISIONS WITHIN THE SURVEY AREA

Scale in Miles
8 4 0 8 16

THE CLAY-SILT PLAIN OF THE COPPERMINE-RICHARDSON-RAE RIVERMOUTHS.

(Map I, Plates 19, 20.)

An area of unconsolidated material, principally clays of glacial origin, covers an area of hundreds of square miles west of the Asiak River. Between the Asiak and the Coppermine rivers the areas of clay are widely interrupted by basaltic flow outcrops of diabase, but from the Coppermine River westward the diabase outcrops become lower and more narrow so that the character of a plain with some low scarps is assumed. This area goes south to the higher ground of the Lower Coppermine Series. Clay was never seen at a height much exceeding 320 feet and this height may be considered a limiting factor. Westward the clay extends at least 25 miles up the Rae and Richardson Rivers but its exact extent and nature is uncertain. The only recorded traverse is by Chipman and Cox and it does not make the matter clear.

The material itself varies somewhat. In some areas it may lack colloidal substance and be a pure silt, but in most cases it was found to be clayey when wet, although the amount of stickiness varies.

No varves were found in the clays and silts and it is suggested that this shows flocculation of the material in salt water. They are then marine deposits. Their existence almost everywhere, to a height of 300 feet plus, indicates a 320' minimum rise of the sea. Marine strandlines are observable on the coastal plain between Coppermine River mouth and Back's Inlet. They run without interruption to over 100 feet above the sea. It is suggested that their formation at greater heights was inhibited by scarps protecting the inner areas from violent wave action.

There is a well preserved area of delta sands standing at a height of 300 to 320 feet, and nearly 4 square miles in extent, on the plain north of Bloody Falls. It is undoubtedly a delta of glacial sands formed by a

river falling out at that point and at that height. There are sands along all the beaches in greater or lesser quantities between the Coppermine River and the mouth of the Rae River. The Asiak River estuary is another notable area of sand deposition.

The banks of the rivers are steep near-vertical slopes in the clay-silt material and are rarely vegetated. Only where the river crosses a diabase flow are there rock walls to the stream. The clay-silt banks range from a few feet to a hundred or so in height. The rivers have meandered considerably in the lower flats of these plains and terrace forms are common. In the lowest parts the rivers exhibit non-matching meander terraces showing a continuous very gentle uplift for the area of the last 100 feet of the post-glacial rise.

The river estuaries of the Rae, Richardson, Coppermine, Niparktoktuak and Asiak rivers are areas of deposition. All have bars and flats, some above high water, some within the tidal range and some submerged. Boats up to 2 feet in draft can enter the Rae, Richardson and Coppermine fairly easily by various channels. The Rae can be navigated upwards for 8 miles when a series of falls begins. The Richardson can be ascended for over 25 miles when full of water, and shallowness rather than the first rapids prevents further penetration. The Coppermine River will take boats for well over 100 miles but a series of violent rapids discourages navigation. It is regularly ascended the ten miles to Bloody Falls which is the first portage point. The Niparktoktuak River has shoals extending nearly two miles out to sea. It can be entered in a canoe but its navigable extent is less than one mile. The Asiak River has filled the area between its mouth and the island off shore with sandy shoals. Its river mouth is difficult to enter even in a canoe and any further progress is prohibited by shallows. The rivers are all muddy.

There are three old river beds linking with the Coppermine River

north of Bloody Falls. All three are postglacial, since they are cut in the clay-silt materials, itself a glacial deposit. They contain isolated lakes and have small misfit streams in places.

Apart from the distinctive rivers, the area has three distinguishing features, diabase scarps; clay-banked gullies and badlands; and thermokarst lakes and depressions.

The scarps of the diabase flows of the Upper Coppermine Series rise only 200 feet or so above the sea in this area. Due to their being submerged in clay and silt there is only a small exposure of bed-rock but these all have similar expression, a long gentle dip slope to the north, and a steep, often vertical, face to the south. The islands of Coronation Gulf are identical features and represent seaward parts of the scarps visible on the Rae-Richardson river-plains. In times of the sea's advance the scarps of the clay plain would show as islands exactly similar to those in Coronation Gulf today.

The clay gullies and badlands are to be found chiefly about the Coppermine River and eastward, where greater relief allows fluvial action full scope. Streams entering the Coppermine River north of Bloody Falls typically do so in gullies. These gullies normally have bare barren walls but older examples may be vegetated, especially in sands. Square miles of gullying have given some areas of "badlands", especially east of Bloody Falls and in the middle reaches of the Niparktoktuak River. Clay "tailing piles" and isolated clay mounds south of Bloody Falls are caused by this process stripping away the clays from bed-rock ground and leaving some isolated interfluves.

On the plain west of Coppermine River there are many peculiarly round lakes. Some are linked with an old river system. There are also

many dry, or nearly dry, depressions of similar form. Some of these have edges which are cracking and sinking at the present time. They are caused by melting out of ice in the permafrost. Some depressions so caused become lakes, others are drained, leaving depressions up to one mile across, ten feet or more deep and roughly flat floored.

The vegetation of this region is the richest and most varied in the survey area. There is every kind of plant association: Rock desert communities on the scarps and their screes, all the type of tundra association, strand communities and a sparse plant life in some of the fresh waters. Some willows in the area reach a height of seven to eight feet in favoured locations.

THE CUESTA REGION. (Map 11 and 11a, Plates 21, 22.)

In the area between the Coppermine River and the mouth of the Niparktoktuak River the scarps made by the diabase flows of the Upper Coppermine Series increasingly dominate the general scene, until at the Asiak River the form resolves itself into two long regular dip-slopes and the south facing vertical scarps, with clay and glacial till masking the lowest slopes only. Both scarps run out to the sea, the most northerly at 113°55' W, and the southerly one at the Kugaryuak River. Isolated fragments of the latter flow and some thin bedded shales, etc., cap rocks east of the Kugaryuak as far as Gray's Bay and beyond. These isolated scarps and mesas have the general characteristics of the diabase surface everywhere. One such isolated fragment makes the promontory at Port Epworth and another is responsible for the headland making Gray's Bay, together with Hepburn Island. The islands of Coronation Gulf are made up of further flows and sills of the same series and properly belong in the regional description.

It should be noted that there is a further classic area of basaltic flows south of the survey area proper, for over 100 miles down the Coppermine River. It too forms a series of scarps, with the distinction that they are of basalt and very thinly bedded. The topography is described by Richardson in an appendix to Franklin's account of his first journey, and by Sandberg (1912) in an appendix to Douglas' book. It is believed by the writer that this series of flows, known as the Lower Coppermine Series, has the Upper Series lying upon it unconformably, a fact hitherto unsuggested. The diabase flows have markedly resisted river erosion. No drainage pattern proper has formed on any of the flow surfaces, the vast majority of the drainage forms being rivers from the main surface to the south which have breached the scarps, either by superimposition or along faults. Some small single

streams running directly down slopes have formed on the basalt, but only where there is some sort of superficial drift to aid the process. The flow surfaces are breached by the Coppermine River, the Niparktoktuak River, the Asiak River, an unnamed bifurcated river, the Kugaryuak River, the Tree River and an unnamed river four miles east of Port Epworth, all of which have their sources on the upland surfaces to the south. There are six insignificant streams reaching the sea between the unnamed bifurcated river and the Kugaryuak. One stream draining a lake on the upper surface cuts a diabase mesa 10 miles east of the Kugaryuak.

Drainage from the south between 114°20' and 113°30' W is blocked and diverted by the southernmost diabase scarp with the result that there is an east-west line of lakes and interconnecting streams, extending nearly thirty miles along the foot of the scarp. The scarp top averages just over 900 feet; the lake river system stands at a maximum of a little over 700 feet. The water escapes to the sea by the bifurcated stream and the Kugaryuak.

The basalt surface everywhere is a markedly even one, although there may be local roughness with a relief of 10-15 feet. The general surface is even and is made of bed rock. There is little or no soil. There are generally only a few stagnant pools of water on the surface and fresh water can be difficult to find. The only vegetation is of a rock desert type, unevenly scattered. Some areas are almost totally barren, as above Port Epworth harbour. No animals save ravens and one wolf were seen on these truly barren areas and the few animals usually live on the areas of unconsolidated material between or near the flows.

Between the Asiak River and the Kugaryuak there is a clay plain with some reworked drumlinoid forms on it. This has a richer tundra vegetation and supports, birds, ground squirrels and other small animals, but it

is an accident in the diabase scarp scene. The scarps themselves where they overlook the fertile areas of the other regions are a favoured haunt of the birds of prey. The islands were found to be almost devoid of vegetation except for lichens and hardy "rock garden" plants, but nevertheless supported a thin population of Arctic Hares and some birds of prey, together with occasional nesting gulls.

The topographic features which are most striking are the even dip slopes and the vertical scarps, the latter being a serious obstacle to north-south travel, even on foot, together with the typical gorges through which the drainage must cross the flows. The greatest height recorded for a scarp top was 950 feet, a height approaching that of the upland surface. Spot maximum heights along the flows from west to east are recorded as follows. South of the Asiak River mouth, 920', sixteen miles east, 950', on the Kugaryuak River's first bend, 600', at Port Epworth, 640', at Gray's Bay, 540.

THE DRUMLINISED REGION. (Map III; Plates 23, 24, 25)

South of the diabase scarp previously described, between the longitudes of 114°20' and 113°40' W. there is a large swarm of drumlinoid forms, covering the land southward for at least 25 miles. West of these drumlinoid forms is an area of clays and debris strongly suggestive of reworked glacial deposits. These and the drumlins incompletely mask the geology, which from west to east consists of an uncertain part of the Coppermine Series, the Epworth Series (dolomite and sandstone) and parts of the Teshierpi Granite. All these rocks have outcrops on the streams, or in incompletely masked ridges. The surface however is so uniform and so completely dominated by drumlinoid forms that there is a regional quality imparted by the glacial drift.

To the west the drumlins have almost been erased, possibly by marine action, and later modified by stream erosion. Only occasionally are the elongated ridges preserved, and the whole surface is reduced to gently rolling ridges which are probably minor scarplets of bedding of the Lower Coppermine Series. By the Asiak River however, the drumlinoid forms become more positive, and east of the river there are hundreds of fine examples of pure drumlin forms. They run approximately N 38° W., with an increasingly westward trend in the western part of the area. The drumlins stand 80 to 180 feet in height, are usually 600 yards or so wide and half a mile to 4 miles long. The great majority are about two miles long. They are made of clays and cobbles (stones about 4" to 8" across) with occasional boulders. The drumlins seen by the party stand on the surface rising uniformly from 700 feet to just over 1,000 feet.

No outcrop in the area has a major relief form. An Epworth sandstone shows as north-south razor-backed ridges 20 to 40 feet high; there is

a small outcrop of dolomite limestone, and various small exposures. A line of a basaltic rock can be traced for twenty miles without any major relief expression at the northern limit of the dolomite between 114° and 114°35' W.

Streams run generally between the drumlins and do not cut them, but a scarp foot stream cuts off all drumlins from actual contact with the cliff, if indeed they ever had any. Only the Asiak and the Niparktoktuak cut or modify drumlin forms. Occasionally there is ponding of streams and the lakes so formed are typically elongated. Nearly all streams are of clear water.

Following the general stream pattern and sometimes actually on the streams, there are five esker forms in the region. They are all "Irish" or multiple type eskers and from aerial photographs and field examination all seem to have delta forms immediately south of the southernmost diabase scarp.

Both eskers and drumlins have at one time extended over the Cuesta area, but these have been much modified by the sea and river erosion, being completely eroded from large areas. As a result it is only south of the diabase that the glacial forms dominate the scene.

The vegetation of the glacial drift area is consistently of moss-lichen heath on the higher parts. Only in the low ill-drained areas between drumlins or about the deltas are there areas of niggerheads, sedges, grasses and willow thicket. Walking in the area is easier than in any other part described in this survey so long as the traveller is moving north and south.

Animals apart from ptarmigan and a very few ground squirrel seem few in the area. Some loons were seen on the larger lakes, and one wolf was heard at the scarp foot. However many Eskimo caches and cairns, pos-

sibly from caribou drive-alleys were seen, and it may be an area for caribou when a migration occurs.

It is an area lacking large relief features. The most striking when encountered are the eskers. These make excellent routeways by nature of their form, surface and vegetation.

THE DOLOMITE LIMESTONE REGION. (Map, IV; Plates 26, 27)

A dolomite limestone known as the Epworth Dolomite, outcrops in a ribbon running from Port Epworth westward as far as the Asiak River, where its outcrop runs southward and out of the survey area. Its scenery is distinctive because of its petrology. The Epworth Dolomite consists of over 4,000 feet of beds which rarely exceed two feet in thickness and often are measured only in inches. This rock is not easily soluble nor readily eroded. As a result it has little surface soil cover, and its structure is obvious on the ground or from the air. The bedding is exceedingly contorted. Around Port Epworth a diabase flow lies on it nonconformably, and it in turn lies unconformably upon the granitic rocks. The ribbon is interrupted at about 114°W by an area of exceedingly fine sandstone, believed to be an outcrop of the basal sandstone of the Epworth Series.

Because of the contorted bedding the topography of the limestone scene has considerable variety. When the beds lie relatively flat and parallel to the surface, the hills resemble nothing so much as stacks of planks with irregular ends. Where there are synclines and anticlines there is a marked tendency to structural relief indicating that, at least in these areas nearest the coast, the surface is an exhumed one. There is a distinct erosional top surface at just over 1,000 feet just as is shown in the granitic rocks. Unlike the granitic rocks however, erosion along faults and bedding has provided spectacular and varied scenes. In the area about Tree River where shales, diabase, granite, and limestone meet there are remarkable features with relief as great as 600 feet. There is no consistent topographic manifestation, and the region is best given a geological limit.

The region is difficult to traverse in any direction. The streams and their fault valleys are filled by angular debris, lines of travel are rarely consistent, and the relief is considerable. The upper barren surfaces are exceedingly easy to walk upon but present no great directional extent in most cases.

The dolomite is crossed by three major rivers, the Asiak, Kugaryuak and the Tree but the streams of the area itself are poorly developed, often being merely lake overflows. The Tree River itself occupies a line which was probably originally dictated by the junction of the limestone and the granites but is in any case a river rising outside the region. A very fine esker fills a valley parallel to the western Tree River for over eight miles. There is a permanent ice patch one mile long and ten feet or more thick at the foot of this esker at 112°06'W and 77°34'N. All the streams north of the region were found to contain dolomite erratics among their debris. All the streams are of clear water.

The vegetation of the area is relatively scanty. The limestone outcrops are almost completely barren. There are dwarf-shrub heath, wet tundra, willow thickets, moss-lichen heath and rock desert associations in small areas wherever alluvium has been deposited by a lake or stream side, or at the junction of two faults; but the areas are never large.

The area is not known to be rich in animal life. Well worn tracks were observed in many places in 1954, and this area was at one time in the route of a regular migration of caribou. A great number of wolves were seen and heard about Port Epworth in 1954, but not actually in the limestone area. Not enough is known for a definite statement on the subject.

THE ROCK-KNOB UPLAND. (Map, V; Plates 28, 29)

At a point west of the Kugaryuak River mouth, hidden by drift, a granitic outcrop begins. It is part of a vast area of the Shield which runs southward indefinitely. It is interrupted in the south here for a few miles by the Epworth Dolomite, and also to the east for ten miles at Port Epworth. The whole land block east of Tree River and south of the coastal basalt is made up of a granitic block, probably the Teshierpi granite. The exact nature of the rock is immensely varied. Varieties of granite, with schists and syenites are everywhere closely associated. The precise geology is unknown. However the general erosion characteristics are similar enough to give a regional character. While not sufficiently well developed to be properly termed a Laurentide landscape it has been called here a rock-knob upland.

The upland surface which stands at 1,000 feet within four miles of the coast, and rises very gently inland, is broken up into more or less rectangular blocks by general erosion along joints. The relief caused by this is rarely much more than 150 feet and often a good deal less. Deeper erosion has cut deep trenches along the line of faults. The faults all run very approximately north and south, with a tendency to be running eastward of true north. Some faults intersect. Relief of the features along the faults may be 300 feet and possibly more. The faults have also interrupted the dolomite which lies over the granite, and in some cases, east of Tree River and along the line of the Anialik River in Gray's Bay, have also interrupted the overlying diabase. Granitic rocks only reach the coast in the survey area between the Kugaryuak and the western promontory of Port Epworth. For the most part, a capping of a diabase flow forms the actual coastline. Between the Kugaryuak River and Port Epworth, inland for 20 miles, 50% of the surface is capped with diabase dipping very gently northward.

The drainage pattern of the area is confined to the jointing and faulting pattern. Streams rarely attain any size in joints and the major streams are in the prolonged linears caused by faults. The valleys are typically wall-sided. It is only in the stream-occupied cuts that there is any alluviation and soil formation at all. The upstanding blocks, or 'knobs' are very sparsely vegetated, generally having only lichens. Many of the fault valleys have boulder trains in their floors, the area from wall to wall being covered by cobbles and boulders, including many erratics. Lakes are exceedingly numerous, occupying variously rock basins, joint crossings, and valleys dammed by unconsolidated materials. The Anialik River has a thick unconsolidated plug at its exit which was probably caused by stagnant ice damming the stream in the early post-glacial period, and a resulting deposition of outwash materials. All the streams are of clear water.

Vegetation is principally of a rock-desert type, lodging in crevices and small localised areas of alluviation, but some low parts have a richer vegetation approximating to dwarf-shrub heath tundra, or moss lichen tundra. Some fault valleys have considerable areas of grasses. Willow thickets sometimes occupy wet boulder trains, near-dry lake floors and similar sites. The coastal plain has more of the dwarf-shrub heath and large areas of niggerhead, because it is covered with unconsolidated materials.

This is the area most favoured by the caribou at the present time and they are possibly numerous during migrations. The uplands, however, are devoid of smaller animals and birds. Some duck were seen on lakes in 1954, but the only animals seen commonly were on the lower coastal plain where there are numerous small birds, ptarmigan and ground squirrel. Wolverine are moderately common and wolves are to be found everywhere. In

lean years the wolves come down to the lower areas, and specifically to semi-permanent settlements and camps to scavenge. Ptarmigan flocks are occasionally encountered among boulder trains, even on the uplands. The lakes of the area probably contain more fish than do the lakes of other regions.

Where the granite reaches the sea it presents a relatively straight coastline. Beaches are narrow, rarely have sand, and are usually made of gravels and rock. Approach by shallow draft boats is easy and it is possible to get ashore without wading from canoes and boats drawing up to two feet. Larger boats would have to stand only a few yards offshore. Between Tree River and Gray's Bay the granitic rocks reach the sea, but they are wholly protected by large diabase capped islands. Sailing along the coast, these islands give an impression of being the shore line, but it is possible to go behind them via several narrows. These passages have many feet of water and the bays behind are well sheltered. These waters and the waters of Gray's Bay have a good many skerries and reefs, low flat areas of sea-cut granite, above and below water level. The immediate coastal area behind all beaches on granite is open firm ground for at least half a mile and usually more.

A point of some importance about the granitic regions is that all relief is steeply edged. The region is therefore difficult to traverse even on foot, except along fault valleys. Tracked vehicles would find it exceedingly difficult to move over this country, because the walls of the 'knobs' are in all cases almost cliff-like. (Plates 30, 31.)

HUMAN GEOGRAPHY

1) History of Exploration.

2) History of Settlement.

3) Coppermine.

4) Functions of the Settlement.

5) The Site and Buildings of Coppermine.

6) Present Communications in the Area.

7) The Eskimo.

8) Present Resources and Their Utilization.

HISTORY OF EXPLORATION.

Coppermine settlement lies at the middle of the Arctic coast of North America and yet it was the first point on that coast to be reached by white men. The mouth of the Coppermine River was reached on July 17th, 1771 by Samuel Hearne, a Hudson's Bay Company employee whose commission for the voyage had been ".....to promote an extension of our trade, as well as for the discovery of a Northwest Passage, Copper Mines, etc.;..."[9] It was his third attempt to reach the area since his commission in 1769 by Governor Moses Norton at Churchill on Hudson Bay,[10] and he did it by accompanying a war party of Indians, who went to get copper only as a secondary object. Their prime purpose was to fight Eskimo, and a number of Copper Eskimos were in fact massacred at the site named Bloody Falls from the event. Hearne did nothing more than view the ocean before turning back with the Indians. The "Copper Mine" he was shown by them proved exceedingly disappointing and not as rich as stories had led the Company to believe.

The fame of the area preceded its actual discovery by many years. In 1631 Luke Fox found Eskimo graves with artifacts having copper heads at a point 63° N on the west side of Hudson Bay. In 1714 M. Jeremie, a French trader at York Factory, then Port Bourbon, said that the Dogrib Indians of the "Copper Mine" area had a mine of pure copper and that this was certain because Chipewyan war parties brought back fragments and worked particles of pure copper. The Indian name for the Coppermine River was Tzan Deze, or "metal river".

[9] Hearne, Samuel. 'A Journey from Prince of Wales' Fort in Hudson's Bay to the Northern Ocean, etc.' P. 162. London, Strahan and Cadell, 1795.

[10] Ibid. Introduction.

In 1717 a young lad of 17 called Richard Norton was sent with two Indians to find this mine. His year's travel on the search had results which have been confused in the records, but certainly there was at that time a source of information later proved to be fairly accurate. Two years later the Hudson's Bay Company who sent him, also sent an expedition of two ships from England, under the command of Captain Knight. Both ships were wrecked and all members of the expedition died.

A Captain Christopher Middleton, writing in 1743, made some remarkable deductions from all sources of information. He placed the "Copper Mine" just north of the Arctic Circle and 900 miles west of Wager River's mouth. In fact, it is 700, but clearly a good part of the truth was known. He assumed a routeway lying east of it, which must be the Coppermine River.

A Mr. Frost, quoted in Arthur Dobb's "Account of the Countries Adjoining to Hudson's Bay" in 1744, quotes the "Copper Mines" as a fact and accuses the Hudson's Bay Company of failing to trace them in case it developed a Northwest Passage and injured their own monopoly. Clearly Hearne was proceeding to a reasonably well-known destination when he set out on his journey and his discoveries surprised no one.[11]

Franklin, in his land journeys of 1820, found the Coppermine River a useful routeway. By way of the Mackenzie, Athabasca and Great Bear Lake he reached the river and descended to the scene of the massacre. From the river's mouth he took boat eastward, as far as Point Turnagain, naming the Tree River, Port Epworth, the islands of the Gulf, the Gulf itself, Gray's Bay and Hepburn Island. His return overland from Bathurst was almost disastrous.[12] During his second journey in 1825-27 a detachment from his party, under Richardson, and including Kendall, went east from the

[11]The preceding four paragraphs is an account derived from J. B. Tyrrel's 'Coppermine Country'. Canadian Mining Journal, Vol. 34, 1913. Pp. 117-153.

[12]Franklin, Sir John 'Narrative of a journey to the shores of the Polar Sea in the years 1819, 20, 21 and 22.' London, Murray, 1823.

Mackenzie River and coming through Dolphin and Union Straits, named after their boats, made surveys including the coastline from Krusenstern round to the Coppermine River, and returned to Fort Franklin via the river in 1825.[13]

In 1838 Dease and Simpson used the Mackenzie-Athabasca-Great Bear-Coppermine River route to the coast and in two attempts extended the survey of the coast eastward as far as Castor and Pollux Bay. They descended and returned by the Coppermine River in both cases.[14] Simpson added nothing to the knowledge or the names of the survey area. There is a cairn erected by Simpson 10 miles east of Port Epworth.

In 1851, Dr. John Rae, deputed by Sir John Richardson who was commanding a search party for Franklin, used the Coppermine River again for reaching and leaving the search area,[15] but his actual search was not conducted in the survey area, but to the north. It is of interest that on his return Rae lost one of his men, drowned in the rapids at Bloody Falls. Taken with the facts that the Catholic priests Rouviere and LeRoux were murdered there in 1913,[16] and that Pete Norberg, a trader who had unsuccessfully tried to shoot the rapids once, disappeared in 1925 after leaving his son 20 miles or so upstream and heading north in a canoe,[17] and of course the massacre, the odd number of fatalities at the Bloody Falls is very striking.

[13]Franklin, John 'Narrative of a second expedition to the shores of the Polar Sea, in the years 1825, 1826, and 1827.' P. 267. London: Murray, 1828.

[14]Simpson, T. 'Narrative of the discoveries on the north coast of America; effected by the Officers of the Hudson's Bay Company during the years 1836-39.' London: Bentley, 1843.

[15]Richardson, Sir John 'Arctic Searching Expedition: a journal of a boat-voyage through Rupert's Land and the Arctic Sea; in search of the discovery ships under command of Sir John Franklin.' Pp. 121 and 129. London: Longman, Brown, Green and Longmans, 1851.

[16]Steele, Harwood 'Policing the Arctic.' P. 189. London: Jarrolds, 1936.

[17]Finnie, Richard 'Lure of the North.' P. 213. Philadelphia: David McKay Company, 1940.

From that date until 1902, when the sportsman Hanbury passed along the coast and up the river at the end of the journey described in "Sport and Travel in Canada's Northland", there was no white activity in the area. Hanbury made some collections of plants, butterflies, and rocks in the area and also recorded some Eskimo place names. Stefansson passed up the river en route for Great Bear Lake in 1910.[18] He claims to have engineered the first friendly contact between Indians and Eskimos in that year. Douglas and Sandberg came down the river in 1912, but failed to do more than record the geology along the river and turned back from its mouth.[19]

The most serious work to date was that carried out by the Canadian Arctic Expedition (Southern Party) 1914-16.[20] From a base at Bernard Harbour they did a great deal of work in the whole area, providing reports on anthropology, ethnology, fishes, geography, geology, marine and mammal biology, etc. Many of these reports and their lists are the only accounts or lists extant on these subjects in this area.

A wild life investigator for the Northwest Territories Administration travelled widely in the whole area during 1924-25. He was W. H. B. Hoare, and his report, while having no other specific value, is an excellent work on the animals of the area and their habits. It compares in an interesting fashion with today's conditions and distribution.[21]

A party of the 5th Thule Expedition under K. Rasmussen touched on the area in 1925 when they made some studies at Tree River. They did not

[18] Stefansson, V. Op. Cit. P. 208.

[19] Douglas, G. M. 'Lands Forlorn.' New York, Putnam, 1914.

[20] Canadian Arctic Expedition, 1913-18. Report. 77 Nos. in 14 Volumes. Ottawa, King's Printer, 1919-46.

[21] Hoare, W. H. B. 'Report of Investigations affecting Eskimo and Wild Life. District of Mackenzie, 1924-1925-1926.' Canada, Dept. Interior. (N.W.T. & Y. Branch,) 1926.

proceed along the coast from there, but struck in a direct line for Dolphin and Union Straits.[22]

Aerial geological prospecting came to the area in 1929 when Dominion Exploration Ltd., looking for the ever-elusive copper, began searching the area southwest of Coppermine.[23] In 1930, Northern Aerial Mineral Exploration began prospecting from aircraft actually based on Coppermine settlement with a base hut there. Since that time there have been other geologists in the area but exactly who, where, or when, is not a matter available in published literature.

22 Rasmussen, K. 'Intellectual Culture of the Copper Eskimos.' Report of the 5th Thule Expedition 1921-24. Vol. IX

23 Norrie, J. P. 'Prospecting and Exploration of Dominion Exploration Ltd., in the Great Bear Lake-Coppermine River area.' Canadian Mining and Metallurgical Bull. No. 227. Pp. 349-362.

HISTORY OF SETTLEMENT.

Since the Copper Eskimo and associated settlements are distributed over an area which extends north to Minto Inlet they do not all belong properly within the delimited survey area. However, in this part it is considered wise to discuss settlement as a whole rather than strictly within the survey limits since otherwise many significant details would be lost. At the present time apart from Coppermine itself there are the following settlements in the area occupied by the Copper Eskimo. To the north there are H.B.C. trading posts at Read Island and Holman Island, both with associated prosperous Eskimo owning huts and large boats. At Holman Island there is also a Roman Catholic Mission with two Fathers. Shacks alone remain of the various trader-trappers who lived in the area at Krusenstern, Basil Bay and Richardson Island.[24] Bernard Harbour, Rymer Point and Tree River no longer exist as they were in the 1930's, nor is there any trace of C. Lewin's shack at the mouth of the Richardson. There is a small fishing shack near Bloody Falls owned by the Oblate Mission in Coppermine. Other settlements in the area now consist only of shifting bands of Eskimo, the gathering grounds of which, in tent or igloo by season, is discussed under the heading 'Eskimo.'

The first true settlement in the area came shortly after the murder in 1913 of the first white men to attempt to settle there, the Roman Catholic missionaries, Rouviere and LeRoux. In 1914 the Canadian Arctic Expedition chose as base Bernard Harbour in Dolphin and Union Strait, and built there the first permanent buildings in the area.[25] In 1915 an Anglican missionary,

[24] Statements by Rev. J. Sperry, Anglican missionary, Coppermine, and Ikey Bolt, School Native Assistant, Coppermine.

[25] Anderson, R. M. 'Recent Explorations on the Canadian Arctic Coast.' P. 249. The Geographical Review. Vol. IV, No. 4.

the Rev. Girling, followed the Expedition in, and in fact, took over their building when they left in 1916.[26] In that year the Hudson's Bay Company took a post into Bernard Harbour at the same time as Christian ('Charlie') Klengenberg set up his private store at the Coppermine mouth and initiated the present settlement.[27] In 1917 the Northern Trading Company installed the post at Tree River, but the direct competition of the H.B.C., twelve miles east at the Agirak River in Gray's Bay, soon triumphed and the H.B.C. moved in to take over their store in Epworth Harbour.[28] The R.C.M.P. followed in 1919, establishing the police on the Coronation Gulf for the first time.[29] This was the beginning of the drive by the R.C.M.P. to control an area which was completely lawless and especially troublesome at the time after the murders of the two priests at Bloody Falls, and Radford and Street at Bathurst, both necessitating long patrols for the arrest of the murderers.

In 1923 Klengenberg abandoned the Coppermine store but the H.B.C. operated a floating post there in 1925[30] and in 1926 began a permanent store[31] which came into operation in 1927.[32] The activities at the western end of the Gulf at this time made the Police leave Tree River and move to the centre of activity at Bernard Harbour,[33] only to move again to Coppermine in 1931 when that site developed so firmly (see "Coppermine" below).

[26]Hoare, W. R. B. 'Report of Investigations affecting Eskimo and Wild Life in the District of Mackenzie, 1924-1925-1926.' P. 33
Canada. Dept. Interior (N.W.T. and Y. Branch)

[27]Ibid.

[28]Ibid

[29]Ibid

[30]Ibid

[31]Ibid

[32]Finnie, R. 'Lure of the North' P. 85. Philadelphia, David McKay Company.

[33]Hoare, W. R. B. Loc. Cit. P. 35. 1940.

Coppermine usurped the attractions of all other sites over the years so that today it is the only settlement on the south coast of Coronation Gulf in the survey area. The two small trading posts at Holman and Read are the only other white settlements near.

Native settlements, such as they are, are discussed under the heading 'Eskimo' below, and Coppermine and its functions is now described.

COPPERMINE.

The only white settlement in the survey area is that at Coppermine. There is an R.C.M.P. barracks, Catholic and Anglican missions, a Hudson's Bay Company trading post, an Eskimo day school and a four-bed nursing station. The Department of Transport has a radio-meteorological station and radiosonde. There are a few permanent native huts housing such permanent native residents as the retired H.B.C. native assistant, the school assistant and the police interpreter. There is a constantly fluctuating number of tents (or igloos in winter) housing the numerous wandering Eskimo.

The settlement is an area which has long been a gathering ground for the nomad Eskimo. Hearne and his Indians of course met Eskimo at Bloody Falls, while Franklin's parties encountered Eskimo in the vicinity on both occasions of their passages,[34a,b] as did Simpson[35] and later Rae.[36] Hanbury encountered them in the area in 1902,[37] and Hornby in 1912 was able to give personal accounts of them there to the Douglas's with Sandberg who in turn encountered groups of them on the flats west of the river mouth.[38] The R.C.

34(a) Franklin, Sir John 'The journey to the Polar Sea.' P. 308. London: J. M. Dent and Sons Ltd. 1910, 1924.

(b) Franklin, John. 'Narrative of a second expedition to the shores of the Polar Sea in the years 1825, 1826 and 1827.' P. 267 London: John Murray, 1828.

35 Simpson, Thomas 'Narrative of the discoveries on the north coast of America.' Pp. 260, 262. London: Richard Bentley, 1843.

36 Richardson, Sir John 'Arctic searching expedition; a journal of a boat voyage through Rupert's Land and the Arctic Sea, in search of the discovery ships under command of Sir John Franklin.' P. 123

37 Hanbury, David T. 'Sport and travel in the northland of Canada.' London: Arnold, 1904

38 Douglas, G. M. 'Lands Forlorn.' P. 50

priests, Rouviere and LeRoux, deemed it a centre for a mission and the R.C.M.P. who investigated their murder found a group including one of the murderers and all the evidence in the same place.[39] The Canadian Arctic Expedition of 1913-18 names Coppermine as an area of native settlement as do the accounts of the 5th Thule Expedition. The fishing is so good in the river that it is probable there have always been Eskimo thereabout in the fishing season, however far they wandered at other times. The fishing is famed among the Eskimo from Minto Inlet in the north to the Tree River and Cape Barrow to the east.

Captain Joseph Bernard had a profitable season when his schooner was more or less accidentally frozen in ten miles east of the Coppermine mouth in 1910, but the first real white settlement on the present site was the store run by "Charlie" Klengenberg between 1916 and 1922.[40] There was an interval after he moved to more profitable areas, but the H.B.C. had a floating post there in 1925, and in 1927 the final settlement began when F. A. Barnes, an ex-R.C.M.P. then with the H.B.C., moved in to set up the Hudson's Bay trading post. The settlement was consolidated by what was probably sheer accident. A severe influenza epidemic broke out at Bernard Harbour which so frightened the Eskimo that they boycotted the place, which prompted Canon Webster to move the Mission of St. Andrew to Coppermine.[41] There were two Russian trappers in the area, one of whom went mad on what is now known as Fishhouse Island in 1930,[42] and a Swedish trapper living ten miles west at the mouth of the Richardson River.[43] It is probable there was

[39] Steele, Harwood 'Policing the Arctic' Pp. 189, 190. Jarrolds: London, 1936.

[40] Klengenberg, C. 'Klengenberg of the Arctic.' P. 276 Ed. Tom MacInnes

[41] Statement by Rev. J. Sperry.

[42] Finnie, Richard 'Lure of the North.' P. 91. Philadelphia: David McKay Company, 1940.

[43] Ibid. Pp. 9, 150.

also another white trader-trapper living some twenty-five miles up the Rae River, using Coppermine as a base for his operations.

In 1929 a Government Medical Officer was sent in. He was Dr. Russell D. Martin who after a year with the Grenfell Mission was sent by the Government to Coppermine to build and operate a small hospital which was to operate for only two years.[44] Many of its functions were then taken over by the Rev. J. W. Webster of the Anglican Mission.[45] The Oblate Mission of Our Lady of Light was built in the same year.[46]

In 1930 the most stabilizing feature of all ensured the permanence of this settlement. A Government meteorological-wireless station was installed.[47] This, together with the base huts for the aerial prospecting survey of the N.A.M.E. prospecting group which operated in the area during 1930,[48] made Coppermine temporarily the largest and most active settlement on the Canadian Arctic coast. Since then it has become the only settlement in the survey area with the elimination by death or competition of the small traders like Bill Seymour, then at Krusenstern, and the Klengenberg family's varied interests; and by a rationalization policy which has left the H.B.C. only at Bathurst Inlet, Coppermine and Read Island. The Police moved into the now large settlement in 1931.

Since that time the nursing station was re-established in 1948,[49]

[44] Finnie, Richard Op. Cit. P. 95, 214.

[45] Statement by Rev. J. Sperry

[46] Buliard, Roger P. 'Inuk.'
New York: Farrar, Strauss and Young, Inc. Copyright 1951.

[47] Finnie, Richard Op. Cit. P. 63

[48] Duncan, G. G. 'Exploration in Coppermine River Area, N.W.T.'
Trans. Can. Inst. Mining and Met. V. 34, 1931. Pp. 124-156.

[49] Personal statement by Mrs. D. Coleman, Nurse.

a radiosonde has been added to the meteorological station and an Eskimo day school established. Due to the difficulty of maintaining a class because of the constant movement of families, a hostel has now been added to the school (1954) and is planned to come into operation in 1955. This, by keeping 20-25 children permanently in the settlement, will ensure continuity in teaching while the parents are still free to move about their varied occupations.

The present white population required to operate the various concerns numbers a basic 13, but since nearly all are married and have children, while some posts change every two years, the real white population fluctuates around 25. The settlement was deemed typical enough, yet sufficiently remote, to be honoured by the Royal Visit of Prince Philip in 1954, during his tour of Canada.

FUNCTIONS OF THE SETTLEMENT.

Coppermine now is a definite regional centre. This is due to the frontier nature of settlement in the North. The Eskimo coming into contact with the white man and the Government does so on a number of planes which he is forced to adopt. To obtain white man's clothing, food and equipment he must operate through a trader. To obtain family allowances, and relief in time of starvation, he must be registered, and registration of births and marriages, the allotment of allowance and relief is made by the R.C.M.P. in Coppermine. Medical aid at a higher level is only available at the nursing station, and at the settlement is the radio which can call in aircraft for the flying out of the seriously sick and tubercular patients. All these services come from sources which must be static and remain at one site. Because of their increasing importance in Eskimo life they are now tending to stabilize the once nomad Eskimo too, and most certainly form a hub around which must centre their activity. The history and nature of these services is outlined under separate headings below:

Hudson's Bay Company:

There is a fur trading store at Coppermine run by the Hudson's Bay Company. It was first opened in 1927 by F. A. Barnes, an ex-R.C.M.P. Sergeant then working for the Company. Its trade was at first flourishing but has now somewhat declined due to the shortage of fur animals locally and the tendency for the Coppermine Eskimo to live upon the easily caught fish and seal. The main profit of the store now comes not from the fur trade but from the spending of family allowances and relief payments by the Eskimo. There are some sales of stock to white residents. The few furs traded are almost entirely fox, any other skins like bear, muskrat, or the more valuable mink and ermine being literally in occasional ones or twos.[50]

[50] Personal statements by R. Cruickshank, H.B.C. Trader, Coppermine.

Since the recent failure of the migrating caribou to pass near the settlement there has been a curious reversal of function since the trader has occasionally found it profitable to bring a few caribou skins from Bathurst and sell them to the Eskimo for clothing and sleeping robes.

The supplies for the store are brought in from Aklavik or Paulituk after shipment down the Mackenzie River, by one of two ships, a large ocean-going motor vessel, the "Fort Hearne", and a small motor schooner, the "Nechilik". Formerly, supplies came from Vancouver through Bering Strait and round Point Barrow. The ocean-going vessel "Baychimo" which originally carried out the work was crushed in the ice off Point Barrow in September 1931.[51] With the development of the Mackenzie waterway and the growth of Aklavik, this dangerous and uncertain route was abandoned. Today these two vessels supply all the posts of this section of the Arctic coast. They may call once or twice during the open season.

The "Fort Hearne" is too large to come inshore over the sandy shoals as the "Nechilik" does, and so is unloaded via scows which are towed out and back by a small power boat. Local Eskimo supply labour on a daily rate of pay, and "ship-time" is regarded as a period of certain cash-income, and the days following as a time of spending in the store for the native men and women. It is one of the few periods when natives actually handle cash as such, relief and allowance being in kind only, and the fur trade being normally a redemption of credit given in the form of "outfits" at the beginning of the trapping season.

The Company has three large buildings and several small huts. The larger ones include the dwelling, a modern house of standard company type, oil heated, and the only one in the settlement with hot and cold

[51] Finnie, Richard 'Lure of the North.' P. 46
Philadelphia, David McKay Company, 1940.

running water. There is an unheated store with counter and display shelves, and a large warehouse with fur loft. Subsidiary huts house the retired native assistant, a petrol store and windcharged batteries. Near the warehouse is a small landing stage, the only one on the settlement's shoreline.

Royal Canadian Mounted Police:

An island off Coppermine was the scene of the famous arrest in May 1916 by the (then Royal North West) Mounted Police of one of the Eskimo murderers of the Catholic Fathers Rouviere and LeRoux,[52] but there has only been a permanent detachment there since 1931 when the R.C.M.P. came from Bernard Harbour. The detachment comprises two men and a native interpreter, with a barracks and 30-foot sea-going patrol vessel (Columbia fishing boat type) named "Coppermine".

Crime, even of the most serious kind, is more frequent than is customarily credited to Eskimo communities. Coronation Gulf has seen a great number of murders and was the scene of a drive by the R.C.M.P. to establish order in the 1920's and early "30's".[53] But apart from dealing with these more serious crimes, the policemen have many other functions, which they assume as the only representatives of law and order in the area, and which are more important in binding the natives to the settlement.

The constable in charge is also Game Officer, the official Game Warden who administers the Game Regulations. He acts as Notary Public and Commissioner for Oaths, Sub-mining Recorder, Registrar of Births, Deaths and Marriages, and Welfare Officer, as well as being responsible for the innoculation of all dogs over three months old. The position of Welfare Officer is more properly the function of an Eskimo Agent and one may be

[52] Steele, Harwood 'Policing the Arctic.' Pp. 189, 190. Jarrolds: London, 1936.

[53] Ibid. P. 202

appointed to the District soon, thus relieving the police of work extra to their normal duties.

The detachment is responsible for an area comprising 25,000 square miles and containing 600 Eskimos. This area extends east to Bathurst Inlet, west to Minto Inlet and inland 100 miles between these two meridians. All points occupied by significant numbers of Eskimos are visited at least twice annually, once in winter and once in summer. The inland patrol has been abandoned since 1949 as there are at the present time only half a dozen families who will occasionally follow the old habit of hunting inland during the summer. In 1954 only two families went inland for a brief period and in 1953 eleven.

The patrols are usually carried out in loops, one east and one west of Coppermine (with an interlude in Coppermine between) but the actual routes vary. One complete circuit of all points is made in winter by sledge and one complete circuit in summer by boat.

The constable is District Registrar, entirely responsible for the issue of Family Allowance, and has been since the inception of the allowance in 1946. He is responsible for the issue of a registration number and a disc with the number upon it to every child born in his district. He also issues family allowance registration books to new mothers, and records therein any further births to her. These books represent the woman's entitlement to draw the appropriate allowances either from the constable or a district sub-registrar (a person like the trader at Read Island, especially appointed as being on the spot). The allowance is issued in the form of credit with the H.B.C. which can only be drawn within a specified range of goods, excluding the possible purchase of things useless to the child. This allowance is available monthly, but due to the nomadic nature of some of the groups it is

not always collected promptly. Some natives in 1954 had credit amounting to $300 which they remained entitled to collect.[54]

The police also administer the giving of "Relief" to needy cases. This may be given to returning hospital patients needing convalescence, or to long absent hospital cases who may require almost complete rehabilitation on their return. Due to the communal attitude to property maintained by the Eskimo, the latter person on his return usually finds his goods dispersed or used. Generally relief for hospital cases is recommended by the hospital concerned. Other cases, for local reasons, are judged on the current local situation. For example, a large amount of relief was necessary in the area in early 1954. In 1953 the caribou which used to supply so much of the Coppermine natives' food did not appear at all, and many dogs starved to death. The families who had intended living on meat now returned to Coppermine and lived on the catch of those who had stayed to fish. Despite the fact that fishing had been excellent, by Christmas all stocks were exhausted and the remaining dogs starving and weak. Winter sealing, the last hope, is a ranging affair since the seal maintains many holes when the ice is still fairly thin, and so dogs are vital to the hunt. These were few in number and weak. Relief for men and dogs was given out and all active persons urged out of the settlement to hunt seal by the police, but the kill was poor. By spring most of the settlement required help in some form or other, and there were many cases of real hardship which the police had to discover and evaluate.[55] They may act upon information from any reliable source.

From time to time the barracks also has to act as a guardhouse

[54] The above account of Police duties was gained in personal conversation with Constable Coleman, Coppermine.

[55] The above account given largely by Rev. J. Sperry, Anglican Mission, Coppermine.

where are kept any Eskimo serving a jail sentence of less than 2 years. Usually they sleep in a tent, and work by day for the police. They may not leave the area of the settlement but can have visitors.

Nursing Station:

The nursing station was established in 1948, seventeen years after the short-lived station built and run by Dr. Martin for the Federal Government. In its short life the station has had six nurses, but the present policy, of the nurse being the wife of the constable, presents promise of more stability. The actual building was also moved, in 1950, to its present site higher up from the shore on bed rock. Besides the actual clinic there are four beds and appropriate facilities, together with living quarters for the nurse.

No fixed hours are maintained because of the nature of the work and the temperament of the people. An average of seventy Eskimo utilize the service in any one month and the use of the clinic has increased steadily since its opening. Most cases are simple ones, such as dressing burns and cuts, but when it is considered that no Eskimo tent has facilities for cleansing, disinfecting or dressing, this is perhaps not an insignificant service. Maternity cases always call at some time for pre-natal advice and a check-up after the birth, but the actual accouchements rarely require attendance. There were twenty-two births between January and September 1954.

The main troubles encountered are T.B., influenza and measles. T.B. is being combated by the Mass Radiography Unit run from the Camsell Hospital. This arrives by aircraft every Easter when the greatest number of Eskimo are in the settlement, and film is taken and scrutinized within

one week. Whilst the analysis is being carried out the aircraft flies to Holman and Read Islands to carry out the same process. Active cases detected are taken outside immediately, usually to the Camsell Hospital at Edmonton. Thirteen cases were detected in 1953, eight of them active. The menace is not now so great as it was even in Dr. Martin's time. A very large percentage of the natives have healed tubercular lesions as shown by X-ray photographs.

Influenza has been serious and in the past epidemics have caused a great number of deaths, as at Bernard Harbour in 1920 and a number of times since. As recently as the spring of 1954 there were 100 cases in an epidemic at Coppermine, two of which were fatal. Pneumonia is relatively rare and when it does occur is generally a complication of 'flu or measles. Influenza cannot be treated at the station because of the small number of beds, so treatment is by visiting, the giving of antibiotics and the teaching of elementary procedure such as the maintenance of as constant a temperature as possible, and the drinking of a great deal of liquid.

Measles is epidemic and sometimes fatal, usually by complications setting in. The last epidemic was in 1952.

Other common items requiring the nurse's services are snow-blindness, conjunctivitis and occasional fish tape worms. There is no venereal disease, and practically no vermin. Teeth are attended to by a doctor who visits monthly, although the Anglican missionary may operate in emergency. A dentist visits annually and cases requiring more complex treatment go out to Edmonton.

Elementary local nursing service is provided at the more remote communities by the Catholic Fathers at Holman Island, and the H.B.C. traders at Read and Bathurst. They can receive advice upon serious cases by radio from Coppermine. The Government flies out all serious emergency

cases for treatment where possible.[56]

Department of Transport: (Meteorological Station and Radiosonde)

The meteorological station and radio were installed during the summer of 1930 and were operating before Christmas of that year. The transmitting-receiving radio has always had facilities for both radio telegraphy and radio telephony. The operating staff normally consists of a chief radio operator and an assistant. Since they are stationed on a year to year basis the staff or its members change fairly frequently, younger assistants especially tending to go north for a period of one or two years only.

The meteorological data is collected by standard procedure and transmitted at the appropriate intervals. The radio is used to assist aircraft in navigation and to give current weather situations at Coppermine to incoming aircraft. It may be used for personal messages by anyone as a public telegraph service linking with an Army Engineers radio on Great Bear Lake and the public Canadian system, and charges appropriately. It is used most commonly for the ordering of goods to be brought in by aircraft and may be used for late orders to boats leaving the Mackenzie. It receives encoded advice on pricing, etc., to the Hudson's Bay trader to keep him in touch with fur prices. It is used by the nursing service for advice on complex cases, or for calling in assistance or an ambulance plane in an emergency which the nursing station cannot handle. The police also frequently need its service. It is a fact that the radio is the principal feature differentiating modern settlements from the old type with their remoteness and limited function, and the Coppermine radio is Coppermine's real vital centre.

[56]The description of the Nursing Station and its activities was kindly given by the nurse at Coppermine, Mrs. Coleman.

The radiosonde, built more recently, obtains its data by standard procedure and transmits them also by the radio. It is a separate establishment.

The met-radio station has two large buildings, one a dwelling and the other housing two transmitter-receiver units, a power generator and emergency power generator (both very old in 1954), and one bedroom for the operator. There is a small library.

The radiosonde also has two main buildings, one large dwelling housing all the staff, and a large shack for storing the expendable equipment necessary to the work.

At the present the wife of the Radio Officer is in charge of the Post Office.

The Missions:

There are two missions in Coppermine, the Oblate Mission of Our Lady of Light and the Anglican Mission of St. Andrew.

Anglican Mission:

There has been an Anglican mission station in Coppermine since 1928. This, the Mission of St. Andrew, is one of fifteen active missions included in the Diocese of the Arctic which is administered from Toronto.

The Mission is at present responsible for an area which includes the following principal areas of Eskimo settlement, permanent or periodic. The main groupings can be located at Minto Inlet, Holman Island, Rymer Point, Read Island, Coppermine, Bathurst Inlet and Cambridge Bay (see map at end of section). The total number of Eskimos approximates 900, but Cambridge Bay will not long be included in the parish of the present missionary since the Rev. Peter Emerson is to reopen in 1955 the Anglican

Mission closed there in 1943. He will then include in his parish the natives of Bathurst Inlet; and the Coppermine Mission will be left with the areas outlined above. The Eskimo served by the Coppermine Mission will then number between four and five hundred. Bathurst and Cambridge Bay were included in the charge of Canon Webster when the war prevented funds from abroad maintaining the Cambridge Bay Mission in 1943.

The Mission came to Coppermine in 1928 when Canon Webster moved it from Bernard Harbour where it had been established by the Rev. Girling in 1916, when he met there the Canadian Arctic Expedition and took over their building when they left. An influenza epidemic in 1928 led to the boycotting of Bernard Harbour by the frightened natives which prompted the move to Coppermine, an area which was known to have been a gathering area of Eskimo for many years.

The Mission has two buildings, a dwelling and the church proper. The dwelling once included the chapel and the bell tower. The present church was built in 1950 and finally finished in 1951. Until that time the chapel in the mission house was used for all services except the large Easter services when a large tent-roofed "igloo" was used capable of holding fifty or more persons. Services at the outlying areas visited are invariably held in igloos: either the largest in the encampment, or one especially built for the visit by the congregation. The present church seats 150, has coal stove heating and a harmonium. It was built from material brought in by boat and the building labour was one-half paid, one-half voluntary.

The present missionary came to Coppermine in 1950 and took over from Canon Webster in 1952. In order to look after his area he adopts the following travel system. Travelling by sledge and dogteam he visits Read Island some time in the New Year. Later he undertakes his major winter

journey by land again and on to Holman Island. Then there is a final journey in spring to Cambridge Bay and Bathurst. This last is timed to catch the maximum number of people actually in the settlement as the Bathurst Eskimo are primarily caribou hunters and hence scattered nomads except for the spring period of rest and outfitting before the caribou come north once more. On these sledge journeys every camp encountered is visited for at least one day. In this manner nearly every Eskimo in the mission's area is encountered at least once in the year. Christmas, Easter and the summer are spent in Coppermine itself. Coppermine in summer is an area of congregation because of the fishing.

Until 1948 the Mission also served as the only nursing station, elementary clinical work being carried out by Canon Webster. The Rev. Sperry is still the official local dentist and is also the Ranger Lieutenant assembling a platoon of reliable Eskimo guides.[57]

The Oblate Mission:

The Roman Catholic missionaries were actually the first to arrive in the area, though not the first to build a mission. Buliard recounts how Rouviere, after a reconnaissance among the Eskimos hunting to the N.E. of Great Bear Lake, decided to go in as a missionary.[58] He and LeRoux accordingly travelled over to the mouth of the Coppermine in the summer of 1913. After an initial welcome they were warned that they stood the risk of murder for their belongings and accordingly started south again. They were overtaken and murdered near Bloody Falls by two Eskimos. These men were arrested by the police some three years later, after the Canadian Arctic Expedition had found certain of the Fathers' belongings among the Eskimos,

[57] Account of Mission given by present Missionary, Rev. J. Sperry.

[58] Buliard, Roger P. 'Inuk' P. 15.

and Indians on Great Bear Lake had reported Rouviere's shack empty and ransacked, while Eskimos had been seen wearing surplices.

The present mission, however, that of Our Lady of Light, was established in 1929 by Father Fallaise and two others. The buildings consist of the mission house which contains the chapel, and an earthen ice house. There was only one Father there in 1954. His charge does not include so great an area as does that of the Anglican Mission for there are other Catholic missions at Bathurst and Holman. Therefore he is concerned only with the Eskimos living in the immediate area and along the nearer coasts northward and east. He does not have a travelling program like the Anglican, spending the time constantly on short visits to encampments and fishing settlements in the area. The congregation is small compared to that of the Anglican one in this particular area.[59]

The Federal Day School:

The school is the most recent installation in Coppermine. It has a large two-story frame building with large windows and exceedingly modern equipment. A great deal of trouble in heating it has been encountered. Teachers teaching there are volunteers doing a two year contract. No knowledge of Eskimo is essential to obtaining the post. The school has had little success in its short existence largely because of the migratory habits of the Eskimo who take their children with them. Teachers therefore have constantly varying numbers and components in their classes.

In an effort to surmount this difficulty and lend force to the purpose of the school a hostel was built in 1954 at which it was planned to maintain about 25 children in the future. This group would provide a permanent educable group for the school to work with.

[59] Account given by Father Lapointe.

There is one teacher who lives with his family in an apartment built into the schoolhouse. He has a native assistant acting as janitor and interpreter. The school has a movie projector and occasional film shows are given, open free to all Eskimos.

Permanent Eskimo Population in Coppermine:

In the settlement there live permanently some natives whose present activities depend solely on the presence of the settlement. They live in permanent shacks. They include the permanently disabled who live on relief money, and the following workers: a police interpreter, a nursing station assistant, the retired H.B.C. native assistant and the school assistant. Other natives are employed by all the establishments from time to time, as at ship time, or at ice storing time, but are by no means consistently employed, and do not live permanently in Coppermine.

THE SITE AND BUILDINGS OF COPPERMINE.

The actual buildings of the settlement are all somewhat similar except for the school building. The general mode of construction is frame building, double walls with insulation packed between. They have shingled roofs. The foundations are not deep. They are all oil heated. Most buildings have modern oil-burning cooking stoves. There is only one building with hot and cold running water, some have running cold water (by hand-pumping water into a roof tank), and some keep water in a boiled out and aluminium painted 50-gallon gas drum to be ladled out when needed. Sanitation is by chemical closet, whether inside or out, but the case is different with the Eskimo who relieve themselves literally anywhere. Most buildings are electrically lighted by batteries which are charged by windmills. Nearly all windcharger plants have emergency gasoline engined generators for charging in periods of calm. Some buildings possess washing machines powered by small gasoline engines.

The site itself is the north or seaward dip slope of a small diabase outcrop. Most of the buildings are on a ridge of beach material now well vegetated and consolidated, standing some 15 feet above sea level. Between this ridge and the rock outcrop is a hollow, possibly a former lagoon, which is exceedingly ill drained and marshy at this time, although several drainage cuts have been made across it which are in constant flow during the summer. On the rock itself are the two large buildings of the school and the nursing station. The settlement is scattered and nearly one mile in length.

There is no drinking water on the site save one small spring above the school, too often polluted by natives washing clothes. Water is brought from the Coppermine River and each establishment must own a

boat in order to get round the point and into the fresh water of the river where drinking water can be obtained. This is brought in 50 gallon drums to the shore of the settlement and then carried bucketfull by bucketfull, usually on yokes, to the storage barrels in the houses. This carrying problem is especially serious for the buildings further back, like the nursing station. In winter the sea ice confines the fresh waters and so it may be obtained quite simply by breaking through the ice offshore from the settlement, but it must still be carried to the houses. The most serious difficulty occurs during the spring break-up of the ice at the end of May. The river is not accessible because of the broken ice, and is in any case polluted by whatever debris has been left on the ice surface and muddy from the excess water and leaving of the clay banks by the ice. At this period, which is of variable duration, water for drinking comes purely from melted ice, which is cut and stored in large blocks near the houses during the winter. Clearly the water supply is a major problem.

Oil for heating and motors is used in large quantities. The result is that each house has near it a considerable number of fuel drums, each painted with an identifying letter. At ship time empties are replaced. It is normal to leave the newly arrived drums on the shore until snow comes when they can be sledged up to the houses quite easily, otherwise it would be exceedingly difficult to take the 50 gallon drums very far, as there is no road and no wheeled transport. These drums, covering areas 50 yards square sometimes, are a distinctive feature of the settlement. Another is the ice block mounds in spring for use as drinking water during break-up. These are invariably covered with tarpaulins to guard against fouling by the dogs.

A further problem, made light of under settlement conditions, but

which may become troublesome, is sanitation. Dogs are maintained by the natives and many whites. These are normally kept chained on a permanent "dog-line". As there are a considerable number of dogs and as dogs are very little used in summer, the fouling is considerable. The Eskimo too, whether in tents or shack is quite indiscriminate and cannot reasonably be expected to be anything else.

PRESENT COMMUNICATIONS.

Although Coppermine was first reached overland by its River this method is never used today. There are two modes of entrance to the area.

Radio is the permanent communication method, coming before post for all matters requiring immediate attention. Mail is dispatched and received once monthly by aircraft on a Government contract. This may go more frequently in practice, since any passing aircraft will take mail, and post it at their destination. During break-up and freeze-up there may be an interval longer than one month since there is no airstrip, and neither ski nor pontoon landing is feasible on the shattered drifting sea ice.

Associated Airways run a schedule flight monthly and this is the method of arrival and departure for men, mail and all light goods. For special purposes and times, aircraft have to be chartered at Yellowknife for the 350 mile flight, from one of two companies, Wardair or Associated Airways. The cost of freight is high and quite prohibitive for heavy or bulk goods. These are brought in by ship.

The ships usually concerned are the Hudson's Bay Company's M.V. "Fort Hearne" and schooner "Nechilik". They bring bulk freight that has come by rail and river to the Mackenzie Delta and distribute it along the Arctic coast and islands. It is much cheaper than air freighting, but has the serious disadvantage that it requires ordering one full year ahead because of the winter freezing up of the Mackenzie and Arctic Ocean. These boats may call only once or twice during the open summer season. Precise dates of arrival are uncertain, varying with conditions.

Regular communications within the area itself are non-existent. To arrive at any specific point on the south shore of Coronation Gulf one must either fly in by chartered plane, or travel by small boat and then

on foot. The Eskimo in his irregular movements uses sledges in winter and small boats or canoes, usually gasoline engined, in summer. All journeys inland must be done on foot. The rivers of the area are generally too shallow or broken by rapids for use by boats, only the Richardson being penetrable to a useful distance by shallow draught boats. The Tree and Rae Rivers are too broken up by rapids, and the Coppermine, although useful for nine miles up to Bloody Falls, thereafter requires more portage than boat work, until far south of the area discussed here.

The future for aircraft communication within the area is the only one worth discussion, since roads are out of the question. Aircraft on pontoons in summer, and skis in winter have an unlimited number of lakes on which to land. Within the survey area it would be impossible not to find a suitable lake within five miles of any given point, and usually the distance would be less. All prospecting in the area is now done from aircraft. It is the most reasonable method, but expensive. Boats are cheaper for freighting but can move along the coast only. The aircraft are useless during break-up and freeze-up since the lakes then are occupied by irregular floes or too thin ice. The open lakes become unsafe about the end of May while ice may still be found in thin floes as late as July 10th. Aerial photos from 1949 reveal ice <u>on some lakes only</u> as late as July 21st. They freeze again in mid-October but may not be safe for ski landings until mid-November and later.

The possibility of airstrips is in most cases only a question of expenditure. There are flat areas near Coppermine and near any other possible settlement site, but the cost of draining and finishing as a strip is prohibitive, unless there is a large scale development which would justify it. Also, any airstrip would need a road to the settlement site and

would probably require its fuel stocks freighted in by air if sited inland. Associated Airways maintains a fuel cache on the shore at Coppermine since their landings are always on the sea in front of the settlement.

The only reasonable air transport without extensive road building and heavy freight commitments is by the present method of aircraft on skis or floats. A D.H. "Dove", a plane landing at relatively high speed on a tricycle undercarriage, made an emergency landing on a sandbar in the river one mile upstream from Coppermine and took off again successfully in August 1954, but this must be regarded as a freak. The bar could make only a unidirectional strip and is too short for safety.

THE ESKIMO.

The number of Eskimos normally living between the Richardson and Rae Rivers to the west and Gray's Bay to the east was about 200 in 1954.[60] They are part of a more widespread distinctive group known as the Copper Eskimo from their formerly using native copper in making weapons and implements. Any general statement therefore refers to this entire group. In other places it has been relevant to contrast the Copper Eskimo of this area with those of the two other principal areas of settlement. The total number of Copper Eskimos including all mixed blood was about 900 in 1954.

The Copper Eskimos are one of the only two groups of Eskimo known to have utilized metal in their original culture. This was due to the presence locally of pure copper in free native form. Their first contacts with white men date back to the Franklin Expedition, for one can hardly call the presence of Hearne at the Bloody Falls massacre a contact. Through the frequent passage of white explorers they must have been quite familiar with the existence of white men, but there was no exchange of culture or materials until the first traders moved in, in 1910 and 1916. They had no contact with the Indian because of mutual fear until 1910.[61] When the northernmost group was discovered by Stefansson in 1910-11 they were completely unspoiled and the purest undisturbed culture remaining at that time. Their life in all its detail is excellently described by D. Jenness in four volumes of the Report of the Canadian Arctic Expedition. Volume XII particularly includes a complete account of the country, the Eskimo, their distribution, dwellings, organization, food, mode of life and a great deal else. No better picture would be possible. Other accounts are to be found in

[60] Statements by Constable Coleman and Rev. J. Sperry.

[61] Stefansson, V. 'My Life with the Eskimo' P. 217.

Stefansson's "My Life with the Eskimo"; and Vol. IX of the 5th Thule Expedition Report, "Intellectual Culture of the Copper Eskimos" by E. Rasmussen, records the culture as of 1925.

Jenness recorded in 1915 that a change was beginning among the Copper Eskimo due to the influence of traded goods and the arrival of permanent white settlement. This change is very evident today. The following is a general account of the Eskimo in the area followed by some notes on the more significant changes. For a complete picture of the primitive culture one should read Jenness.

The Copper Eskimo in the survey area was known formerly as an 'inlander' because in summer the families moved inland and pursued caribou which were to be found in great numbers on the Barren Grounds. Only in winter when the caribou wintered in the forests to the south would the Eskimos return to the coast, there to exist on seal and fish until the next spring and the next caribou migration. A certain percentage, often the old or disabled, would stay behind and fish at the various river mouths, drying huge quantities of fish to keep for winter. The caribou hunters often returned on sledge with the first snows, making the sledges of the wood obtained at the furthest south. The area between Great Bear Lake and Coppermine was a favourite, but Eskimos went inland all along the coast. The 1954 survey found numerous old caches on the islands a mile or so offshore east and west of the Kugaryuak. Islands were chosen to deposit all goods too heavy to carry inland, or useless in summer, because there the caches could not be attacked by wolf, wolverine or bear.

Hunting was by bow, spear and harpoon - the weapons having sharp heads made of copper. Caribou could be killed only by organizing drives. The animals were frightened down a corridor made by planting willows with rags, etc., in rock cairns. The frightened animals thus driven had only

one line of exit, where was hidden the hunter with a bow. If the caribou could be forced through some kind of natural defile a spear might be used. Seal could only be harpooned on the winter ice. Dogs would find the breathing hole and the Eskimo sat beside the hole with a harpoon carrying a barbed detachable head on a hide line. Sometimes a float warning device was used. The seal was speared and then pulled out by force, the large square-flipper seal when speared requiring many men to haul it in. Ptarmigan could be killed with the bow or by rocks. Fishing was done either by jigging, using a copper hook on a line of caribou sinew, or by spearing with pronged and barbed spears, either in fish trap weirs, or at some shallow or hole during the spawning run. Bloody Falls was a famous site for this last method. Deadfall traps were used for other animals, and ground squirrel was killed with rocks, speared, or shot by bow.

The product of the hunt was used completely. Fish was eaten raw, boiled, frozen or dried, and every part was consumed save the bones, including the intestines and head. The caribou's hide was used for clothing, tents, sleeping bags and many other things, the meat eaten raw or boiled, fresh or dried. Even the intestines were eaten and the half digested vegetable contents of the first stomach. Stefansson reports that Eskimos sometimes ate the excrement, but this was probably in times of hardship. The horn was used for toggle buttons, handles and various implements as for instance, a root-grubber. The shoulder blades were used to scrape hides.

Every part of a seal was eaten and its skin removed in different ways according to the intended use. It could be made into line or material for the waterproof boots, or else by skinning in a special way, bags for use in travelling or storing liquids, fat, etc. Ptarmigan were eaten complete and the skin with its feathers used as a towel. Ground squirrel was eaten and its fur used for inner socks, fancy clothing and trimming.

Cooking was done over a seal-oil lamp, usually made of soapstone, or over driftwood or dead willow fires. Dry mosses were used when better fuel was unavailable. Flame could only be obtained by sparking pyrites onto suitable tinder. The pyrites came from two sources only, one in Victoria Island and one in a creek a few miles east of Coppermine.

Travel was by dog-sled in the winter, and on foot in the summer. Kayaks were known but did not play so important a part in the economy as elsewhere. There were a great number of superstitions, folk tales, and customs unique to the group.[62]

Today the picture is very different. The caribou are now more scarce and very erratic in their appearance. The use of rifles must have played at least some part in this change from even thirty years ago. Fishing is now the major occupation of the Copper Eskimos of the survey area, for young and old, fit and disabled alike. In 1954 only two families went inland in the old tradition. Such an existence had become too uncertain, and the native preferred to fish and seal, and if necessary labour in the settlement. The children's allowance, paid in kind to the Eskimo is a contributary factor in this tying of the native to the settlement area, and is a factor previously completely unknown.

Hunting today is by rifle. Whilst the rifle was misused in slaughtering herds of caribou, it has undoubtedly been exceedingly helpful to the Eskimo sealer. The old system of harpooning on ice is replaced by the ability to hunt all year around. In winter the seal can be shot while basking on the ice from a distance which makes stalking relatively simple. In spring, summer and fall the seal can be shot from boats, although in mid-summer the bodies may sink before they can be retrieved.

62 Most of this generalised account is derived from the D. Jenness reports mentioned above and listed in the Bibliography.

Fishing is totally revolutionized and its scope infinitely increased by the introduction of the gill-net. The possible catch of one Eskimo has increased more than tenfold and the work is less tedious. As a result, at the larger rivers, and especially at the Coppermine, many natives now live almost entirely on fish plus such variety as can be obtained by the children's allowance, labour for the white man, trapping, and the sale of leatherwork, curios and soapstone carvings directly to visitors or via the school and the Handicrafts Guild in Yellowknife.

Traps, while introducing a new range of possibility to the natives, have not had a revolutionary effect. This is possibly because the area is one relatively poor in fur bearing animals. As a contrast, the Copper Eskimos of Victoria Island are industrious trappers and a materially wealthier group. Coppermine however is a poor fur trading post.

The product of the hunt is not used today so completely or so ingeniously as it used to be. For example the strings, yarns and ropes available at the store are far more useful, reliable and simple to utilize than the old sinews and hide strips, although it might be mentioned that hide is still used to lash sledges because of its special qualities. A good deal of clothing is made from factory made fabrics, more especially the summer clothing. Wool stockings and underclothes are common, together with tailored clothing like shirts, pants, jackets and so on, which may be bought at the store. In 1954 two men had double-breasted suits bought from a Simpson-Sears catalogue and one had a blazer and flannel trousers. Needles and threads are used for most repair jobs or sewing and buttons are used on clothing. Galvanized buckets, tin cans and cooking pans are bought at the store. Tents are made of canvas. Dog harness can be made of standard units, has steel snap-links, padded collars and other manufactured items including heavy steel sledge anchors.

As a result of the presence of these manufactured and useful items which can be bought, the native no longer makes full use of his hunting. Food is the only concern after he has obtained sufficient caribou hide to make winter clothing, and sufficient sealskin to make waterproof boots. They no longer eat the product of the hunt so completely either, so that compared with the old intensive utilization, the present usage is relatively wasteful. Caribou and seal skins are often allowed to rot, and seal may be killed only for their liver for one meal. The native makes up the margin to his former existence by the fur trade, or by the Family Allowance, or by working for a white man. When all these sources are insufficient to cover the gap in times of scarcity he may have to go 'on relief' and receive free aid in the form of supplies from the Government.

The Eskimo frequently cook on Primus or gas-stoves and of course now have the boon of matches. The dog sled for winter travel is unrivalled, but there is a marked antipathy to walking far, and most travel in summer is by boat. The kayak is now unknown and the great majority of the boats are clinker built rowing and power boats brought in from outside. There are a few canoes. Many natives own outboard motors and some have inboard engines. They display great ingenuity in maintaining the engines and the boats.

A great number of the Eskimo speak a little English. Generally the ones who do so well are found to have been to the schools in Aklavik. Some have permanent jobs in the settlement, as for example, the police interpreter, the teacher's assistant and the nursing station assistant. Others take temporary jobs for a day or so, doing odd jobs for various people in the settlement and receiving a previously stipulated payment,

either in credit on the H.B.C., or in goods. Nearly every man counts on earning cash by helping unload the stores when they are brought by ship to the Hudson's Bay store. The cost of employing a man is open to negotiation, but in 1954 a man would request $4.00 or $5.00 for a day, though he might accept $90.00 - $100.00 for a full month's work. Larger sums were always expected to be paid in credit on the H.B.C., to pay off debts or buy desirable goods. Smaller amounts could be paid in credit, cash or kind. Occasionally trouble is met when a man having a great debt to the H.B.C. will try to have his pay without resorting to credit on the Company. One minor source of income is the sale of goods to Handicraft Guilds. These include leather slippers, Eskimo artifacts and soapstone carvings. One crippled native who had lost a leg earned an extension to his relief payments by making a great number of these carvings. The soapstone comes from Fort Epworth and is brought to Coppermine by natives, or the police, or, on one occasion, the schoolmaster. Carvings are generally small, about seven inches high and $10.00 is expected for an average specimen. A great number of the old soapstone lamps are being cut up to make into these objects.

The Eskimos in Coppermine are predominantly Anglican in their religion. Most of the old folk tales have now disappeared and many of their stories show signs of the white man's influence. Two or three of the older people still do drum dancing and have the spectacular drum-dancing outfits, but the younger people prefer the square dances, usually held at the school to the music of guitar and accordian.

Although the Eskimo is still something of a nomad, he does not range so widely as he formerly did. The greatest number of the 200 population in the survey area live within one day's boating of Coppermine

settlement in summer. They fish about Coppermine river mouth, or the nearby islands, at Point Mackenzie, down Back's Inlet and at the mouth of the Rae and the Richardson. A few families live at Basil Bay. Along the coast there can usually be found four or five families at traditional sites. In 1954 there was a family at the Kugaryuak in the spring. One family lived in Port Epworth all summer, and three families were said to be on the coast east of Gray's Bay.[63] The winter distribution is similar except that the groups tend to become closer.[64] It is in the spring that there is some wandering. A considerable number of Eskimos go to the sealing camps at open water 25-30 miles out in the Gulf. Families out sealing may wander great distances on their own. The movements are not regular and are in no way predictable.

The natives of the survey area show considerable differences from the remainder of the Copper Eskimos at the present time. For example, to the north, on Victoria Island, the Eskimo does not depend on fish, and takes hardly any caribou at all. Sealing provides the mainstay of living and most Eskimos are relatively wealthier because of better and more active fur-trapping.[65] The Copper Eskimo to the east, at Bathurst Inlet, can still depend upon the caribou as the basis to the economy, with fish as a subsidiary and some trapping.[66]

The Eskimos at Coppermine have most of the problems of the Eskimo everywhere in the Canadian Arctic, but it is an area where the Administration is experimenting. There is a school, and now a hostel to stabilize the

[63] Population distribution as here described was determined from numerous sources: Eskimo, police, missions and personal encounters in the field.

[64] Statements by Constable Coleman and Rev. J. Sperry.

[65] Statements by Constable Coleman, Rev. J. Sperry and H.B.C. trader at Read Island.

[66] Statements by Rev. J. Sperry and Constable Coleman.

school population. There is also the nursing station. Fortunately at the moment the situation is not complicated by the presence of large bodies of white men for military or economic purposes.

RESOURCES OF THE AREA AND THEIR UTILISATION.

For convenience the resources of the area are here classified as vegetational, animal, mineral, human and power.

Vegetation. The overall vegetation of tundra and rock desert formations has no economic value whatever, apart from its support of the animal population. Farming is impracticable. The vegetation would however support reindeer and might, in certain areas, support sheep.

Animal. The animal population of the area was at one time its major resource. The vast herds of caribou were a seemingly infinite source of meat and skins. They have today been greatly reduced in numbers and do not appear regularly. Polar bear and musk-ox have been wiped out. The area has foxes and wolverines whose furs have a trade value, but the area is not rich in these as compared to other regions, even nearby. There are a very few muskrats which are not trapped. Fishes and seals which are numerous, are the mainstay of life for the native, but are not exportable commodities. There are insufficient eider-ducks to provide a source of eider-down for sale or working.

Mineral. In minerals lies the greatest possible resource of the area and yet at the same time the mineral wealth may be mythical. The fact that the Eskimos obtained pure copper by picking it from the ground was taken to imply vast ore-bodies. The native copper forms however do not necessarily imply such a fact.

Despite quite intense prospecting no rich copper bearing area has been found. Claims made as far back as 1930 have been renewed, and there are a number of claims registered between the survey area

and Great Bear Lake. None of these claims are rich enough to justify development of some way to export the product. Even given transport to the sea it is doubtful if there is one claim worth developing in the whole north between Great Bear Lake and the sea. With transportation problems as they are, the claims are not being worked at all. The Upper Coppermine Series which is all that comes within the survey area is probably not mineralized at all. Other minerals of economic value are unknown.

Human. The native population of 200 is relatively undeveloped. Although at present less than a quarter can speak any kind of English they are an intelligent group who would probably learn any type of work rapidly. At the present stage of their development the trouble would not be intelligence but reliability. The native is essentially nomad and even today is liable to give up a job after one day or in the middle of a morning. It is possible that now the population does not move so much as it did, the natives may become more stable in their outlook. There is no kind of work for them at present, except as described before, of doing domestic work for settlers, unloading Hudson's Bay Company stores, and selling objects like carvings, leatherwork, etc. The first two could not lead to economic development, the latter has a very limited development and the market would soon fade.

Power. One resource which is certain and undeveloped is water power. All the rivers have sufficient fall to provide limited power without damming, and the possibilities for damming are great in many places, especially in the east. But the problem of winter freezing eliminates power supply in winter. The Coppermine River flows all winter.

In 1954 the Tree River Falls were observed to have broken through from underneath and so it too, possibly flows all the year round. Other streams certainly do not. Even in those two, problems of ice damage to generators in the break-up season would be an inhibiting factor. At the present time there is no large scale demand for electric power, but it could be useful to mining concerns or military installations. The only large scale developments could be on the Coppermine but there might possibly be some on the Tree River.

The resources are such that a population can barely keep itself alive and operative. The fur trade is poor. Mineral development is nonexistent at the present and unlikely in the future. It is probable that if it were not for the artificial settlement, and the Government's subsidy, the natives of the area would be exceedingly poor and suffer considerable hardship.

APPENDIX

1) Personnel, routing and itinerary of the Coppermine Survey 1954.

2) Techniques and methods used in investigation.

3) Equipment and Food.

4) Illustrations.

5) General Map.

PERSONNEL, ROUTING AND ITINERARY OF THE COPPERMINE SURVEY, 1954.

The party consisted of two geographers, M. Marsden and G. Falconer. During the summer two Eskimo guides were employed, first J. Niptunatisk and then W. Bolt.

Marsden and Falconer left Montreal on May 10th, arriving in Edmonton by train on the 13th, and flying to Yellowknife on the 14th. A chartered plane of Associated Airways took them into Coppermine with all their equipment, arriving on the evening of the 15th. Their time in the field is summarized below:

1) A period of local walks.

2) May 19th - 28th. A sledge reconnaissance to the Tree River and beyond.

3) May 29th. The Coppermine River went out.

4) June 1st - 22nd. A long period of waiting for the sea and river ice to disperse. Work on the local scarp and the old bed of the Coppermine River. Also work in the base camp, sorting the aerial photographs to be keyed and the way to tackle them in the light of the reconnaissance. Opportunity was taken to investigate the Human Geography of the settlement: the operation and histories of the Met. station and radio, the R.C.M.P., the school, the Hudson's Bay Company store and the local Eskimo. A good deal of time was spent bird watching with D. V. Ellis, a marine biologist working in Coppermine from May to August. With his aid a bird list was prepared.

5) June 22nd - 26th. First real photo work in the area of Bloody Falls, interrupted by bad weather.

6) June 29th - July 5th. Bloody Falls area finished.

7) July 13th - 20th. The Rae and Richardson Rivers. Work cut short and then return delayed by bad weather and a gale. The same wind brought the sea ice back inshore and prevented the plan of going straight East.

8) July 27th - August 8th. Canoe to Gray's Bay, Tree River, etc. Large area of ground was examined and keyed. Ran out of film and returned earlier than was the plan.

9) August 10th. Visit of Prince Philip to Coppermine.

10) To August 16th. Waiting for film to arrive. Collecting information about the Missions and Eskimo fishing.

11) August 16th - 31st. Canoe to the Kugaryuak River and beyond. Same type of journey and work as the last, finally interrupted by the first poor weather since July 20th.

12) Wait to go to the Palaeozoic area in poor weather; fog and squalls. Plane to take party out delayed by the fog. Left finally on September 7th.

Arrived Yellowknife on the 7th in Associated Airways charter plane. Edmonton by Canadian Pacific Airlines on the 8th. Return to Montreal was by rail.

TECHNIQUES AND METHODS USED IN INVESTIGATION.

Because the Aerial Photographic Interpretation Key was regarded as the primary work and was used in evolving all the other aspects, its preparation dominated the field planning.

The aerial photographs were laid out as a whole, bearing in mind the obvious regionalism depicted in the project plan and seen in the sledge reconnaissance. One photo or more was chosen from within each area which could be regarded as typical of the major part. Since there are boundary cases and unique details, further selections were made which showed a) the junction of two regions, b) details atypical of a region but within it, and c) photographs showing individual peculiarities of any kind. Bearing in mind that unexplained features or typical areas were reported in other regions the final number of photographs selected for keying was 20 showing all possible features, with some others to be looked at in case they should prove to be unusual in any way.

The location of the actual ground depicted in the photographs was then ascertained upon the eight mile map, for the planning of the field excursions. In the field the actual spot was located on the ground direct from the photographs. A number of field excursions were then proposed to cover the different areas.

1) A trip up the Coppermine River to be undertaken before the ice melted at sea.
2) A trip west by canoe when the sea ice first cleared, around the point and into the Richardson River, keying photos from there to the Rae River mouth and north to Cape Kendall.
3) By canoe to the extreme east of the survey area working back west, the trip to last three weeks, and to return direct from some halfway point, probably the Kugaryuak River.

4) Canoe to the Kugaryuak and work back west to Coppermine.

5) Cover the Palaeozoic area about Cape Kendall.

By working in this order it was thought possible to work a little before and during the break-up of the sea ice. A move would then be made to the extreme limits of the area in order that all later work should be nearer and nearer base, involving less travelling time to centres, and less trouble in the event of engine failure etc. The palaeozoic area was originally planned as in with the Richardson-Rae work, but when bad weather prevented that, it was put to last on the list, since, being almost local, and easily accessible to the canoe, it was the job most easily hurried if necessary.

The party proceeded by canoe to the nearest possible point of access to the ground which it was proposed to cover. If arrival was late in the day, or conditions were dull, the ground was walked over and observations made as to the height, direction of striae, nature of vegetation drainage, accessibility of vantage points, and, probably the most important, whether all details of the photographs had been interpreted correctly beforehand. In cases where the party arrived at a site late, or the terrain keyed was reached only after a long walk, these observations were carried on concurrently.

Each aerial photograph was accompanied by a list of proposed ground photographs intended to present the interesting features or clarify puzzling detail. Where possible even the rough site of each ground photo was planned beforehand, and a tour of the aerial photograph outlined on a Kodatrace cover to that photograph. This cover also protected the photo. The exact spot being found suitable on the ground, photographs were taken in a certain combination.

All these photographs had the site on which they were taken most precisely recorded upon the Kodatrace, with an arrow pointing in the direction in which they were taken. Each site was assigned a number merely chronological in the order of taking, and this number went under the head 'View' in the photographic record book. Every photo had the following data recorded: the number of the roll; the exposure on the roll; the aperture; the filter, if any; exposure time; view number; and a brief descriptive title. These titles form a major part of the field notes, since, taken with the printed photographs, they far exceed most notes in value. The briefness was, however, expanded elsewhere, together with such detail as was not photographically recordable.

These pictures and their records were thought sufficient for the Interpretation Key and provided a large part of the geographical notes, but many other important details had to be recorded.

An aneroid (Paulin), level, and Brunton compass were always carried. Due to the distances covered, and circular trips, the aneroid could not be used in one-hour circuits at all times, and so the inaccuracies inherent in aneroid readings, taken and corrected back to a point of departure ten or twelve hours before, is present in most readings. Any precise readings were recorded as such; the rest must be taken as accurate only within ten to thirty feet. Height differences at a point were quite accurate as they were taken on the spot without any considerable time elapsing. Readings on the Brunton were recorded as read and not corrected. They are corrected to read from true north in the final report.

Notes were taken continuously and comprised generally all or some of the following:

1) General views on the landscape, including nature of the bedrock.

2) 'Grain' of the land, directions of easiest and most difficult traverses.

3) Spot and generalized heights.

4) Any obvious geomorphic history - terraces, cutting, etc.

5) Soils - peat or clay, etc.

6) Vegetation type and distribution.

7) Nature of slopes.

8) Evidences of glaciation.

9) Water - moving or otherwise, depth, cleanliness and accessibility.

10) Animals.

11) General and odd details: as, snow remains; Eskimo composites; cairn remnants; surprises as differing from the map; with an occasional relating of the total picture of a region as it formed in the field.

These notes were obviously a vital part of the survey, but there is little point in describing a purely personal system. The notes were at first kept in small notebooks 4" x 6", but later books 5" x 7" were used, being more convenient for writing if not for carrying.

Travel was by canoe and by foot. The canoe was a twenty-footer with a Johnson 5 h.p. outboard engine. It could carry three persons and equipment for a three weeks' trip quite easily, together with fuel adequate for a round trip of over 250 miles, together with an adequate reserve. The loaded canoe was quite stable. The engine gave just under seven miles to the gallon when the canoe was moderately loaded. Heavily loaded, as at the outset of the longer journeys, only six miles per gallon or even less was the rule.

Camp sites each night were upon, or as close as possible to, the area to be worked upon the next day. Due to limitations imposed by the

weight of the camping gear (see notes on 'Equipment'), a new technique for reaching the more remote sites had to be evolved in the field. Carrying only instruments, cameras, and a small quantity of such concentrated foods as chocolate and raisins, a traverse would be made of the region throughout the day, working and photographing until darkness, and the return made during the light night or the next day. This gave a similar range to a two or three day back pack, but infinitely more mobility in the field. The effort of making height readings, being particular about photo sites and so on made the strain of such work with a heavy pack such that it inhibited the best work. Taking packs, a 13-mile traverse in one day over rough country was an unpleasant experience during which little work could be done, whereas by the travelling light method, a 38-mile trip of some importance was carried out in 36 hours, and many similar examples could be quoted. Nevertheless, since the system depended on good weather, it would be preferable to have some extremely light gear for regions less easy of access than the Coppermine area.

Information relative to the human geography was largely done by personal interview with the appropriate personnel - the police, the trader, the missionaries, the radio operators, all Eskimo encountered and so on. Much of such material is liable to personal bias and has accordingly been sorted. Facts only are stated as definite, and opinions recorded as such. There was great difficulty in gaining accurate information from Eskimo due to their disconcerting habit of agreeing with any even slightly leading question. A definite technique in questioning had to be learned. There was also the trouble of working through an interpreter.

EQUIPMENT AND FOOD.

There are two possible views of the equipment used during the field season. It was all of high quality, no single item save a stereo camera being defective or poor in quality. On the other hand, it was for the most part too heavy for easy back packing and cut down the mobility of the party while on foot. The main items are listed below, itemized in order of importance under the following general headings: travel gear, camping gear, instruments, and cameras.

Travel. The canoe used was a 20-foot 'freight' canoe with a backboard for an outboard motor. It proved very stable when loaded, but was dangerous to use in the open sea with any kind of short waves running because of its tendency to cut into waves rather than mount them, thus becoming liable to swamping. It could carry three persons and equipment for a three weeks journey, together with fuel sufficient for a 250-mile trip with an adequate reserve. The loaded canoe was difficult to paddle. It was the ideal mode of transport along this coast. The outboard motor was a Johnson 5 h.p. outboard. It ran well, but this motor appeared to need decarbonization after having used about 35-40 gallons of petrol. Starting became uncertain and sometimes running was uneven. The built-in starter rope broke and an ordinary line had to be used. The engine gave about seven miles to the gallon when the canoe was moderately loaded. Heavily loaded, as at the outset of the longer journeys, six miles to the gallon or less was the rule. It could move the moderately loaded boat at about ten knots.

Camping Gear. The Mt. Logan tent was excellent as a base tent, being roomy and stout. On the other hand, it was too heavy to pack far in addition to the bags, food, cooking gear and instruments. It was also bulky

out of proportion to its weight. It should have been supplemented by a pup tent. The sleeping bags, by Holden and Woods, were warm and comfortable but far too heavy. They too were bulky out of all proportion to their weight. Also they were too warm for the summer months, although the warmth was necessary in the spring and fall. A double bag is recommended in their place. A bag like the Blacks 'Icelandic Special' is quite as warm, considerably lighter and rolls up very much smaller. Further, since it consists of a light down inner and a heavy down outer, a variety of combinations is possible. Both together for extreme cold, the heavy outer for spring and fall, and the light inner for the summer months.

The Coleman stoves supplied were excellent in every way until they burned off their combustion heads after fairly long and continuous use. Since the head is also the vaporiser, the stoves then became useless. Spare heads would seem to be essential when these stoves are to be relied upon for any long period. As it was, a replacement had to be bought in the field, a stove of the heavier type, which in turn added to the burden for the long walking tours.

Cooking utensils were of ordinary household type. Apart from the weight of such items they are also awkward and bulky to carry.

A summary of the camping gear must make clear that it was all too heavy and bulky for real mobility. As a result, while it was possible to pack all gear for living and work over a reasonable distance, it was not possible to work at the same time. This either increased the time necessary for any given piece of work or else seriously inhibited it.

Instruments. These were few and all excellently suited to the work. They include the standard Brunton compass and the Abney level. Special mention should be made of the Paulin Altimeter. This is easily the

best height instrument available for such work. It is light, yet proved robust. It settles rapidly and accurately. Its mode of use allows of extreme accuracy when a check point is available, and reasonable accuracy on large traverses. Its mode of use can also record a reading until the next is taken, a fact which facilitates rapid work in the field.

Cameras. Individual comment is made below:

Kodak Retina IIa - 35 mm. A very good camera for this work. Adequate in every respect and exceedingly small and light. A fast and reliable lens, a reliable and robust shutter. There is no unfavourable comment upon this camera at all.

Kodak 'Tourist' - 620 Roll film. A cruder camera adequate in most conditions. As a reserve camera, it was used by this party for taking panorama in good light conditions.

Voigtlander 'Bessa' - A good camera of the 120 rollfilm type, well suited for the work intended, giving a large negative capable of great enlargement. For any technical detailed shot this is a safer camera to use than any 35 mm. camera because of its large negative size.

'Revere' Stereo - 35 mm. stereoscopic camera. This was the one item not trusted. Its marked shutter speeds and aperture were adequate for all purposes but the quality was suspect from the start. The range finder was incorrect at all distances, including infinity, when new, and since the finder is the only focusing scale, some concern was felt about this. The shutter ceased to operate for no apparent reason when changing a film. The prints suggest that the speeds shown on the aperture scale are inaccurate since there are wrong exposures when pictures taken with the Voigtlander at precisely the same aperture and speed are per-

fect. After the shutter broke the stereo pictures were taken with the Voigtlander using a tripod and moving the camera right for a second shot.

On the matter of film it is felt that the wrong policy was used. The stereo black and whites suffer from extreme graininess. The film used was Kodak Super XX, a very fast film. At no time was the camera lens at the limit of its speed and, indeed, it is felt that pictures taken under extreme conditions are of little value in a key. It would seem better, therefore, to use as a standard film a slower, less grainy film in order to produce better prints. Over 90% could have been taken on very slow, fine grain film. For example, the colour film used was literally ten times as slow as the Super XX, and yet was only twice unusable for snapshot exposure in the available light.

Food. Little can be said about a matter subject to personal idiosyncrasy, but these points should be made about the food supply of this survey. When a great deal of packing has to be done, bulk and weight have to be avoided in the choice of foods. The lightest foods available are the dehydrated ones supplied by Beardmore, but they are none of them good food value, being mainly filling. These give acceptable and pleasant bulk to meals in the field, but must be complemented by concentrated food value in smaller bulk. This was supplied by the use of such foods as dried fruits, cheeses, meats, malted milk, dried milk, Bovril and so on. Canned vegetables and fruits were taken only in small quantities and were regarded as occasional luxuries. Dehydrated soups were a basis of many meals, providing a core for the better foods in their smaller quantities. Biscuit was used instead of bread and was quite severely rationed. It proved difficult to carry as the containers in which they were sold were quite ridiculously fragile. Their place was frequently taken by the use of dumplings

in the soups, and fried bannock, both made simply from flour. Both butter and biscuit were seriously underestimated in the original estimate and both had to be supplemented by purchase at the Hudson's Bay store. Fresh fish were everywhere freely available in this area and proved a valuable addition to the diet. The Hudson's Bay Company stores in these areas can generally provide all basic items of food like tea, flour, tinned butter, raisins, salt, matches, oatmeal and sugar, so considerable expenses involved in freighting can be avoided by contacting the trader beforehand to make sure what stores are available. More unusual items, like chocolate and dehydrated foods, cheeses and most canned luxuries, will have to be taken in.

GENERAL MAP OF THE AREA.

Made from parts of two sheets of the National Topographic Series (Canada), eight miles to one inch. The western part is from the sheet titled "Coppermine', numbered 86 N.W. and 86 N.E.; and the eastern part is from the sheet titled 'Bathurst Inlet' and numbered 76 N.W. and 76 N.E.

1. OUTCROPS OF THE COPPERMINE SERIES.

The scarp described in the text as possibly representing the lowest flows of the Upper Coppermine Series runs up the centre-line of this photograph. In the lower right quarter are the ridges which are suggested to be the outcrops of the Lower Coppermine Series.

R.C.A.F. photo: T3111-88.

2. Raised beaches in rock debris at Gray's Bay. Granitic area in background (P.23). See also No. 15.

3. (Below) Typical marine cliffs in basaltic rock where the flows have been breached by rivers or faulting. East of Tree River (P.22).

4. STRANDLINES ON DRUMLINOID FEATURES.

Showing how strandlines of former beaches may be left only where unconsolidated materials have provided beach materials. The points running into the sea are all drumlin features. (P.24)

R.C.A.F. photo: A11525-285

5. OLD SAND DELTA AT FORMER SEA EXIT OF COPPERMINE RIVER.

Inside the arc marked in ink is the perimeter of a well formed old delta made of almost pure sands. (P. 25)

5b. Gullies in old delta showing sands, bedding and snow-patch erosion.

6. Gorge at Bloody Falls. This photograph shows how the broad river is confined to a narrow cut as it crosses the basaltic scarp and then opens out on the plain beyond. Notice banks of clay-silt beyond the gorge.

7. Old meander terraces of lower Coppermine River. P.30.

8. Typical river bank in unconsolidated Clay-Silt plain. Clay bank about sixty feet high. In the foreground is a thick silt deposit on grounded ice. (P.29)

9. Glaciation. In centre ground can be seen a granitic mass which has been glacially smoothed. To the right can be seen plucked facets of rock. Evidence of glaciation and direction of flow of this sort are common in the area. (P.33)

10. Glaciation. Typical glacially smoothed granite upland surface at 1,000 feet near Gray's Bay.

11. Glaciation. Typical esker form north of gap in basaltic cuesta. (P. 35)

12. Glaciation. Drumlins viewed from scarp-top.

13. Frost-heaved block of basalt. Four feet in height this block keyed perfectly into the apparent debris filled cavity below it. Numerous examples are to be found. (P.39)

14. Active snow-patch erosion taking place in an old sand delta near Bloody Falls.

15. THERMOKARST LAKES IN CLAY-SILT PLAIN.

Apart from the strikingly symmetrical lakes which are ascribed to thermokarst (P.39) there are other important features on this aerial view. 1 and 2 are former channels of the Coppermine River. 3 is an area of raised beaches. 4 and 5 are typical thermokarst depressions now dry. 6 is an area of 'badlands' - gully erosion in clay.

Spartan: A13608-72.

16. Typical thermokarst lakes and depressions. (P.39)

17. Patterned ground, non-sorted circles in clay-silt material. (P.41)

18. Boulder stripe with boulders up to two feet across. (Pp. 34 and 43)

19. Clay-silt plain. A typical scene in the area of the Rae-Richardson and Coppermine Rivers mouths. In the background may be seen the scarps of the Upper Coppermine Series. (P.90)

20. AERIAL VIEW OF CLAY-SILT PLAIN.

Typical view over gullies in clay-silt plain. At the right side a basaltic flow outcrops. The Coppermine River crosses the background. Varying vegetations are indicated by the different tones. (P.90 et seq.)

R.C.A.F. photo: T311R-86

21. Typical scene in cuesta region showing columnar scarp of a basaltic flow overlooking an alluviated plain. (Pp. 92 and 94)

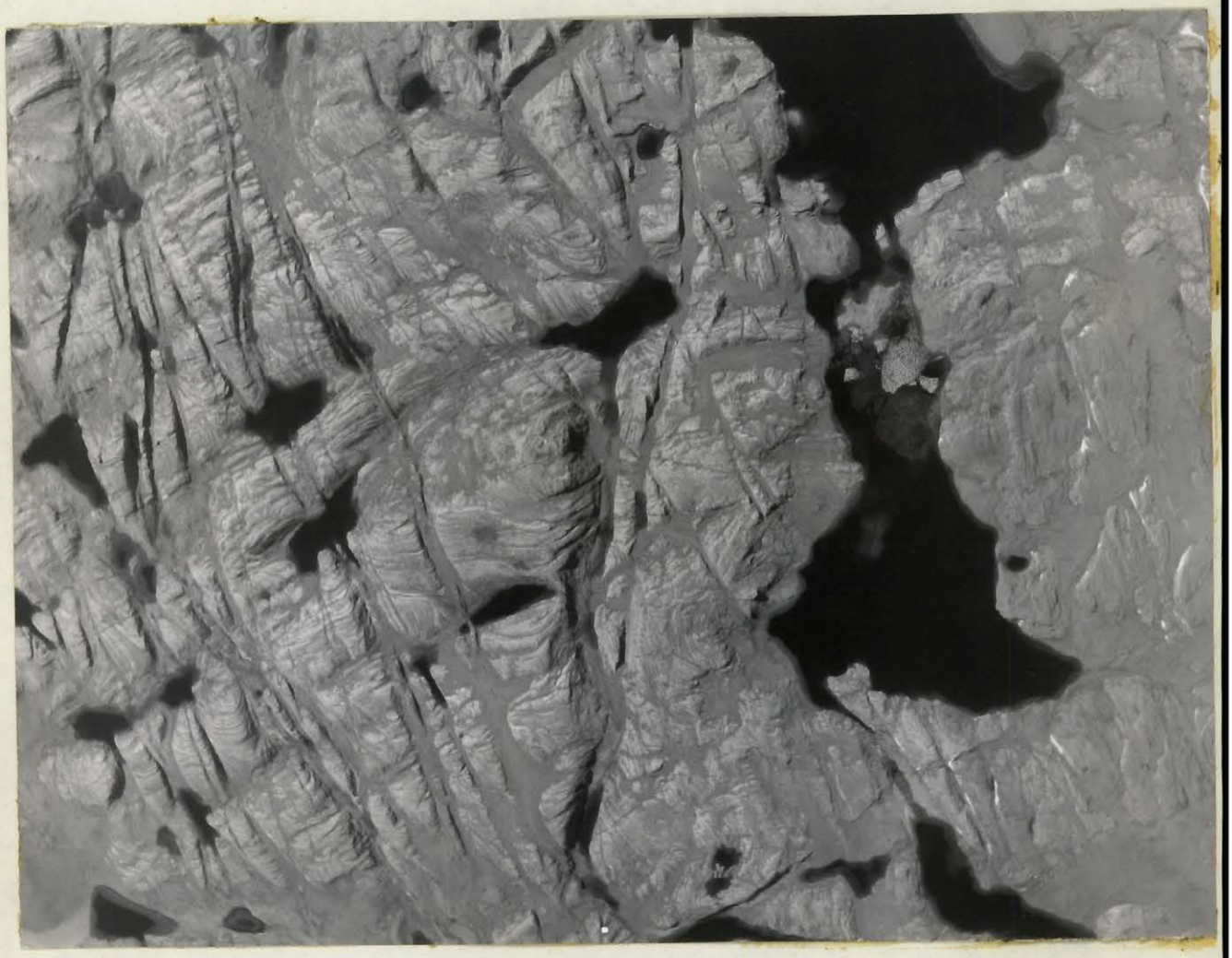
22. Upper surface of a basaltic flow which shows signs of glaciation. Notice especially the smoothness, the lack of marked local relief and the absence of soil and vegetation. (Pp. 94 and 95)

23. AERIAL VIEW OF DRUMLINISED REGION. (P.97)

R.C.A.F. photo: T3081-89.

24. View from scarp top across drumlinoid features. (Angular feature under scarp at right background is an esker delta feature). (P.97)

25. View across drumlin lying among razor-back ridges of Epworth Sandstone. (P. 34, l. 14 and P.97.)



26. AERIAL VIEW OF EPWORTH SERIES DOLOMITE LIMESTONE.

This view shows typically obvious bedding and light tone which is analytic of the dolomite in the area. Shows also the erosions along fault lines, and alluviation of the valley floors. (P. 100)

Photo. R.C.A.F. T484C-60

27. View from sea in Port Epworth. The hill in background presents typical aspect of the Epworth Dolomite. (P.100, l. 15)

28. View looking south along typically eroded fault line in the granitic rock area. (P.102)

29. Glacially smoothed upper surface of granitic complex at 1,000 feet. (P.104)

30. Granitic shore-line. The mammillated rocks in background are almost certainly glacially smoothed initially but may be sea-worn since. Striations on their surface are consistent with the general direction of glaciation. (P.22 and Pp. 102, 104)

31. AERIAL OBLIQUE OF ROCK-KNOB REGION. (Pp. 102, 104)

R.C.A.F. photo: T311L-223.

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