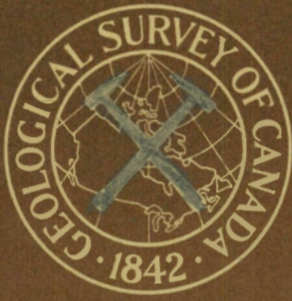


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PAPER 60-18

SURFICIAL GEOLOGY OF
NORTH-CENTRAL DISTRICT OF MACKENZIE,
NORTHWEST TERRITORIES

B. G. Craig



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By

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SURFICIAL GEOLOGY OF NORTH-CENTRAL
DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

INTRODUCTION

The map-area is bounded on the east by the 112th meridian, on the west by the 124th meridian, on the north by the Arctic coast, and on the south by the 65th parallel except for a small area lying southwest, south, and southeast of Great Bear Lake.

This account of the surficial geology is based on air-photograph compilation and field data gathered during the 1959 field season on the helicopter-supported 'Operation Coppermine'. Traverses throughout the area by the writer and other members of the party provided several hundred ground observations. These were used to check the air-photograph study and to provide additional information about the surficial deposits. The bedrock geology of the area is described by Fraser (1960)¹.

The area was glaciated by Wisconsin Laurentide ice and exhibits a profusion of glacial landforms. Everywhere there are erratic boulders indicating the former presence of glacial ice. West and north of a line between Dease Arm and Coronation Gulf the terrain is characterized by large and numerous end-moraine ridges and vast areas of hummocky moraine. The morainal ridges are composed mostly of bouldery clay till. Some are quite sandy and composite in nature and are more properly classified as kame moraines. Although they vary greatly, maximum heights of 180, 140, and 150 feet were measured for the ridges south of Horton Lake, south of Darnley Bay, and east of the south end of Bluenose Lake, respectively. The hummocky moraine consists of rounded unoriented knobs of clay till with a relief of up to 50 feet. Some dead-ice plateaux were noted within the area of hummocky moraine. The kame hills with the hummocky moraine have a relief of up to 200 feet. All of those examined were composed of gravel and sandy gravel. They are conspicuous features of the landscape, being conical in shape and rising high above the hummocky moraine around them. South and southeast of

¹ Dates or names and dates in parentheses refer to publications listed in the References.

this ice-marginal zone these ice-front features are not found. There the area is characterized by more eskers, which show a regular dendritic pattern, and by a less-complicated pattern of ice-flow features. The significance of these two zones — a peripheral zone of marginal fluctuation and a central zone of regular ice-retreat — has been outlined by Craig and Fyles (1960).

PATTERN OF ICE-RETREAT

Ice-flow features show that the area was affected by two distinct lobes of the retreating ice-sheet (see Craig and Fyles, 1960). East of Darnley Bay, and south of Dolphin and Union Strait, the ice moved to the southwest, although the drift contains many granitic rocks that could only have been derived from the mainland to the east and southeast. In the Darnley Bay area the ice lobe that produced these features has been called the Amundsen Gulf lobe (Mackay, 1958, p. 35), but it is believed to be more extensive; it persisted as a separate lobe as it retreated to the Keewatin ice-divide (Craig and Fyles, 1960). South of Darnley Bay, Mackay (1953, 1958) has described a series of side-hill channels and attributes their formation to the blocking of normal seaward drainage by glacial ice in the bay. The two end-moraines south of Darnley Bay, also described by Mackay, were formed apparently by these two ice lobes, approximately at right angles to the direction of their flow. Undeformed drumlins between the northwestward-trending end moraine and the Hornaday River suggests that a tongue of the southern lobe continued to move along the valley for a few miles after the northern lobe had retreated seaward, and hence the two end-moraines were not formed simultaneously. West of Coronation Gulf a series of end moraines were built, apparently by ice coming off Victoria Island; in places these appear to have been overridden by the northwestward-moving ice. The age relations of intersecting striae just north of the end moraines lend further support to this contention. North of the west end of Coronation Gulf the two lobes merged and flowed northwestward.

Early in the retreat, the southern lobe became separated into two actively flowing sublobes that moved along the low ground on either side of Melville Hills and the high land northwest of Bluenose Lake; one along the Hornaday River valley and the other along the Inman and Hoppner Rivers and the sea-coast. When the front had retreated to about latitude 68° , the active ice was directed along the valley of the Richardson River and deflected to the southwest by the high land south of Bluenose Lake. Ice that had been directed along the low re-entrant northwest from Dease Arm, Great Bear Lake, stagnated in the western part of the map-area forming great masses of hummocky moraine and numerous large kames. Active ice in Smith Arm, Great Bear Lake,

prevented for a time, the escape of meltwater to the south, and channels were carved that carried the meltwater northward over the divide between Great Bear Lake and the sea. Many of these are now abandoned or occupied by misfit streams. As the ice-front retreated farther downslope north of Smith Arm, a series of side-hill channels were cut. At first drainage was over the divide to the north but later to the west as the western part of the glacial lake in the basin of Great Bear Lake began to form. Further eastward-opening of this lake caused the ice north of Dease Arm to be drawn down to the southwest toward the open water. With further ice-retreat and opening of that part of the glacial lake in McTavish Arm, northwestward-moving ice in the Coppermine River valley was drawn down similarly to the west and southwest. The ice-margin along Coronation Gulf appears to have been static for some time while these fluctuations were taking place in the region to the southwest, probably due to the early entry of the sea between the two major ice lobes as a re-entrant along Dolphin and Union Strait and along the gulf. Eventually the ice-margin extended fairly regularly from the west end of Coronation Gulf to the east side of Great Bear Lake, and from there the pattern of glacial features indicates a regular and orderly retreat to the east and southeast.

PROGLACIAL LAKES

Abandoned shorelines indicate the extent of former glacial lakes in the area. Most of these lakes were small and resulted from the blocking of natural drainage lines by the retreating ice-front. Along the southern part of the east shore of Takiyuak Lake, beaches are found at an elevation of 1,395 feet¹ above sea-level or about 100 feet above the level of the present lake. Thirty miles northwest of Bluenose Lake, a small lake, held up by an end-moraine ridge, left shorelines about 25 feet above the present lake or about 1,985 feet above sea-level. Until the end moraine was breached, this lake drained to the north through a channel connecting it to the Roscoe River.

The largest glacial lake in the area was located in the Great Bear Lake basin. Abandoned storm ridges are found east of about 122° longitude, along the north shore. These clearly indicate the former upper limit of the lake. At the east end of Dease Arm and Hornby Bay, and along the steep and rugged east shore north of Port Radium, strand lines are rare and discontinuous. The highest shoreline,

¹ Elevations are based on measurements by aneroid barometer.

found at lat. $66^{\circ}41'$, long. $117^{\circ}47'$, north of the east end of Hornby Bay, records a water level 980 feet above sea-level or 470 feet above the present lake. Elevations of the highest strand lines decrease to the west. On the north side of the Dease River at lat. $66^{\circ}57'$, long. $118^{\circ}52'$, beaches are found up to 790 feet above sea-level encircling a hill that was not completely inundated. The most-westerly measured strand line was found at lat. $66^{\circ}51'$, long. $121^{\circ}29'$, near the Big Spruce River, where the highest beach on the hillside is found at 675 feet above sea-level. Beaches are found as far west as long. 122° , and although their elevations were not measured they are probably about 600 feet above sea-level.

Initially the lake appears to have drained westward through a channel at the west end of Smith Arm. When the eastern part of the basin became ice-free, the lake was connected southward from McTavish Arm to the glacial lake in the basin of Great Slave Lake and drainage was southward along the valley of Slave River. Normal westerly drainage of the lake during its early stage appears to have been prevented by differential isostatic depression of the basin, which was at a maximum on the east side of the basin. As isostatic readjustment took place, the southward connection to Great Slave Lake was drained and the present Great Bear River outlet to the Mackenzie River came into use.

POST-GLACIAL MARINE SUBMERGENCE

Along much of the sea-coast a remarkable series of abandoned strand lines and vast areas of marine silt and clay record higher levels of the sea. The extent of this submergence can be precisely located in some places along steep cliffs or where there is a distinct change in the drift due to modification by marine action. Elsewhere, the extent can be only approximately located by the distribution of sediments shown to be marine by fossils or by similarity to known marine sediments, and by extrapolation on the basis of the elevation of the ground surface. As in other areas, neither strand lines nor fossils are found up to the limit of submergence. Raised strand lines are generally former storm beaches, mostly shingly or bouldery, and barren of organic remains. Pelecypod shells are very abundant in the bottom clay at some localities but only below the maximum limit. Foraminiferal tests are less common and not as widespread in occurrence as pelecypod shells. The distribution of fossils¹ is shown in Table I.

¹ Fossil identification by F. J. E. Wagner, Geological Survey of Canada.

Table I

Distribution of Pleistocene Fossils

Locality Number (see map)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
<i>Pelecypoda</i>	*		*										*										
<i>Macoma balthica</i> (Linné)	x			x						x				x		x							
<i>Macoma calcarea</i> (Gmelin)										x				x		x				x	x	x	
<i>Hiatella arctica</i> (Linné)	x			x			x	x	x	x		x		x						x	x	x	
<i>Mya truncata</i> Linné											x			x		x				x	x	x	x
<i>Mya pseudoarenaria</i> Schlesch										x													
<i>Mytilus edulis</i> Linné															x							x	
<i>Yoldia arctica</i> (Gray)						x																	
<i>Foraminifera</i>	**		**		**	**						**	**	**	**	**	**	**	**	**	**	**	**
<i>Laryngosigma williamsoni</i> (Terquem)										x													
<i>Elphidium clavatum</i> Cushman		x						x	x	x					x								
<i>Elphidium subarcticum</i> Cushman										x													
<i>Elphidium orbiculare</i> (Brady)		x		x			x	x															
<i>Globulina glacialis</i> Cushman & Ozawa																							
<i>Collina melo</i> d'Orbigny								x															
<i>Cassidulina islandica</i> Nørvang								x															

*Shell fragments at locality, no collection made.

**No sample collected.

The limit of marine submergence decreases in elevation from east to west. At the east side of the area the limit is now about 700 feet above sea-level. This decreases to about 480 feet above sea-level just east of the Coppermine River, to 300 feet above sea-level at long. 118°, and to 150 feet at long. 120°. West of the latter meridian no obvious features resulting from marine action were observed

RADIOCARBON AGE-DETERMINATIONS

Radiocarbon ages were determined for samples of marine shells from four localities¹ (see Table II). None of these shells were

Table II

List of Radiocarbon Dates

Locality No. (see map)	Dating No.	Elevation of Sample (feet above sea-level)	Radiocarbon Age (years)
2	I(GSC)-25	245	10,530 \pm 260
20	I(GSC)-22	430	8,275 \pm 220
21	I(GSC)-16	495	9,100 \pm 180
22	I(GSC)-17	280	10,215 \pm 220

collected from strand-line deposits and they cannot be used to determine the precise height of the sea at the time they were deposited. Localities 20 and 21 (see map), however, are very near the upper limit, and at locality 20, shells were collected from an esker delta that must have formed very near the ice-front. The shells found at the two lower elevations were exposed by erosion of the bottom clay in which they were deposited, and no estimate can be made of the position of sea-level at the time of deposition. They do indicate, however, that the sea-coast was free of ice 10,000 years ago. Shells from the two higher localities, which are also younger, suggest that the ice-front remained static for some time. This contention is supported by other lines of evidence already mentioned. The pattern of ice-retreat outlined earlier suggests

¹ A radiocarbon age of 8,290 \pm 330 years was obtained (Dating No. I (GSC)-13) for shells collected by O'Neill (1924, p. 33A, Sta. No. 5289) at the south end of Port Epworth at an elevation of 320 feet above sea-level.

that an arm of the sea extended from the west along Dolphin and Union Strait and Coronation Gulf early in the deglaciation of the area, and that this marine re-entrant persisted while much of the marginal fluctuation was taking place in the western part of the map-area. Only in this region of the Arctic coast (Craig and Fyles, 1960) are thick deposits of marine clay and silt found. These bottom deposits are pebbly, probably the result of coarse material that was dropped from melting icebergs. The age and elevation of the youngest, though not the highest, sample suggests that, as well as the ice-front remaining relatively stationary, isostatic readjustment had begun at least as soon as the coast was ice-free. It has been suggested (Craig and Fyles, 1960) that the Wisconsin Laurentide ice-sheet had disappeared by 7,000 years ago, at least in the southern part of the Keewatin ice-divide. The time interval—1,000 years for ice-retreat from just south of Coronation Gulf to final wasting along the divide—seems small and may indicate some discrepancy in the shell dates. However, the age and spatial relationships of the shells from the four localities does indicate a sequence of events that agrees with the general pattern of deglaciation.

PINGOS

In the northern and western parts of the area several pingos were noted. Only those that were seen in the field are shown on the map, and of these, only four were examined on the ground. So far as could be determined, all the pingos seem to be the closed system or Mackenzie type described by Müller (1959).

The pingo 6 miles east of Horton Lake is at the edge of a small pond in the braided outwash of a former meltwater channel leading into Horton Lake. It is 72 feet high and 250 feet in diameter. The crater in the centre is about 50 feet in diameter and reveals a 5-foot section of the materials comprising the pingo; the surface layer is coarse sandy gravel underlain by finer sand and silt—the alluvial outwash material—and this in turn is underlain by poorly indurated clay shale. Spores and pollen¹ from the shale show that it is Lower Cretaceous in age. Clear ice was found in two places in the floor of the crater.

Between Horton and Hornaday Rivers at lat. 68°29', a pingo occurs in a swampy flood plain of a small stream. It is about 50 feet high and 250 feet in diameter. The crater exposes a few feet of

¹ Palaeobotanical study by D. C. McGregor, Geological Survey of Canada.

peaty clay.

The pingo at lat. $68^{\circ}23'$, long. $117^{\circ}28'$ occurs in the centre of a small lake. It is about 20 feet high and 100 feet in diameter. The crater reveals a thin layer of peaty clay underlain by bouldery clay till.

The pingo near the Harding River at lat. $68^{\circ}28'$ is found in a swampy area beside a small lake. It is 70 feet high and 200 feet in diameter. The outer surface is dolomite of Lower Palaeozoic, possibly Devonian age (Fraser, 1960). In the crater, about 10 feet of the rock has been exposed.

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