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SURFICIAL GEOLOGY OF BOOTHIA PENINSULA AND SOMERSET, KING WILLIAM, AND PRINCE OF WALES ISLANDS, DISTRICT OF FRANKLIN

(Report, Map 46-1963, Appendix)

B. G. Craig

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By

B.G. Craig

D E P A R T M E N T O F

M I N E S A N D T E C H N I C A L S U R V E Y S

C A N A D A

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SURFICIAL GEOLOGY OF BOOTHIA PENINSULA, AND SOMERSET, KING WILLIAM, AND PRINCE OF WALES ISLANDS, DISTRICT OF FRANKLIN

INTRODUCTION

The data presented here were collected during the 1962 field season on Operation Prince of Wales. The account is based on field observations and airphoto interpretation by the author, supplemented by data collected by other members of the party, whose primary purpose was a study of the bedrock geology. The field party consisted of R.G. Blackadar, R.L. Christie, F.C. Taylor, W. Nassichuk, and the author. A Piper Super Cub aircraft equipped with large low-pressure tires and a Bell 47 G2A helicopter were used for traversing.

Some observations on the surficial geology of the area have been made by earlier workers. Fortier (1948)[1], made ground observations at scattered localities on Prince of Wales Island, King William Island, and Boothia Peninsula, and numerous air observations on flights over most of the map-area. Fraser (1958) has described the physiography of the region around Boothia Isthmus and drawn some conclusions as to the glacial and post-glacial history. Bird (1959; in Olson and Broecker, 1961) made some observations on marine submergence on Somerset Island and collected marine shells for which age determinations have been made from two localities, on Prince of Wales Island near Transition Bay and on Somerset Island near Four Rivers Bay. Fraser and Henoch (1959) have discussed the glaciation of King William Island. Observations made (on northern Prince of Wales and Somerset Islands) during the course of 'Operation Franklin' have been recorded on Map 19-1959 of the Geological Survey of Canada. The surficial geology of the area immediately to the south has been described by the writer (1961) and that of Victoria Island, across M'Clintock Channel to the west is described by Fyles (in press).

PHYSICAL SETTING

Bedrock in the map-area is of Precambrian and lower Palaeozoic age[2]. The older rocks comprise the Boothia Arch, which occupies the central two thirds of Boothia Peninsula, narrow strips

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

[2] The bedrock geology of the map-area has been described by Blackadar and Christie (1963).

along most of the west side of Somerset Island, and the east side of Prince of Wales Island. Drift is thin or absent over most of the area underlain by Precambrian rocks, except in the southern part of Boothia Peninsula where there are large areas with no bedrock exposed. Maximum elevations along the Boothia Arch increase from a few hundred feet in the southern part to 1,500 feet or more in the central part of Boothia Peninsula and northward to Aston Bay on Somerset Island. Slightly lower elevations are found along that part of the arch on Prince of Wales Island.

Lower Palaeozoic rocks flank the Boothia Arch and underlie all of King William Island. They are mostly flat-lying to gently dipping except locally near the arch, and are composed mostly of limestone and dolomite with lesser amounts of sandstone and minor shale. Good exposures are found only along scarps and in river valleys. Maximum elevations of most of the area on Boothia Peninsula underlain by Palaeozoic rocks are generally less than 500 feet. The highest point on King William Island is probably 250 to 300 feet above sea-level. South of Creswell Bay on the east side of Somerset Island the area underlain by Palaeozoic rocks is also less than 500 feet in elevation. However, north of Creswell Bay the Palaeozoic terrain is a high plateau with elevations ranging between 1,000 and 1,600 feet, except for a re-entrant along the valleys of the Creswell River system. Most of Prince of Wales Island west of the Boothia Arch lies below 250 feet in elevation except for that part between Inner Browne Bay and Transition Bay where plateau remnants rise to slightly above 500 feet, and north of a line between Browne Bay and Cape Smith Bay where similar remnants rise to almost 800 feet.

The map-area can be divided roughly into four main, easily-defined physiographic units: the Precambrian upland, the Palaeozoic plateaux, the Palaeozoic lowlands, and the glacial lowlands. The Precambrian upland comprises most of the Boothia Arch except in the southern part, roughly south of a line between the east end of Boothia Isthmus and Pasley Bay. The upland surface has little or no drift, and bedrock structures can be traced for many miles. The Palaeozoic plateaux comprise most of the northern parts of Somerset and Prince of Wales Islands. They are mostly flat, relatively featureless barren areas, with a thin drift cover. Steep-sided river valleys and low scarps provide good exposures of the bedrock. The Palaeozoic lowlands lie on either side of the Boothia Arch on Boothia Peninsula and the east side of Somerset Island south of Creswell Bay. They are at sufficiently low elevations to have been submerged almost everywhere by the post-glacial marine inundation, and exhibit remarkable flights of abandoned beaches composed almost entirely of flaggy limestone fragments. The glacial lowlands include that part of the map-area where the physiography is due almost entirely to glacial landforms, and comprise parts of southern Boothia Peninsula, the whole of King William Island, and

about the southern three fifths of Prince of Wales Island. In the areas underlain by Palaeozoic rocks, the drift cover is almost continuous, but over the southern part of the Boothia Arch it is patchy and does not effectively conceal the underlying bedrock, except locally.

GLACIAL DEPOSITS AND LANDFORMS

Eskers are not numerous even in the glacial lowlands, except on King William Island, the west side of Prince of Wales Island, and the southern and southwestern parts of Boothia Peninsula. They are mostly simple, easily distinguishable, sharp-crested ridges, and are generally subparallel to the direction of ice-movement, except on Prince of Wales Island where the overall pattern of ice-flow features is more complicated. There, many of the eskers resemble morainal ridges, both in their orientation and their form.

Kames are a striking feature of the topography of south-central Boothia Peninsula (especially west and southwest of Sanagak Lake) and of western Prince of Wales Island. Those on the Peninsula occur as broad areas, up to several miles in diameter, of randomly oriented sharp-crested hills and ridges and as isolated conical hills. They rise as much as 400 feet above the land around them, but are generally from a few tens of feet to 200 feet high. On Prince of Wales Island, kames are found mostly along the west side in the region around Ommanney Bay. They occur within broad zones that appear to be ice-frontal, and are found also as isolated groups of hills and ridges and as individual hills.

Drumlins are found mostly in the glacial lowlands. They occur in vast drumlin fields on King William Island, south-central Prince of Wales Island, and in the area around Boothia Isthmus, but also in small patches here and there throughout the map-area. Within the larger drumlin fields many of the drumlins are ovoid in plan and suggest the absolute direction of ice-movement, but within the smaller fields and patches, where the drumlins themselves are generally smaller, they are symmetrical.

Three types of features that were formed at or close to and parallel to the ice-margin are found within the map-area. These include end moraines, minor moraines, and morainal complexes. End moraines, as shown on Map 46-1963, differ from minor moraines in that (1) they occur as individual ridges; whereas the minor moraines occur in groups or fields, and (2) they generally have greater dimensions. Measurements made on some of these features indicate that the end moraines are from 50 to 70 feet high, whereas the minor moraines are from 5 to 20 feet high. All the end moraines are longer than the minor moraine ridges. On the western side of Prince of Wales

Island, certain linear features have characteristics of both end moraines and eskers. Those shown on the accompanying map as end moraines are less sinuous than those shown as eskers, and show less the effects of marine action, presumably because they are composed of till and hence are less susceptible to marine erosion than the sandy eskers. A morainal complex is found on the west side of Prince of Wales Island crossing the two peninsulas that enclose Ommanney Bay. It is essentially a linear zone of thicker drift than is found elsewhere, but includes within it series of kame hills and, in the southern part, an end-moraine ridge that aligns with and extends beyond it. It closely resembles similar features described by Fyles (in press) on Victoria Island. This zone, and especially the kames within it, is the most prominent topographic feature in this flat area, and parts of it have been formally named, e.g. Rawlinson Hills and Mount Clarendon.

EXTENT OF GLACIATION

The area was probably completely glaciated by Laurentide ice. In an earlier report Craig and Fyles (1960, p. 2 and Fig. 1) stated: "... on Somerset and Prince of Wales Islands, little evidence is available regarding the extent of Laurentide ice, of regional ice from a more northerly source, and of local ice-caps. The Laurentide boundary is tentatively placed between southern lowlands with fresh glacial landforms and northern highlands that are reported to bear only indefinite evidence of glaciation." As a result of the current investigations, it appears that the Palaeozoic plateaux (the "northern highlands" of the above quotation) were overridden by the Laurentide (continental) ice-sheet at the same time as the region to the south. Most of the Palaeozoic plateaux are mantled with a thin layer of silty, rubbly, glacial till. Nearly all the larger fragments are composed of carbonate rock, the dominant rock type in the area. However, boulders of various sizes composed of Precambrian rock types are found everywhere, and were probably carried to their present sites by the continental ice-sheet. Although most of the upland surface is monotonously featureless, there are small areas here and there exhibiting the typical topography of ground moraine, and in places isolated kame hills are found. Abandoned stream channels along and subparallel to larger valleys and crossing ridge tops are common, especially on Somerset Island, and could only have been formed if the streams responsible for them were confined originally along one or both sides by glacial ice.

PATTERN OF ICE-RETREAT

The pattern of ice-flow features gives some indication as to the mode of retreat of the waning ice-sheet, even though the distribution of these features throughout much of the map-area is meagre and, especially on the northern parts of Somerset and Prince of Wales Islands, many of the small drumlin fields do not provide decisive evidence of the absolute direction of glacial movement.

In the northern part of the area the pattern is complex and appears to portray an overall shrinking back of the ice-margin toward the south, across the area of which these islands are a part, complicated by late-phase local movements controlled by the deep channels between the islands. The most widespread indication of flow direction on Prince of Wales Island is a vast drumlin field trending northerly and northwesterly between Guillemard Bay and Ommanney Bay. These features appear to be the oldest and to have formed when the ice covered the whole northern part of the map-area as a continental ice-mass. Later ice-movements are indicated in the region around Fisher Lake where north-trending drumlins show evidence of over-riding by eastward-flowing ice. Other outward movements are indicated by minor moraines in Browne Bay and by local drumlin fields with anomalous orientations. Most of the upland area of Somerset Island shows little evidence of ice-movement except between Aston Bay and the basin of the Creswell River system where a few drumlins suggest frontal retreat, probably from north to south. Easterly-oriented striae along the west side of the island probably resulted from lateral movement adjacent to a late tongue of ice in Peel Sound.

In the southern part of the map-area the major controls on the direction of ice flow were provided by topographic depressions, northwestward into M'Clintock Channel and northeastward through Boothia Isthmus into the Gulf of Boothia, either by accelerated wastage into arms of the sea that occupied these depressions or by accelerated glacial flow in them. The pattern of ice-flow features produced at this time is continuous into the area to the south (see Craig, 1961).

CHRONOLOGY AND POST-GLACIAL HISTORY

As the area became ice-free, marine water invaded much of the present land area. In general, this invasion inundated most of the Palaeozoic lowlands, much of the glacial lowlands, and the southern part of the Precambrian upland. Criteria for determining the inland extent and the elevation of the upper limit at various places within the map-area are contradictory and unreliable. The map-area lies near the outer margin of the area covered by the Wisconsin Laurentide

ice-sheet, and in general the elevation of the marine limit increases toward the south, the direction of ice-retreat. In the southern part of the map-area and in the area immediately to the south (see Craig, 1961), marine shells, and sediments presumed to be of marine origin have been found at all elevations up to 650 feet above sea-level; the maximum upper limit is probably a few feet to tens of feet higher than this. On the southwest side of Boothia Peninsula, between Pasley Bay and Josephine Bay and up to 10 to 12 miles inland from the present coast, a well-defined line shows clearly on air photographs and appears on the ground as a low scarp 3 to 4 feet high. This undoubtedly marks a stand of the sea but is only about 400 feet above sea-level; other criteria indicate that at its maximum stand, sea-level was higher in this area. On Somerset Island south of Creswell Bay, a similar line of demarcation in the drift exists on the east side of the Boothia Arch. It is at an elevation of about 520 feet above sea-level. As no evidence of post-glacial marine activity was found at higher elevations in this vicinity it is assumed that this line marks the upper limit of marine submergence there. The scarp-bound coasts of much of the northern parts of Somerset and Prince of Wales Islands provide little evidence for determination of the marine limit. Fortier[1] found raised beaches and marine shells up to 415 feet above sea-level on the north coast of Prince of Wales Island, an elevation that is probably close to that of the marine limit.

Marine shells were collected at many localities and at various elevations within the map-area (see Table I, in pocket; and Appendix). Radiocarbon ages determined for shells from four localities are listed in Table II.

Table II

List of Radiocarbon Dates

Locality No. (see Map 46-1963)	Dating No.	Elevation of Sample (feet above sea-level)	Radiocarbon Age (years)
2	GSC-123	744	$31,860^{+2,560}_{-1,940}$
4	GSC-135	639	>23,300
24	GSC-136	418	9,180 ± 170
47	GSC-150	204	9,180 ± 170

[1] Note in Arctic, vol. 1, No. 1, 1948, pp. 67-68.

Radiocarbon ages have also been determined for samples collected by Bird (Olson and Broecker, 1961, pp. 150-151) on Prince of Wales Island near Transition Bay (sample No. L-571 B) and from Somerset Island near Four Rivers Bay (sample No. L-571 A); the former is from an elevation of 370 feet and has a radiocarbon age of 9,200 ± 160 years, and the latter is from an elevation of 100 feet and has a radiocarbon age of 7,150 ± 350 years.

The samples from localities 2 and 4 predate the last glaciation. They occur at elevations 200 to 300 feet higher than other collections nearby and some 100 to 200 feet above the assumed marine limit. At locality 2, fragments of Hiatella occur in material that is probably till, at the foot of an end-moraine ridge; it seems probable that they were moved to their present site during the last glaciation. At locality 4 the shells also occur as fragments but represent four species, three of which do not occur at any other localities in post-glacial material, except at much lower elevations (see Table I). It may be assumed that the shells at locality 1, for which no age determination has been made, also predate the last glaciation.

The samples from localities 24 and 47 were dated in an attempt to determine the time of deglaciation of the areas where they were found, as they represent the highest (above sea-level) collections in their vicinity. However, they are only a few hundred years older than collections made some 350 miles to the south (Craig, 1961, Map 7-1961, localities 3 and 11; Dyck and Fyles, 1962, p. 24, sample Nos. GSC 44 and 47). In view of the pattern of ice-retreat, Somerset Island should have been deglaciated earlier than the area to the south, and hence the shells at localities 24 and 47 must have been deposited some considerable time after these localities became ice-free.

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Appendix

PALAEONTOLOGICAL REMARKS ON SHELLS COLLECTED ON 'OPERATION PRINCE OF WALES'

by

F.J.E. Wagner

Studies of marine molluscan assemblages in East Greenland waters (Ockelmann, 1958) led to recognition of several faunal communities. These communities have since been noted in eastern Canadian Arctic waters, and one of them, the Macoma community, has also been found along the southern fringe of the Queen Elizabeth Islands, in Dolphin and Union Strait, and as far west as Point Barrow, Alaska (Ellis, 1960). The writer (Wagner, 1961) found it possible to assign fossil assemblages from northern District of Keewatin to certain of these communities.

The Macoma community, characterized by Macoma calcarea, occurs in shallow water to depths of about 50 metres on sandy to muddy bottoms. A zone with Astarte borealis and A. montagui (and varieties) as the characteristic species is recognizable within the Macoma community between depths of 5 and 20 metres. Where there is freshening of the waters, e.g. off glacier fronts and river mouths, the Macoma community is replaced by the Yoldia arctica community. The Gomphina fluctuosa community is the coarse-bottom depth equivalent of the Macoma community. The Astarte crenata and Foraminifera communities are found at depths greater than 50 metres.

Assemblages from the following localities are probably referable to the Macoma community (0-50 metres depth). Those indicative of the Astarte zone of the Macoma community are listed separately.

Macoma community: Localities 30, 40, 46, 49, 58, 59a, 59b, 62b, 64c, and 70.

Astarte zone of the Macoma community: Localities 37a, 37b, 54, 56, 62a, 65a, 65b, 67a, 67b, 68, 69, 71, 74a, 75, 76, 78a, 80a, 80b, 80c, 81, 82, and 83.

One assemblage, that from locality 4, may be assigned to the Yoldia arctica community. Assemblages from Localities 53, 62c, 73, 78b, 78c, and 79 show affinities with both the Yoldia arctica and Macoma communities.

A large number of assemblages are characterized by Hiatella and/or Mya, with few, if any, other species. These two species are common from low water to a depth of about 90 metres, and are tolerant of more varied bottom conditions (mud - sand - gravel - larger stones). Assemblages from the following localities fall within this category: Localities 5a, 5b, 5c, 5d, 7, 8, 9, 10a, 10b, 11a, 11b, 12, 13, 16, 17, 20, 21, 22a, 22b, 23, 24a, 24b, 24c, 25, 26, 27, 28, 29, 31, 33, 34, 35, 36, 38, 39, 43, 44, 45, 47a, 47b, 47c, 48, 50, 51, 55, 60, 61, 63, 64a, 64b, 64d, 66, 72, 74b, and 77.

Samples from the following localities consist only of fragments, and their community affinities are not determinable: Localities 1, 2, 3, 6, 14, 15, 18, 19, 32, 41, 42, 52, and 57.

The Hiatella-Mya association was not mentioned by either Ockelmann or Ellis. Observations on the occurrence of these fossils in the field (Craig, 1963, personal communication) render it unlikely that this is an artificial association resulting from the weathering out of less-heavy-shelled forms.

Possibly some of the assemblages from higher elevations lived in somewhat deeper water, down to a depth of 90-100 metres. Below an elevation of about 200 feet above sea-level the faunas definitely indicate shallow water (0-20 metres, and possibly as much as 50 metres, deep). The situation in this map-area, then, apparently parallels that postulated for the northern District of Keewatin area (Wagner, 1961, p. 8), i.e. the faunas at higher elevation suggesting water depths somewhat greater than those indicated by the faunas from below 180-200 feet above sea-level.

All species found are presented in Table I (in pocket).

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