A

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 69-1
Part A

REPORT OF ACTIVITIES,

Part A: April to October, 1968

Price, $2.00

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CANADA

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ABSTRACT

This report, containing 153 short papers, many illustrated by page-size maps and figures, presents the preliminary results of field work undertaken by members of the Geological Survey of Canada in 1968.

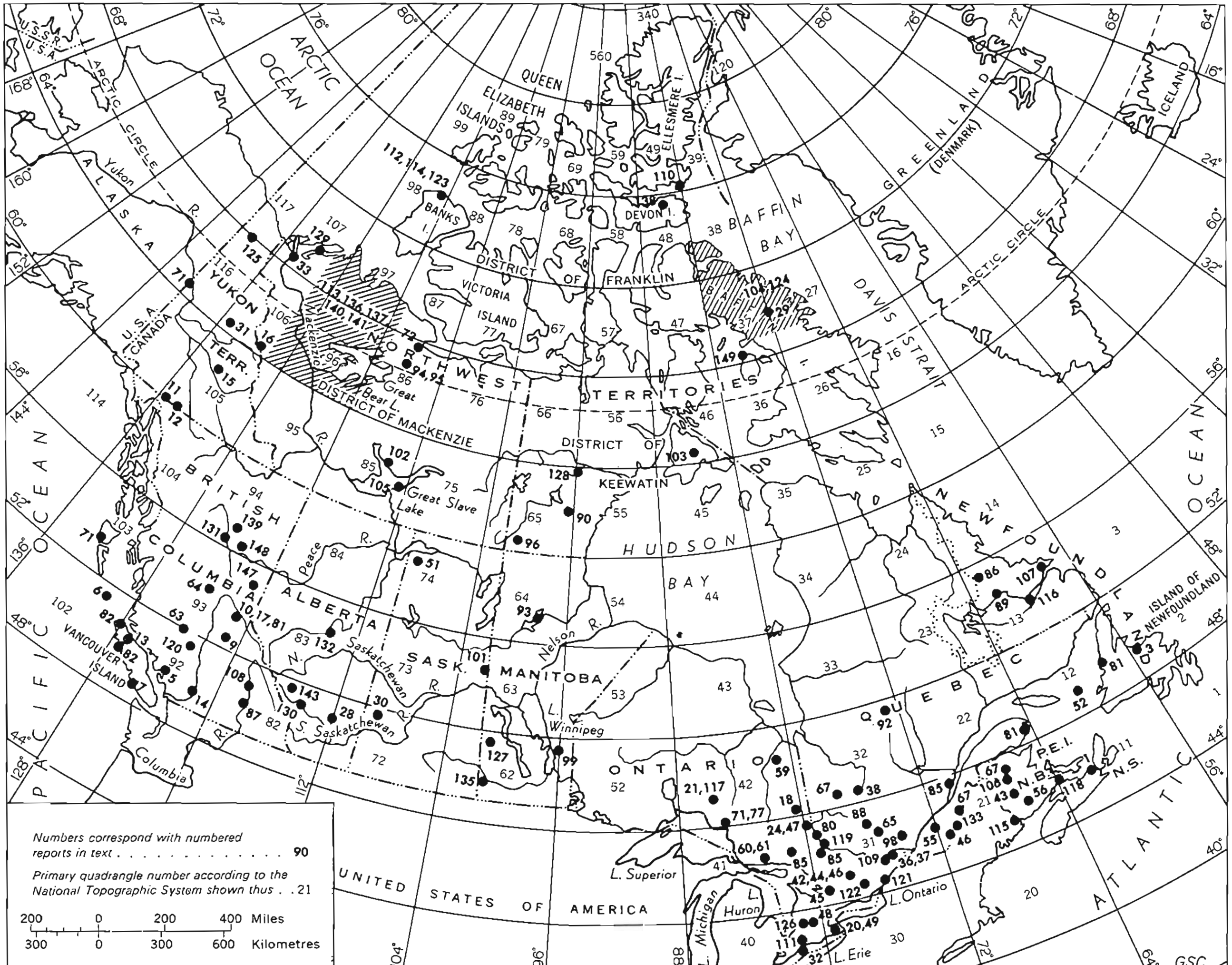

Figure 1. Distribution of most of the 1968 Geological Survey field parties

INTRODUCTION

The main objectives of the Geological Survey are to systematically investigate, describe and explain the geology of Canada, to carry on other research that contributes to knowledge of how the rocks of the earth and their enclosed mineral deposits formed, and to develop new instruments and methods as aids to geological investigations and to the search for mineral deposits. In support of these objectives about 100 full-season field parties of the Survey carried out studies in many parts of Canada last summer. The distribution of most of these parties is shown on the index map on the facing page. The systematic study of the geology of Canada is supported by research in many fields of geoscience including analytical chemistry, coal research, geochemistry, geomorphology, geophysics, mineralogy, paleontology, petrology, and sedimentology. As well as the main parties many shorter projects were carried out in 1968 – most were engaged in collecting support-data for other research.

This report is based on submissions made by Survey officers following their field work and in order to expedite publication it has been given a minimum of editorial attention and uses illustrative material as submitted by the authors. The report is designed to provide the earliest possible release of information that may be useful both to the mining and petroleum industries and to the general public. It comprises 153 papers arranged in broad categories that roughly correspond to the principal scientific sections of the Survey. An index to geographic locations (arranged by province, territory or district) and an author's index follow the text. For internal use the Geological Survey's project numbers are included in the title of each paper and are indexed serially following the text. Except in the case of regional studies the reports are keyed to the National Topographic System as revised in 1960. Material for this report was accepted until 31 October, 1968; all scientific results contained in this publication are subject to confirmation by office and laboratory studies. Requests for announcement cards, geological reports, maps, or information on specific areas or topics should be addressed to: Geological Survey of Canada, Department of Energy, Mines and Resources, 601 Booth Street, Ottawa 4, Canada.

This report (Paper 69-1, Part A) describes activities of the Survey carried out between April and October 1968. Paper 69-1, Part B will include brief reports on work done between November 1968 and March 1969. These reports, together with reports on isotopic and radiocarbon dating, the annual index of publications, and the volume of abstracts of papers published by Geological Survey personnel in non-Survey publications, provide an annual accounting of most of the scientific work of the organization.

APPALACHIAN GEOLOGY

1. GEOLOGICAL STUDY OF THE ANTIGONISH BASIN, NOVA SCOTIA (11 F/12, 11 F/13)

Project 660019

D. G. Benson

Field work was completed in the Antigonish (11 F/12) and Cape George (11 F/13) map-areas. Several outcrops beneath St. Georges Bay were examined by scuba diving.

The Antigonish Basin appears to comprise two basins or sub-basins, which were at least partly separated by a northeast-trending ridge of pre-Carboniferous Browns Mountain Group during early Carboniferous time. Lower Carboniferous Horton Group rocks to the north of the ridge consist essentially of red and grey conglomerate and coarse-grained wacke (outcrops at the mouth of McInnis Brook contain a Devonian spore assemblage) with minor arenite and on Cape George with associated dark green amygdaloidal basalt flows and dykes. To the south and east grey arenite and siltstone predominate. The conformably overlying Windsor Group and the Upper Carboniferous sediments appear to have been deposited in one basin.

Several faults along the shore of St. Georges Bay have been traced seaward. Lower Carboniferous Windsor limestone (tentatively identified as B 2) was discovered while scuba diving on outer Judique Bank, five miles west of Judique. The thickness of the Carboniferous sequence in St. Georges Bay is thus about 8,000 feet, rather than a previous estimate of more than 18,000 feet. However, massive reddish grey coarse-grained, quartz-feldspar arenite, similar to the Inverness Formation (Pictou Group) outcrops on Henry Island Bank, five miles west of Henry Island. Its presence there suggests the possibility of a thick Carboniferous section in Northumberland Strait at the mouth of St. Georges Bay.

Minor amounts of pyrite with traces of chalcopyrite were discovered in light grey coarse-grained quartz-feldspar wacke of the Horton Group along the railway on the west bank of Tracadie River.

Traces of sphalerite and galena were observed in narrow calcite veinlets in Windsor limestone on the east side of Cape Jack.

2. BLANC-SABLON, QUEBEC AND NEWFOUNDLAND-LABRADOR

Project 680130

L.M. Cumming

In preparation for mapping of Paleozoic strata on both sides of the Strait of Belle Isle at a later date, 10 days were spent examining typical exposures of lower Paleozoic formations in western Newfoundland. In association with B.V. Sanford, Cambrian and Ordovician type sections were sampled in the Port Saunders and Port au Port areas. During a 2 day visit to St. John's, valuable information regarding the planning of Operation Strait of Belle Isle was obtained from J.H. McKillop, Director, Newfoundland Mineral Resources Division and from R.D. Hughes, Department of Geology, Memorial University.

3. BOTWOOD MAP-AREA, NEWFOUNDLAND (2E)

Project 610039

H. Williams

Approximately two months were spent in the Botwood area remapping key areas and studying the results of recent detailed work conducted by graduate students of Columbia University.

Detailed stratigraphic investigation and discovery of new graptolite localities from the Exploits Group (Badger Bay Series)[1] at Badger Bay indicate that the rocks are not one continuous succession but that the Burtons Head and Julies Harbour groups are possibly equivalent in part to the Gull Island Formation and underlying beds. The extent of wildflysch rocks in the Dildo Run area was determined and similar rocks were outlined as far southwest as Stanhope in Exploits Bay. The wildflysch rocks locally contain suspended blocks up to several hundred feet across that lie in a matrix of scaly argillite. One such block on the southeast side of Dunnage Island is composed of volcanic breccia that contains a Middle Cambrian fossiliferous limestone lens (Marshall Kay, pers. comm. 1968).

Three days were spent with R.K. Stevens of University of Western Ontario studying the geology of the Hare Bay klippe in extreme northern Newfoundland. A highlight of this excursion was the discovery of Early Ordovician (Tremadocian) graptolites in black slate within a transported volcanic sequence that in places tectonically overlies the Middle Ordovician Table Head Formation.

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[1] Espenshade, G.H.: Geology and mineral deposits of the Pilleys Island area; Nfld. Dept. Nat. Resources, Bull. No. 6, 56p. (1937).

COAL RESEARCH

4. RADIOACTIVITY OF TERTIARY LIGNITES IN SASKATCHEWAN, ALBERTA AND BRITISH COLUMBIA

Project 680106

A. R. Cameron, P. A. Hacquebard, J. R. Donaldson
and T. F. Birmingham

Radioactivity measurements of Tertiary lignites were carried out with a scintillometer at about 200 stations in southwestern Saskatchewan, southeastern Alberta, and a large area of south and central British Columbia. All visible coal occurrences were checked including thin lenses, dirty coal, carbonaceous shales, etc. Readings above two or three times the background were considered significant for sampling and about 35 samples were collected. The most appropriate of these will be processed for chemical determination of the uranium content.

In Saskatchewan 73 stations were examined in the Cypress Hills district coal area. This was extended into Alberta to include the western and southern flanks of the Cypress Hills. With a background of 5 to 15 microroentgens per hour most readings ranged from 0 to 25 microroentgens above the background. However, in the vicinity of Eastend, Saskatchewan, two good readings were obtained (a) 380 μR/hr with background of 19 μR/hr and (b) 600 μR/hr and background of 31. The latter occurrence is 3/4 mile due west of a similarly good reading obtained last field season.

In British Columbia 125 stations of Tertiary coal areas were surveyed at White Lake, Princeton, Tulameen, Merritt-Quilchena, Spence's Bridge, Hat Creek, Kamloops, Chu Chua, Alexandria, Quesnel, and Bowron River. In most areas readings above or even approaching the two times background were rarely obtained, with the following exceptions; White Lake, a high of 16 μR/hr above a background of 14 μR/hr; Princeton, a high of 19 μR/hr above a background of 8 μR/hr; Chu Chua, a high of 33 μR/hr above a background of 7 μR/hr; and in the Bowron River sector, a high of 40 μR/hr above a background of 4 μR/hr.

Along with the uraniferous lignite survey, column samples were collected in the following areas for coal petrographic studies: Eastend, Saskatchewan (3), Luscar, Alberta (1), and in British Columbia, at Michel (3), Hat Creek (1), and Bowron River (1). From the Blakeburn strip mine at Coalmont 21 samples were taken for the coal reflectance studies.

CONTINENTAL MARGINS

5. MARINE GEOLOGY OF UPPER JERVIS INLET, BRITISH COLUMBIA

Project 680138

R. D. Macdonald and J. W. Murray

Department of Geology, University of British Columbia

The marine geological investigation of Upper Jervis Inlet, which commenced in 1966 was continued through the summer of 1968. The results of this study will be compared with those of an earlier study on Howe Sound. Jervis Inlet was chosen because it is a medium runoff inlet receiving an annual average runoff of 180 m^3/sec. versus Howe Sound, a high runoff inlet which receives an annual average runoff of 460 m^3/sec.[1]. Systematic sampling of the northern portion of the inlet (Queens Reach and Princess Royal Reach) revealed a localized deposit of ferromanganese oxide concretions or nodules. This locality corresponds to station 19-67, Figure 1.

Field data were collected during three oceanographic cruises as shown in Table 1.

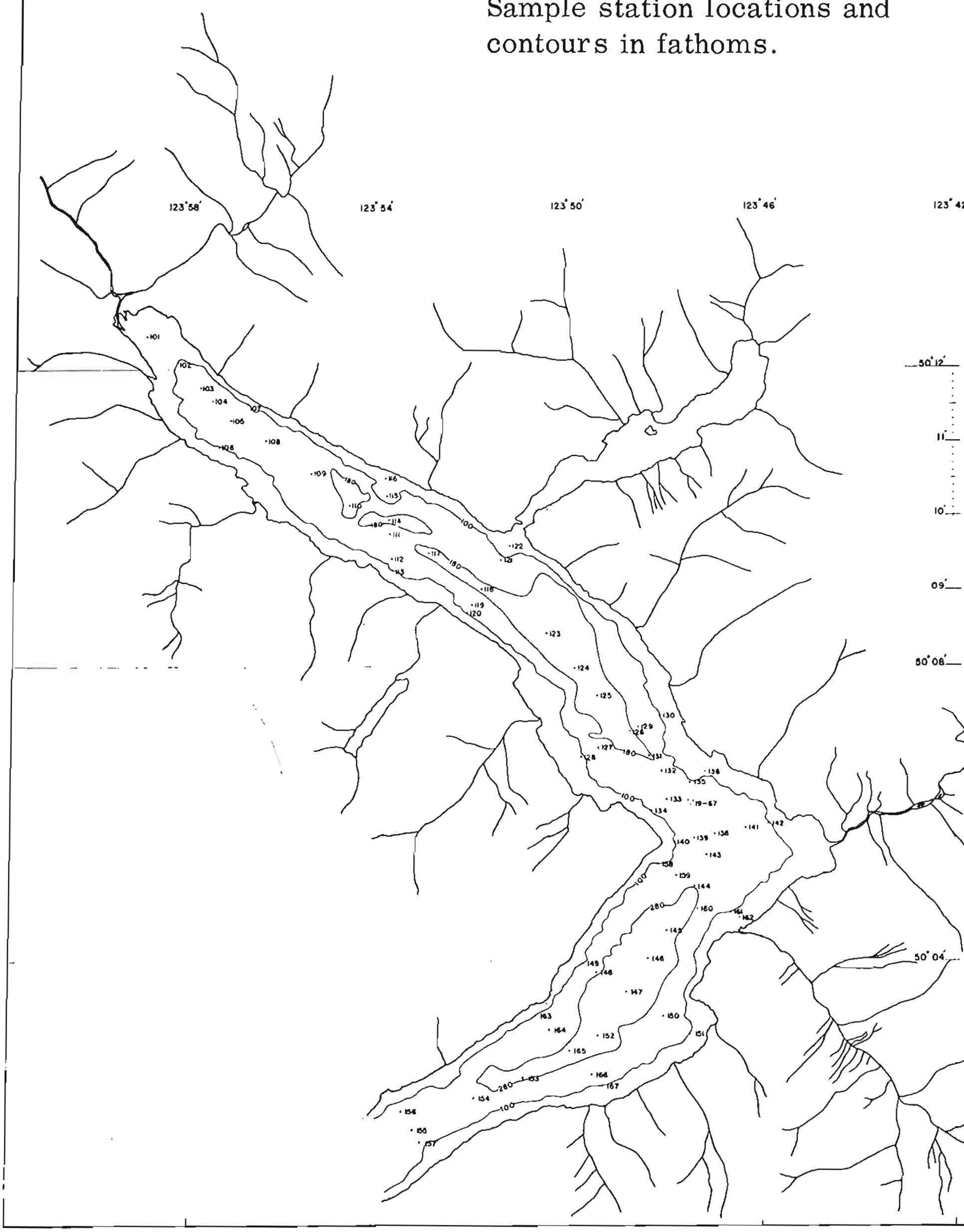
Table 1

Oceanographic cruises to Jervis Inlet, British Columbia

Cruise No.	Cruise Duration	Ship	Ship Owner
66/19	6 days	Ehkoli	Dept. Energy, Mines and Resources
67/13	5 days	Ehkoli	Dept. Energy, Mines and Resources
67/24	3 days	Vector	Dept. Energy, Mines and Resources

During the initial cruise the nodule locality was extensively sampled and photographed. The second and third cruises were used to take sediment samples over the northern portion of the inlet using a 1/5 $meter^2$ Petterson grab sampler and a gravity corer. Seventy grab samples and 5 cores were collected, the locations of which are shown on Figure 1. The grab

Figure 1. Jervis Inlet (northern portion). Sample station locations and contours in fathoms.



samples were analyzed for grain size distribution and total carbon content. The mineralogy of certain of the grab samples is being determined using a petrographic microscope for the + 62 micron size fraction and X-ray diffraction for the - 62 micron fraction. The cores will be split and logged.

The ferromanganese nodules are typically either spheroidal or disc-shaped. A cross-section reveals a concentric layering of oxide material about a nucleus which in this locality is usually a fragment of granitic rock – reflecting the geology of the surrounding mountains. The porosity of successive layers is variable possibly indicating changes in the rate of deposition of oxide material. The chemistry of these nodules is currently being investigated by Dr. E. V. Grill, Institute of Oceanography, University of British Columbia. Recent work[2] on the mineralogy of these nodules indicates the presence of todorokite – a hydrous manganese oxide mineral with the following unit cell formula:

$$(Ca, Na, Mn^{+2}, K)\ (Mn^{+4}, Mn^{+2}, Mg)_6\ O_{12} \cdot 3\ H_2O$$

The sediments when collected are typically olive-green in colour. Those collected along the axes of the basins below a depth of approximately 180 fathoms usually smell of H_2S indicating a reducing environment. Generally the sediments are poorly sorted to very poorly sorted[3]. The clay size particle and total carbon percentages of each basin show distinct correlation with depth and distance from the upper boundary of the basin. The sill on which the nodules are forming is a distinct barrier between the two basins under study.

Bottom photographs taken over the sill show gravels as being the surficial sediments in the area where the nodules are forming. However, elsewhere on the sill the surficial bottom sediments are much finer. Apparently a bottom current is winnowing the finer material from the sediments in the area of the nodule locality. Reasonably well-sorted fine sand is found on the south flank of the sill below the locality. Thus the nodules are forming in an environment where there is little or no deposition of sediments and where the bottom waters are in motion. The bottom photographs also indicate that in certain areas material is slumping from shallow near-shore areas into the depths of the basin. In some instances bottom samples collected from depth contain the shells of shallow water fauna in considerable abundance.

---

[1] Pickard, G. L.: Oceanographic features of inlets in the British Columbia mainland coast; J. Fish. Research Board Can., vol. 18, No. 6, pp. 907-999 (1961).

2 Grill, E. V., Murray, J. W., and Macdonald, R. D.: Todorokite in manganese nodules from a British Columbia fjord; Nature, vol. 219, No. 5152, pp. 358-359 (1968).

3 Folk, R. L.: Petrology of sedimentary rocks, Hemphill's, Austin, Texas (1965).

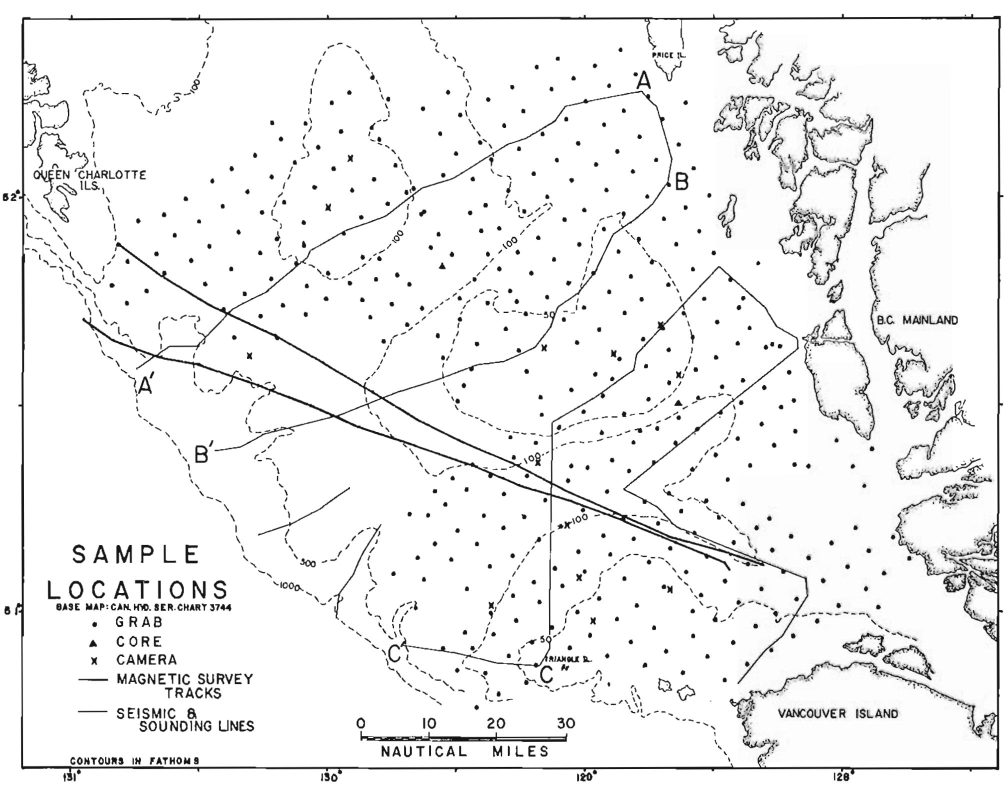


Figure 1. The location and type of information obtained to date in Queen Charlotte Sound.

6. No. 6. SEDIMENTS OF QUEEN CHARLOTTE SOUND, BRITISH COLUMBIA

Project 680138

John L. Luternauer and J. W. Murray

Department of Geology, University of British Columbia

This project has been undertaken to delineate the sedimentary environments and the economic potential of the surficial sediments on the Queen Charlotte Sound continental shelf. The study area lies adjacent to the British Columbia coast southeast of the Queen Charlotte Islands and northwest of Vancouver Island and is bounded seaward by the continental shelf break which occurs generally between 100-150 fathoms (see Figs. 1 and 2). Physiographically, the area is represented by a series of banks and troughs. The three major banks lie, respectively, just off northern Vancouver Island and at the central and northern portions of the study area. The troughs adjacent to the banks extend either along the mainland coast or offshore roughly perpendicular to it (see Fig. 1).

Data for this project has been obtained in large part during the following cruises on Canadian Naval Auxiliary Vessels:

Endeavour	(May 2-14, 1967)
Laymore	(June 12-17, 1967)
Endeavour	(July 7-13, 1967)
Endeavour	(May 28-June 10, 1968)
Endeavour	(August 19-30, 1968)

Cruise work has concentrated on the collection of bottom samples over a four-mile grid covering the study area (see Fig. 1). The samples have been obtained primarily with Pettersson grabs or Dietz-LaFond snappers. Dredge hauls were taken where the bottom sediments appeared to be far too coarse to be collected by the above two sampling methods. Echo-sounding lines have been obtained coincident with a 5, 000 joule sparker survey (Figs. 1 and 2). Two magnetometer profiles have been obtained across the area. Sixteen underwater camera stations have been obtained.

Approximately one quarter of the bottom samples have been size-analyzed. Upon completion of this aspect of the study the data will be prepared for computer analysis for which a program is already available. Although the sediments exhibit the expected general decrease in mean size with depth there are very apparent variations in the character (e.g. colour, roundness, sorting, heavy mineral content, etc.) and composition (e.g. nature of associated gravels and/or faunal components) which do not appear to follow such a regular pattern and require further investigation.

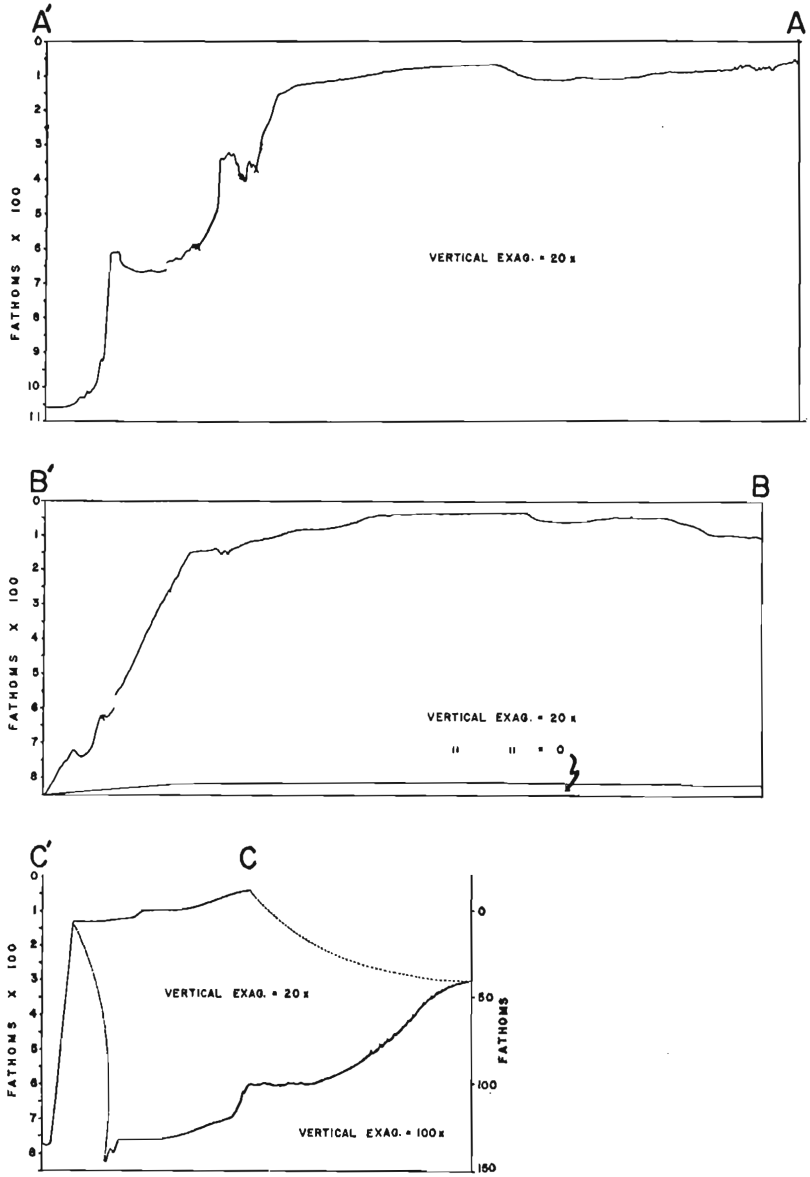


Figure 2. Bathymetric profiles drawn from echo-sounding traces over Queen Charlotte Sound, British Columbia. For location of sounding tracks refer to Figure 1.

Sediments on the bank adjacent to Vancouver Island appear to possess the most heterogeneous sediment distribution. The sediments range from almost pure shell hash in the vicinity of the channel at the northwestern tip of Vancouver Island to boulders adjacent to the string of islands extending to Triangle Island. The rocky character of the bottom sediments in this area is reflected in the jaggedness of the nearshore portion of echo-sounding profile C'-C (see Figs. 1 and 2). What appear to be fairly uniform and coarse relict sands have also been collected near the centre of this bank. These sediments may likely represent a beach submerged during the post-Pleistocene rise in sea level. Dating of any associated shell material may produce supporting evidence for this hypothesis. Correlation of the occurrences of relict sands and possible submerged surf-cut terraces may permit creation of paleoshoreline maps.

The central bank has boulders and shelly gravels on its seaward half which grade into well-sorted sands towards the mainland. This is evidence for landward winnowing of sands by strong current action. The sediments of the northernmost bank are distinguished from those of the other banks by possessing a greater biogenic component consisting of foraminifera. This may result in part from the comparatively greater depth of this bank.

The troughs in the Queen Charlotte Sound area appear to be accumulating muddy sands and sandy muds. The difference in coarseness of their sediments from place to place apparently is related to the proximity and sediment character of adjacent banks.

The sediments in Queen Charlotte Sound may have several possible sources. They may be detrital, biogenic, relict, residual or authigenic. The detrital component is at present being supplied from (a) the straits lying between Vancouver Island and the mainland, (b) the mainland opposite the sound and (c) Hecate Straits just north of the study area. Because the fiords act as traps for the coarser sediments it is likely much of the material being introduced into Queen Charlotte Sound is carried in suspension. This suggests that the sandy and gravelly inorganic detrital component of the sediments in the sound (particularly in the central portion) was transported there either in a glacier that overrode the shelf or by ice-rafting. Electron microscopic investigation of the quartz-sand particles in these sediments may reveal surface features concordant with these origins. Such features are not apparent on the gravels. The biogenic component probably rivals the detrital as a sediment contributor, especially in the troughs. There is evidence that relict and residual sediments are significant in the sediment budget, but these factors along with the possible occurrence of authigenic minerals have not been properly evaluated yet.

The sparker records show the area is underlain by gently folded beds (Tertiary and Cretaceous) unconformably overlain by a veneer of Pleistocene and Holocene sediments. There is evidence of considerable channelling (scour and fill features) between the central and northern banks and the mainland.

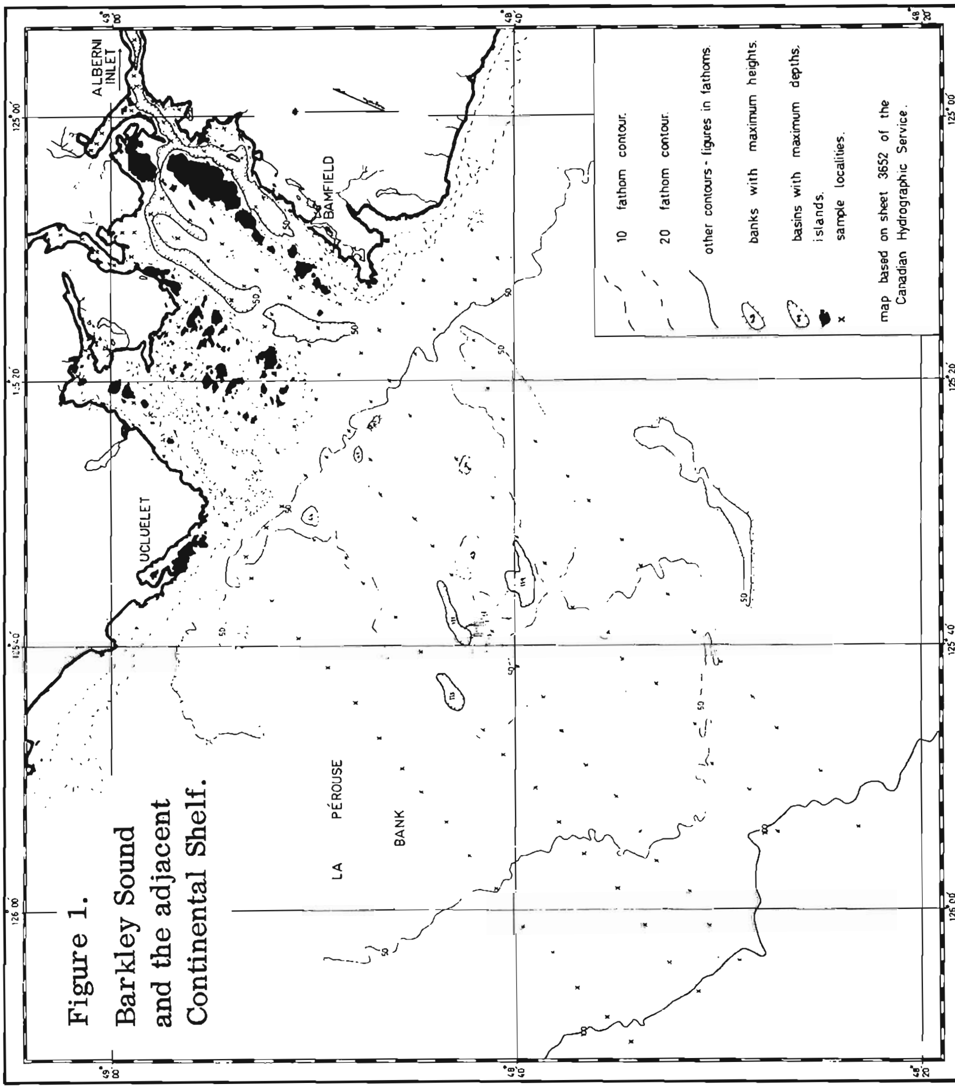


Figure 1. Barkley Sound and the adjacent Continental Shelf.

7. TOPOGRAPHY AND BOTTOM SEDIMENTS IN BARKLEY SOUND AND THE ADJACENT CONTINENTAL SHELF, SOUTHWESTERN BRITISH COLUMBIA

Project 680138

L. Carter and J. W. Murray

Department of Geology, University of British Columbia

In May 1968, a study was commenced on the sediments in Barkley Sound, a large inlet on the west coast of Vancouver Island, and the adjacent continental shelf. Field work was carried out for a two week period from the vessels C. N. A. V. "Laymore" and C. S. S. "Vector", and involved depth recording, grab sampling, and gravity coring. Bottom samples from the less accessible parts of the sound were obtained using a small boat. As provenance of the sediments is a major aim of this study, samples of rock, soil, and river sediment were also collected bringing the total number of specimens to 260.

The bathymetric map, generalized in Figure 1, is based on depth recordings made during the sampling operations, and on data obtained from the Canadian Hydrographic Service. The map showed the bottom topography to be complex. The southeastern half of Barkley Sound contains several elongate basins aligned northeast-southwest. They have an average depth of 60 fathoms, although the most southerly depression reaches 140 fathoms at the mouth of Alberni Inlet. The northwest portion of the sound is considerably shallower, averaging approximately 20 fathoms, and containing several prominent banks especially in the vicinity of Ucluelet.

The continental shelf northwest of the area of study, is essentially a gently sloping, featureless surface, about 26 miles wide, and ending at the continental slope, the beginning of which roughly corresponds to the 100-fathom line. However, opposite the sound the shelf is transected by a northeast-southwest trending basin within which is a series of smaller basins and banks. The smaller depressions are also aligned northeast-southwest, and often reach depths of 100+ fathoms. In several cases the basin sides are markedly linear and extremely steep, suggesting possible fault movement. Southwest of this irregular topography the continental shelf resumes its gently sloping character.

The main sediment in Barkley Sound is an olive-green, organic-rich mud which is occasionally rich in H_2S especially in some of the small inlets leading into the sound. In the shallow coastal waters sands and gravels predominate, the latter being common at the mouths of rivers and streams which are at present eroding drift. The sands tend to be concentrated northeast of the river mouths; this distribution probably is in part related to the wind and Pacific swells, both of which prevail to the northeast.

On the continental shelf a relationship between lithology and bathymetry is apparent.

1. The bank tops are covered with a sandy gravel, although sand may be locally important. As the continental slope is approached there is an overall reduction in grain-size, the sediment near the slope being a silty sand. The bank top gravels are mainly composed of well-rounded fragments of diorite and granodiorite, while the sands are rich in quartz and feldspar.

2. Olive-green muds are the dominant lithology in the basins. Occasionally they contain sand and gravel which appears to be sediment redeposited from the bank tops.

The fauna associated with the sediments bears a close relationship to depth and sediment type. In the shallow coastal water, thick-shelled clams (Mytilus, Polinices, Schizothaerus) are common while in the basins more fragile animals represented by thin-walled echinoids, soft-shelled clams, and holothurians, are dominant. On the gravelly banks, calcareous worm tubes, bryozoans, and pectinids (Chlamys) are common, but where the bottom is sandy, small bivalves and gastropods such as Olivella predominate.

The samples collected during the summer are at present undergoing investigation to determine grain sizes, mineralogy, heavy minerals, and chemistry (organic, calcium carbonate, trace element contents). Future work in the area will entail additional coring, underwater photography, and skin diving in the shallower parts of Barkley Sound.

8. STRUCTURE OF THE CONTINENTAL MARGIN WEST OF VANCOUVER ISLAND, BRITISH COLUMBIA

Project 680138

J. W. Murray and D. L. Tiffin

Department of Geology, University of British Columbia

In 1967 a reconnaissance program of continuous seismic profiling off the west coast of Vancouver Island by University of British Columbia geologists and geophysicists obtained six profiles across the continental shelf and slope. The lines begin in shallow water three to five miles from shore, and terminate over the base of the continental slope. Because of the reconnaissance nature of the survey, the profiles were spaced at approximately 30 miles and run perpendicular to the trend of the coastline.

The results of this preliminary survey showed a variety of structures in a sedimentary basin forming the edge of the continental shelf, and extending from Cape Scott at the north end of Vancouver Island to Cape Flattery on the Juan de Fuca Strait in the south, a distance of some 200 nautical miles. The eastern margin of the Tofino Basin lies either slightly landward or seaward of the west coast of Vancouver Island and the western margin is the continental slope.

In 1968, with the aid of the Geological Survey of Canada, this continuous seismic profiling project was greatly expanded. Continuous seismic profiling equipment was purchased consisting of a 5, 000 joule sparker, a sensitive 20 element hydrophone array, and an amplifier-filter unit. Recording is accomplished by feeding the amplifier output to an Alden wet-paper recorder. With this equipment, an additional 26 (733 miles) seismic profiles were obtained, to outline more completely the extent and structure of the Tofino Basin. In addition, precision echo-sounding was run simultaneously with the seismic profiling. Sixteen successful dredge hauls were made for bedrock samples on the continental shelf and slope.

The results of this study to date show several interesting highlights as follows:

1. An apparently late Tertiary sedimentary unit exists as an offshore wedge of the Tofino Basin. This unit extends from about 5 miles southwest of Cape Scott to at least Barkley Sound. Its inshore edge roughly corresponds to the 50-fathom contour on Chart 3001. Offshore it extends to the edge of the continental shelf and beyond, in places, to the upper continental slope. It approaches the shoreline in the north to within 3 miles of Cape Palmerston; in the south, it moves offshore to about 20 miles off Lennard Island. At Brooks Peninsula, and again off Kyuquot Sound, this latest sedimentary unit is absent. In the former case, off Brooks Peninsula, the continental shelf is very narrow and severely broken by faulting. In the latter case, however, an arch rises off Kyuquot Sound and this late sedimentary unit pinches out against its flanks. This youngest Tertiary unit is seismically distinct and is called 'Layer A'.

2. Layer A rests with a profound angular unconformity upon an older (Tertiary?) sedimentary unit which consists of more reflective sedimentary rock. This older sedimentary unit, called 'Layer B', can be recognized only locally where it rises near, or to, the surface of the shelf in the cores of major structures, or forms the entire continental shelf where Layer A is absent.

3. Sixteen dredge hauls have recovered numerous samples from both Layer A and Layer B. Layer A samples generally are soft, greyish green, platy mudstone whereas Layer B is usually a hard, dense, platy mudstone.

4. South of Kyuquot Sound the Tofino Basin contains numerous structural culminations, either fault blocks or anticlinal folds which involve principally Layer B strata. The axes of these culminations are en echelon and subparallel to the coast. Layer A was deposited, at least in part, simultaneously with this deformation of Layer B. Thus Layer A sediments reach a maximum thickness in local intervening basins and thin dramatically or pinch out on the flanks of the structural culminations. Thus the observed structure in Layer A is largely supratenuous. Some compressional folding is present on the outer part of the continental shelf off central and southern Vancouver Island.

5. Where Layer A sediments pinch out against the crests of the structural culminations, Layer B sediments outcrop on the sea floor allowing sampling. Echo-sounding over such Layer B outcrops in the cores of these structures show rugged topography with as much as 30 feet of relief.

6. The strata of the Tofino Basin are essentially flat lying north of Kyuquot Sound.

7. The shelf width, depth of the shelf-slope boundary (picked at the first major break in slope), and dip of the continental shelf and upper slope for 6 profiles off Vancouver Island are given in Table 1.

Table 1

Line	Shelf width	Depth of shelf-slope boundary (FMS)	Apparent dip of continental shelf from profiles	Apparent dip of upper continental slope from profiles
Scott Islands	12.0	117	0° 30' (Inner) 0° 18' (Outer)	35°.6
Brooks Peninsula	3.8	72	0° 24'	19°.5
Kyuquot Sound	16.0	103	0° 12' (Inner) 0° 17' (Outer)	13°.7
Nootka Island	19.4	132	0° 10'	7°.3
Estevan Point	19.8	101	0° 8'	8°.7
Ucluelet Inlet	31.0	113	0° 11'	26°.6

8. Seismic profiles across the continental slope off northern Vancouver Island show 'Layer A' is abruptly truncated on the steeper continental slope in this area and samples have been dredged from this locality. The slope in this area has originated either by faulting or by large-scale slumping. It is tempting to speculate that the Queen Charlotte Fault system may extend into this area. On the other hand, the continental slope off central Vancouver Island is clearly aggrading, for the dip of the strata is essentially parallel to the dip of the topography. Thus the continental margin off British Columbia is undergoing simultaneous aggradation and degradation.

CORDILLERAN GEOLOGY

9. STRUCTURAL STUDIES NEAR CROOKED LAKE, QUESNEL LAKE MAP-AREA, BRITISH COLUMBIA (93A)

Project 680066

K. V. Campbell

The project involved a detailed structural study of a large syncline near Crooked Lake[1]. The syncline is flanked by anticlines that coincide with metamorphic highs centred near Mount Perseus to the northeast and Boss Mountain to the southwest.

The syncline involves the following five rock units listed from oldest to youngest:

1. Kaza Group micaceous garnetiferous quartzite and schist; late Precambrian in age.

2. Amphibolite gneiss believed to be the metamorphic equivalent of the Antler Formation of the Slide Mountain Group to the north[2] and of the Fennell Formation to the south[3]. These formations are Early Mississippian or younger. The unit ranges up to 2, 500 feet in thickness but locally is thin or absent.

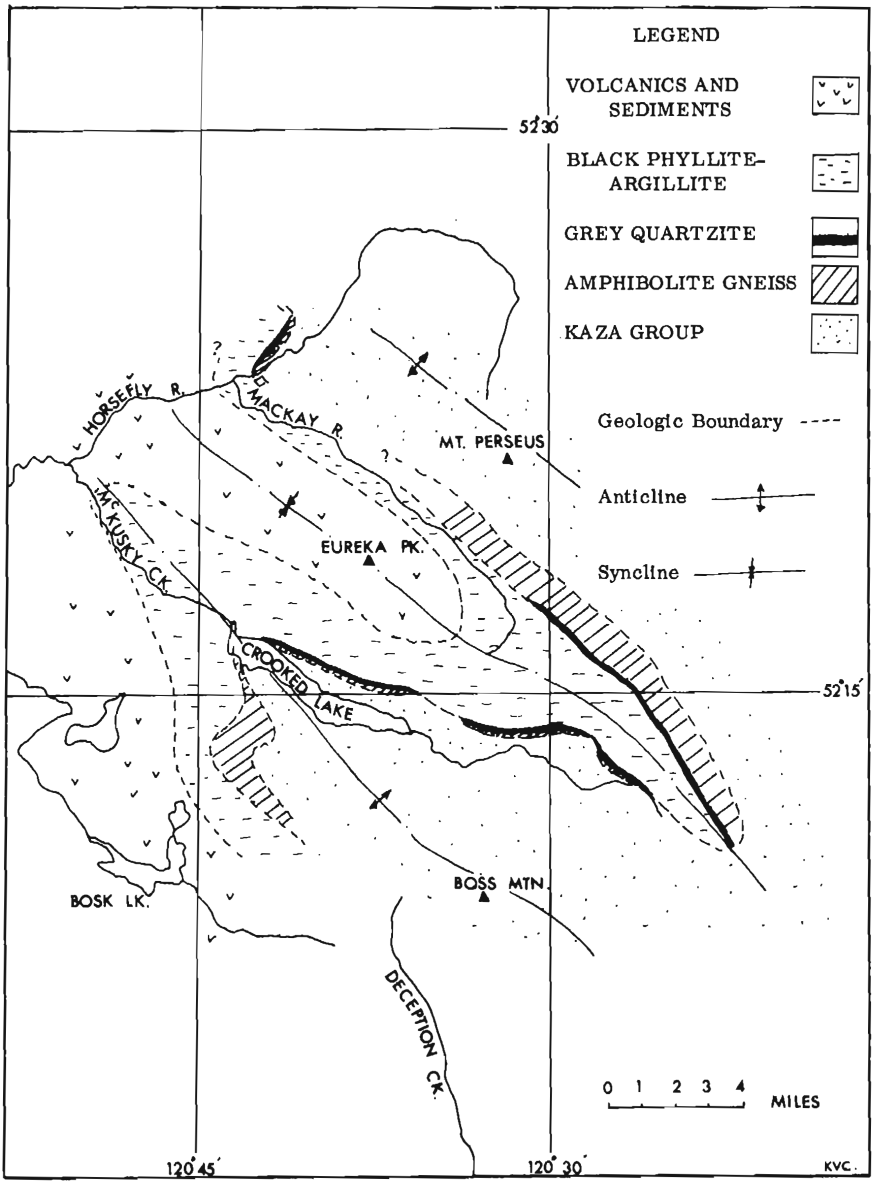
3. Grey quartzite of unknown age ranges up to about 800 feet thick.

4. Black phyllite-argillite of uncertain but possible late Triassic age; this unit may be 8, 000 feet thick.

5. Volcanic and sedimentary rocks of late Triassic and/or early Jurassic age.

The upper and lower contacts of the amphibolite gneiss are believed to be unconformities. The contact of the grey quartzite and black phyllite-argillite appears to be conformable and gradational but the relationship is obscured by deformation involving the development of phyllonite in the black unit at the contact. The nature of the upper contact of the black phyllite-argillite with the volcanic and sedimentary rocks is not well understood; superficially it appears to be conformable.

Apparently all observed minor folds developed synchronously with and are related to the major folds. The axial surfaces of minor folds on the



Sketch map of the generalized geology of the Crooked Lake area, B.C.

limbs of the major syncline are parallel with the limbs whereas those of folds in the axial region are parallel with the axial surface of the major fold. The character of the minor folds varies with stratigraphic depth. Folds in the essentially unmetamorphosed volcanic and sedimentary rocks are related to a distinct fracture cleavage, those in the black phyllite-argillite exhibit a penetrative axial plane foliation, and those in the medium-grade metamorphic rocks of the Kaza Group appear to be a combination of shear and flow folds.

Planned petrographic and tectonic fabric studies will investigate the relation between style of folding, relative competency, metamorphic grade, and the degree of transposition of bedding.

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[1] Campbell, R. B.: Quesnel Lake, east half; Geol. Surv. Can., Map 1-1963 (1963).

[2] Sutherland-Brown, A.: Geology of the Antler Creek area, Cariboo district, British Columbia; B.C. Dept. Mines, Bull. 38 (1957).

[3] Campbell, R. B., and Tipper, H. W.: Bonaparte River; Geol. Surv. Can., Map 3-1966 (1966).

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10. McBRIDE MAP-AREA, BRITISH COLUMBIA (93H)

Project 680066

R. B. Campbell

The study of McBride map-area, begun in 1966 and continued in 1967, was completed in 1968 during two weeks of work devoted mainly to specific structural problems near the Rocky Mountain Trench. No major changes to the geology as depicted following the 1967 field season[1] are necessary, though some modifications will be made. E. W. Mountjoy spent a short time working in the northeast corner of the map-area and W. H. Fritz made a detailed study of the stratigraphy, with special emphasis on paleontology, of sections of Cambrian rocks on either side of the Rocky Mountain Trench (see his report elsewhere in this publication).

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[1] Campbell, R. B.: McBride (93H) map-area, British Columbia, in Report of Activities, Part A, 1967; Geol. Surv. Can., Paper 68-1, pp. 14-19 (1968).

11. STUDY OF A TERTIARY CAULDRON SUBSIDENCE COMPLEX, BENNETT LAKE, BRITISH COLUMBIA AND YUKON TERRITORY (104 M/14, 105 D/5)

Project 670011

M. B. Lambert

Detailed mapping, begun in 1967[1], of the Skukum volcanics was completed near the West Arm of Lake Bennett in parts of the Wheaton River (105 D/5) and Homan Lake (104 M/14) map-areas. This is a presumed cauldron subsidence area (Fig. 1) with a history of explosive acidic volcanism and rapid sedimentation that resulted in the accumulation of great thicknesses of tuffs, breccias, ignimbrites and conglomerates.

Granitic and metamorphic rocks completely surround the layered rocks of the Skukum Group in this region. Isolated masses of pre-Mesozoic[2] metamorphic rocks (unit 1) consist of quartz-feldspar schists and gneisses, quartz-biotite schists, quartzites, and gneissic granodiorite. Granitic rocks (unit 2) of the Coast Range Intrusions range from hornblende granodiorite, through biotite quartz monzonite to biotite leucogranite. These rocks are shattered and brecciated in the vicinity of known fault zones, generally around the periphery of the central volcanic rocks, and in breccia pipes. Disruption of these rocks was probably caused by explosive volcanism and by faulting during the initial stages of subsidence of a central cauldron.

The early products of explosive volcanism, which include a variety of light-coloured breccias and tuffs (unit 3), accumulated on an irregular granitic terrain to a maximum thickness of about 1, 500 feet. The late products of this eruptive series form a sequence of ignimbrites (unit 4) with a maximum thickness of 2, 000 feet.

Tuff and breccia pipes, composite tuff-rhyolite and tuff-dacite dykes, and ignimbritic dykes are considered to be the sources (unit 5) of the pyroclastic rocks. These vents, which are scattered around the periphery and north-central parts of the area, commonly occur along fracture zones or along contacts between granitic and metamorphic rocks. Vent forms vary from pipes with elliptical to completely irregular cross-sections, to steeply dipping dykes. During a period of erosion following the explosive eruptions, a sequence of essentially unsorted granitic boulder conglomerates (unit 7) accumulated to thicknesses as great as 1, 000 feet in the southeast corner of the area. In the central parts of the area, the conglomerate beds interfinger with tuff and ignimbrite units. The conglomerates are overlain by coarse-grained sandstones, tuffaceous sandstones and tuffs. A maze of faults occurs throughout the central part of the area. One of the larger faults has a vertical

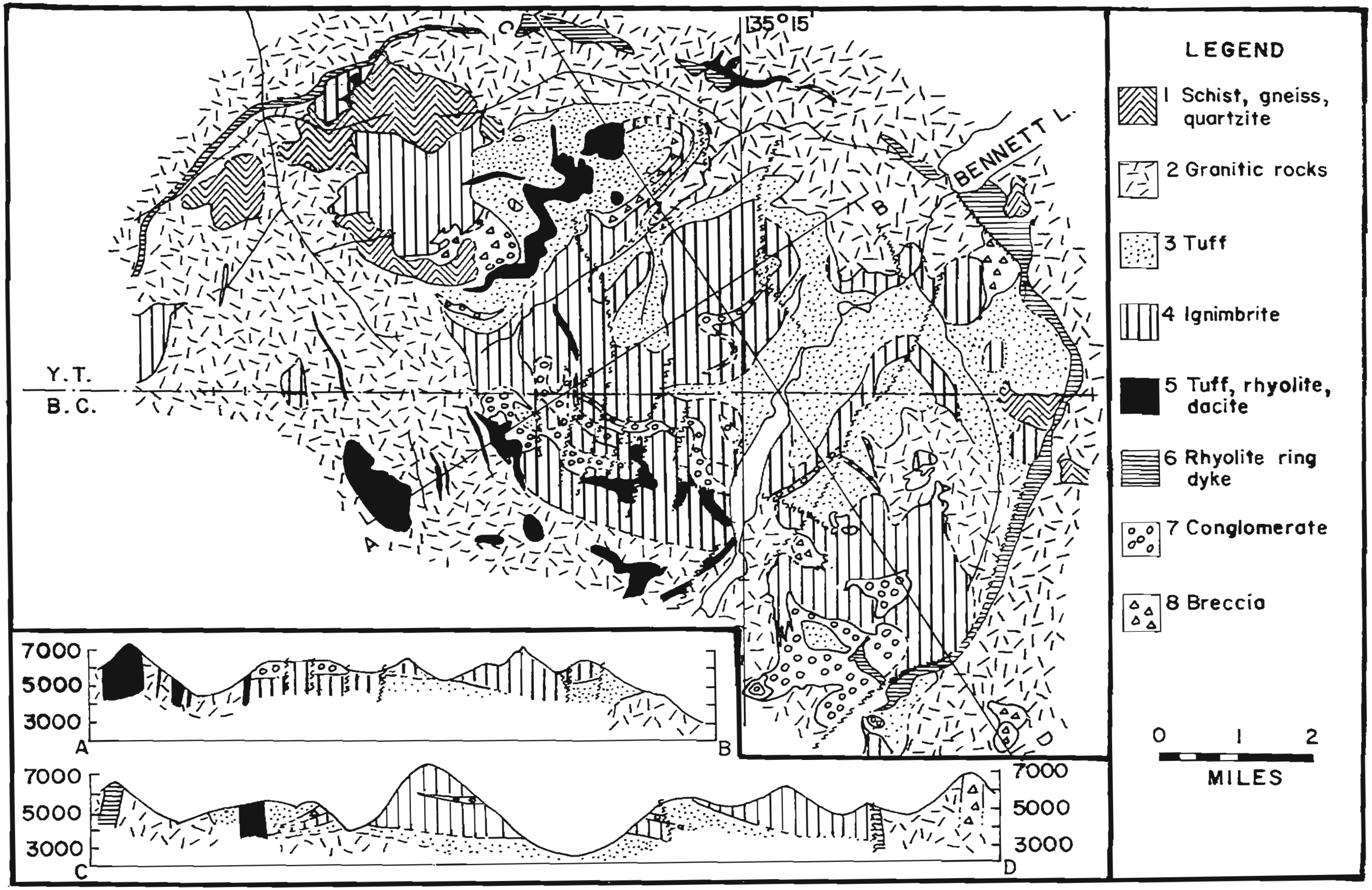

Figure 1. Cauldron subsidence area, Bennett Lake, British Columbia and Yukon Territory.

displacement of 500 feet. Fault relations indicate that the layered rocks suffered disruption and jostling at intervals both during and after deposition.

A final period of faulting along peripheral arcuate fracture systems was accompanied by (1) a second period of explosive volcanism, which resulted in deposition of relatively thin layers of tuff; (2) extrusion of basalt lava flows; and (3) intrusion of a large ring dyke. The vertical to steeply outward dipping, porphyritic rhyolite ring dyke (unit 6) forms a broad, discontinuous arc, about 22 miles long, around the northern and eastern periphery of the area. The dyke pinches and swells and has a maximum thickness of 1,500 feet. The dyke, near its ends, flares out into a maze of smaller dykes, ranging from a few inches to 20 feet wide. Andesitic and basaltic magma intruded the volcanic pile and reached the surface to form very small lava flows. The volume of lava flows is very small (less than one per cent) in relation to the total bulk of pyroclastic rocks.

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[1] Lambert, M.B.: Wheaton River and Homan Lake, Yukon and British Columbia; in Report of Activities May to October 1967, Geol. Surv. Can., Paper 68-1A, p. 32 (1968).

[2] Wheeler, J.O.: Whitehorse map-area, Yukon Territory; Geol. Surv. Can., Mem. 312 (1961).

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12. LATE PALEOZOIC ROCKS OF THE ATLIN HORST, NORTHWESTERN BRITISH COLUMBIA AND SOUTH-CENTRAL YUKON (104M, N, 105C, D)

Project 660002

J.W.H. Monger

Field investigation of the stratigraphy and structure of late Paleozoic rocks comprising the Atlin Horst[1] was concluded in 1968. Rocks in areas A, B, C (Fig. 1) were studied in detail and those near Angel Lake, Disella Lake, Hurricane Creek and Kedahda Lake (localities A, D, H, K, Fig. 1) were examined briefly. Stratigraphic sections given below (Figs. 1, 2) are composite and result from detailed mapping. Fusulinids used to correlate these sections were tentatively identified in the field on sawn, etched surfaces of hand specimens. Sections D and E, from previous work[2], are included for comparison.

Rapid facies changes characterize the upper Paleozoic sequence in the Atlin Horst. Four northwest-trending 'facies belts', defined by predominant lithologies, are shown in the facies map (Fig. 2).

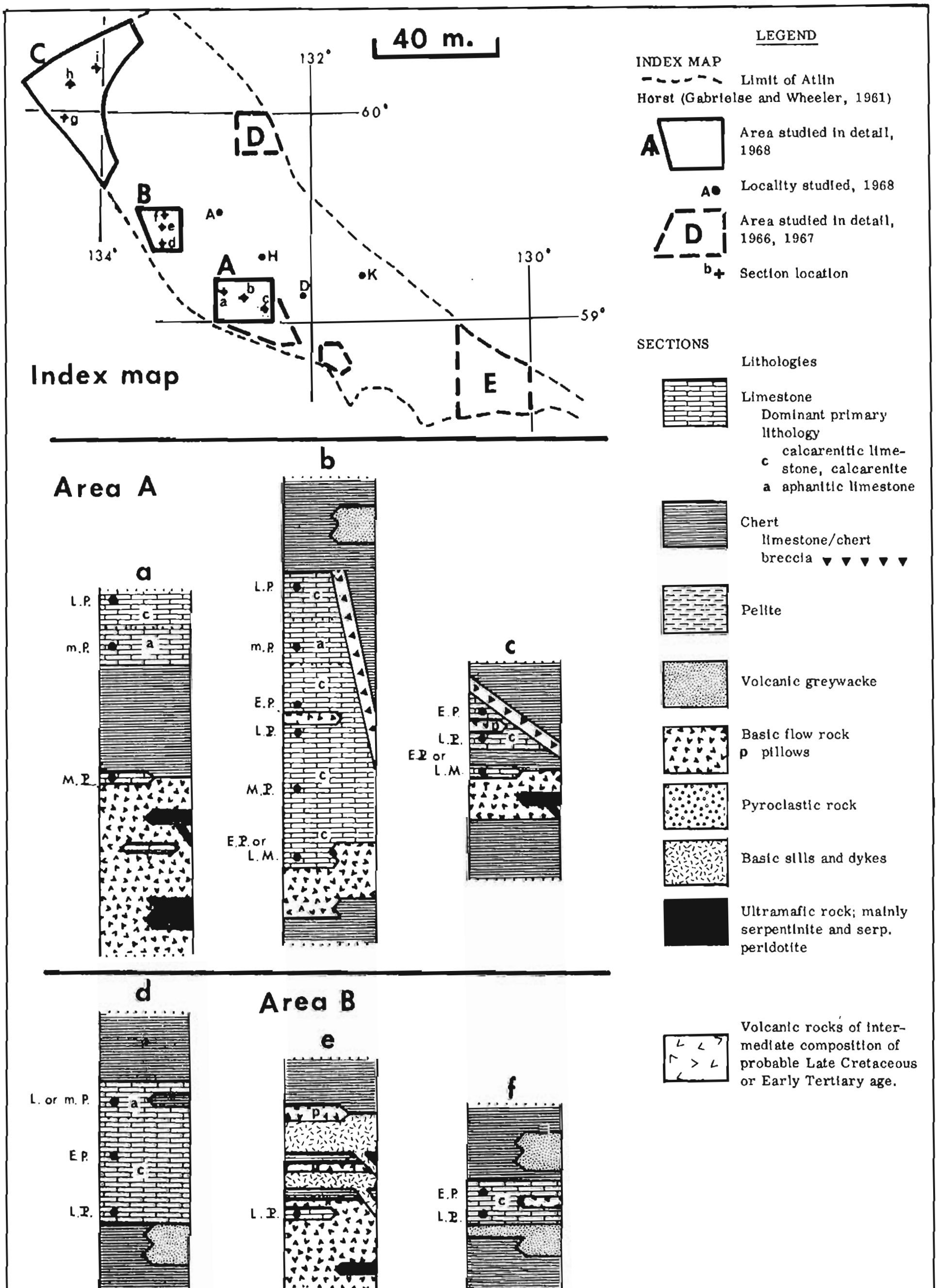

FIGURE 1: INDEX MAP AND COMPOSITE SECTIONS, ATLIN HORST.

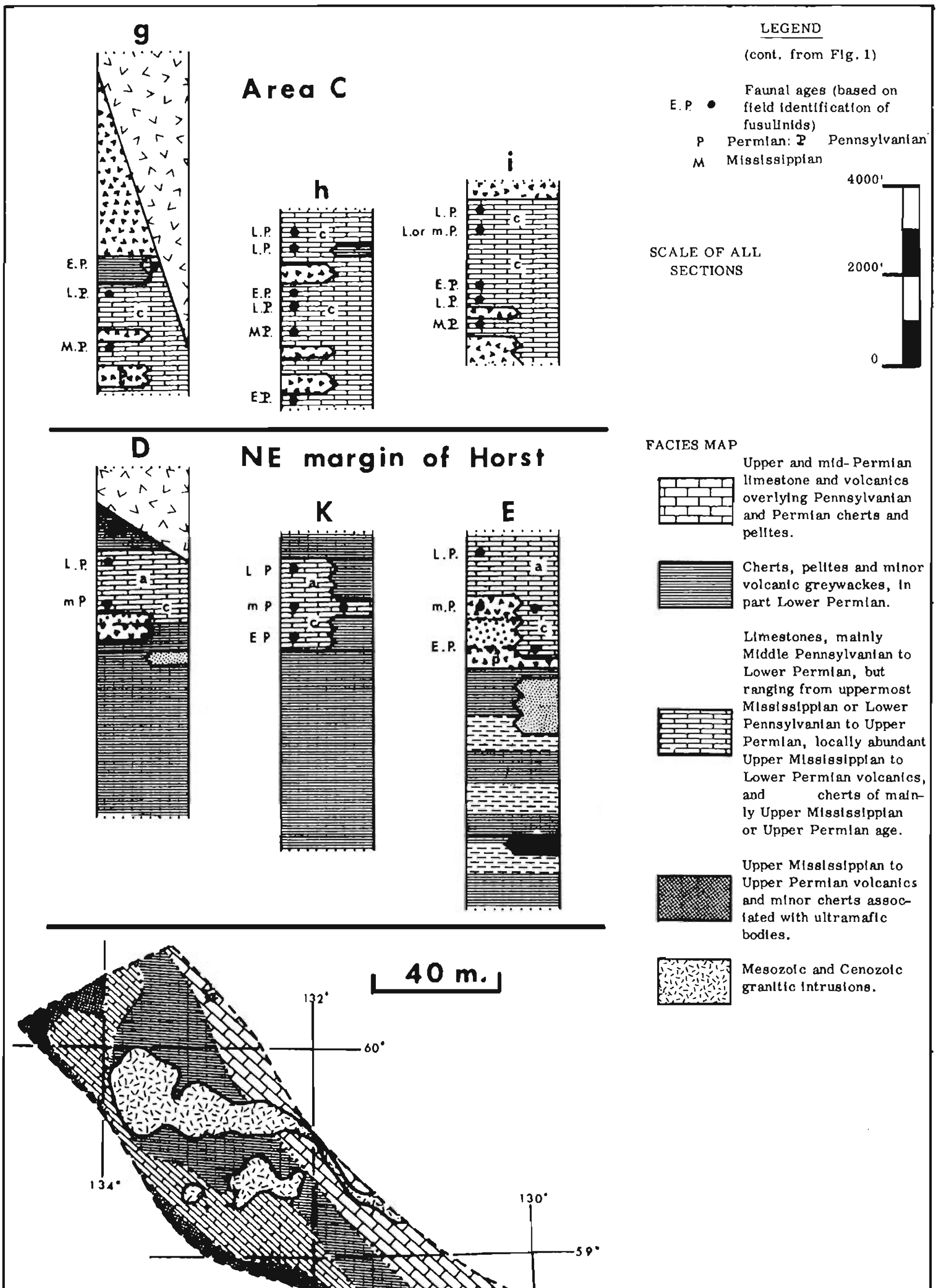

FIGURE 2: COMPOSITE SECTIONS AND FACIES MAP, ATLIN HORST.

In order of increasing areal abundance, upper Paleozoic rocks in the Atlin Horst are ultramafic, volcanic, limestone, and chert. Commonly the latter are associated with pelite and minor volcanic greywacke.

The ultramafic rocks, mainly serpentinite and serpentinized peridotite, are closely associated with the volcanic rocks and are most abundant in the southwesternmost facies belt. Elsewhere they tend to be associated with volcanics of Mississippian or Pennsylvanian rather than Permian age.

The volcanic rocks are predominantly green, fine-grained basic flows that typically consist of unaltered pyroxene crystals in a mesh of saussuritized feldspar laths. In the southern and western parts of the horst they range from Mississippian to latest Permian with little apparent variation in composition. However, the Permian volcanic sequence in the northeastern facies belt (sections D, E, Fig. 2) contains locally abundant pyroclastic rocks and hard, siliceous, banded flows in addition to basic flows.

The volcanic rocks provide the most sensitive indication of the grade of metamorphism; most belong to the low greenschist facies. In the eastern part of the horst (area E, Fig. 2) they grade locally into blueschist containing crossite, and in the westernmost part, many of the volcanics are fine-grained amphibolite.

Limestone is most abundant in the southern and western parts of the horst (areas A, C, Figs. 1, 2) where it ranges in age from latest Mississippian or Early Pennsylvanian to Early Permian, although Middle Pennsylvanian to Upper Permian limestone is the most extensive. These carbonates are mainly crinoidal or foraminiferal calcarenite or calcarentic limestone[3] that possibly accumulated as banks and reefs fringing volcanic islands to the south and west. In contrast are the predominantly aphanitic[3] mid- to Upper Permian carbonates of the northwestern facies belt (areas C, D, Fig. 2), that contain algal structures and appear to have accumulated in extremely shallow, protected waters.

Chert, associated with pelite and minor volcanic greywacke is most abundant in the facies belt separating the two contrasting limestone types. Limestone pods within the chert contain Early Permian fossils. North and south of this facies belt, chert both underlies and overlies the limestone/volcanic sequences. The volcanic greywackes are derived mainly from acid to intermediate volcanic rocks.

No rocks older than Late (?) Mississippian are known from the horst. Erosion in latest Permian (?) time locally has removed as much as 4, 000 feet of Upper Permian to Upper Pennsylvanian limestone in area A. Rocks above the basal limestone/chert breccia overlying the unconformity are mainly chert that lithologically and structurally resembles other late Paleozoic chert in the area, and thus are believed to be either uppermost

Permian or Lower Triassic. Elsewhere in the horst, predominantly intermediate volcanic rocks unconformably overlying the upper Paleozoic rocks are believed to be equivalent to Upper Cretaceous and lower Tertiary volcanic rocks elsewhere in the region.

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[1] Gabrielse, H., and Wheeler, J. O.: Tectonic framework of southern Yukon and northwestern British Columbia; Geol. Surv. Can., Paper 60-24 (1961).

[2] Monger, J. W. H.: Atlin Horst, British Columbia; in Report of Activities, May to October, 1967; Geol. Surv. Can., Paper 68-1, Pt. A (1968).

[3] Powers, R. W.: Arabian Upper Jurassic carbonate reservoir rocks; in Classification of carbonate rocks; Am. Assoc. Petrol. Geol., Mem. 1 (1962).

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13. NORTHERN VANCOUVER ISLAND (92E, K, L, 102I)

Project 680038

J. E. Muller

Following completion of the Alberni map-area[1] reconnaissance mapping of the remaining part of the island north of latitude 49° was started in 1968. About 1, 300 miles of coastline, from Tofino northwest to Cape Scott, and thence southeast to Campbell River were investigated, using a chartered motor vessel as a moving base camp and Canova rubber boats for the shoreline traverses. Many logging roads were also traversed, using 2- and 4-wheel motor transport.

J. A. Jeletzky joined the party during July, familiarized the writer with his previous stratigraphic work in the area, and aided substantially in the examination of new stratigraphic sections and by the preliminary identification of fossils.

The gross distribution of formations has been outlined on a geological sketch-map of Vancouver Island[2], to be revised soon on the basis of the recent work. The north part of the island may be divided roughly into two zones along a line from Cape Scott southeast through Holberg and Neroutsos inlets and thence towards Gold River. The northeastern zone is underlain predominantly by Triassic Karmutsen volcanic rocks and to a lesser extent by Upper Triassic carbonate and clastic sediments and Lower Jurassic volcanic and minor sedimentary rocks. Jurassic Island Intrusions invading the rocks described above form the central 'backbone' of this zone.

The southwestern zone consists largely of Lower Jurassic 'Bonanza' volcanic rocks, more diverse and less basic in composition than the Karmutsen, and some sedimentary intercalations. Triassic volcanic and sedimentary rocks occupy small areas along the coast and inlets between Quatsino and Nootka sounds.

The Westcoast Metamorphic Complex[1] continues north from Tofino as a 15-mile wide belt to Esperanza Inlet and reappears on Brooks Peninsula.

Lower Cretaceous sandstone and shale, overlain by boulder conglomerate, occupy a large area between Quatsino Sound and Holberg Inlet and small areas north of the latter. Lower Cretaceous beds, newly discovered east of Cape Scott, continue southeastward east of Stranby River. The strata lie directly on Triassic volcanic and sedimentary rocks. Sediments of the Upper Cretaceous Nanaimo Group underlie the lowland between Port Hardy and Port McNeill and are also present east of Neroutsos Inlet. Oligocene sediments fringe the west coast between Flores Island and Kyuquot Sound[3].

Volcanic breccia of Tertiary age outcrops on Eel Reef in Port McNeill harbour[4], and similar breccia was found south of Port McNeill on Twin Peaks[5]. Rhyodacite overlies Nanaimo Group rocks east of Neroutsos Inlet and similar rocks underlie an area north of Holberg Inlet. However, reliable stratigraphic or lithologic criteria to distinguish Tertiary from Jurassic volcanic rocks have not yet been established. Fossil collections made from beds associated with post-Triassic volcanic rocks are either clearly Jurassic or as yet undetermined. Nevertheless Tertiary volcanic rocks may be more widespread judging by many large dykes of basalt and rhyodacite cutting Cretaceous rocks on the north coast.

The discovery of large tonnages of copper ore in the Port Hardy area in 1967 has resulted in intense staking and exploration activity on northern Vancouver Island by more than twenty exploration companies. The mineralization appears to be mainly in siliceous volcanic rocks, assigned to the Bonanza Group. Detailed mapping of the ore-bearing area is now in progress by K. Northcote of the British Columbia Department of Mines.

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[1] Muller, J. E., and Carson, D. J. T.: Geology and mineral deposits of Alberni map-area, Vancouver Island and Gulf Islands, British Columbia; Geol. Surv. Can., Paper 68-50 (in press).

[2] Muller, J. E.: Geological sketch map of Vancouver Island, British Columbia; Geol. Surv. Can., Open File 9 (1968).

[3] Jeletzky, J. A.: Tertiary rocks of the Hesquiat-Nootka area, west coast of Vancouver Island, British Columbia; Geol. Surv. Can., Paper 53-17 (1954).

[4] Dawson, G. M.: Report on a geological examination of the northern part of Vancouver Island and adjacent coasts; Geol. Surv. Can., Ann. Rept. 1886, vol. 2, Pt. B, pp. 1-107 (1887).

[5] Muller, J. E.: Port McNeill Area and Nanaimo Basin, Vancouver Island; in Report of Activities, May to October 1966, Geol. Surv. Can., Paper 67-1, Pt. A, 81-83 (1967).

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14. NORTHWESTERN PART OF HOPE MAP-AREA, BRITISH COLUMBIA (92H (west half))

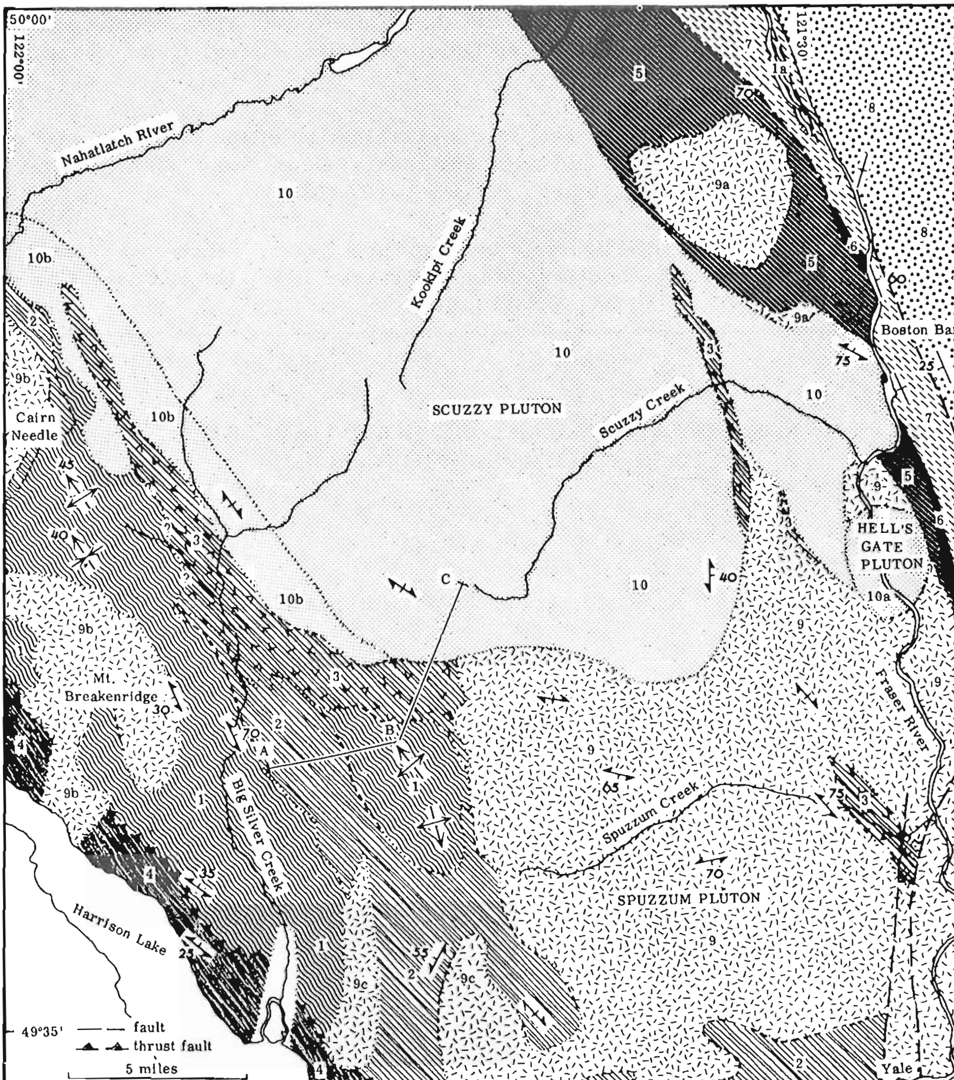
Project 680142

J. A. Roddick and W. W. Hutchison

This report covers the previously unmapped, northwestern part of Hope map-area. Two weeks were spent in the field at the end of the 1968 season. Time did not permit examination of rock thin sections.

The oldest rocks in the area are thought to be the gneisses that are exposed mainly on the eastern part of the ridge containing Cairn Needle and Mount Breakenridge (see Fig. 1). Owing to their granitoid character these rocks commonly appear to be homogeneous plutonic rock when viewed from the air. Most of the rock is light coloured granitoid gneiss (Fig. 3B) consisting of variable proportions of feldspar, quartz, biotite and muscovite. In it are zones of regularly layered gneiss in which quartzo-feldspathic layers alternate with fine-grained amphibolite layers 3 to 6 inches wide. Screens of biotite-quartz schist, some containing garnet, kyanite, and staurolite, form about 10 per cent of the unit. In many places the biotite is smeared out and the rock is strongly foliated, as if intensely sheared with subsequent partial recrystallization that healed the breaks. Also present are rare zones of agmatite, and other zones up to about 30 feet in width containing 10 to 15 per cent elongate amphibolitic inclusions. Both conformable and crosscutting pegmatite veins, from 2 inches to about 3 feet wide, are common. In places the pegmatite contains abundant long (2- to 3-inch) biotite crystals.

Unit 1 appears also in the core of an anticlinal or domal structure between Big Silver Creek and the head of Scuzzy Creek (see Fig. 2). There the dominant rock is a very well foliated, gneissic, nebulitic granodiorite or



LEGEND

5	HOZAMEEN GROUP?, phyllite, micaceous quartzite; near plutonic rocks, biotite-quartz schist, biotite quartz granulite, muscovite-quartz schist
4	Greenstone, sericite schist, chlorite-sericite schist
3	Migmatitic equivalent of unit 2; intercalated layers of granitoid gneiss, schist and amphibolite
2	Biotite schist, garnet-biotite schist, amphibolite, sillimanite-biotite schist, staurolite-garnet-biotite schist; conglomerate
1	Granitoid gneiss: includes muscovite-quartz-feldspar gneiss, biotite-garnet gneiss and minor amphibolite 1a, chloritized dioritic gneiss
10	Coarse-grained biotite granodiorite, SCUZZY PLUTON; 10a, fine-medium grained biotite granodiorite, HELL'S GATE PLUTON; 10b, quartz diorite border phase
9	Coarse-grained hornblende biotite quartz diorite, SPUZZUM PLUTON; 9a, garnetiferous quartz diorite; 9b, biotite quartz diorite; 9c, quartz diorite and diorite
8	JACKASS MOUNTAIN GROUP: conglomerate, argillite, greywacke
7	Laminated argillite, commonly phyllitic, locally micaceous; minor quartzite
6	Serpentinized ultrabasic rock

quartz diorite with screens of amphibolite and zones of irregularly layered gneiss with bands of garnet-biotite schist. In places the gneissic granodiorite contains scattered garnet crystals.

The base of unit 1 is not exposed. In the anticlinal area mentioned it is overlain along a sharp but apparently concordant contact by unit 2 and its migmatitic equivalent, unit 3. Except in the anticlinal area, unit 1 has a consistent northwest trend and in most places dips 35 to 70 degrees northeast. It appears to be thrust over unit 4 on the ridge overlooking Harrison Lake, but the actual contact was not observed and may not be exposed. In excellent cirque exposures between Cairn Needle and Mount Breakenridge dark amphibolitic layers outline several anticlines and synclines. The folds with amplitudes and wave lengths of about 2 miles plunge about 40 degrees to the northwest. The axial planes dip steeply to the northeast.

Near the northern border of the map-area along Fraser River, a small body of quartz dioritic gneiss (1a) is exposed. It is chloritized and has a streaky foliation striking northwest and dipping vertically. It is tentatively assigned to unit 1, but little is known about it. A fault on its east side seems to separate it from unit 17.

The age of unit 1 is not known. It may be correlative with the Custer gneiss[1] or the Skagit gneiss of Misch[2] which he believes (op. cit. p. 103) is Paleozoic with pre-Jurassic and probably pre-Mesozoic metamorphism.

Unit 2 outcrops on the west limb of the anticlinal area between Big Silver Creek and the head of Spuzzum Creek. The southern part is split by a tongue of Spuzzum Pluton. Rocks west of Yale thought to be correlative with unit 2 were not examined. Along cross-section line A-B, the unit consists mainly of fine-grained, dark grey, biotite-quartz schist which in places contains garnet, sillimanite and staurolite, intercalated with thinly layered

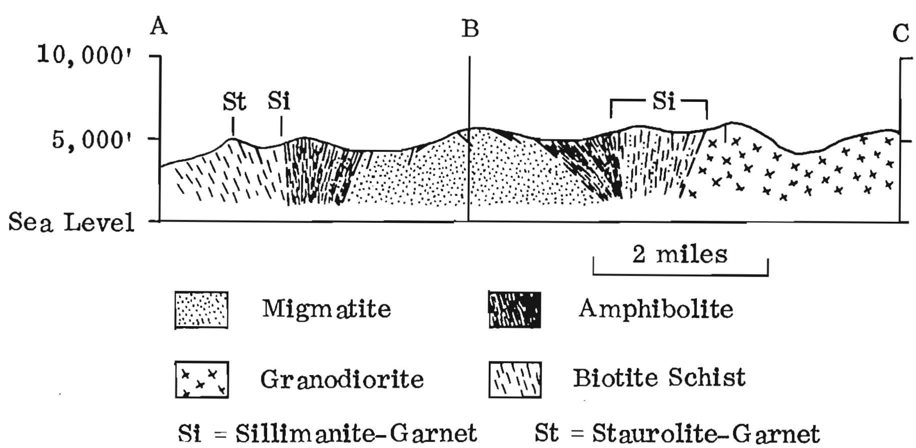


Figure 2. Cross-section A-B-C. Between Big Silver Creek and head of Scuzzy Creek.

(1/2 to 2 inches thick), light coloured quartz-feldspar schist. Rare zones of coarse sillimanite-biotite schist and gneiss were observed. Amphibolite and granitoid layers are common in the lower part of the section, and rare in the upper part. A few beds of thinly layered impure quartzite are also present. To the northwest in the valley of Big Silver Creek and south of Cairn Needle the same materials make up a striking banded gneiss (Fig. 3A).

The eastern branch of the southern, bifurcated part of the unit consists mainly of dark grey, fine-grained garnet-biotite-quartz schist. Sillimanite is commonly present, but not apparently systematically distributed. In places sillimanite forms randomly oriented crystals up to 3 inches long that give the rock a peculiar streaked appearance. Some sillimanite seems to be pseudomorphic after kyanite. In the schist are a few beds of conglomerate up to 20 feet thick. These are made up of argillaceous, quartz-feldspar granodiorite and gneiss fragments. Some of the argillaceous fragments are nearly completely changed to garnet. The fragments are angular to subangular (in marked contrast to the well-rounded clasts in the Jackass Mountain Group) and range from 1/4 to 8 inches across. The larger fragments are granitic and they commonly form 15 to 25 per cent of the rock. The matrix is a dark grey, very fine grained greywacke which in hand specimens appears scarcely metamorphosed yet may be criss-crossed by long sillimanite megacrysts. A few rock fragments are also found in the dominant schist indicating that much of this rock may have been derived from conglomeratic material. In this area the conglomerate fragments are not stretched but on the east side of the western fork of the bifurcation the fragments are severely stretched out in a northwesterly direction. In contrast with their abundance farther north granitoid layers are rare in the southern part of the unit. Bedding although measurable is much less distinct to the south.

The contact with the Spuzzum quartz diorite was examined at only one place - where it consists of <u>lit</u>-<u>par</u>-<u>lit</u> migmatite over a zone about 100 yards wide. The plutonic element is more leucocratic than that forming most of Spuzzum Pluton, and may be granodiorite rather than quartz diorite.

The contact between units 1 and 2 seems to be sharp and concordant in the vicinity of the cross-section. The unit trends generally northwest. Dips near the anticlinal area are moderate to steep southwesterly, and are vertical in Big Silver Creek. This unit is younger than unit 1, but its age is not known. Crickmay[1] included these rocks in the Chilliwack Group (late Paleozoic) and McTaggart and Thompson[3], finding no definite evidence for such a correlation, tentatively included them with the Hozameen Group. If unit 5 is truly Hozameen, these rocks could well be a more highly metamorphosed equivalent.

Unit 3 forms the northeast limb of the anticlinal structure shown in the cross-section. It is the migmatitic equivalent of unit 2, and consists of fine-grained biotite-quartz schist (Fig. 3C, D) commonly with garnet, and locally with sillimanite. It contains numerous layers of granitoid gneiss 2 to

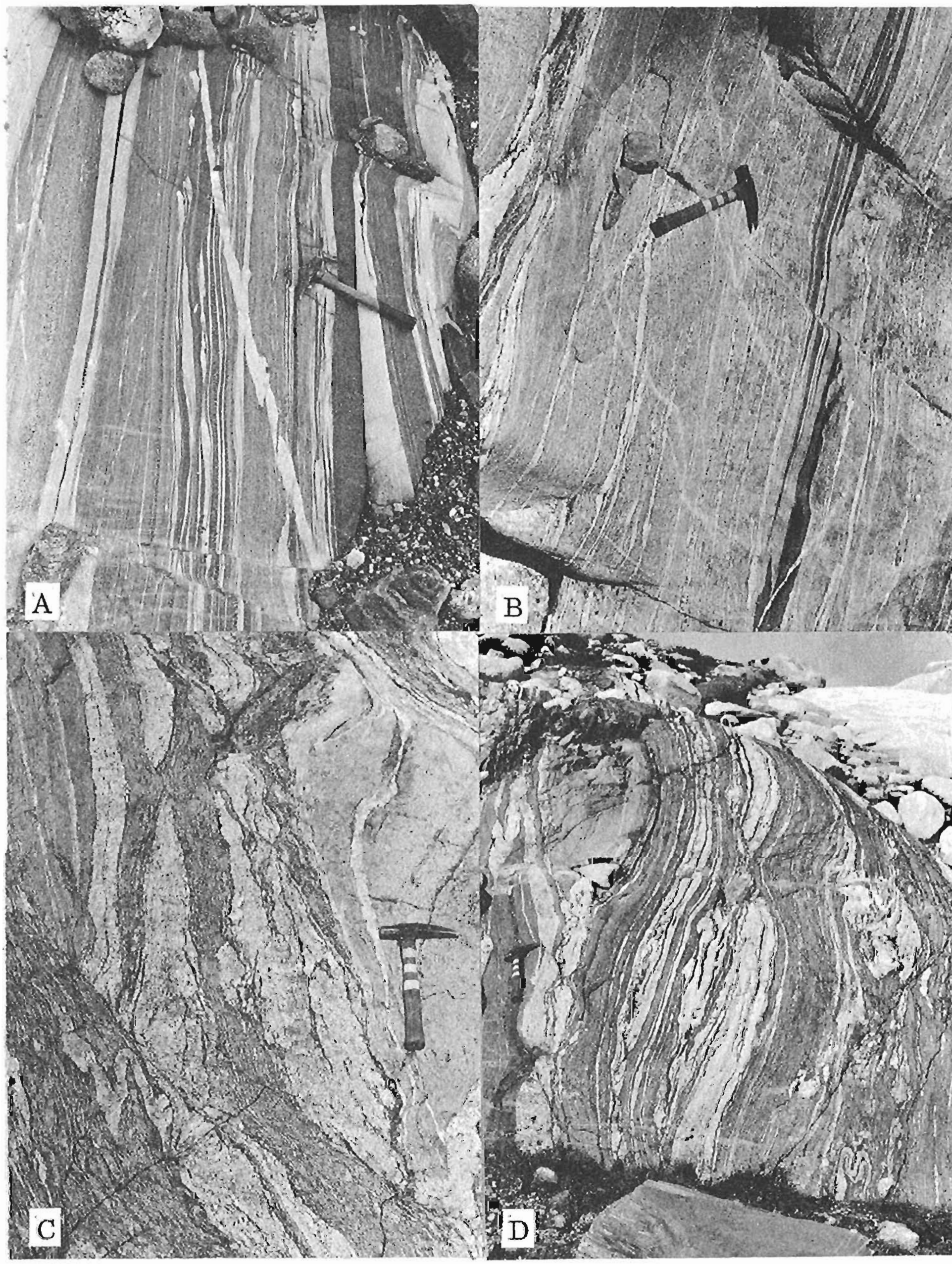


Figure 3. A - Banded gneiss in Unit 1 about 2 miles south of Cairn Needle.
B - Typical gneiss in Unit 1, near point B in Figure 2.
C and D - Irregularly layered gneiss containing sillimanite in biotite schist between points B and C in Figure 2.

6 inches wide which appear to be of biotite granodiorite composition, and commonly grades into pegmatite. Both dark and light layers pinch and swell, and vary in proportion from about 30 to 70 per cent. Locally cross-cutting veins of the granitoid material have formed agmatite. As in unit 2 amphibolitic layers are more abundant near unit 1 of the anticlinal core, that is, in the lower part of the section.

The general northwest trend of the unit is deflected to nearly westerly by the anticlinal structure. The southern end is truncated by the Spuzzum Pluton. The contact with the Scuzzy Pluton is fairly sharp and marked by a transition zone 5 to 25 feet wide that contains abundant pegmatitic and aplitic material.

Owing to the sparseness of information, the precise extent and structure of the northern extension of the unit is not known.

A small body of similar schist and gneiss outcrops in the lower part of Spuzzum Creek. Some of the schist contains garnet and sillimanite. Much of the rock is best termed an irregularly layered gneiss. To the southeast it is truncated by the Yale Fault. To the northwest its extension is not known but it apparently fails to reach the ridge crest. The narrower screen that crosses Scuzzy Creek consists of similar rock but sillimanite was not observed in it.

Information on unit 4 is scanty, mainly because time did not permit an examination of the outcrops along the northeast shore of Harrison Lake. Where examined the rock consists of massive, rusty weathering, dark schistose amphibolite, sericite schist and chlorite-sericite schist, but farther northwest (in Pitt Lake map-area) where the unit forms the Stokke Creek pendant, it consists mainly of fine-grained garnet-biotite granulite and gneiss, micaceous schist, stretched-pebble conglomerate and schistose amphibolite (ref. 4, pp. 26-27). Near the thrust the schist beds are crumpled, elsewhere the dominant trend is northwest with vertical to steep northeasterly dips.

The age of this unit is not known. It extends into rocks mapped as Twin Islands Group[4] about which little is known except that they were thought to be pre-Jurassic. The unit could be a part of the Hozameen Group.

The main body of unit 5 extends northwest from Boston Bar, and is bounded by granodiorite of Scuzzy Pluton on the west and the commonly serpentinized Hozameen Fault on the east.

Near the northern boundary of the map-area the unit consists mainly of dark grey phyllite and minor greywacke. North of the area, argillite and stretched-pebble conglomerate also are reported (ref. 5, p. 27) in the unit. Owing probably to the proximity of the Scuzzy granodiorite mass, and the quartz diorite pluton (9a) within unit 5, most outcrops of the unit examined contained metamorphosed rocks, the most abundant being thinly bedded biotite-quartz schist and granulite, and muscovite-quartz schist. Near the contact with Scuzzy granodiorite on Kookipi Creek, the rock is a thinly bedded, schistose, micaceous quartzite.

South of the contained quartz diorite pluton, abundant minor folds are exposed. Their axial planes strike northwest and dip about 40° northeast, and their axes are vertical. Elsewhere the beds trend northwest and dip vertically.

The contact with Scuzzy Pluton on Kookipi Creek is not actually exposed but it can be located to within a few feet. Talus blocks indicate that the plutonic rock is a streaky quartz diorite at the contact. No blocks of unit 5 appear in the plutonic rock. Several sill-like layers of quartz diorite appear in rusty phyllite and quartzite over a zone about 0.1 mile wide. A coarsening of the crystals in the metasedimentary rocks is evident near the contact but no high temperature minerals were observed. South of unit 5 near Fraser River the Scuzzy granodiorite contains blocks of schist and gneiss that may have been derived from unit 5. The northern contact with the body of garnetiferous quartz diorite (9a) is exposed on The Nipple. At the contact the plutonic rock is a coarse-grained hornblende diorite that grades into the more typical biotite > hornblende quartz diorite (garnetiferous) within 200 feet. The contact is sharp and discordant. No blocks of unit 5 appear in the plutonic rock there.

It is not certain that these rocks should be assigned to the Hozameen Group but they are lithologically similar to part of that group and are on strike with Hozameen rocks to the south. The age of the Hozameen Group is not known. On the basis of some similarities with part of the Cache Creek Group, it was assigned tentatively to the Carboniferous or Permian[1].

Unit 6 consists chiefly of serpentine but is not well exposed in the map-area. The serpentine is dark green to black and weathers a dark brown. It is extensively fractured and fresh surfaces are difficult to obtain. In places thin layers of serpentine seem to be intercalated with laminated argillite (unit 7). The serpentine has apparently intruded along the Hozameen fault-zone. To the north in the Ashcroft map-area, the serpentine has been derived from ultrabasic rock (ref. 5, p. 75) and the same is probably true in Hope map-area. No thin sections, however, were examined.

The age of the serpentine is not known. Duffell and McTaggart (ref. 5, p. 76) thought "the serpentine rocks along Fraser Valley probably reached their present positions in post-Lower Cretaceous times, it is possible that the ultrabasic rocks from which they are derived were emplaced much earlier and at some distance from the present positions of the serpentine bodies".

Unit 7 consists chiefly of laminated argillite that is commonly phyllitic and locally micaceous. A few thin beds of quartzite form a minor part of the unit. The thin dark grey to light grey or buff laminae of this argillite are distinctive. Most of the laminae vary from 1/16 to 1/6 inch wide; a few are 1/4 inch wide. The lighter layers are coarser and finely granular, whereas the dark layers are silty. Where phyllitic, the rocks commonly exhibit kink bands. With that exception the bedding and foliation are parallel. The unit trends northwest and dips vertically to 50 degrees northeast. The dips are generally steeper than those of the overlying Jackass Mountain Group.

The age of unit 7 is not known. It could be correlated with the Cultus Formation (Lower Jurassic) but the distinctive laminations of the unit are rarely found in that formation.

Unit 8 is part of the Jackass Mountain Group of Duffell and McTaggart[5]. Most of the rock in Hope map-area is probably part of their Division C (op. cit., pp. 41-43). The conglomerate is most distinctive but the dominant lithology is dark massive greywacke and thinly interbedded greywacke and argillite. Locally the greywacke contains slabs and pebbles of black argillite. The conglomerate contains well-rounded cobbles of a variety of rock types. Quartz-rich leucocratic granitic cobbles may form 30 to 90 per cent of the rock. Volcanic rock, argillite, quartzite, feldspar porphyry, chert and gneiss are also present. One gneiss cobble examined is identical to blocks found in the marginal phase of Spuzzum Pluton at the west end of Alexandria Bridge. The unit has a northerly trend and dips moderately to the east.

The Jackass Mountain Group has yielded Lower Cretaceous and possibly Upper Jurassic fossils in the Ashcroft map-area (ref. 5, p. 50). That part of the group that lies in Hope map-area appears to be Lower Cretaceous.

Map-unit 9 is mainly quartz diorite. The largest body is in Spuzzum Pluton which underlies the southeast quarter of the map-area. It is characteristically a massive hornblende > biotite quartz diorite which lacks inclusions. The total mafic content ranges from 15 to 25 per cent and quartz averages 10 per cent. In Fraser Canyon the Spuzzum quartz diorite is commonly altered and veined by aplite and pegmatite, and locally sheared. In the central part of the pluton a weak foliation strikes westerly but swings to southeasterly near Fraser River. The tentative time of emplacement is 76 ± 4 m.y. ago (Upper Cretaceous), based on a concordant hornblende-biotite K/Ar determination reported[6] for material collected approximately 3 miles north of Yale. The quartz diorite body south of The Nipple (unit 9a) is similar to that of Spuzzum Pluton but it characteristically contains more biotite and small garnets.

The pluton on Mount Breakenridge (9b) is a biotite quartz diorite which commonly contains up to 10 per cent dark elongate inclusions. Total mafic content is about 20 per cent. The biotite forms coarse crystals but both quartz and feldspar are fine grained and granular; epidote is disseminated throughout.

Two areas east of the mouth of Big Silver Creek are underlain by hornblende > biotite quartz diorite and diorite (9c) which contain 20 to 25 per cent total mafic. Presumably this body grades into the Spuzzum quartz diorite to the east.

Scuzzy Pluton (10) is dominated by granodiorite which underlies most of the northern part of the map-area. In most places the rock is white weathering and devoid of inclusions or veins. Commonly the rock has coarse-grained quartz and feldspar, and much finer grained biotite along with minor muscovite. Mafic content is distinctly lower than in the quartz diorite and ranges from 2 to 15 per cent and averages 5 per cent or less.

Between Boston Bar and the screen of unit 3 about 5 miles to the west, the plutonic rock is similar to and appears to be contiguous with Scuzzy Pluton. Angular biotite schist and gneiss inclusions (1 foot to 30 feet long) are locally abundant; they may be derived from unit 5.

At Hell's Gate Canyon, the plutonic rock is finer grained and light grey coloured. Small rounded inclusions are locally present. It appears to be a biotite granodiorite or trondhjemite[7] related to Scuzzy Pluton. It cuts the Spuzzum quartz diorite which in Fraser Canyon is mapped as Custer granodiorite[1]. A K/Ar date of 35 m.y. determined on biotite from this small pluton[8] probably sets a minimum age (Oligocene) for Scuzzy Pluton.

The contact between Scuzzy Pluton and the metasediments is concordant and well-defined. Along the western margin of Scuzzy Pluton the granodiorite grades into a narrow zone of biotite-rich quartz diorite (10b). The relationship between Scuzzy and Spuzzum plutons is not certainly known but the evidence from Hell's Gate Canyon and isotope age determinations suggests that Scuzzy Pluton is younger.

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15. ANVIL-VANGORDA DISTRICT, YUKON (105K)

Project 670009

D. J. Tempelman-Kluit

Investigations in the Anvil-Vangorda district were completed by examining exposures in a 10-mile-wide strip along Pelly River in Tay River map-area. Certain localities studied during the previous field season were re-examined.

No new evidence was found to substantiate or refute assignment to the Cambrian of the phyllitic rocks (unit 3)[1] that are host to the mineral deposits.

Unit 3 can be subdivided into two members. The 'lower' about 1,000 feet thick, contains medium grey, lustrous, quartz-rich phyllite with dark grey graphitic quartz phyllite near its base, and small chloritic greenstone lenses and tuffaceous phyllite in its upper part. The 'upper' member of unit 3 is about 3,000 feet thick and contains pale greenish grey, lustrous, non-quartzose phyllite with many large greenstone lenses and 10 feet thick sections of phyllitic tuff. Distinction of the 'lower' member is based on the presence of quartz and graphite in the phyllite and on the absence of thick greenstone lenses.

Sulphide bodies discovered to date occur in the 'lower' member of unit 3 some distance 'above' the graphitic horizons and a considerable distance 'below' the lowest thick greenstones. The terms 'lower' and 'upper' refer only to the present disposition of the units with respect to the crenulation foliation, for although bedding is visible in detail its gross orientation is unknown.

Probable Late Permian fusulinids were collected from one of the limestone knobs in Tintina Trench 3 miles southeast of the mouth of Grew Creek. It appears that this limestone is the youngest member of the Pennsylvanian and Permian chert-andesite sequence mapped as unit 9[1]. Unit 11 contains cobbles derived from this limestone and is probably post Permian.

Several important faults, subsidiary to Tintina Fault as mapped by Roddick and Green[2], have been delineated. The continuation of Vangorda Fault[1] southeast of Blind Creek has been established.

No new mineral occurrences were discovered. Several bodies of highly fractured, hematitic and pyritic quartz-feldspar porphyry along the southern side of Tintina Trench contain a disseminated mineral resembling chalcocite. Although the rock was assayed for copper and tested for uranium with negative results this area is thought worthy of careful examination.

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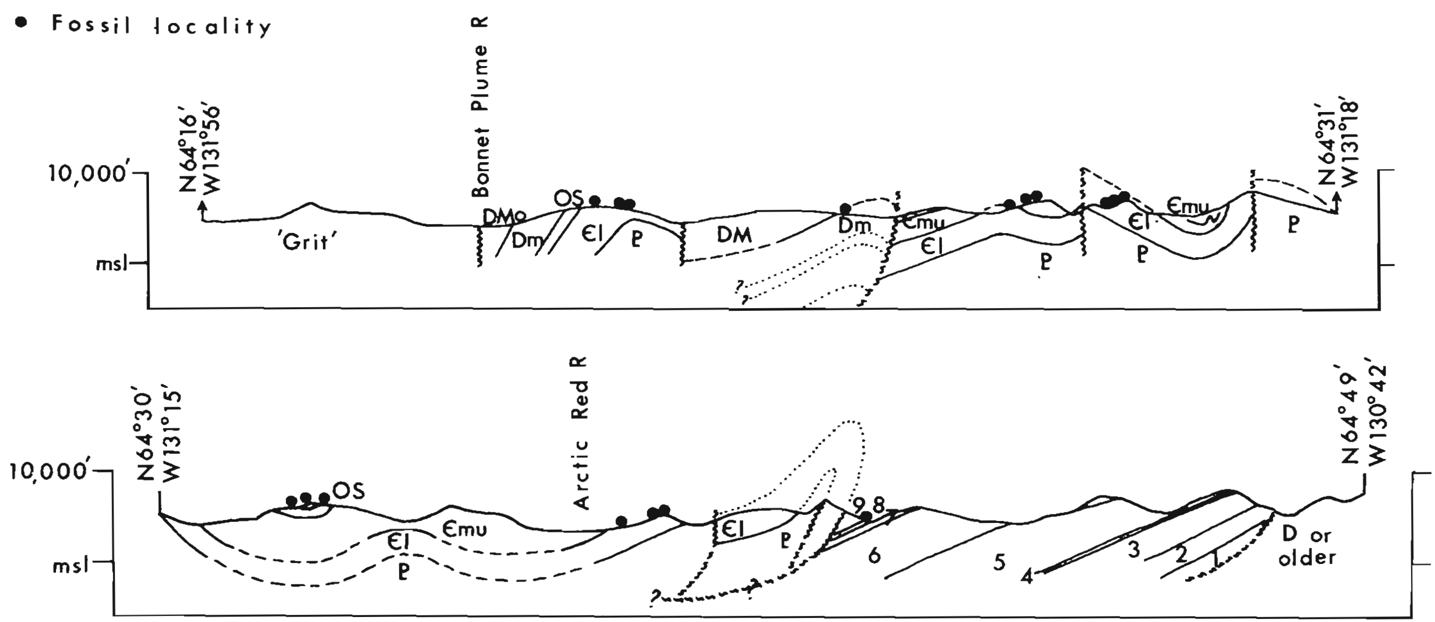

9	Recessive black shale	34*	DM	Recessive pyritic shale	34*
8	Fossiliferous grey dolomite	Headless ??	Dm	Thick-bedded light grey dolomite	
7	Brownish weathering dolomite	Sombre Arnica	OS	Whittaker Fm. and graptolitic shale	23 & 24*
6	Dark grey, thin-bedded, resistant dolomite	Landry	Єmu	Buff weathering wavy banded silty dolomite	18*
5	Yellowish weathering thick-bedded carbonate	17* ??	Єl	Resistant orange weathering dolomite	15
4	Massive white orthoquartzite	13a*	P	Resistant massive pink orthoquartzite	13a*
3	Orange weathering dolomitic sandstone	10*			
2	Brown weathering recessive shale	9*			
1	Orange weathering dolomitic sandstone	8*			

* Possible correlatives described by Gabrielse, H., Roddick, J.A. and Blusson, S. 1965: Flat River, Glacier Lake, and Wrigley Lake, District of Mackenzie and Yukon Territory; Geol. Surv.Can., Paper 64-52

Figure 1. Structure section of part of Bonnet Plume Lake map-area.

16. STRUCTURAL CROSS-SECTION, BONNET PLUME LAKE MAP-AREA, YUKON (106B)

Project 670009

D. J. Tempelman-Kluit

In preparation for Operation Stewart scheduled for the near future, a reconnaissance traverse was made from Bonnet Plume Lake to the northeast corner of Bonnet Plume Lake map-area. Oblique aerial colour photographs were taken of much of the project area.

Results of the traverse across Bonnet Plume Lake area are summarized in the structural cross-section in Figure 1.

17. LOWER CAMBRIAN STRATIGRAPHIC STUDIES IN THE McBRIDE AREA, BRITISH COLUMBIA (93H)

Project 670059

F. G. Young

The field study of the stratigraphy of the Lower Cambrian Gog and Cariboo groups in McBride map-area, begun in 1967, was completed. The work was mainly on the Gog Group in Rocky Mountains and complements that of the previous season which was concentrated on the Cariboo Group in Cariboo Mountains. Data have now been obtained across the full outcrop width of the sequence. Some time was devoted to an investigation of sedimentary features in the Gog Group in its type area in the Jasper-Lake Louise region.

Within the McNaughton Formation, the lowest unit of the Gog Group, several fluviodeltaic complexes have been recognized, but without further analysis of the data, their full significance, interrelationships, and correlation to units in the Cariboo Group are unknown. The impression that the McNaughton Formation is predominantly a thick succession of quartzite derives from restriction of previous mapping and stratigraphic studies to the east and southeast [1, 2]. This character is maintained in the most easterly exposures in Rocky Mountains in McBride map-area but toward the western Rockies the proportion of shale gradually increases in the uppermost two thirds. A prominent quartzite unit everywhere marks the basal third of the formation and is either in abrupt contact with Upper Miette Group shale or phyllite or lies above a basal unit of interbedded massive quartzite and shale.

The Mural Formation in the Rocky Mountains conformably overlies the McNaughton, and includes a prominent, thin, orthoquartzite at the base which is overlain by limy shale. The shale is overlain by massive limestone in the west, but grades directly into sandy dolomite in the east. The Mural Formation is the only unit that provides an obvious tie between the Cariboo and Gog groups, and thus it provides the foundation for more detailed correlations.

The Mahto Formation, the upper unit of the Gog Group, lies in gradational contact, above the Mural, and consists of cross-stratified, fine-grained quartzite commonly with shale interbeds in the east, but becomes finer grained with increasing shale in the west. Across the Rocky Mountain Trench in Cariboo Mountains siltstone and black shale lie above the Mural Formation.

No adjustments to the previously reported stratigraphic succession of the Cariboo Group[3, 4] in Cariboo Mountains have been necessary. Rhythmic sedimentation has been recognized in the Cariboo Group, especially within the Yankee Belle and Yanks Peak Formations. The rhythms occur in several orders of magnitude involving both carbonate and clastic rocks, and are not dissimilar to those described by J. D. Aitken[5] for the Middle and Upper Cambrian portions of the same sequence in the Rockies. Cyclic characteristics within the Gog Group, however, were recognizable only as periodic deltaic advances in the Mahto and upper McNaughton Formations. An attempt will be made to correlate units within the Cariboo Groups on the basis of sedimentary rhythms.

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ENGINEERING AND INDICATOR GEOLOGY

18. FURTHER NOTES ON THE MUNRO ESKER, ONTARIO

Project 620035

H.A. Lee

Three weeks were spent in the Matheson and Kirkland Lake region to complete studies of the Munro esker. Emphasis was placed on searching for a relationship between abundances of economic indicator elements and lithologies of clastics within the esker. Colorimetric and atomic absorption analyses were made for Pb, Zn, Cu, Ni, Co, and Ag from samples of the A_2 and B soil zones and as a channel sample from depth 0 to 4 feet in the massive gravelly sand stratum of the esker. Approximately a 60-mile length of the esker was sampled between Lake Abitibi at the north and Catherine Township at the south.

A concentration of gold particles occurs in the esker within Munro Township[1]. An additional piece of evidence characterizing this concentration is a new find of a gold mineralized block about 1 foot by 1 foot that assays 0.04 oz. Au/ton and 0.025 oz. Ag/ton. The block is composed of approximately 50 per cent very fine grained quartz and 50 per cent combined fine-grained potash feldspar and sericite and can be classified as a siliceous rhyolite. Pyrite occurs along numerous fractures in the rock and may be the source of some of the gold particles in the esker.

A concentration of pyrope garnet occurs in the esker within Gauthier Township[2]. Three kimberlite blocks were collected from this site and analyzed. Certain characteristics are now known which make it easier to recognize kimberlite blocks occurring with other clastics in esker material. The kimberlite is recognizable in esker material by its deconsolidated nature, retaining a primary structure characterized by combined fluidal texture of phlogopite and clear to pale yellow, fractured, glassy grains of olivine. Block surfaces are mixed grey to reddish buff, representing altered phlogopite and abundant iron oxides, respectively. Concentrates of heavy minerals from the blocks include the indicator minerals pyrope and a green clino-pyroxene; no diamonds were recognized.

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19. ENGINEERING GEOLOGY OF DAM SITES AND OTHER CONSTRUCTION PROJECTS, NORTHWESTERN ONTARIO (PARTS OF 42, 43, 52, 53)

Project 670038

E.B. Owen

Three dam sites, all on Albany River, were visited in order to provide geological advice to engineers of the Inland Waters Branch. These included Hat dam site (83°57', 51°18'), Chard dam site (84°54', 51°16') and Wabimeig dam site (85°33', 51°39'). These sites as well as Buffaloskin dam site, which is also on Albany River, are underlain by Paleozoic rocks. Bedrock cores from these sites were examined. Test borings at Attawapiskat dam site (86°18', 52°16') and Winisk dam site (87°20', 53°08') have not as yet been completed.

Bedrock at Hat dam site consists of grey arenaceous limestone and cherty limestone of the Straping River Formation. Core recovery was poor ranging from 10 to 54 per cent. Considerable groundwater under flowing-artesian conditions was encountered in the upper part of bedrock. At Chard dam site bedrock consists of interbedded, fine-grained, grey dolomite, grey siltstone and white sandstone of the Kenogami River Formation. About 50 per cent of the rock encountered in 5 borings consisted of siltstone. Core recovery ranged from 26 to 60 per cent.

At Wabimeig dam site bedrock consists almost entirely of fine-grained, grey limestone of the Severn River Formation. Core recovery ranged from 52 to 75 per cent. Bedrock at Buffaloskin dam site consists of fine-grained, white to grey sandstone. One boring at Buffaloskin site penetrated 103 feet of sandstone to the Precambrian surface. Core recovery at Buffaloskin dam site ranged from 25 to 52 per cent.

The extremely poor core recovery from the Paleozoic rocks underlying the four dam sites on Albany River prevented anything more than a general assessment of the engineering properties of these rocks. It is doubtful if any will provide satisfactory foundation material unless considerable remedial work is carried out. In places core fragments of extremely vuggy limestone and dolomite were recovered, suggesting that there are highly permeable beds in these rocks. A dense, impervious, basal till overlying bedrock may be useful as dyke material, but with this exception there is a shortage of construction materials at all the sites.

20. ENGINEERING GEOLOGY AND MAPPING, WELLAND CANAL (PARTS OF 30M, L)

Project 620052

E. B. Owen

Field work was concentrated on NTS sheets 30M/3b (Allanburg) and 30L/14g (Welland Junction) where excavations for the 8-mile-long Welland Canal By-Pass between Port Robinson and Port Colborne, Ontario are continuing. As of September 25, 1968 about 5 miles of the by-pass is being excavated. Within a year it is expected that work will be going on along its entire length and should be completed by 1972.

The materials exposed in the excavations were examined and compared with those described in the specifications supplied to the various contractors at the time of bidding the excavation and dyke construction contracts. In general the information provided the contractors by the St. Lawrence Seaway Authority has been found to be correct.

Test borings indicate that the thickness of the Quaternary deposits throughout the construction areas ranges from 90 to 125 feet. As the maximum depth of the excavations is about 65 feet a complete vertical section of the unconsolidated materials will not be exposed. Excavations to date have revealed soft, brownish grey, glaciolacustrine clayey silt with scattered varved clay zones overlying a soft, brown, clayey, silty till which in turn overlies a more dense, reddish brown, granular till. The surface of the lower till has a relief of about 15 feet. A discontinuous deposit of banded, clayey silt separating the two tills usually occurs in low spots in the surface of the lower till. Large, subrounded, striated boulders up to 6 feet in diameter and fragments of the lower till frequently occur in the lower part of the upper till.

Excavation techniques used by the various contractors presently employed on the Welland Canal By-Pass are similar. Scrapers are utilized where possible, but in very soft material, where traction is poor, drag lines are used.

Surface mapping of surficial deposits was confined to areas adjacent to the excavations. About one third of map-sheets 30M/3b and 30L/14g has been completed.

In conjunction with engineers of the St. Lawrence Seaway Authority deposits of potential filter material and rip-rap in the Niagara Peninsula were investigated. Tests on these materials are currently under-way in both the laboratories of the Authority and the Department of Public Works in Ottawa. Investigations by the Authority have determined that an average of 42 freeze-thaw cycles occur annually in the Welland Canal area. A discrepancy appears in the laboratory testing of rip-rap materials where rocks are reported to be breaking down after 275 cycles whereas similar rocks used during construction of the Third Welland Canal, some 60 years ago, are still in excellent condition.

GEOCHEMISTRY

21. GEOCHEMICAL STUDY, MANITOUWADGE, ONTARIO (42 F/4)

Project 670097

R. G. Garrett

As part of a general program to investigate systematically the application of geochemical prospecting methods in the environment of the Canadian Shield a three-month (June-August) field program was undertaken in the region of Manitouwadge, Ontario.

The field area covered the synformal structure of Archean rocks containing the known sulphide zones. The ore assemblage consists of pyrite, pyrrhotite and chalcopyrite, with lesser amounts of sphalerite and galena. The glacial history of the area is complex (see also D. R. Grant, this report). Near the known orebodies the till is of distant origin and highly calcareous. An earlier till of more local origin was recognized in only a few localities on the south slopes of major hills where pockets were protected during a readvance of the ice sheet from the north. In the surrounding country there is abundant evidence of glaciofluvial and lacustrine activity.

Tills, soils comprising humisols and podsols, and stream sediments were collected and Cu, Pb, and Zn determined in the -80 mesh fraction by colorimetry after a potassium pyrosulphate fusion. In addition, vegetation samples, spruce twigs and birch bark were collected over the Big Nama Creek Mines orebody for later study.

Anomalous levels of Cu, Pb, and Zn were observed in the soils and at the top of the till sheet over deposits at Geco Mine and Big Nama Creek Mine when the till thickness was less than 4 feet. Where the till thickness was greater than 4 feet, anomalies were not observed in either the soil or at the top of the till sheet. Detailed profile sampling over the Big Nama Creek Mines orebody indicated that anomalous levels are generally restricted to the bottom 2 feet of till for Cu, and bottom 3 feet for Zn. No down-ice dispersion of metal caused by mechanical transport was noted. The anomalies are hydromorphic and the highly calcareous nature of the till certainly restricts the dispersion pattern, less severely in the case of Zn due to the amphoteric nature of that element. The hydromorphic nature of the anomalies makes the dispersion patterns highly dependent on the groundwater regime and subcrop topography.

The stream sediment sampling and analysis revealed patterns of Cu distribution, and to a lesser extent Pb and Zn, which could be related to the major features of the bedrock geology and Pleistocene history. Stream sediments appear to be a successful exploration tool in areas of high relief in the central and eastern parts of the synform. However, to the west where relief is gentler and the area was probably once covered by glacial lakes, the results are not encouraging. A number of weakly anomalous zones were outlined by the survey but these were not followed up.

Any general conclusions as to the applicability of geochemistry as an exploration tool on the Canadian Shield would be premature as features of the work carried out are both encouraging and discouraging. One important point, however, is clear from this past work; a thorough knowledge of the Pleistocene history of any area is very necessary before correct sampling techniques and interpretation criteria can be devised.

22. GEOCHEMICAL STUDY OF BLACK SHALES AND ASSOCIATED SULPHIDE DEPOSITS, ONTARIO AND QUEBEC

Project 680021

A. Baumann

The purpose of this study is to determine whether the black shales in the eastern part of the Canadian Shield are important as low grade ore deposits. Other aspects to be investigated are the problems of the possible genetic relationship of these sediments to nearby ore deposits and the sedimentary processes and the environment leading to the formation of these shales in Precambrian time.

The field work carried out in June and July 1968 consisted of the sampling of black and dark grey shales, slates, and argillites in the Precambrian of Ontario and Quebec. Rocks with a visible sulphide content and a graphite content have been preferentially sampled. Approximately 800 samples were collected from 180 localities.

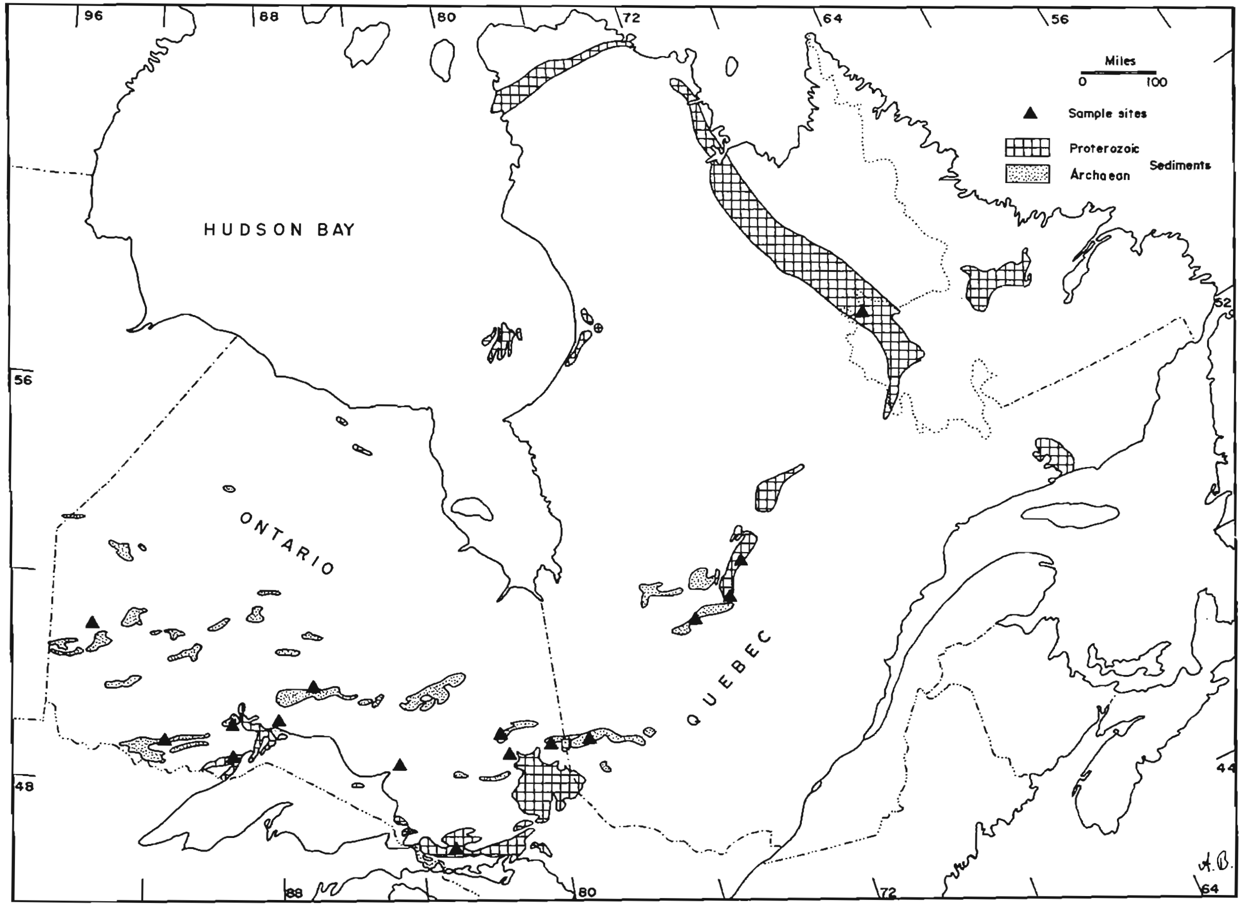

Figure 1. Map showing the Precambrian sediments in Ontario and Quebec and the main sample sites.

The main sampling locations (Fig. 1) for Precambrian fine-grained sediments and metasediments were:

in the Archean:

Lac des Iles area)	
Geralton area)	
Timmins area)	
Montreal River area)	Timiskaming
Larder Lake area)	
River Kenojevis area)	
Desmeloizes area)	
Michipicoten area)	
Atikokan area)	Keewatin
Red Lake area)	
Amos-Barraute area)	

in the Proterozoic:

Blind River area)	
Iron Bridge area)	Gowganda Formation
Maisonville area)	
Lakehead area	Rove and Gunflint formations
Bignell area	Chibougamau Series
Lake Albanel area	Mistassini Series
Schefferville area	Knob Lake Group (Attikamagen, Ruth and Menihey formations)

The majority of the 800 samples are surface samples. Diamond-drill core samples were collected when available. Field data cards have been prepared for a later computer analysis.

Antimony, arsenic, molybdenum, and tungsten have been determined by colorimetric methods, uranium by a fluorimetric method: 147 samples were chosen for a preliminary review; tungsten and uranium were not detectable (< 2 ppm) in these samples and thus were not determined in the remaining samples.

Cobalt, copper, lead, nickel and zinc are being determined by atomic absorption spectrometry. The data will be prepared for a statistical analysis.

23. DEVELOPMENT OF RADIOCHEMICAL EXPLORATION METHODS USING RADON, ONTARIO AND QUEBEC

Project 680028

Willy Dyck and J. C. Pelchat

Radon determinations in surface waters and soil gases made during the 1967 field season were encouraging enough to warrant the construction of an instrument which would permit in situ measurements of radon in soils as well as in waters for the investigation of the behaviour of naturally-occurring radon in more detail.

The instrument and procedure adopted for this season's work made possible the detection of both radon-222, normally referred to as radon, and radon-220, also known as thoron, in soils. In this discussion the two isotopes will be referred to as radon and thoron, respectively.

Current investigations were carried out in three different geological environments - Gatineau Hills, Quebec, Sudbury, and Elliot Lake, Ontario and consisted of detailed radon distribution studies in lakes and radon determinations in soil emanations in the respective areas.

Gatineau Hills

The high radon levels in Fortune and Kingsmere lakes in Gatineau Park, detected in the 1967 survey, are traceable to radioactive pegmatite dykes and weathered radioactive material associated with the dykes. These were traced by determining in detail the radon distribution in the lakes and measuring the radon emanating from the soil around the lakes and up the slopes. Large seasonal variations in radon concentrations (factors of two to four) were observed in individual lakes as well as in soil sampling sites, but patterns of highs and lows along traverses were roughly reproducible throughout the season.

Elliot Lake

In the Elliot Lake area the gamma ray intensity and radon-thoron emanations over a typical subcrop of uraniferous conglomerate was determined. This is shown in Figure 1. The overburden depth varies between five and fifteen feet. The three radon-thoron graphs represent three, successive, one minute counting intervals of a soil gas sample taken from a freshly made hole one foot in depth. The minute to minute decrease in the number of counts at most test sites is due to the prevalence of the short lived (54.5 sec) half life of thoron. The relatively larger minute to minute decrease in the number of counts at the lower concentrations indicates a relatively larger thoron content at these lower concentrations. The important factor to note is the activity ratio of approximately 15 for peak to background radon-thoron levels, whereas the gamma ray intensity ratio for the same soil stations is 3. Boulders and/or outcrop gamma ray intensities increase the peak to background ratio across the deposit to ten.

Determinations of radon in water were confined to a detailed study of three small lakes (approximately 0.1 square mile each) in the southern end of the Elliot Lake uranium belt, and to several sections of Ten Mile Lake. Two of the lakes had received contaminated water several years ago via a water supply line. Radon values varied from about 10 to 400 pc/l and clearly indicated the direction of surficial as well as subsurface flow. The other small lake, not in the main drainage channel, showed radon concentrations barely exceeding the sensitivity level of the instrument. Although some shore water samples from Ten Mile Lake contained easily detectable radon levels (5-15 picocuries per litre (pc/l)) and the creek deltas concentrations of up to 75 pc/l, the radon levels 50 feet offshore seldom exceeded 4 pc/l. Generally speaking, the radon abundance in uncontaminated lakes showed the following order: surface shore > offshore bottom > offshore surface.

Sudbury

In order better to evaluate the results obtained in the two areas noted above and to obtain a measure of the radon levels in geological environments without uranium deposits, a number of tests were carried out in the eastern quarter of the Sudbury Eruptive. Soil emanation determinations were carried out across outcropping and buried nickel-copper deposits, contact zones between norite and granite, norite and quartz diorite, and norite and greenstone, and across a stretch of gravel. Except for the gravel, soil

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Figure 1.

A. Geological cross-section, Elliot Lake area.

B. Surface gamma ray activity at radon-thoron test sites.

C. Radon-thoron alpha activity of soil gas samples from freshly made holes, one foot deep. Dots indicate first minute-, stars second minute-, and triangles third minute counts. The dotted line indicates average first minute counts obtained from emanations from gravel sites in the Sudbury basin.

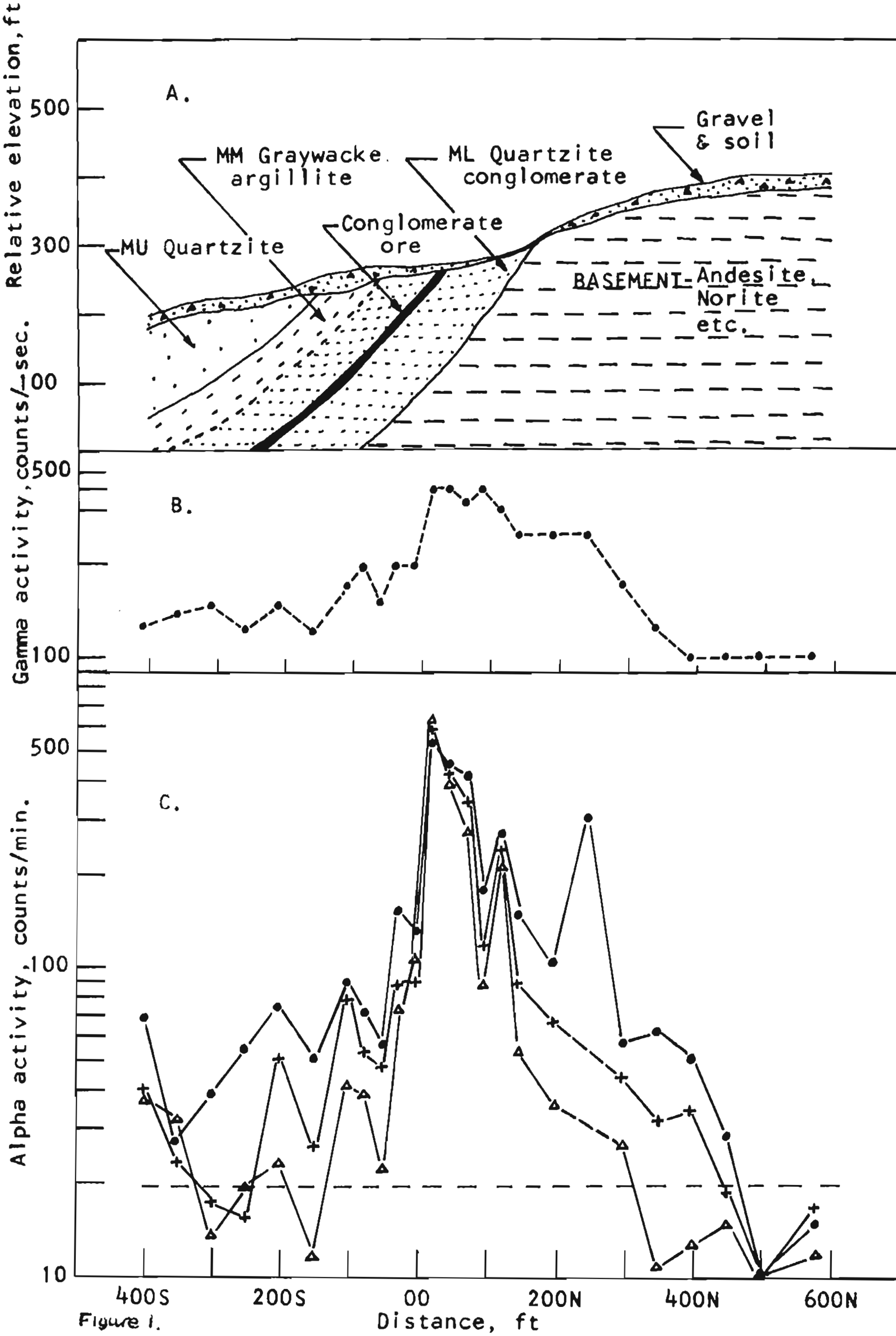
A.
Gravel
& soil
MM Graywacke
argillite
ML Quartzite
conglomerate
Conglomerate
ore
MU Quartzite
BASEMENT-Andesite,
Norite
etc.
Relative elevation, ft
500
300
100
B.
Gamma activity, counts/sec.
500
100
C.
Alpha activity, counts/min.
500
100
10
400S
200S
00
200N
400N
600N
Distance, ft

Figure 1.

thicknesses were such that it was difficult to find enough soil in which to make a hole one foot deep. Although radon and thoron were present in detectable quantities in soils over all formations, with thoron predominating, no significant variations in levels could be detected between rock formations. Only the gravel gave somewhat higher readings. The average first minute count of emanations from 16 gravel sites was 21. This average is indicated by the dotted line in the figure below. The second and third minute averages were roughly 10 and 7 counts, respectively.

Surface water radon concentrations from about 130 easily accessible sample sites, distributed over 200 square miles of the eastern quarter of the Sudbury Eruptive, ranged from 0 to 112 pc/l. The higher values can be correlated roughly with running water (creeks) and/or red, coarse-grained granite. The highest concentration was found in a small nameless beaver lake located 5 miles north of Capreol. The range and average radon concentration of 37 samples taken from sites along the shore and the middle surface and bottom were 448 to 17 pc/l and 52 pc/l, respectively. Noticeably higher radon values in the northern or inflow end of the lake suggest that the radioactive matter was carried into the lake. Except for one small granite outcrop near the lake, which gave a gamma ray activity of about 10 microroentgens per hour, or twice that of most granites in the area, no source for the comparatively high radon level in the water was evident.

24. DEVELOPMENT OF BIOGEOCHEMICAL EXPLORATION METHODS FOR METALLIC MINERAL DEPOSITS FOR WINTER USE, COBALT, ONTARIO (31 M/5 AND 12)

Project 680051

E. H. W. Hornbrook

The effectiveness of biogeochemical exploration methods for detecting the silver vein deposits at Silverfields Mining Corp. Ltd., Hi Ho Silver Mines, Ltd., and Agnico Silver Mines Ltd., in the Cobalt, Ontario area, was evaluated during the summer of 1968.

As in previous summers, all operational phases of exploration were carried out simultaneously. These included: the operation, by a three-man crew, of the spectrographic analytical facilities housed in two mobile trailer laboratories; the operation, by a two-man crew, of the atomic absorption analytical facilities set up in laboratories of the Northern Institute of Applied Arts and Technology at Haileybury; the collection, by a three-man crew, of soil and vegetation samples; the making, by a two-man crew (under the direction of G. D. Hobson), of shallow seismic investigations to determine the depth of surficial material along profiles.

Approximately 2,000 samples of soil and vegetation were collected from 560 stations, and were prepared and analyzed during two and one half months. Samples comprised B horizon and A horizon material, and bark, twig and leaf organs of trembling aspen and white birch.

As a result of a preliminary examination of about 15,000 single element determinations that have been compiled to date, the following observations are warranted: the A horizon concentrates silver and associated elements relative to the B horizon and it is a more useful horizon to examine for geochemical exploration. Certain elements, which are concentrated in specific tree organs, show anomalous amounts over silver-bearing veins. Where surficial material is less than 10 feet thick the anomalous amounts are probably related to individual vein systems. For most elements, the lowest concentrations found in tree organs collected near a silver deposit are substantially greater than those found in background areas remote from silver mineralization. Therefore, biogeochemical exploration methods may be an effective regional exploration method in the Cobalt area.

25. THE GEOCHEMICAL COMPOSITION OF ULTRAMAFIC ROCKS AND ITS RELATION TO THEIR CONTAINED MINERAL DEPOSITS, MANITOBA, ONTARIO, QUEBEC

Project 680061

Gordon Siddeley

An investigation is being made of the possibility of using rock geochemistry as an indicator of the ore-bearing potential of ultramafic bodies, and thus as a guide in mineral exploration.

Approximately 730 samples have been collected from a field area between Lynn Lake (Manitoba) and Eastern Townships (Quebec). They consist of dunites, peridorites and pyroxenites, with a few talc-chlorite schists, hornblendites, etc. During the summer, samples were sent to the Ottawa laboratories for the determination of major and trace elements by chemical and spectrographic methods.

Fifty sampling localities are represented. Fourteen of these are ore-bearing or with good ore potential, twenty-two are considered barren (from earlier exploration) and fourteen have unknown ore-potential. The chemical data (as yet incomplete) will be used to compare the ore-associated type with the barren type. If significant differences are determined, then the group with unknown ore-potential will be examined, and on the basis of its geochemistry, assigned to either the potentially ore-bearing or barren group. The chemical data will also contribute to a geochemical census of Canadian ultramafic rocks.

Geological investigations have revealed a variability in ore occurrences associated with ultramafics. This may be attributed to factors such as structural control, magmatic segregation, or wall-rock reaction. Some ores have clear genetic affinity with the ultramafic intrusion (at Werner Lake and Moak Lake), whereas others appear to have nothing more than spatial association (as at Lynn Lake and Chibougamau).

26. DEVELOPMENT OF GEOCHEMICAL EXPLORATION METHODS FOR URANIUM, BANCROFT AND ELLIOT LAKE, ONTARIO (31C, 31D, 31E, 31F; 41J)

Project 670030

A. Y. Smith

Following last year's feasibility studies on the use of radon-222 in surface water as a reconnaissance tool in uranium exploration, two programs were carried out to test this technique on a regional scale. An area of 1, 650 square miles in the Bancroft district was covered with both lake and stream water samples at a density of approximately one sample per two square miles. In the Elliot Lake region an area of 560 square miles was covered with lake water samples only, at a density of approximately 1.5 samples per square mile. The sample collection was made by means of motor vehicles, small fixed-wing aircraft and helicopters. Water temperature, air temperature, barometric pressure, pH of the water, water turbulence and other descriptive factors were recorded for each sample site. Determination of radon-222 was carried out within 24 hours of collection at centrally located field laboratories in each area. Uranium determinations on all Bancroft and Elliot Lake water samples were done fluorimetrically in a mobile field laboratory located at Elliot Lake.

Although the assessment of the large amount of data collected is not yet complete, some preliminary remarks are warranted. As was found last year, stream and creek waters contain a higher level of radon in the Bancroft region than do lake and pond waters. In the Bancroft region the method is apparently successful in outlining areas of increased uranium potential. At Elliot Lake the radon levels are markedly lower than at

Bancroft. The reasons for this may be that: (1) only lake waters were collected at Elliot Lake and would be expected to have a lower level of radon; (2) much of the most suitable drainage at Elliot Lake is contaminated with radium and radon from mine wastes and had therefore to be excluded; (3) many of the smaller lakes and ponds at Elliot Lake are apparently not in contact with the main water-table but reflect local, perched water-tables and thus do not receive supplies of radium and radon from groundwater sources. Undoubtedly many other factors are at work in the observed distribution of radon in surface waters. The method will require careful orientation studies prior to its application to an area. An understanding of many facets of the surficial landscape and groundwater regime will be required for correct interpretation of field data. Such, however, is the case with any geochemical method.

In southern New Brunswick and Nova Scotia, terrestrial sediments of Carboniferous age have been considered to have some uranium potential because of their similarity to uraniferous sediments on the Colorado Plateau. Samples from stream sediment surveys made in 1958 to 1961 were available, and it was decided to make a preliminary assessment of the area by analyzing these samples for uranium. Although this work is not yet completed, initial results from the Moncton Basin area of southern New Brunswick show an increased uranium content over certain of the Carboniferous formations, notably the Hillsborough and parts of the Albert formations. Also, the results clearly show no association of uranium with known copper sulphide deposits of the red bed type, such as the Dorchester Mine. It is too soon to tell whether economic concentrations of uranium are indicated, but investigation has already demonstrated the value of this approach.

GEOMORPHOLOGY AND SEDIMENTOLOGY

27. GEOMORPHOLOGICAL INVESTIGATIONS, GENERATOR LAKE, BAFFIN ISLAND, DISTRICT OF FRANKLIN (PARTS OF 27C, 37D)

Project 680040

D.M. Barnett

Geomorphological investigations of Generator Lake, Baffin Island were continued in an attempt to develop a model for landforms associated with a proglacial lake in a 'cold ice' environment.

Present sub-lacustrine features were detected by echo-sounding profiles constructed from several hundred spot readings. A series of 19 moraines is indicated in a test profile in the older northeastern part of the lake basin. An experimental attempt to determine sublacustrine vertical profiles of the cliffs of the ice dam was partially successful but further equipment modification is necessary.

Boulder dimension data were gathered to assess the process of rounding in the present littoral zone and also differences along the abandoned former lake shoreline. The method appears adequate for detecting the effects of present processes.

Several samples of detrital vegetation were collected from deltas developed in the former lake which when dated by the carbon-14 method will yield not only dates for the evolution of Generator Lake, but a cross-check on the accuracy of lichenometrical dating of features in the lake basin. Further lichen data were collected to supplement the findings outlined earlier[1].

Repetition of historical photographs indicates a considerable change in both the position and morphology of the calving ice cliffs. Net retreat and decrease in cliffing is apparent.

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[1] Barnett, D.M.: Development, landforms and chronology of Generator Lake, Baffin Island, N.W.T.; Canada, Dept. Energy, Mines and Resources, Geog. Bull., vol. 9, No. 3, pp. 169-188 (1967).

28. MORPHOTECTONIC OBSERVATIONS ALONG CHIN COULEE, ALBERTA (72E; PARTS OF 72L, 82I, 82H)

Project 680097

M. J. J. Bik

Chin Coulee, one of several deep valleys in southern Alberta that have previously been interpreted as glacial meltwater channels[1, 2], extends from Chin (tp. 9, rge. 19) to Murray Lake (tp. 9, rge. 8). Its deepest segment is up to approximately 1 mile wide and 250 feet deep.

The presence of several terraces along the coulee indicates that the valley was cut in several stages. The largest and most continuous terrace occurs from 20 to 50 feet below the adjoining till or lacustrine plains. Though the current direction inferred from foreset beds exposed in gravel pits and from the orientation of disc-shaped pebbles and cobbles was to the east during the formation of this terrace, its present gradient is reversed at at least two locations between Nemiscam and Chin; the gradient of the channel floor shows similar reversions.

From north of Wrentham (sec. 29, tp. 7, rge. 16) the principal terrace descends to the west from approximately 2, 975 feet a.s.l. to approximately 2, 800 feet a.s.l. south of Chin (sec. 13, tp. 9, rge. 19). From the dam at sec. 27, tp. 8, rge. 18 (to the north of the Lakeside Colony) the channel floor descends to the west from 2, 800 feet a.s.l. to 2, 770 feet a.s.l. near Chin (sec. 28, tp. 6, rge. 11).

From north of Foremost (Lsd. 7, sec. 28, tp. 6, rge. 11) the channel floor gradient descends to the west from 2, 700 feet a.s.l. to 2, 640 feet a.s.l. at Lsd. 12, sec. 27, tp. 6, rge. 12, a distance of 5 miles. Along this valley segment, the principal terrace descends from approximately 2, 890 feet a.s.l. to approximately 2, 850 feet a.s.l., also to the west.

Earlier work on the origin of prairie mounds [3, 4, 5], many of which occur in this area, concluded that there was a genetic relation between the shorelines of proglacial lakes and this landform. Elevation data derived from prairie mound occurrences along Chin Coulee would, on the basis of this deduced relationship, indicate the maximum level of proglacial inundation following the last major glacial episode. The elevation data derived from prairie mounds correlate qualitatively and quantitatively with the warping of the channel and terrace gradients found along Chin Coulee between Chin and Nemiscam.

Radiocarbon dating of glacial events in this area suggest that warping occurred during the last 20, 000 years B.P.

[1]Stalker, A.M.: Surficial geology, Lethbridge (east half), Alberta; Geol. Surv. Can., Map 41-1962 (1962).

[2]Westgate, J.A.: Surficial Geology of the Foremost-Cypress Hills area, Alberta; Research Council Alberta, Bull. 22 (1968).

[3]Bik, M.J.J.: On the periglacial origin of prairie mounds; North Dakota Geol. Surv., Misc. Ser. No. 30, pp. 83-94 (1967).

[4]Bik, M.J.J.: Morphoclimatic observations on prairie mounds; Z. für Geomorph., N.E., Bd. 12, pp. 408-469 (1968).

[5]Bik, M.J.J.: The origin and age of the prairie mounds of southern Alberta, Canada; Biul. Perygl., vol. 19 (in press).

29. EKALUGAD OUTWASH PLAIN, BAFFIN ISLAND, DISTRICT OF FRANKLIN (PART OF 27B)

Project 680042

M. Church

The study of recent alluvial deposits at the head of Sarvalik Fiord, initiated in 1966*, was completed in 1968. Three aspects of study were pursued: the morphology of the deposits, the erosion and deposition of sediment by the rivers, and the general geology and climate of the area.

Electrical resistivity measurements were made to determine the total depth of alluvium. Studies were carried out of the sedimentary materials in the river channels, and observations of the evolution of particular channel deposits initiated in 1966, were completed. Routine stream gauging and suspended sediment transport sampling were continued in the three major rivers.

An experimental program of direct bedload sediment transport observations was attempted using a box-type sampler. Though the equipment apparently worked well, few observations were gained because of the persistently low streamflows all season.

*The project was initiated in the former Geographical Branch, Department of Energy, Mines and Resources, and was transferred to the Geological Survey in 1968.

A bathymetric survey, bottom sediment sampling, and limited water temperature and density observations were carried out in Tasiujaq Cove at the end of the alluvial plain. Stratigraphic studies were made on exposures of a former major alluvial plain, now a terrace, in order to draw comparisons between contemporary deposits and those of earlier post-glacial time.

The 1968 season was continuously cool, so that very little runoff occurred, and substantially complete snow cover persisted above 900 metres even in late August. Hence there were no major floods and sediment transport was very minor in this season, compared with those of 1966 and 1967.

Laboratory analysis of the field results is presently in progress.

30. SAND DUNE STUDIES IN SOUTHWESTERN SASKATCHEWAN (72K)

Project 670035

P.P. David

Field work in the Great Sand Hills and surrounding smaller dune areas was completed during the 1968 field season. The stratigraphy of the eolian and underlying sediments in the Great Sand Hills was determined from auger holes drilled at 34 localities. The eolian sand, always oxidized and of variable grain-size, is generally less than 15 feet thick in inter-dune areas. In the southwest this sand is underlain by unoxidized medium- to coarse-grained fluvioglacial sand, in the north by fine-grained sand and lacustrine silt and clay and in the east by silt. Everywhere till underlies the stratified deposits, and locally it occurs directly below dune sand.

The mode and rate of mass-transfer of sand over an active dune was studied by means of fixed-surveying laths laid out along traverses across the dune. A standard M. S. C. Anemometer Type 45B, on loan from the Meteorological Branch, Department of Transport, was installed at a ranch near the dune and was used to study the wind regime. From these studies it is concluded that (1) movement of sand is accomplished by the formation and maintenance of resistance-forms of various size categories, e.g. dunes, sand rises, and ripple ridges; (2) the rate of migration of a resistance form is inversely related to its size category; and (3) the rate of mass transfer is affected by the physical conditions of the sand.

Dunes that are presently active are being gradually stabilized by vegetation. The rate of stabilization depends on the rate of migration of the dunes. The complexity of the vegetational cover on a dune appears to be related to the length of time since its stabilization. A study of stabilized areas burnt recently by prairie fires revealed that fire cannot destroy the stabilizing vegetation unless the climate is sufficiently dry.

Mounds of sand as high as 10 feet, more or less circular in plan, and symmetrical in transverse profiles were observed at several localities across the Sand Hills. Some of the mounds that were found near places of known former Indian activities were presumed to have been built by Indians.

31. MASS WASTING FORMS AND PROCESSES IN A MOUNTAIN ENVIRONMENT, YUKON TERRITORY (106D, 116B, C (east half))

Project 670033

J. T. Gray

Investigation of talus cones and pro-talus rock glaciers in the Bear River valley in the Wernecke Mountains (Nash Creek map-area) and in Tombstone region in the Ogilvie Mountains (Dawson map-area) was continued in 1968 with the aim of determining processes involved in their development and also of establishing their rate of accumulation.

A sampling program on ten talus cones was completed. This program was designed to assess the influence of the lithology on the slope angle, through its control of texture and form of the talus material. The importance of avalanche modification of the slopes was also ascertained by examination of the orientation and lichen cover of the particles. Laboratory work involving the simulation of cones is being conducted under a variety of controlled conditions and is designed to complement the field work already completed.

Marked boulders on twelve talus cones and four rock glaciers were re-surveyed. Movement in the order of a few centimetres was observed for many of the points on the rock glaciers, but few of the points surveyed on talus have moved measurably. Markers installed on solifluction forms during 1967 were also re-surveyed.

In order to determine the rate of erosion of rock slopes, volume estimates were made for fifteen talus cones in the Bear River valley and for five cones in the Tombstone region, in situations where active glaciers have almost certainly removed the pre-existing debris during the last major regional glaciation. In these situations a reasonably accurate time span for the accumulation of the talus can be estimated and a mean rate of accumulation can be calculated, thus providing a mean rate of erosion from the rock-wall above.

Short-term rates of rockfall accumulation will be determined by measuring debris accumulated on nets emplaced during the 1968 season. Current plans call for measurement of the accumulated debris after the snow melt in 1969 and also at the end of the summer season. The nets were anchored on two talus cones down the centre line of the cone from the gully zone at the top to the base. Locations are: (1) Bear River valley below a slope consisting of thin-bedded dolomite, (2) Tombstone region below a slope consisting of massively jointed syenite and quartz monzonite.

32. QUATERNARY GEOLOGY OF THE GREAT LAKES

Projects 650037, 680055

C. F. M. Lewis

Uplift Studies, Lake Huron Basin

Field work in 1968 was directed chiefly to instrumental measurement of raised beaches along the Lake Huron coast from Sarnia to Manitoulin Island. Most work was concentrated on well-developed shore features of Nipissing and Algoma(?) ages in the Sarnia, Kettle Point, and Thedford Marsh areas. Large pelecypod shells and driftwood were noted and recovered from beach materials of this region. In situ peat sediments beneath transgressive Nipissing beach gravels were sampled for radiocarbon dating. Observations during reconnaissance flights by chartered aircraft of the shore zone confirmed the absence of raised beaches between Grand Bend and Kincardine and located beaches for detailed study on Bruce Penninsula and adjacent islands.

Survey of a distinct shore bluff encircling the present Lake Mindemoya basin on Manitoulin Island showed this beach to be slightly higher than the classic Nipissing beach in the area, but lower than previously recognized beaches of the post-Algonquin series, and with a slope intermediate between that of the Nipissing and Algonquin beaches. Radiocarbon analysis of associated organic materials may establish this beach as a new Algonquin-Stanley transition phase or as a previously unrecognized maximum phase of the Nipissing transgression.

Sedimentological and Paleolimnological Studies

Research of the regional sediment distribution and post-glacial stratigraphic succession were continued in Lake Ontario and Lake Erie. These studies are closely integrated with related projects of the limnogeology group at the Canada Centre for Inland Waters.

Piston cores, recovered from western Lake Erie, confirmed the presence of buried organic Early Lake Erie sediments and provide material for ecological and radiocarbon analyses. Although buried peat deposits are extensive they were found to be more variable in thickness than previously believed. In addition, long mud cores were collected from each basin of the lake.

Late in August the writer participated in a joint Ohio Geological Survey-Geological Survey of Canada seismic reflection survey of bedrock topography and overburden thickness in the western basin of Lake Erie. The survey is described elsewhere in this publication by G.D. Hobson.

A major coring and echo sounding program in Lake Ontario yielded piston cores up to 60 feet in length from representative areas of mud throughout the lake. The new Departmental vessel C.S.S. Limnos proved to be an ideal platform for these operations. A variety of shallow-water environments were indicated at depth beneath present deep-water silty clay sediments: a mud-buried gravel ridge 250 feet below water level in western Lake Ontario; peat deposits in large embayments such as Henderson Bay, Sodus Bay and Hamilton Harbour; and erosion surfaces on glacial lake clays in eastern Lake Ontario. All of these paleoenvironments are believed to relate to the late-glacial low-level Admiralty phase or to subsequent phases of a rising Lake Ontario. Following X-radiographic, sedimentological, geochemical and paleoecological analysis a stratigraphic interpretation of Lake Ontario's sediments will be attempted. Dr. J.H. McAndrews, Royal Ontario Museum Toronto, is studying modern and ancient pollen distribution in these Lake Ontario deposits.

33. THE DIVISION OF DELTA LAKES, MACKENZIE DELTA, DISTRICT OF MACKENZIE (PART OF 107B)

Project 680046

C.P. Lewis

The objectives of this project are to determine the mechanisms and stages of development involved in the division of delta lakes by reversing-flow channels. Field operations in 1968 were concentrated on one lake-channel system located on the east side of the Mackenzie Delta, about 50 km northwest of Inuvik (107 B/11 (East Half)). Periodic observations were made on other systems in the immediate area and several longer trips were made by boat and plane to the seaward part of the delta.

Daily observations of water stage, turbidity and temperature were made at several locations in the lake-channel system selected for detailed analysis. Standard meteorological data were also collected. Irregular determinations of discharge in the reversing-flow channel were made. In addition to process studies of this nature, extensive survey and sediment sampling programs were initiated to provide information on the morphometry and morphology of existing forms.

The major conclusion which can be drawn without further analysis of the field data is that almost all of the annual sediment input into the lakes occurs during spring flooding. During this period, water stage in the reversing-flow channel rose over 4 m, inflow velocities reached 1 m/sec., and from 2 to 7 cm of silt and clay were deposited on the levees of the lake delta. For the rest of the summer, flow direction in the channel was primarily out of the lake. The few flow reversals which did occur were of short duration and added little sediment to that brought in during flood. The summer of 1968 was unusual in that an abnormally low number of reversals occurred. However, data collected in 1967, when there were many more periods of inflow, support the conclusion that the quantity of sediment added to the lakes by summer flow reversals is very small in comparison to that brought in during spring flood.

34. GEOMORPHIC PROCESSES, MACKENZIE VALLEY-ARCTIC COAST, DISTRICT OF MACKENZIE

Project 680047

J.R. Mackay

During June, a boat trip was made between Fort Providence (mile 50) on the Mackenzie River and Inuvik. Between mile 148 and mile 208 (Fort Simpson) measurements were made on the rate of movement of ice-shoved boulder pavements which had been marked in previous years.

The rate of mixing of the Liard-Mackenzie waters was studied downstream from their confluence at mile 208. Water samples were collected, across the river, at about 30-mile intervals from mile 211 to mile 503. Eight samples were collected at each cross-section and chemical analyses were done by the Inland Waters Branch. For a distance of 300 miles, the Mackenzie and Liard waters are distinguishable upon the basis of each of the five types of data obtained: viz, temperature, transparency, turbidity, sodium and chloride content.

Ten days were spent with Dr. W.H. Mathews (University of British Columbia) in a field investigation of the glacial and postglacial history of the Fort Good Hope area of the Mackenzie River. Postglacial water levels were measured upstream and downstream from 'The Ramparts'; a study was made of the abandoned Rampart Falls; and specimens collected for radiocarbon dating. The Hare Indian River follows an old interglacial (?) course of the Mackenzie River.

Pleistocene sections were measured between Fort Good Hope and the Mackenzie Delta.

Permafrost studies comprised temperature measurements in a 2,000 foot hole near Tununuk, N.W.T. (107C). Although ground temperatures have not reached equilibrium following the 1966 drilling operation, a depth of about 1,200 feet for permafrost is presently indicated (work being done in collaboration with Dr. A.M. Jessop, Observatories Branch).

During the winter of 1967-68, about half of the 110 ice-wedges under observation on Garry Island cracked, probably in February. Cracking ceased in early March. The differential summer-winter expansion-contraction of polygons, across the ice-wedges, averages less than 0.1 inch. A geophone, breaking temperature cables stretched across ice-wedges, and ground temperature cables have been installed and attached to recorders for winter observations of ice-wedge cracking and ground deformation.

At Paulatuk measurements were made on wind abraded glacial erratics in a coastal area with strong katabatic winds. Small and large glacial erratics show, statistically, a shorter downwind dimension than a cross-wind dimension. The difference may be attributed to postglacial rock abrasion and/or rotation. The mean slopes of faceted boulders vary, statistically, according to rock type with limestones being the lowest, granites the highest. Four totalizing anemometers have been installed to measure the run-of-the-wind and vertical velocity profile. Equipment has been emplaced to measure winter abrasion by sand and snow.

Following the forest and tundra fire in the Inuvik area in August, 1968, several plots were marked in burnt and unburnt areas in order to record geomorphic and permafrost changes.

35. ESKER GEOLOGY, DISTRICT OF KEEWATIN

Project 660030

B.C. McDonald

The second phase of a continuing program to study the sedimentology and morphology of eskers comprised 6 weeks of field work in the Baker Lake area, District of Keewatin[1]. Three weeks were spent about 100 miles southeast of Baker Lake, in an area southeast of the Keewatin ice divide and below the limit of the Tyrrell Sea, and three weeks were spent about 100 miles northwest of Baker Lake, in an area northwest of the ice divide and largely above the limit of postglacial marine inundation. Daily use was made of a Cessna 180 aircraft on pontoons.

Primary esker morphology has been modified by several geomorphic processes which have been active subsequent to esker formation. These include: (1) beach formation, wave-washing, and the sorting and re-deposition that accompanied subsequent glacial-lake or marine episodes; (2) solifluction; (3) frost-heaving and frost-cracking; (4) slumping; and (5) eolian activity. The influence of these processes greatly hinders surface-sampling for meaningful grain-size-variation studies, and it prevents reliable consideration of minor topographic variations as representing esker phenomena.

The major variations in esker morphology seem to be related to the deglacial environment. Eskers deposited at altitudes higher than adjacent bodies of standing water are characterized by: (1) very abrupt topography with numerous sharp kettles; and (2) evidence of stream activity on and/or adjacent to the esker ridge. Such evidence includes trains of outwash sand and gravel flanking and partially burying the esker, abandoned stream channels incised into and across esker segments, stream-eroded till bluffs bordering the entire glaciofluvial complex, and deep meltwater channels in nearby bedrock. Broad, flat crests of esker ridges, elongate marginal kettles, and the occurrence of outwash and stream-cut till features downcurrent from present water divides are further accepted as indications that at least the latest phases of esker formation were subaerial. Eskers that formed where either glacial lakes or the sea abutted the ice-front are characterized by: (1) a lack of associated features related to stream activity; (2) occasional broadening and fining into esker-delta facies; and (3) beaches, bars, or boulder lags that resulted from washing. This latter characteristic is most pronounced where the sea, rather than a glacial lake, was involved because modification of the esker was continued longer by a larger water body, and because the drop in relative sea level was gradual rather than abrupt. As a result of this washing, the topography of eskers formed below sea level is commonly greatly subdued, with no kettles evident and with extensive beach and boulder-lag development. The peculiar 'beaded' eskers of southeastern District of Keewatin may owe their topographic expression to this subsequent washing rather than to primary episodic deposition.

Two sizes of pebbles, 1/4-1/2 inch and 1/2-1 inch, were sampled at regular intervals on the crests of some esker segments to study characteristics of sediment transport. Early results indicate an abnormally high energy environment at the confluence of two esker streams, resulting in the abrupt decrease in abundance of less resistant rock types. Also, a high rate of attrition in esker streams may be the cause of a higher proportion of resistant clasts in esker sediments than in the adjacent till.

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GEOPHYSICS

36. AUDIO FREQUENCY STUDIES, OTTAWA, ONTARIO (PARTS OF 31G)

Project 620056

R.H. Ahrens

The purpose of this project is to study the frequency dispersion effects with frequency of in-phase and quadrature measurements of rocks and soils in the field. The design of the equipment has been completed and field tested. The major problem to be overcome is isolation of the receiver grounding from the transmitter.

37. D.C. RESISTIVITY, OTTAWA-HAWKESBURY, ONTARIO (31G)

Project 670062

P. Andrieux

An International Travelall was outfitted with D.C. and new McPhar Resistivity System Model R201/2/3 and reels. The first two or three weeks were spent in familiarizing the crew with the equipment and checking the accuracy of the receivers. Several soundings were made in the Leitrim and South Gloucester areas and in the Luskville area in the Gatineau. The Schlumberger array was used in all soundings.

During the first week in June, operations commenced in the Alfred area. A summary of the number of soundings is as follows:

Location	No. of electrical soundings
Alfred	61
McCrimmon	3
Merivale Road	8
South Gloucester	4
Gatineau	3
Miscellaneous	10

The latter part of the season was spent on the compilation and interpretation of the data.

38. A GRENVILLE FRONT MAGNETIC ANOMALY MEGISCANE LAKE AREA, QUEBEC (PART OF 32B (West Half) and 32C (East Half)

Project 680095

W. Charbonneau

Aeromagnetic compilations of Federal-Provincial maps[1, 2] in west-central Quebec reveal the presence of an extremely interesting magnetic anomaly. This anomaly, which centres on 48° 30'N. and 75° 45'W. is interesting from three main standpoints:

1. Areally this large anomaly extends nearly fifty miles in a northeast direction and averages some ten miles in width.
2. It is an intense anomaly, for such a large feature, with a maximum amplitude of approximately 2, 000 gammas above background values.
3. The anomaly is located in an extremely interesting geological environment, in that the presently accepted position of the Grenville-Superior structural province boundary[3] passes through it in a northeast direction.

Reconnaissance geological mapping at a scale of one inch to three miles had previously been carried out over that portion of the anomaly which lies between longitudes 75° 30' and 76° 00'W.[4]. Those portions of the anomaly which extend beyond these longitudes to the northeast and the southwest lie in unmapped terrain. The reconnaissance mapping defined only a broad-sweeping contact between granite gneiss without garnet to the north and banded gneiss with garnet to the south. This contact cuts obliquely across magnetic trends in the area. The presently accepted position of the Grenville-Superior front is keyed to the above-mentioned contact being extrapolated through the area from Haig Township to the southwest[5]. The banded gneiss unit was not subdivided at that time (1935) and only a minimal amount of foliation and other bedrock structural information was presented. Although their mapped relationships were not shown, mention was made of the occurrence of amphibolites and gabbro-diorite bodies within the composite banded gneiss unit south of the above regional contact[4]. Thus existing mapping in the area while not establishing contacts of lithologic units which could explain the anomaly does mention the occurrence of rocks within a composite banded gneiss unit which could possibly explain it.

<u>Field Work</u> Two months field work during June, July and early August was carried out on the anomaly by the author with two main objectives in mind:

1. To map the geology in the anomalous zone.

2. To run some ground magnetic profiles over the magnetic belt and to collect a good areal distribution of representative rock samples for future magnetic susceptibility measurements and petrological work. The ultimate aim of this second objective was to establish definitely whether the anomaly was explainable by surface geology, and if so, which rock type, or types were the magnetic ones, and ultimately the source of magnetism in these rocks. The second objective was an extremely interesting one as the flanks of the anomaly have a shallow slope suggesting the possibility that the causative body might lie at some depth beneath the present surface. The known occurrence of some gabbroic material in the zone added further interest to this line of reasoning. Possibly a large gabbro body at depth was causing the anomaly and it would be found that the surface rock material would not explain the magnetic pattern.

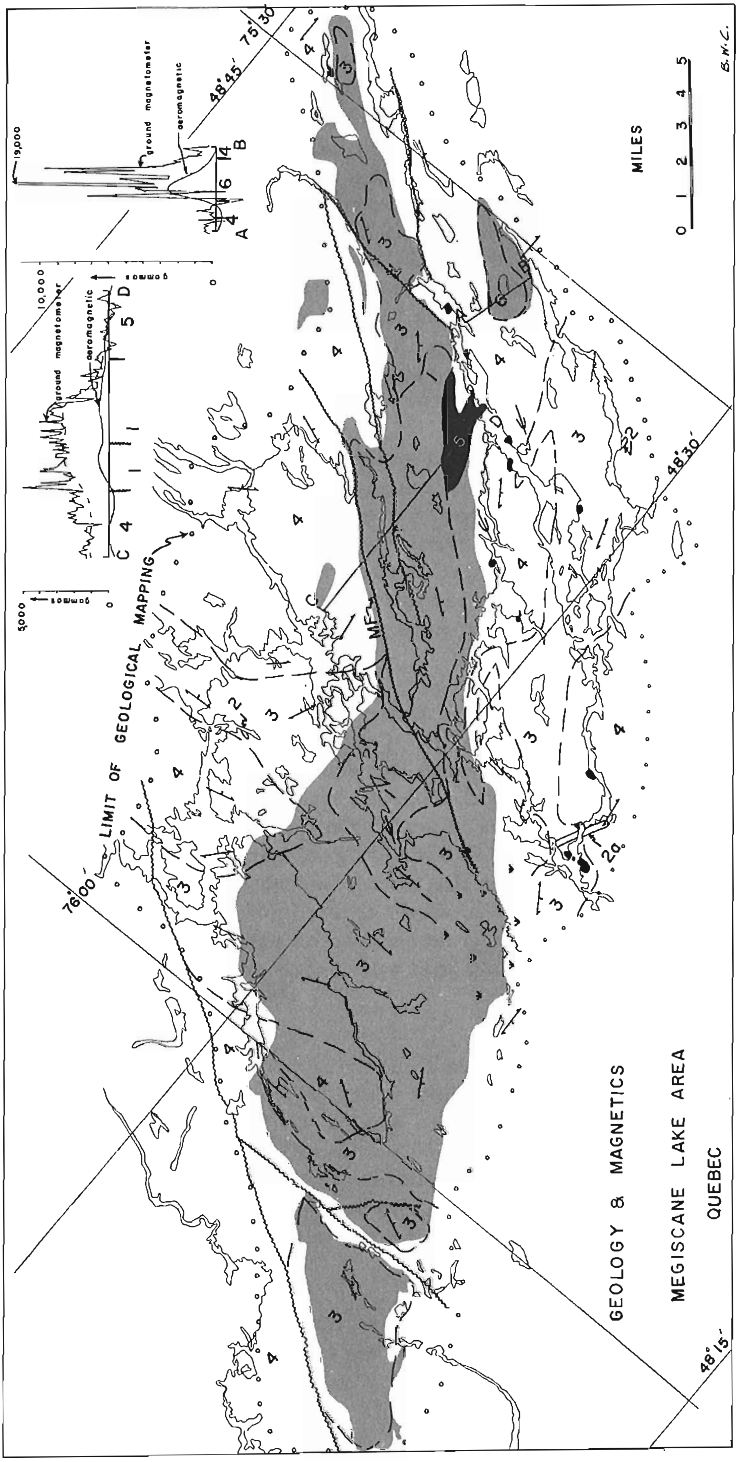
Analysis of regional gravity data provided by the Dominion Observatory[6] revealed that the magnetic belt is located on a regional gravity gradient which is becoming more positive to the south. No anomaly in the gravity field appears to be correlative with the magnetic belt itself, although no gravity stations were actually taken right on the belt. The postulation of a deep gabbro source for the magnetic anomaly thus seemed unlikely because a deep source should have been indicated by the gravity stations immediately lateral to the belt.

During the summer nearly five hundred outcrops were examined and most of these were sampled. Drift, consisting almost entirely of sand, was extensive and outcrops were infrequent and isolated, especially inland from the numerous lakes and rivers. However, a reasonably good areal distribution of rock outcrop was found. On the accompanying preliminary geological sketch map (Fig. 1) six major geological units are outlined. The geology is plotted directly over the simplified outline of the magnetic anomaly so that the relationship of the anomaly to the underlying geology can be seen at a glance. In addition, ground magnetometer profiles obtained with a Sharpe PMF-3 vertical force ground magnetometer are shown.

Results

1. The magnetic anomaly in the northeast corresponds to a zone of almost massive amphibolite of unit 1 and in the southwest to an area of mixed gneiss of unit 3 and granite of unit 4. The rocks in the southwestern area have approximately 20 per cent bulk content of amphibolite which occurs as digested zones mainly in the mixed gneiss of unit 3. The separate higher amplitude anomaly just south of the northeast part of the main zone is underlain by the biotite-hornblende-calcite rock of unit 6, probably a carbonatite.

2. Although some 18 gabbro bodies (unit 5) were located all are small in area and thus are believed to have only a minor effect on the overall aeromagnetic field.


GEOLOGY & MAGNETICS
MEGISCANE LAKE AREA
QUEBEC
LIMIT OF GEOLOGICAL MAPPING
MILES
0 1 2 3 4 5
ground magnetometer
aeromagnetic
gammas
5000
10,000
19,000
76°00'
75°30'
48°45'
48°30'
48°15'
B.W.C.

LEGEND

6 Carbonatite biotite-hornblende-calcite intrusive rock, black weathering, coarse grained, in addition to above minerals there are garnets and traces of pyrite and magnetite

5 Gabbro – generally medium grained equigranular to streaky, dense, buff weathering rock, plagioclase-pyroxene, usually some garnet, some hornblende and traces of magnetite

4 Gneissic Granite – medium grained, foliated, considerable number of pegmatite injections, up to 10% partly digested remnants of amphibolite and 90% granite, grey on weathered and pink - grey on fresh surface, plagioclase - pink feldspar - quartz-biotite ± hornblende ± garnet - some zones of fine dark specks with reddish alteration around them (allenite ?)

3 Mixed Gneiss – complex mixture of granite and amphibolites averages approximately 80% granite and 20% amphibolite in bulk

2 Pyroxene-bearing Amphibolite – dominantly hornblende 10 - 20% pyroxene (some quartz) coarse grained, nodular weathering outcrop, dark green, dense rock
2a, Pyroxenite – essentially monomineralic pyroxene, medium grained, dark green, hard, dense rock in part broken up by granitic material

1 Amphibolite – medium grained - buff to grey weathering massive to banded, hard, dense rock. This unit averages 70% amphibolite and 30% granite, hornblende-plagioclase ± garnet and traces of magnetite and pyrite

Fault-position assumed from magnetic data and in places granulation of bedrock, the major fault is designated M. F. . . . .

Foliation domain – each symbol shown represents the average strike of numerous foliations in that vicinity. The direction of dip is also shown if there is a consistent direction in that vicinity. . . . .

Geological contact (position assumed from magnetics and geological control) . . . .

Glacial straie each symbol represents the average of numerous straie in that vicinity . . . .

Shaded areas in background of the map are the regions with relative aeromagnetic intensity greater than 5300 gammas on published magnetic maps east of 76° 00' and greater than 2300 gammas west of 76° 00'. This magnetic value is well up on the flanks of the anomaly but defines the basic shape of the anomalous zone. For further details on the magnetic pattern consult reference (1) . . . .

Ground magnetic profile – Sharpe PMF-3 instrument. (Aeromagnetic profile along that line is also shown on the map) . . . .

Limit of geological mapping . . . .

3. Foliation in the rock units parallels the trend of the magnetic anomaly in the northeast portion but generally trend south and intersect the anomalous zone at a high angle in the southwest portion. After entering the anomalous zone these latter foliations swing to parallel the southwest strike of the anomaly.

4. Seven distinctive linear breaks in the continuity of the magnetic pattern are assumed to be the expression of fault zones. Where investigated these zones are represented on the groundby an alignment of foliations. The major fault zone designated MF on the map contains heavily crushed rock along portions of its trace. In places feldspar and quartz eyes are developed in this material. Some crushed rock was also found along the two most easterly assumed faults.

5. As shown by the plotted magnetic profiles the ground magnetometer anomaly in the main zone is approximately 4, 000 gammas above background as compared to 1, 500 gammas along this profile on the aeromagnetic maps. The circular high amplitude anomaly which occurs to the south of the northeastern portion of the main zone has a maximum measured amplitude of 19, 000 gammas on the ground compared to an aeromagnetic expression of 3, 500 gammas. An additional interesting feature of this latter anomaly is that there are three distinct magnetic intensity peaks of approximately 8, 000, 19, 000 and 10, 000 gammas respectively suggesting that the rock causing the magnetic anomaly may be zoned.

In general the ground magnetic profiles give further definition of the aeromagnetic pattern. The pronounced narrow amplitudes increases on the ground magnetic profiles as compared to the aeromagnetic profiles suggest that the causative material is directly at the surface.

6. The southwest portion of the magnetic anomaly is underlain by mixed gneiss of unit 3 and granite of unit 4. This portion of the anomaly rises in places to a 2, 000-gamma peak above background. This is, in fact, larger in amplitude than the anomaly in the northeastern portion which is underlain by almost massive amphibolite of unit 1. This presents a problem in interpretation. Prior to actual measurements of magnetic susceptibility on the samples it is assumed that the southwest portion of the anomaly, which contains numerous zones and schlieren of amphibolite, is not as magnetic as the main zone of amphibolites. However the southwest part of the anomaly is much wider and is underlain by a greater total volume of ferromagnetic material than the northeast part. Therefore the magnetic field has a larger amplitude over the southwest part of the zone than over the northeast part.

7. The gradually increasing slopes of the magnetic anomaly are not due to a depth factor but to a gradual increase of more ferromagnetic surface rock.

8. The exact positioning of the Grenville-Superior front in the area is of course dependent on the parameters which are used to define the transition. These may be structural, metamorphic, lithological or more realistically a combination of these factors[3, 7, 8, 9, 10]. Tentative to further interpretation of field data gathered this summer (metamorphic and structural studies) it should be mentioned that there is a major structural subdivision in the area. This is defined in part by faults and in part by a zone in which there is a sharp change in structural grain.

The position of this change follows a more or less en échelon zone of faulting to the northeast, follows the major fault designated MF in the central part of the area and then passes along the axis of inflection in a diffuse zone in which the foliations swing from southerly on the north side to northeasterly on the southern side. Until further study it is difficult to say whether this structural subdivision corresponds to the Grenville front as the north-south foliations are again prominent well within the Grenville Province around the Gouin Reservoir[11]. It therefore seems reasonable that there is a complex structural history in this zone involving more than just the superposition of a northeast Grenville trend on a pre-existing easterly Superior trend[12]. However easterly striking volcanic rocks of definite Superior aspect do outcrop about twenty miles north of the zone[4] and thus the placement of the front must be very near the above boundary.

9. The dominant feature in the geology of the area is the northeast faulting. The major fault in the zone is the one designated MF on the map. The few observable lineations measured on this fault zone had an attitude averaging 110°/50°NE. The northeast faults may well be thrust type. Lineations with similar orientations (as above) were also found along the easternmost fault shown on the map. Nearly vertical joint sets subparallel to the two fault directions were noted at several places in the map area. In addition to the large scale faults, microfaults were noted at numerous localities. These small-scale features were extremely sharp and were usually visible by the offset of an amphibolite band in granite gneiss. No consistent attitude was noted for these features.

Another interesting structural feature in the area is that the vast majority of the foliations (over 90 per cent) dip in a southeast sense. It appears then that this is a zone of superposition of a northeast foliation on a pre-existing complex foliation. This adjustment was accomplished by recrystallization and in part the stresses were taken up by the northeast fault set. Examination of the direction of the seven assumed faults in the zone reveals that four of the faults are consistently northeast and three have a more northerly direction and appear to diverge from the northerly faults. A tentative explanation is that these diverging faults may represent zones of vertical adjustment between blocks of material moving northwestward and up on the northeasterly faults[7].

10. Glaciation was from the direction E25 – E30 north. Glacial striae are rare. The extensive glacial deposits consist almost entirely of sand.

11. The rock mapped as unit 6 biotite-hornblende-calcite rock (carbonatite ?) contain fine traces of pyrite. The amphibolites also carry minor amounts of pyrite which usually occurs in rusty zones of limited extent. No major occurrence of sulphides was found in the rocks of the area.

Future Work

The magnetic susceptibility of chipped portions of all specimens will be measured. These measurements will be made with Sharpe SM-4 balance. The results will be plotted, contoured and compared to the aeromagnetic pattern. It is hoped that a study of thin sections of selected rock specimens will provide an understanding of mineral relations in the rocks. The oxides in the rocks will be studied to reach a conclusion as to the derivation of the magnetite and the possible relationships to petrogeny[13]. A more detailed geological map showing outcrop locations, unit boundaries and the magnetic anomaly will be prepared at a scale of one inch to two miles. Thin section study and magnetic susceptibility measurements, possibly coupled with some remnant magnetic measurements will permit a better interpretation of the magnetic characteristics of the various units. An analysis of foliations will help to provide further insight into the geological structure of the zone. Some changes in the position of the geological boundaries and in the general interpretation presented above may result after these studies. This project is part of a continuing study of the relationship of aeromagnetic pattern to geology in Canada[14].

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39. AIRBORNE INPUT SURVEYS, WINKLER MANITOBA, DRUMHELLER ALBERTA, OTTAWA ONTARIO (62 P/1, 8; 52 M/3, 4, 52 L/14, PART OF 62H, PART OF 82I, P; PART OF 31G)

Project 660043

L.S. Collett

Of the various airborne electromagnetic methods, the INPUT system was chosen to determine its usefulness as a method of supplementing more conventional methods of geological mapping. In 1966, the Geological Survey of Canada contracted with Barringer Research Limited to test INPUT for resistivity geologic mapping over four selected sites in Canada. For ease of handling and processing the large volume of data through use of the computer, it was decided to record the output digitally in the aircraft on a tape recorder. Modifications were made to the existing system and the number of output channels were increased from six to twelve plus the altimeter recording. The camera was used in the conventional manner for positional plotting. Questor Surveys Limited carried out the flying part of the contract.

First flight tests were made in December, 1967, in the Ottawa area over the Paleozoic basin where 500 line miles were flown. A preliminary check on the tests show that the results correspond well with the known structure and lithology of the area. Programs have been written for processing the digital magnetic tapes by computer to produce new tapes for off-line printer output.

Due to inherent technical problems in the digitizer, it was decided after the Ottawa tests to record the data on a 14-channel FM tape recorder in the aircraft. The digitization could then be carried out later in the laboratory under controlled conditions.

In August, 1968, the flying resumed in the Manitoba Department of Mines 'Project Pioneer' area (620 line miles), Winkler Aquifer, Manitoba (300 line miles) and an area southeast of Drumheller, Alberta (1,760 line miles). The latter area was flown in co-operation with the Research Council of Alberta.

Evaluation is still in progress. In the Project Pioneer area, the geology is electrically resistive but the peridotite zones were clearly anomalous. The Winkler area was extended to the east and north of previous work that had been done there to try to trace an old buried depression in the bedrock. In the area near Drumheller, the drift is very conductive with resistive anomalies appearing in the western part of the area.

40. AFMAG/VLF SURVEYS URANIUM CITY AREA, SASKATCHEWAN, UPPER NELSON RIVER AREA, MANITOBA (74 N/7, 8, 9, 10, PARTS OF 63I, J, K, N, O, P)

Project 680123

L.S. Collett

An airborne AFMAG survey was flown in the upper Nelson River area of Manitoba (3, 500 line miles) and in the Uranium City area of Saskatchewan (660 line miles) by contract with McPhar Geophysics Limited. The purpose of using the AFMAG system was to test the usefulness of the method to detect faults and shear zones where they are known and to check if other unknown lithological features can be detected especially beneath overburden and sedimentary cover.

The survey in the upper Nelson River area was flown adjacent to a previous AFMAG survey which was conducted by American Metal Climax Incorporated. This company has generously agreed to release their AFMAG data to the Geological Survey of Canada for publication after January 1, 1970. The area flown by the Survey is contiguous to the AMAX area on the east and west flanks and extends into the area covered by Paleozoic rocks to the south.

From a preliminary assessment of the AFMAG data in the upper Nelson River area, it is evident that a large number of major anomalies have been detected which are believed to be associated with major faults and shear zones. A tentative conclusion is that overburden effects are minimal in spite of the fact that most of the area is covered by swamp and glacial overburden. In the Uranium City area, the AFMAG anomalies have not been checked against the known geology at the time of writing this summary.

VLF (very low frequency) measurements from the naval communication station NLK, Jim Creek, Washington (18.6 KHz) were checked from the air over a 2-mile-wide strip of terrain west of Wabowden, Manitoba, where good AFMAG anomalies were present. Repeatable dip-angle anomalies were recorded at 300 feet. Flying tests at 400 and 500 feet appear to indicate that the anomalies fell off very slowly with height. It was not technically feasible to fly VLF with AFMAG in this survey contract.

41. AIRBORNE GAMMA SPECTROMETRY

Project 670050

A.G. Darnley

Following delivery of a Short Skyvan aircraft at the beginning of May, four months were occupied by assembly and installation of equipment, ground tests, and crew training. The first flight with the high sensitivity airborne gamma-ray spectrometer constructed by Atomic Energy of Canada Limited took place on 30 August. This spectrometer employs 12 9 by 4-inch NaI(Tl) detector crystals. Preliminary flight trials have taken place during September in the Ottawa area and over the Elliot Lake and Bancroft test strips in order to investigate and confirm where necessary:

(a) the height attenuation coefficients;

(b) the 'stripping' ratios for the correction of observed 1.46 MeV and 1.76 MeV count rates;

(c) the range of background count rate at typical survey altitudes;

(d) the cumulative, peak and mean count rates at various elevations over the test strips;

(e) the effectiveness of the on-board analog computer corrections as applied to the strip chart record;

(f) the proper recording and tabulation of raw data by the incremental tape recorder and read-out program.

42. GAMMA-RAY SUPPORT BANCROFT, ONTARIO (31 C, D, E, and F)

Project 670052

A.G. Darnley and V.R. Slaney

In order to supplement the field gamma-ray spectrometer on the Bancroft and Elliot Lake test strips reported last year in Paper 68-1 Part A, measurements have been made over fifteen areas in the vicinity of Bancroft. They have been selected from a study of aerial photographs and are representative of different rock types including granite, syenite, nepheline syenite, gabbro, basic volcanics, marble and metasediments. In each locality measurements were made over an area approximately one half mile square, and as with the test strips in 1967, measurements have been made on a regular pattern irrespective of whether stations fall on outcrop or overburden. The same areas have also been over-flown with a helicopter mounted gamma-ray spectrometer employing 3 5 by 5-inch NaI(Tl) detectors. The mean count rate from each of these areas has been compared. After subtraction of cosmic and instrument background the variation in count rate between the most and least radioactive areas is 12 times for thorium, 9 times for uranium and 4 times for potassium. This indicates the magnitude of the scale within which distinctions of rock and soil type must be made by any airborne spectrometer system. Amongst the incidental unexpected findings is the fact that the Boulter 'granite' on the west side of Fraser Lake is less radioactive than any similar sized area of basic rocks that has been measured. Specimens have been taken from all areas for laboratory analysis.

43. HAMMER SEISMIC SURVEYS, PENNFIELD, NEW BRUNSWICK (21 G/2)

Project 680037

R. M. Gagne and George D. Hobson

A model FS-3 hammer seismograph was used to assist in mapping the Pleistocene deposits. The survey area is underlain by a complex of volcanic, sedimentary and intrusive rocks. The topography is moderately rolling and characteristic of the glaciated Appalachian region. Kames, eskers, outwash plains and sink holes occur in numerous localities within the survey area. Eighty-four locations were surveyed.

Overburden varies between 7 and 266 feet in thickness. Preliminary sections have been compiled to indicate the different layers of Pleistocene material and the bedrock topography. One range of seismic velocities appears frequently in areas of bedrock lows and on the basis of apparent seismic velocities the nature of its composition can only be postulated. It may represent sand and gravel deposits that have been compacted by the Pleistocene ice sheets or perhaps a glacial till. It will be necessary to drill a hole in the material for positive identification. It does not appear to be possible to differentiate bedrock lithology on the basis of seismic velocity within the project area.

44. HAMMER SEISMIC SURVEYS, BANCROFT, ONTARIO (31 C/16)

Project 680037

George D. Hobson

A hammer refraction seismic survey was undertaken to provide information regarding the configuration of bedrock and more specifically the thickness of overburden. Reversed refraction profiles were surveyed over half the gridded area, 450 stations being surveyed in total. The purpose of the survey was to provide information so that some direct correlation could be made between gamma-ray spectrometer readings and thickness of overburden.

The data are generally good. The average overburden thickness is approximately 30 feet. Good interpretable data were obtained and a contoured map of the bedrock topography and isopachous map of the overburden thickness have been compiled.

45. HAMMER SEISMIC SURVEYS, MINDEN, ONTARIO (31 D)

Project 680037

George D. Hobson

A hammer seismograph survey was conducted over the geophysical test range near Minden, Ontario to complete the geophysical survey of the area. A report on the seismic survey has been submitted to be incorporated in a Geological Survey paper setting out the results of the various geophysical surveys over the test range.

46. HAMMER SEISMIC SURVEYS, MEGANTIC, QUEBEC (21 E/11)

Project 680037

George D. Hobson

A portable hammer seismograph was used to conduct a seismograph survey in the Megantic area. The purpose of the survey was to determine the thickness of overburden and bedrock topography within certain selected valleys as an aid to the study of the Pleistocene geology. Lacustrine sediments may overlie glacial deposits. Bedrock in the survey area is principally Compton slate with some scattered areas of granite.

The thickness of overburden varies between 3 and 291 feet. It is possible to differentiate Pleistocene materials and to generally define the bedrock topography within the selected valleys.

47. HAMMER SEISMIC SURVEYS, COBALT, ONTARIO (31 M)

Project 680037

George D. Hobson

Three shallow seismic refraction surveys were conducted in conjunction with biogeochemical projects over silver deposits in the Cobalt area. Thirty-eight reversed refraction profiles were completed at intervals of approximately 300 feet along cut lines. Thickness of overburden was then calculated beneath every station giving a total of 423 separate depth determinations at a spacing of approximately 25 feet.

Overburden on the Hi Ho property varies between 6 and 75 feet in thickness with no outcrop being observed along the cut lines. Overburden on the O'Brien property varies in thickness from 3 to 11 feet with some outcrop being observed near the surveyed lines. Overburden on the Silverfields property is generally very thin with depths of 45 feet being observed over two small areas. Extensive outcrops of diabase were observed along the survey lines of this latter property.

48. HAMMER SEISMIC SURVEYS, WATERLOO, ONTARIO (50 P/7, P/10)

Project 680037

George D. Hobson

A Huntec model FS-3 seismograph was used to obtain data during a refraction seismic survey in the Stratford east half and Conestoga west half map-areas. The purpose of the survey was to determine thickness of overburden to the underlying bedrock as an aid to Pleistocene mapping and the determination of bedrock topography. Thickness of overburden over the six control lines surveyed varies between one hundred and three hundred feet and all data were obtained using a hammer as a source of energy rather than explosives.

The Onondoga escarpment is apparent on two lines surveyed being fairly well defined on one line and apparent on the other as a trend rather than a sharp change in bedrock elevation. Two other lines of control define a depression in the bedrock. Seismic data were tied into drilled wells at several locations throughout the area; depths to bedrock computed from seismic data are generally greater than the depth to bedrock indicated on the well logs. There are peculiarities in the seismic wave train in this project area which bear further investigation; these may explain the discrepancy between seismic and drillhole depths if it is considered that second or later cycles of seismic energy are being recorded from the bedrock surface rather than first cycles of energy.

49. SEISMIC REFRACTION SURVEY, WELLAND - PORT COLBORNE, ONTARIO (30 L, 30 M)

Project 670074

George D. Hobson

The seismic refraction survey begun in 1967 in the Welland - Port Colborne area was continued during the summer of 1968. About 800 locations were surveyed using a model FS-3 hammer seismograph utilizing a sledge hammer struck against a steel plate on the ground as a source of energy. The thickness and nature of the overburden and the configuration of bedrock are readily attainable. Locations surveyed below the Niagara escarpment, on a preliminary interpretation, appear to indicate the presence of a buried valley in the bedrock trending northeast from the city of St. Catharines.

This is a continuing project in areas designated to be of prime importance to the development of the Welland Canal and in areas to complete Pleistocene mapping and the rock topography of adjacent areas.

50. MARINE SEISMIC PROGRAM, LAKE ERIE, ONTARIO (30 O, 40 G)

Project 660054

George D. Hobson

A marine seismic program was conducted on Lake Erie using a repetitive source of energy in the reflection mode. The reconnaissance survey of the western basin of Lake Erie was completed on an approximate 3-by 3-mile control grid during September. The high resolution boomer source initiated reflections which were recorded from the water-sediment interface, interfaces within the unconsolidated sediments and from the bedrock topography. A cursory examination of the records during the survey indicates that in addition to a continuous determination of the water-sediment interface, some stratification within the unconsolidated sediments was visible. It is anticipated that a layer of peat can be traced over an extensive area of the basin. Bedrock topography can be observed over approximately 75 per cent of the survey area while stratification within the bedrock was not observed to any great extent. This latter phenomenon was due to the fact that the energy source was not strong enough to penetrate bedrock but intentionally was kept at a low level for identification of the interfaces within the unconsolidated sediments. The records from this survey are presently being interpreted.

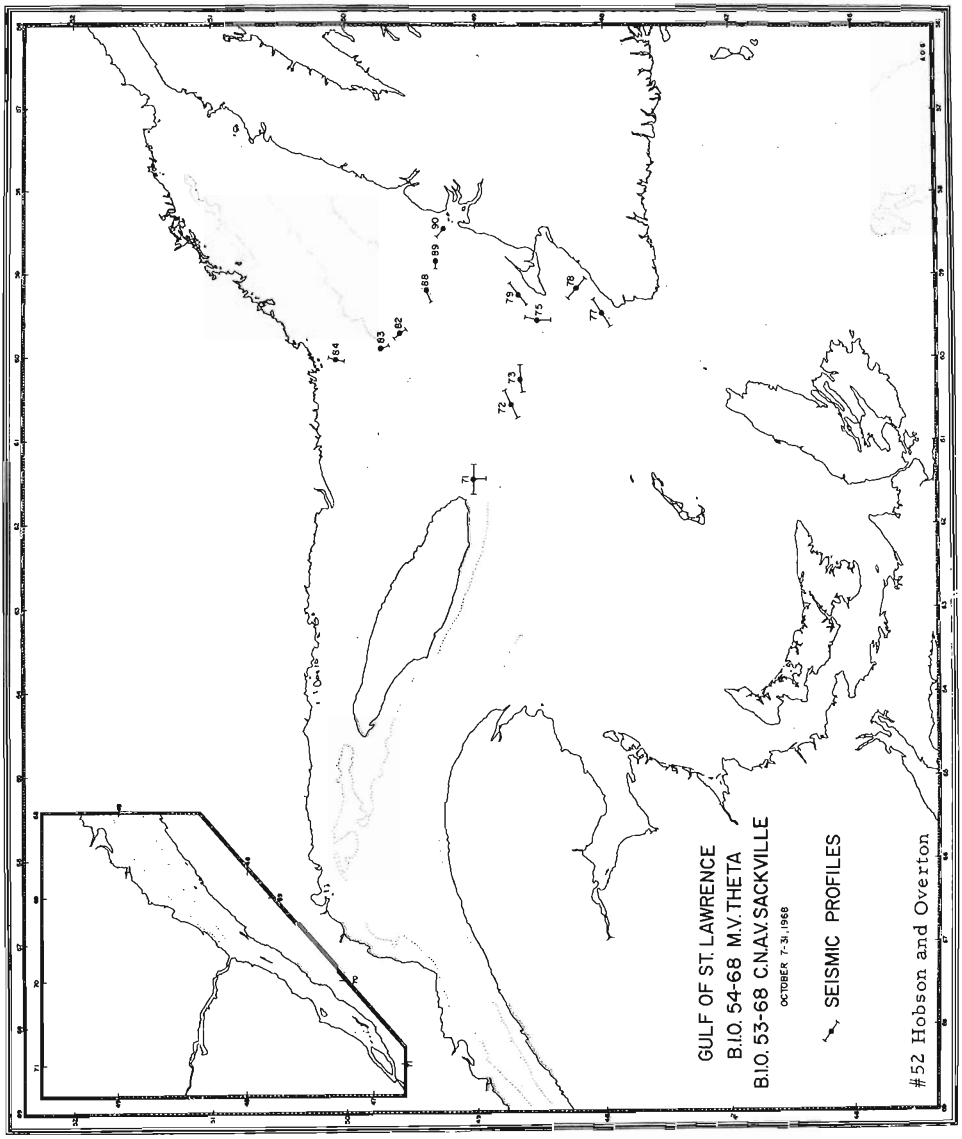
51. SEISMIC SURVEY OF ATHABASCA FORMATION (74 NE, NW)

Project 630023

George D. Hobson and H.A. Macaulay

Conventional refraction seismic surveys were conducted at selected locations over the Athabasca Formation to determine its thickness. The surveys were conducted during March and April using an Otter aircraft to transport the seismic crew from location to location. The seismic detectors were set out on the ice of the lakes and rivers; small charges of explosives were detonated at the bottom of the water being set there through holes drilled in the ice. The feasibility of using such instruments in the reflection mode as an exploratory tool was also evaluated. The results have been interpreted and maps have been compiled to indicate the thickness of the Athabasca Formation and the topography of the pre-Athabasca surface. Critical cross-sections across the extent of the area have been constructed. Thicknesses approaching 5, 000 feet have computed for the Athabasca Formation.

A portable facsimile seismograph, a Huntec model FS-3, was also used during July to evaluate that instrument in the reflection mode. This portable instrument was evaluated at nine locations at which reliable depth calculations had been made by the earlier refraction surveys. In all cases reflections can be identified on the facsimile record. These reflections in some cases are not correlatable with the pre-Athabasca surface but appear to originate from an interface within the Athabasca Formation. Such an interface was suspected from the previous refraction surveys but sufficient data were not available to positively assert the presence of this interface. It is evidently an interface which is detectable by reflection techniques but not by refraction.


GULF OF ST. LAWRENCE
B.I.O. 54-68 M.V. THETA
B.I.O. 53-68 C.N.A.V. SACKVILLE
OCTOBER 7-31, 1968
SEISMIC PROFILES
#52 Hobson and Overton
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52. MARINE SEISMIC INVESTIGATIONS, GULF OF ST. LAWRENCE (12 B, C and G)

Project 640049

George D. Hobson and A. Overton

Thirteen conventional marine refraction seismic profiles were shot in the Gulf of St. Lawrence to investigate the thickness, nature and attitude of the sedimentary rocks underlying the Gulf. The locations of the profiles are shown in Figure 1, p. 87.

Two ships, CNAV Sackville as the recording vessel and M.V. Theta as the shooting vessel, were used to obtain all seismic data. Single-ended profiles only were shot at 4 locations and no reflection data were acquired. Nitrone Super X and Geogel were used as explosive sources of energy.

A cursory examination of the records indicates that excellent quality data were procured. No interpretation of these data has been undertaken since the cruise was completed as late as October 31. Secondary arrivals of energy have been observed frequently and will assist the interpreters considerably.

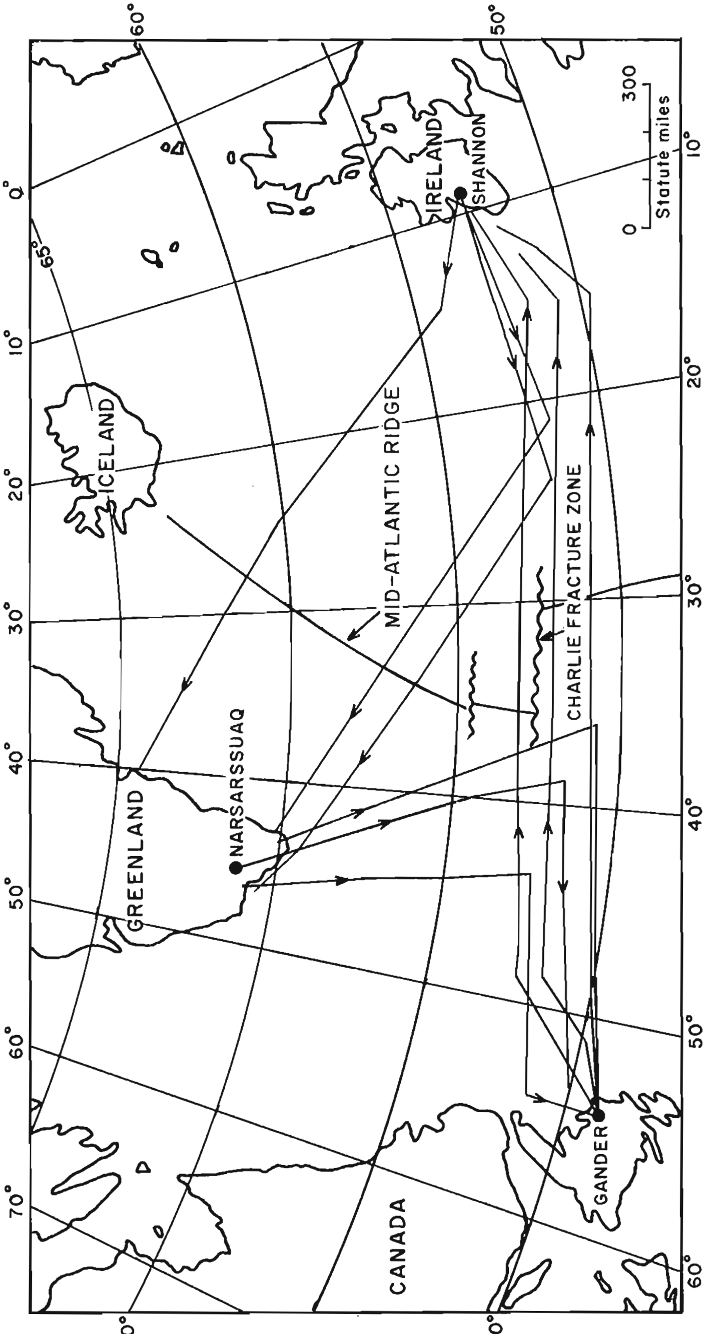
53. AEROMAGNETIC INVESTIGATIONS OF THE NORTH ATLANTIC OCEAN

Project 650007

Peter Hood and P. Sawatzky

The co-operative aeromagnetic project with the National Aeronautical Establishment was continued during 1968 and Figure 1 shows the aeromagnetic profiles obtained across the North Atlantic Ocean during May and June. The equipment used was an optical absorption magnetometer installed in the North Star aircraft of the National Aeronautical Establishment. Approximately 13,000 nautical miles of data were digitally recorded on magnetic tape; the average flight elevation was 1,000 feet and navigation was by Loran A., Doppler, and astro fixes.

The survey lines between Newfoundland and Ireland were positioned to straddle the Charlie fracture zone[1], which appears to be a transform


ICELAND
GREENLAND
NARSARSSUAQ
IRELAND
SHANNON
MID-ATLANTIC RIDGE
CHARLIE FRACTURE ZONE
GANDER
CANADA
0 300
Statute miles
60°
50°
65°
0°
10°
20°
30°
40°
50°
60°
70°

fault, and those farther north were positioned to cross the Reykjanes Ridge orthogonally. The fracture zone is distinguished by its featureless magnetic relief in the midst of typical oceanic anomalies. Thus where aeromagnetic profiles cross fracture zones on the mid-Atlantic ridge, the crestal anomaly is not recorded. For instance, Project Magnet Profile 40 and Dominion Observatory Profile 13 (1954) pass through the Charlie fracture zone and the magnetic signature is quite flat. Thus the contention by Keen[2] that a magnetic anomaly is associated with some parts, but not all, of the central portion of the mid-Atlantic ridge appears to be erroneous, because the profiles that he cites e.g. Dominion Observatory Profile 13 (1954), cross-fracture zones.

The offset of the crestal magnetic anomalies across the Charlie fracture zone is approximately 195 nautical miles. The amplitude of the crestal anomaly recorded immediately south of the Charlie Fracture Zone is very much smaller (less than 500 gammas) than that found farther north on the Reykjanes Ridge, where the main crestal anomaly is in excess of 1,500 gammas.

When plotted in profile form the anomalies in the North Atlantic Ocean appear to be continuous over large distances. For instance the anomalies on either side of the Reykjanes Ridge appear to extend southwards into the North Atlantic Ocean east of Newfoundland. Some of the anomalies to the west of the Reykjanes Ridge also appear to curl around the southern tip of Greenland. In general, the anomalies paralleling the Reykjanes Ridge south of Iceland have a relatively simple pattern. However in the area between Newfoundland and Ireland, that is south of the Charlie fracture zone, it is much more difficult to deduce the trends of the anomalies with certainty from the present coverage.

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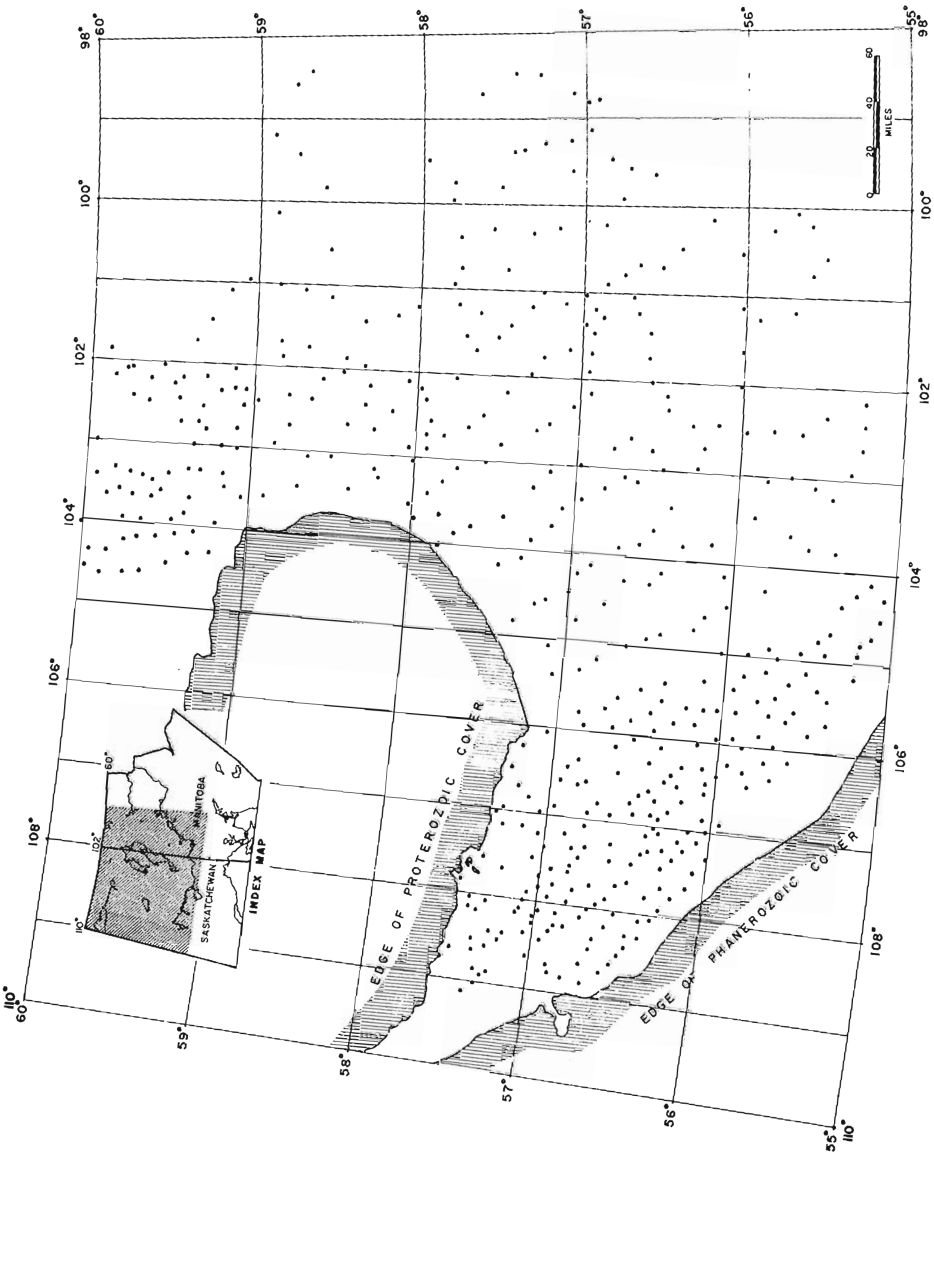
[1]Johnson, G. L.
1967: North Atlantic fracture zones near 53°N; Earth Planetary Sci. Letters, vol. 2, pp. 445-448.

[2]Keen, M.J.
1963: Magnetic anomalies over the mid-Atlantic ridge; Nature, vol. 197, pp. 888-890.



#54 Kornik

Figure 1. Map showing location of sample sites.

54. REGIONAL MAGNETIC SUSCEPTIBILITY SURVEY IN MANITOBA AND SASKATCHEWAN (PARTS OF 64, 73 and 74)

Project 660042

L.J. Kornik

A second field season of a continuing regional magnetic susceptibility survey[1, 2] in northwestern Manitoba and northern Saskatchewan was completed (Fig. 1). The areas of Precambrian Shield which occur between the cover of Phanerozoic rocks and the Athabasca Formation, and the corner of Saskatchewan northeast of the Athabasca Formation cover were sampled. These sample sites (Fig. 1) were visited with a float equipped Cessna 180 aircraft. At each sample site in situ magnetic susceptibility readings, an oriented drill core and a note on the rock type present were collected.

Data collected during this field season have not been fully compiled and will be presented at a later date.

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[1] Kornik, L.J.: Regional magnetic susceptibility survey in Manitoba and Saskatchewan; in Report of Activities, Part A: May to October, 1966, Geol. Surv. Can., Paper 67-1, pp. 126-128 (1967).

[2] Kornik, L.J.: Regional magnetic susceptibility survey in Manitoba and Saskatchewan; in Report of Activities, Part B: November 1967 to March 1968, Geol. Surv. Can., Paper 68-1, pp. 18-22 (1968).

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55. PALEOMAGNETISM, MONTEREGIAN HILLS, QUEBEC (31H, 21E)

Project 680058

A. Larochelle

One hundred and twelve oriented cores were drilled from the Oka, Mount Royal, Yamaska, St. Hilaire, Rougement and Mount Megantic basic intrusives in order to study the paleomagnetism of the latter and to attempt correlating them with previously sampled bodies of the Monteregian Hill Series. An additional 10 cores were drilled from two basic intrusives between Montreal and Oka with the same purpose in mind. Five cores were drilled from a Cambrian (?) diabase dyke in the vicinity of Drummondville as a first step to obtain reliable Cambrian data.

So far the cores from the Monteregian Hills have been examined in the laboratory and a report of the findings has been submitted for publication. The data show conclusively that the Oka and Mount Megantic intrusives are true extensions of the Monteregian Hills proper and suggest that the secular variation of the geomagnetic field was considerably less important in Cretaceous times than a few million years ago. The pole position derived from the new set of data confirms within 2 degrees the result obtained from last year's data on four different intrusives.

56. MAGNETIC SUSCEPTIBILITY AND NATURAL REMANENT MAGNETIZATION OF SELECTED ROCK OUTCROPS IN SOUTHERN NEW BRUNSWICK (21 G, H, J)

Project 680121

P.H. McGrath

In situ magnetic susceptibility measurements[1] were obtained on one hundred and ninety-nine outcrops in southern New Brunswick during the summer of 1968 (Fig. 1). In order to acquire representative susceptibility values for each outcrop several readings were recorded. The resultant data are summarized in Table 1. In addition to these measurements, sixty 1 1/4-inch diameter oriented drill cores were collected from outcrops, which possess an appreciable component of induced magnetization[2]. The magnetic susceptibility, and the intensity and direction of the natural remanent magnetization of these cores will be determined by the rock magnetism laboratory of the Geological Survey of Canada.

The field results indicate that, in general, a spatial relationship exists between high aeromagnetic anomalies and surface exposures of high magnetic susceptibility[3]. For instance, the horseshoe-shaped high magnetic anomaly which surrounds the central portion of the Pokiok intrusion[4] is caused by a zone of porphyritic granite. As seen in hand specimen, this granite is medium to coarse grained and contains large phenocrysts of pink potash feldspar which are surrounded by grey feldspar, quartz and biotite. Similar granites produce the magnetic highs over the Evandale intrusion[4], and the northwestern third of the St. George intrusion[4]. The high magnetic susceptibility of this phase of the granitic intrusion is apparently a function of the partial pressure of oxygen during crystallization of the melt[5]. The final crystallization products of a granitic magma containing an excess of

TABLE I

SUMMARY OF IN SITU MAGNETIC SUSCEPTIBILITY MEASUREMENTS

	Range of Susceptibility x 10^{-6} emu/cc	Number of Measurements
CARBONIFEROUS		
LANCASTER FORMATION:		
sandstone, shale	<20	7
WEST BEACH FORMATION:		
acid and basic volcanic rocks	<10 - 30	23
BALLS LAKE FORMATION:		
shale	<10	7
HOPEWELL GROUP:		
conglomerate	<40	4
MONCTON GROUP:		
rhyolite,	<30	8
rhyolite pyroclastic rocks	2400 - 4000	6
PISKAHEGAN GROUP:		
porphyry	150	2
DEVONIAN (MAINLY)		
PERRY FORMATION:		
shale	<10	2
amygdaloidal lava	280 - 1250	4
POKIOK INTRUSION:		
granite, quartz monzonite and related rocks	<10 - 850	21
ST. GEORGE INTRUSION:		
granite, syenite and related rocks	<10 - 2675	53
gabbro, diorite	<10 - 4250	40
EVANDALE INTRUSION:		
granite	1775 - 1825	5
DEVONIAN AND EARLIER		
ROCKWOOD PARK INTRUSION:		
granite, quartz diorite	<10 - 120	4
FAIRVILLE INTRUSION:		
granite	1000 - 1580	5
granite, albite granite and related rocks	<10 - 1850	56
felsite	175 - 1225	7

TABLE I (Cont'd)

	Range Susceptibility x 10^{-6} emu/cc	Number of Measurements
gabbro, diorite and related rocks	<10 - 9600	77
diabase	<10 - 9400	32
<u>SILURIAN</u>		
greywacke, hornfelsic greywacke, hornfels,	<25	27
slate	<10 - 275	18
acid and intermediate volcanic rocks	<10 - 6000	69
basic volcanic rocks	7200 - 13500	6
<u>ORDOVICIAN</u>		
peridotite, gabbro	2900 - 7600	7
greywacke, slate, argillite	35 - 135	8
CHARLOTTE GROUP:		
slate, argillite, sandstone schist, quartzite	<10 - 140	27
acid volcanic rocks	<10 - 85	16
intermediate volcanic rocks	500 - 1000	5
basic volcanic rocks	1100 - 5000	4
<u>CAMBRIAN</u>		
ST. JOHN GROUP:		
conglomerate, sandstone	<10 - 85	7
<u>PRECAMBRIAN</u>		
MILKISH HEAD INTRUSION:		
granite, granodiorite, gneiss	<10 - 2000	12
COLDBROOK GROUP:		
acid volcanic rocks, schist	<10 - 6000	94
basic volcanic rocks, schist	<10 - 4200	
aplitic granitic	800 - 2550	59
diabase	50 - 2850	
conglomerate, quartzite, breccia	<10 - 700	9
conglomerate, quartzite, breccia	<10 - 700	18
GREENHEAD GROUP:		
quartzite, marble, argillite	<20	11
hornfels, breccia, greenstone	<10 - 23000	18

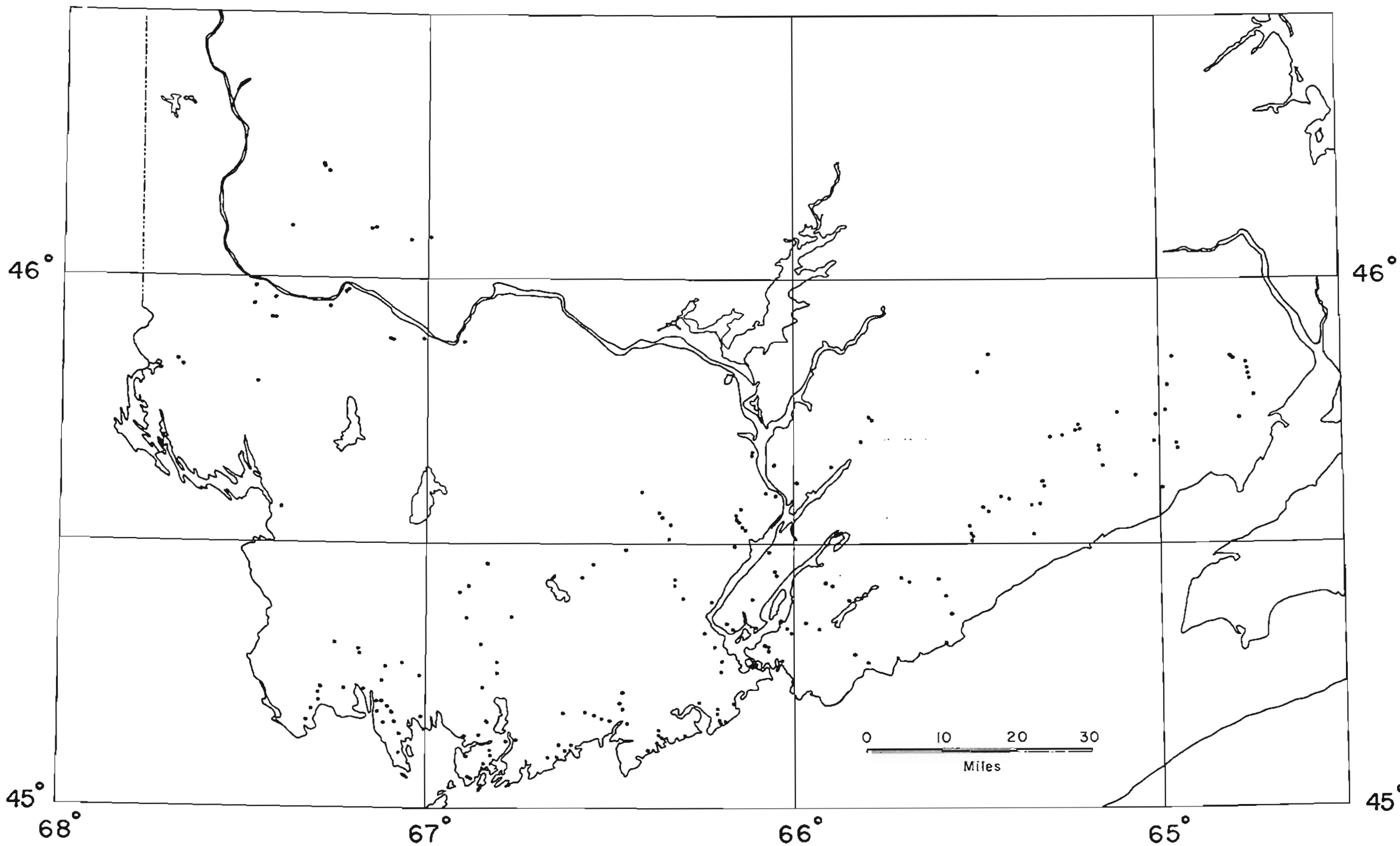

Figure 1. Map of outcrops sampled in southern New Brunswick during 1968.

oxygen will be magnetite, and magnesium-rich biotite and/or hornblende, whereas the final result of an oxygen-poor granitic magma will be iron-biotite, and/or hornblende, and/or pyroxene, and very little magnetite[6, 7]. These results suggest a means by which granitic intrusions may be subdivided.

These data will be incorporated into a continuing program of magnetic interpretation of crustal structure in the Canadian Appalachian Region.

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[1]Hood, P.J. and Sangster, D.F.: The Carey Foster in situ Susceptibility Meter; Geol. Surv. Can., Paper 65-22, (1967).

[2]Larochelle, A.: Geological solar compass; in Summary of Activities, Office and Laboratory, Geol. Surv. Can., Paper 64-2, pp. 44-47 (1964).

[3]Geological Survey of Canada: Aeromagnetic Maps 7036 G, 7037 G and 7041 G (1965).

[4]Potter, R.R. et al.: Geological map of New Brunswick; Dept. Nat. Res., New Brunswick, Map Number N.R. - 1 (1968).

[5]Pecherskiy, D.M.: Statistical analysis of the reasons for the varying magnetization of the granitoids of the Verkhoyansk-Chukotka fold region and the Okhotsk-Chukotka volcanic belt; Internatl. Geol. Rev., vol. 7, No. 11, pp. 1963-1975 (1965).

[6]Wones, D.R. and Eugster, H.P.: Stability of biotite: Experiment, Theory, and Application; Am. Mineralogist, vol. 50, pp. 1228-1272 (1965).

[7]Buddington, A.F., Fahey, Joseph and Vlisidis; Angelina: Degree of oxidation of Adirondack iron oxide and iron-titanium oxide minerals in relation to petrogeny; J. Petrol., vol. 4, Part 1, pp. 138-169 (1963).

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57. CRUSTAL SEISMIC MEASUREMENTS OVER THE APPALACHIAN FRONT (PARTS OF 21, 22)

Project 680122

A. Overton

During June and July the shots of the Dominion Observatories seismic experiment on the Grenville front were recorded at locations on either side of the St. Lawrence River.

The shots were located in central Quebec over and either side of the Grenville front. The Geological Survey recordings, taken with a single portable three-component station, were obtained near Baie-des-Rochers and Hauterive on the northwest shore of the St. Lawrence River. On the south-east shore recordings were obtained near and between Rivière-du-Loup, Quebec and Edmundston, New Brunswick.

When the final shot positions are reported these recordings will be analyzed for seismic differences between the Grenville and Appalachian provinces.

58. PALEOMAGNETISM OF APPALACHIAN ROCKS (1, 2, 11, 12, 20, 21, 22)

Project 680077

G.W. Pearce

Two hundred and twenty-five oriented core samples were collected from the North Mountain Basalt of Nova Scotia. The purpose of the collection was to study in greater detail than has been done in the past the paleomagnetism of this Triassic formation. Laboratory work on these samples is now in progress.

In a continuing effort to establish the movement of the magnetic pole with respect to North America throughout the Paleozoic era, a collection of 251 oriented samples were collected from seven Devonian and Silurian formations in the Maritime Provinces and Gaspé. Laboratory work on these is now in progress.

59. GEOPHYSICAL INVESTIGATIONS, EARDLEY AND CLINTON TOWNSHIPS, QUEBEC, MOOSE RIVER, ONTARIO (31 F19, 21 E/7, 42 I)

Project 670040

W.J. Scott

During the period 15 May to 15 September, a prototype system was constructed to measure the distribution in the earth of an alternating electric field about a pair of embedded electrodes. The generating system employed a low-frequency power oscillator, developed by C. Gauvreau and T.R. Flint, driven by a gas-engine generator. The measuring system employed a portable twelve-channel seismic recorder with special amplifiers and pre-amplifiers, capable of making both seismic and electrical measurements.

Because of unexpected delays in the development of the pre-amplifier design, field work was confined to several days in the period 25 August to 14 September. No actual survey work was carried out. Field work was limited to repetitions of measurements in two locations approximately 20 miles southeast of Ottawa, (a) to determine the operating characteristics of the measuring system, and (b) to outline the modifications necessary to make the system efficient.

60. IDENTIFICATION OF NRM COMPONENTS SUDBURY, ONTARIO (41)

Project 670566

E.J. Schwarz

Thirty-one oriented samples were taken from the Sudbury (dark) norite over about 1/3 mile at right angles to the norite layer. The distance between the samples varies between 3 feet and about 100 feet. The samples are used in evaluating the consistency of the results obtained by comparing the thermal decay of their NRM to the acquisition of TRM in a constant magnetic field of known intensity. It is expected that data will be obtained on the secular variation of the paleomagnetic intensity during the time of cooling of the norite. The Sudbury norite was chosen for this project because of its high magnetic stability.

61. THERMOMAGNETICS OF PYRRHOTITE SUDBURY, ONTARIO (41)

Project 660525

E.J. Schwarz

One hundred and forty-three specimens of pyrrhotite containing rocks were collected from the Strathcona Mine at depths between 1,250 and 2,750 feet. The sulphide-containing rocks form a sheet that dips under about 30 degrees in a southerly direction. The projection on a horizontal plane of the sampled part of the sheet covers an area of about 500 by 1000 feet. The distance between the samples varies from about 5 feet to 100 feet. The thermomagnetic properties and the bulk chemical composition of the pyrrhotite will be determined in order to estimate the relative abundance and composition of the ferrous sulphide phases of different magnetic properties which usually are present in natural pyrrhotite. The variation of these parameters in the sampled part of the mineralized zone will be considered. The cooperation of Falconbridge Nickel Mines Limited is acknowledged.

62. PALEOMAGNETIC STUDIES IN NORTHERN ONTARIO (41, 42)

Project 680053

D.T.A. Symons

Three hundred and ninety-eight oriented samples from 84 sites were collected from the Huronian sediments and the Keweenawan basic intrusives in the Blind River - Elliot Lake area of northern Ontario. The purpose of this study is to determine the stable primary remanence direction of these rocks and, thereby, provide evidence on the structural and depositional history of the area and on the polar wandering curve for the Precambrian. Three weeks were spent in the collection of these samples.

63. PALEOMAGNETIC STUDIES IN SOUTHERN BRITISH COLUMBIA (92, 93)

Project 680052

D. T. A. Symons

Three hundred and seventy-six oriented samples from 73 sites were collected from late Tertiary and Quaternary basaltic lava flows and gabbroic plugs in the Cariboo area of south-central British Columbia. The purpose of this study is to determine their paleomagnetic stratigraphy, and thereby assist in their dating and correlation. Three weeks were spent in the collection of these samples.

64. AEROMAGNETIC INTERPRETATION IN CENTRAL BRITISH COLUMBIA (93 A, B, F, G, J, K, N, O)

Project 680120

M. D. Thomas

Introduction

In 1961 the government of British Columbia co-operated with the federal government in carrying out a total intensity aeromagnetic survey of a part of central British Columbia. The surveyed area is outlined in Figure 1. The systematic geological mapping of the region by the Geological Survey of Canada is now complete and published maps are available on the scale of four miles to one inch. Most of these are in the form of preliminary maps, but final reports are available for the Fort St. James[1] and Nechako River[2] map-areas.

The region as a whole is extensively covered by drift. A study of the aeromagnetic pattern over areas of better known geology, therefore, affords a useful control in the extrapolation of geological features into these drift-covered areas particularly when it is considered that the aeromagnetic grain matches closely the northwesterly trend of the regional geology thus suggesting a close link between the two.

To the writer's knowledge there are no published data on magnetic susceptibilities for this or adjacent areas of British Columbia and as such data facilitate interpretation, a field program was undertaken to obtain

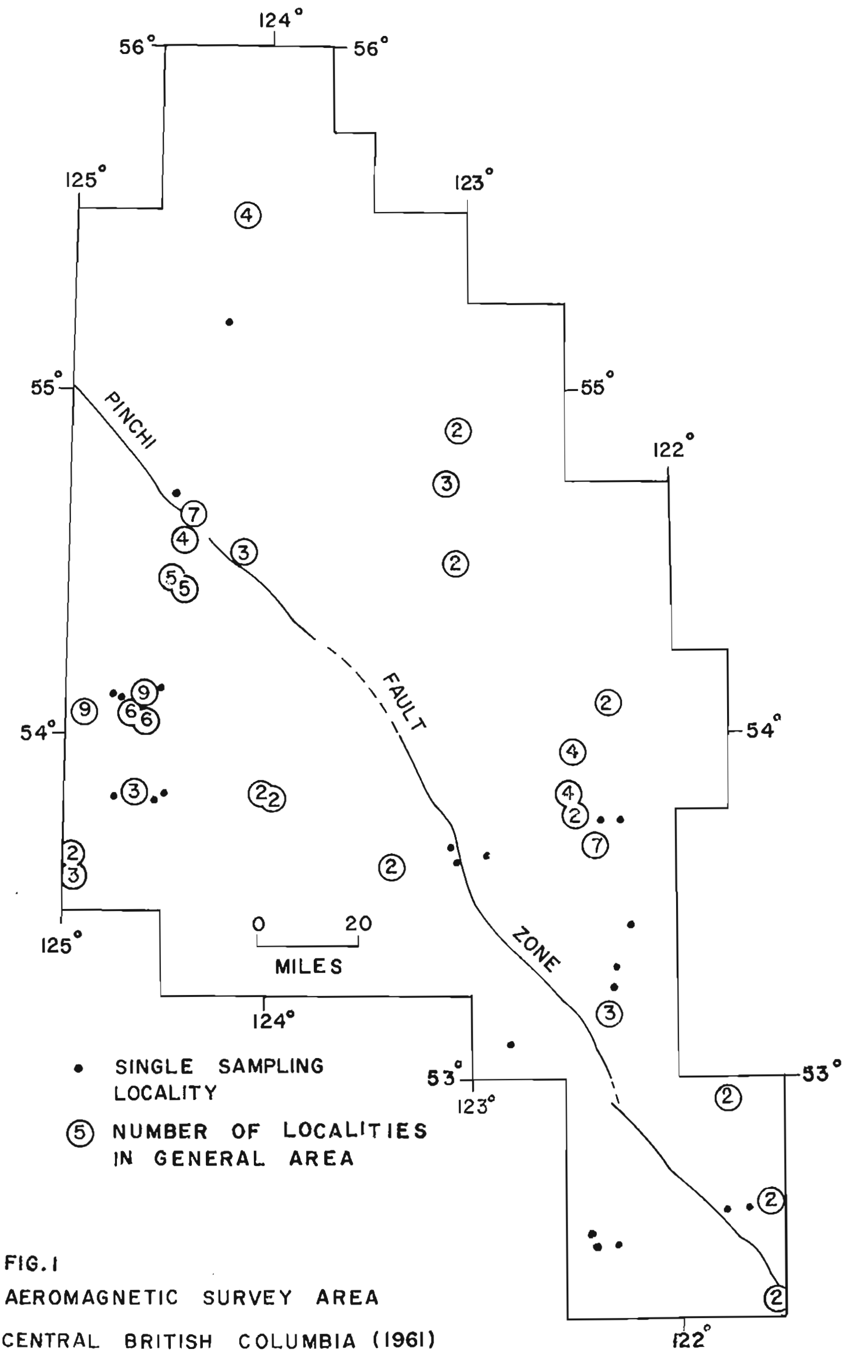

FIG. 1
AEROMAGNETIC SURVEY AREA
CENTRAL BRITISH COLUMBIA (1961)

representative rock samples from the area for susceptibility determinations. Because of the large size of the area the information obtained must be regarded as no more than reconnaissance data, a factor which should be borne in mind in reviewing the results. Ground magnetic surveys were also carried out.

Fieldwork

Approximately 130 localities (see Fig. 1) were visited and some 240 susceptibility determinations carried out on collected rock samples. The measurements were made on rock chips using a Geophysical Specialities Company magnetic susceptibility bridge, model MS-2. The ground magnetic surveys were carried out using a Sharpe MF-1 vertical force magnetometer; these were conducted across selected aeromagnetic anomalies (the main criteria for selection, apart from the geological interest, being the availability of a vehicle route across the anomaly).

Results

Susceptibility data

The more important results only are included here.

1. A comparison of the four-mile aeromagnetic and geological maps indicates that the two principal groups of volcanic rocks in the area, the Endako (Late Tertiary) and the Takla (Upper Triassic-Lower Jurassic), give rise to different anomaly patterns. The Endako Group, occurring mainly in the west of the area and to the south of the Pinchi Fault Zone, is characterized by an irregular 'bird's eye' type of anomaly distribution; the absolute value of anomaly varying by as much as 2,000γ across the outcrop. The pattern over the Takla Group, again occurring dominantly in the west but north of the Pinchi Fault Zone, is generally featureless with the anomaly variation being less than 300γ except where obviously modified by adjacent intrusions. That the respective patterns result essentially from the magnetic properties of the lavas themselves is evident from the susceptibility values.

The Endako results are presented in histogram form in Figure 2. A wide range of susceptibilities is apparent which have an essentially bimodal distribution. Such a distribution of susceptibilities throughout the group might account for the observed magnetic patterns. However further work is required before this can be verified.

Far fewer specimens were obtained from the Takla Group and all were weakly magnetic. The volcanic nature of these samples is yet to be determined (by thin section studies) as they are fine-grained and exhibit no obvious volcanic characteristics as do the Endako examples, e.g. vesicles.

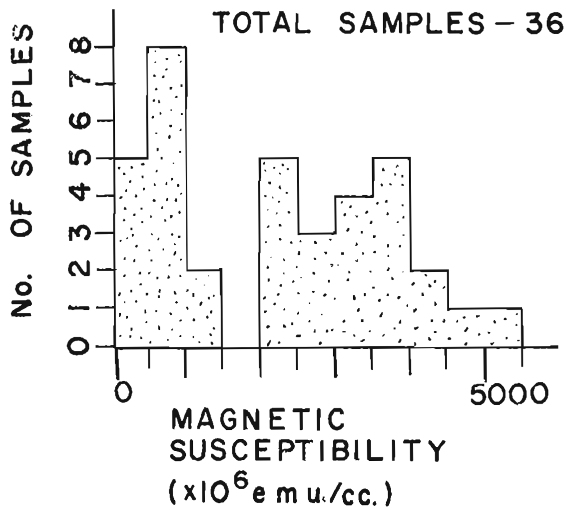

Figure 2. Susceptibility frequency distribution – Endako volcs.

The above evidence indicates a possible method of distinguishing between areas underlain by these respective groups.

2. The coarse-grained igneous rocks of the area exhibit increased susceptibility with increased mafic content. In general, therefore, the various plutonic rock types can be distinguished on the aeromagnetic map because of their contrasting magnetic properties.

3. The ultrabasic rocks of the area, many of which are serpentinized, are often areas of positive magnetic relief. Measured susceptibilities range from 26 to 13, 600 x 10^{-6} emu/cc. The high values yielded by many of the samples confirm that a number of the positive anomalies in the area are produced by ultrabasic bodies.

Ground magnetic surveys

The aeromagnetic anomalies chosen for investigation by ground magnetic traverses are all located along the eastern border of the Prince George map-area. These are briefly described below:

1. The anomaly is oval-shaped and is centred approximately at 122°20' west 53°11' north; it has an amplitude of about 4, 000γ above background. The ground profile, located about two miles to the west of the aeromagnetic anomaly peak, traversed an anomaly which was only about 2, 500γ above background. Geologically the anomaly covers Mesozoic sedimentary terrain although a small area of Mesozoic intrusives occurs near the centre[3]; these are granodioritic in nature (Tipper pers. comm.). Examination of the rocks in the central part of the anomaly located magnetic pyroxenite (susceptibility up to 13, 400 x 10^{-6} emu/cc) to which the anomaly is tentatively attributed.

2. Another elliptical anomaly is centred at 122°24' west 53°41' north on Lower Jurassic and (?) later intrusions which are acid igneous rocks with minor diorite[3]. The anomaly has an amplitude of about 4,000γ above background whereas that measured in the ground profile exceeds 6,000γ rising abruptly from background in a distance of one half mile. In the anomalous zone, numerous scattered blocks of an essentially hornblendic rock were discovered; a probable in situ source of these rocks was also located. The rock, however, is only weakly magnetic (susceptibility: 334×10^{-6} emu/cc). An explanation of the anomaly therefore awaits further analysis although its association with the ultrabasic rock is undoubted.

3. The anomaly is oval and centred at 122°32' west 53°49' north over Mesozoic sedimentary strata (see ref. 3). It is about 1,000γ above background; the ground profile conducted about 1 1/2 miles to the east is about 700γ . In the anomalous region hitherto unmapped amphibolitic and granodioritic rocks were found. The anomaly appears to result from the magnetic amphibolite (susceptibility up to $7,800 \times 10^{-6}$ emu/cc).

Conclusions

The brief outline of the results indicates the potential usefulness of aeromagnetic interpretation in the elucidation of geological problems in this region. Problems have been raised, however, whose solutions require more intensive studies which will be carried out during the winter.

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[1]Armstrong, J.E.: Fort St. James map-area, Cassiar and Coast Districts, British Columbia; Geol. Surv. Can., Mem. 252 (1949).

[2]Tipper, H.W.: Nechako River map-area, British Columbia; Geol. Surv. Can., Mem. 324 (1963).

[3]Tipper, H.W.: Geol. Surv. Can., Map 49-1960, Prince George (1961).

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65. HIGH ALTITUDE PHOTOGRAPHY, MONT LAURIER, QUEBEC, BANCROFT, ONTARIO (31 C, D, E, F, J)

Project 630031

V.R. Slaney

Three flights were obtained in May using an R.C.A.F. CF-100 aircraft with four 70 mm Vinten cameras fitted in the bomb bay. The flights were made at a height of 45,000 feet above sea level near Bancroft, and in the area west of Mont Laurier. Colour, colour-infrared, infrared and filtered panchromatic films were exposed at scales of 1:180,000 and 1:300,000. The colour film proved particularly successful in spite of the time of year at which the photography was carried out.

66. GAMMA-RAY SUPPORT, BANCROFT (31 C, D, E, F)

Project 670052

V.R. Slaney

A description of the ground and helicopter surveys carried out in the Bancroft district is given by A. Darnley (this report, Paper 43).

One aspect of the work not treated elsewhere concerns the problem of locating suitable areas for study. Some 15 areas were needed. Each was to consist of a relatively homogeneous rock, to occupy an area of at least 0.5 square mile, to contain sufficient outcrop to allow a reliable visual check, and to be free of major fractures. The most efficient way of outlining such areas was found to be through the use of aerial photographs. Of the original choice of areas, only 3 were rejected after field check. The reason for rejection was usually lack of outcrop.

67. MAGNETOTELLURIC INVESTIGATIONS, QUEBEC AND NEW BRUNSWICK (21E/7, 21O/1, 21O/7, 32C/5, 32C/11)

Project 660494

J.A. Slankis

Field work in 1968 continued the study begun in 1966 on the use of 8 Hz natural magneto-telluric fields in prospecting for conductive sulphides and in geological mapping. In view of the good results obtained in the earlier work, emphasis was placed during the current field season, on determining the limitations of the telluric and magneto telluric methods and on optimizing survey procedures. Integrators were added to the equipment to permit either integration or recording of the field signals.

Measurements were made over five sulphide deposits in Quebec and two sulphide deposits in New Brunswick (Fig. 1). With one exception, the telluric surveys either detected the sulphide zone or, if the sulphide zone produced no anomaly, indicated the presence of the associated geological feature. The results of telluric surveys are repeatable and the method has good depth penetration. In a survey over a plunging massive sulphide zone, situated in a relatively conductive host rock having an apparent resistivity of approximately 4,000 ohm-metres, the zone was detected to a depth of 250 feet.

Because of equipment bulk and the need for calm weather conditions, magneto-telluric measurements proved practical only for apparent resistivity determinations at selected locations.


60°
64°
68°
72°
76°
80°
52°
48°
44°
CHIBOUGAMAU
MATTAGAMI
BATHURST
SENNETERRE
NORANDA
ROUYN
MONTREAL
OTTAWA
TORONTO
● TEST LOCATIONS
100 0 100 200 300
MILES

68. BOREHOLE AND RELATED GEOPHYSICAL TECHNIQUES USED IN QUATERNARY STUDIES

Project 680035

J. E. Wyder

Surface Resistivity

Approximately 100 miles of resistivity surveys, on a one-half mile spacing, were completed in the Virden (62F) map-area. The results of these surveys and a follow-up drilling program indicate that surface resistivity surveys can be used in the Virden area to outline gravel and colluvium bearing buried river channels and valleys to a depth of approximately 400 feet. On this basis it is assumed that surface resistivity surveys could significantly reduce the cost of locating potential groundwater supplies in this area.

Preliminary resistivity surveys were made around potash mines near Esterhazy, Saskatchewan with a view to detecting possible salt water pollution of groundwater aquifers.

Borehole Geophysics

To date more than 40, 000 feet of logs have been obtained with the recently purchased multifunction borehole logging unit. While the logs have not been analyzed in detail, preliminary results indicate that the potentially most useful tools for correlation problems in Quaternary deposits are the natural gamma (provenance) and gamma-gamma (density) logs. Future work will be concentrated on these two types of logging techniques.

69. INSTALLATION AND TESTING OF BOREHOLE LOGGER FOR USE IN QUATERNARY STUDIES

Project 680011

J. E. Wyder and R. A. Hodge

In March of 1968 the Geological Survey purchased a multifunction borehole geophysics logging unit. The equipment will be used mainly in a research program aimed at evaluating the potential use of borehole logging as a means of correlating Quaternary deposits. As opportunities arise and where time permits, it is intended that the equipment will be used wherever a potentially new use for borehole geophysical measurements can be investigated.

The logging unit is one of the most up-to-date and comprehensive units, for its size, presently available. Wherever possible it has been built and modularized to NIMS standards. Thus as new tools become available they can be readily added to the existing equipment.

At present the following sondes are on hand: 1-inch diameter self-potential and point resistance, 1 1/4-inch diameter, 16-inch and 64-inch normal, 1 1/4-inch diameter caliper, 1 11/16-inch diameter neutron (He^3 detector)-CCL-natural gamma (crystal detector), 1 11/16-inch diameter gamma-gamma density (geiger tube), 1 1/4-inch diameter temperature and fluid resistivity. Except for the fluid resistivity and electrical sondes, all sondes are pulse type.

A power plant mounted under the hood of the truck in which the equipment is mounted, supplies all electrical power for the operation of the unit. The logging cable consists of 6,000 feet of 4-conductor double-wrapped armoured cable. The cable is wound on an hydraulically driven winch.

The equipment was mounted in the truck and tested in Texas before being driven to Calgary, Alberta, which is the operating base for the logging unit.

MINERAL DEPOSITS

70. STUDY OF PEGMATITIC URANIUM DEPOSITS IN THE GRENVILLE PROVINCE

Project 680088

M. Fratta

Uranium deposits in the Grenville Province were visited and studied in order to determine their importance, origin and relationship with surrounding rocks and with the structures.

The Bancroft area of Ontario was visited on two occasions and several samples were collected, both underground and at the surface. The surface showings and the old trenches of Faraday, Bicroft, Dyno and Greyhawk mines were sampled for comparison purposes.

Two weeks and two months, respectively were spent in the St. Simeon and Johan Beetz areas of Quebec, where staking and exploration has lately been active.

The St. Simeon area is underlain by metamorphic rocks of Grenville affiliation, mostly hornblende schists and gneisses and mica schists and gneisses. Intrusive rocks are represented by pink granite, pegmatite and silexite. The properties examined in this area were those of Cambridge Mining Co., Gaspé Park Mines, Quebec Mattagami Minerals and United Obalski Mining Co. Most of these companies did some trenching and diamond drilling.

The Johan Beetz area is situated on the north shore of the St. Lawrence River, 440 miles downstream from Quebec City. A quasi-circular granitic body is surrounded by metasediments (quartzite, biotite quartzite and schists) and basic metamorphic rocks (metagabbro, amphibolite and hornblende gneiss). The granitic stock itself encloses several remnants of the previous rocks, suggesting that only the uppermost part of the stock is exposed. It appears that although some granitization has occurred along the margins the core of the granite body is intrusive. Pegmatite dykes are equally abundant in the granite and in the surrounding rocks.

St. Pierre Uranium Mines, Gulf Uranium Mines and Grandroy Mining Co. continued the exploration started last year. These and several adjacent properties were visited and more than 200 samples were collected for further study.

In both the St. Simeon and Johan Beetz areas, the uraniferous pegmatite shows strikingly similar characteristics. The colour is grey to pink, the grain size is medium coarse (1-4 cm), the accessory mineral is usually biotite, sometimes hornblende, but never muscovite. The muscovite-bearing pegmatite, which is very common in the St. Simeon and Johan Beetz areas, is usually barren of radioactive minerals. In most cases radioactivity is related to magnetite or to unusual concentrations of coarse biotite. Uraninite is the most common uranium mineral, but euxenite, betafite and uranophane also occur and were identified by H.R. Steacy of the Geological Survey. The thorium content of the radioactive samples is usually low, in contrast with the Bancroft uraniferous pegmatites, where thorium is more abundant than uranium. The structures have some control over the mineralization. The pegmatite dykes occur mainly in shear zones, along foliation planes, joints, or at the hinges of folds.

71. GEOLOGY OF IRON DEPOSITS IN CANADA; NORTHERN ONTARIO, YUKON, QUEEN CHARLOTTE ISLANDS (41, 116C, 103F)

Project 570029

G.A. Gross

Field study of Algoma type iron-formations was continued in June in the Michipicoten area, at Moose Mountain Mine, and at Sherman Mine in northern Ontario. Further study of the stratigraphy of the iron-formation was carried out and specimen material was collected in the Michipicoten area to provide reference standards for co-ordinating results of research on mineral phase relationships by Professor Asahiko Sugaki (see this report, paper 77), to co-ordinate information from mining company records on chemical composition and stratigraphy of the iron-formation and its relationship to enclosing volcanic rocks and sediments.

An occurrence of Algoma type iron-formation was examined along Shell Creek, 50 miles northwest of Dawson, Yukon. This iron-formation is composed of two principal types of material, a black slaty magnetite facies and thin banded chert magnetite facies, which are interbanded. Another facies of thin banded grey chert containing pyrite and pyrrhotite occurs near the magnetite iron-formation. The iron-formation is intimately associated with quartz-chlorite and quartz-mica schists which are most probably of volcanic origin and forms part of a tightly folded group of rocks composed of various schists, argillite, slate, buff-brown gritty quartzite, and black maroon and green shales all of Precambrian and/or Cambrian age[1]. The geological environment of the Shell Creek iron-formation is similar in many respects to that of Algoma type iron-formations in Archean rocks of the Canadian Shield which contain stratiform sulphide deposits associated with the iron-formation.

The contact metasomatic type magnetite deposits at the newly developed Wesfrob Mine on Tasu Inlet on Queen Charlotte Islands were examined. Both magnetite and chalcopyrite concentrates are produced in the milling of this complex ore and the geology of the deposits is similar to that of many other contact metasomatic deposits on the islands along the west coast.

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[1] Green, L.H., and Roddick, J.A.: Geology, Dawson, Yukon Territory; Map 13-1962, Paper 62-7, Geol. Surv. Can. (1961).

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72. THE NATURE OF THE COPPERMINE RIVER COPPER DEPOSITS (86 O AND 86 N)

Project 600009

E. D. Kindle

Numerous different types of copper deposits were noted in the Coppermine River area during a visit in August, 1968. As there was time to visit only 25 of a known 75 or more deposits, it is possible that other types besides those enumerated below may exist, but the following will serve as a partial guide to those engaged in prospecting for copper in this area.

1. Quartz veins containing chalcocite and bornite, minor chalcopyrite.
2. Calcite veins containing chalcocite and bornite.
3. Sulphide veins, generally lenticular, of massive chalcocite and/or bornite.
4. Datolite-prehnite veins containing numerous grains of native copper and some chalcocite and tenorite.
5. Shear-vein in which chalcocite occurs both in the sheared basalt and within lenticular quartz veins along the shear.
6. Shatter zone replacement lodes; brecciated basalt replaced by chalcocite and bornite.
7. Fractured zones and sheared zones with chalcocite veinlets and replacements.

8. Carbonated shear zones, basalt altered largely to carbonate and traversed by tiny red sanidine veinlets; contains chalcocite, minor pyrite and minute specks of native copper.
9. Amygdaloidal flow top replacements, flow top breccia replacements and brecciated flow top replacements; these are mostly chalcocite replacement lodes. They commonly have a red colour due to oxidation of their magnetite content and because amygdaloidal cavities have been partly filled by red sanidine.
10. Diabase dyke lodes in which chalcocite occurs along with magnetite disseminated in the groundmass of the rock.
11. Native copper disseminations in massive basalt, as tiny flakes, spots and as linings and partial fillings of quartz-sanidine-calcite amygdules.
12. Native sheet copper occurs in some chalcocite rich veins where copper salts have been reduced by organic material or ferrous oxide to form native copper. Glaciation has removed most of this type.
13. Green-hued sandstone beds contain disseminated chalcocite and chalcocite nodules in one locality along Coppermine River.
14. Red-hued sandstones are copper stained along a diabase dyke contact at the foot of Sandstone Rapids.
15. Chalcopyrite occurs as veinlets in the dolomite below the basalt series at three known localities.

73. URANIUM IN CANADA

Project 670029

H. W. Little

In May and June, 1968, visits were made to the Bancroft area, Ontario and several days were spent in examination of the 1050- and 1200-foot levels of the recently unwatered Faraday Mine, the workings on these having been thoroughly washed down. Of singular interest are anhydrite dykes exposed in the lower levels of the mine and in the deeper drillholes. Like the pegmatite that formed the ore in all levels of the mine, the anhydrite forms irregular, branching dykes up to 40 feet wide, and contains pyroxene (which is largely altered to uralite), cyrtolite, uranothorite, and uraninite, identified by H. R. Steacy of the Geological Survey. In the workings all gradations can be seen between pure pegmatite and pure anhydrite. There can be little doubt, therefore, that so far as emplacement of these rocks is concerned, both crystallized from a common magma although the source of the anhydrite is still open to question. Lead-uranium ages from isotope ratios were determined by R.K. Wanless of the Geological Survey in uraninite which was separated from the anhydrite and, within the limits of experimental error, are the same as those obtained from uraninite in the pegmatite in 1955[1]. Furthermore, because the isotope ratios obtained in the two determinations are virtually identical, strong support is given to the hypothesis that anhydrite and pegmatite are coeval. Evidence obtained underground that the anhydrite did not crystallize later than the plagioclase was confirmed by microscopic examination of thin sections of specimens which was done by T.J. Bottrill of the Geological Survey. Further studies of this interesting association are continuing.

In the Bancroft region, the property of Glenn Explorations Limited near Anstruther Lake was also visited and much diamond-drill core was logged. The host rock is hornblende granitic paragneiss with some zones of amphibolite. Invading this complex are stringers and dykes of pink pegmatite with abundant quartz and, locally, crystals of uranothorite.

In June the writer examined uranium deposits and their environment in the Carboniferous basin of New Brunswick and Nova Scotia, in the company of Dr. John W. Gabelman of the U.S. Atomic Energy Commission. The Carboniferous red beds bear a close resemblance to some of Carboniferous to Jurassic age that contain uranium ore on the Colorado Plateau of the western United States. At the old prospects, and in some road cuts and other exposures, gamma radiation measured from 2 to 4 times background and one, a mile north of Irishville, was up to 10 times background. In several places alteration of red beds was noted that, superficially at least, resembles that commonly associated with ore-roll uranium deposits of the Colorado Plateau. The only anomalous readings noted in the Albert Formation were a mile north of Upper Dorchester where veinlets containing various proportions of barite, fluorite, pyrite and albertite form a stockwork. Radioactivity appears also to be closely associated with extrusive and intrusive rhyolites of Mississippian or earlier age in the basin. The determination of uranium in stream sediments collected several years ago in the Carboniferous Basin is being done and a report on the data will be published.

In August 1968 a visit was made to M. Fratta in the Johan Beetz area, Quebec (<u>see</u> Fratta, this publication), and the properties of Hollinger Exploration Limited and Prospecting Geophysics Limited were examined with him.

At the request of a provincial Royal Commission investigating the source of radon in fluorite mines at St. Lawrence, Newfoundland, the writer visited these mines. A report was submitted to the chairman of the Commission. The underground workings and drill core were examined and were found to have a very low level of radiation. An alteration zone about the south end of the Tarefare vein is slightly more radioactive, and even more so is granite exposed on the coast near Hare's Ears, where 'red alteration' typical of uranium mineralization is seen along joint planes. Specimens collected then are now undergoing laboratory examination.

Two days were spent in radiometric examination of the Shuswap Complex (Monashee Group) in and near the Okanagan Valley of British Columbia[2], at localities that were chosen from careful perusal of field notes taken several years ago, especially in areas that have become accessible in recent years. Only in a shear zone in granodiorite at one locality was an appreciable anomaly recorded and this was too small to be enticing. Slightly higher readings were obtained in adjacent Eocene lavas and sediments and in red syenitic intrusions of about the same age.

Through the courtesy of the U.S. Atomic Energy Commission and the U.S. Geological Survey the writer examined the Midnite Mine and Peter's lease property in northeastern Washington. The former occurs in sheared, rusty, Beltian (Purcell) argillaceous sediments along and near the contact with porphyritic quartz monzonite of Cretaceous (?) age; a similar environment exists northward in British Columbia, east of Kootenay Lake, and should be a favourable prospecting region. Uraniferous basal 'granitic' conglomerate of Oligocene age that rests upon Cretaceous (?) quartz monzonite occurs on the Peter's lease. Similar basal conglomerates in the intermontane Tertiary deposits of the Canadian Cordillera are widespread, and should be examined.

A property south of China Creek in the Trail, British Columbia area[3], owned by Norex Uranium Limited and Calix Mines Limited, was examined, including the cores of seven diamond-drill holes. It comprises pods of pegmatite, some of which contain some uraninite (?), in granitic paragneiss of Shuswap aspect, and which appears to be gradational into Pennsylvanian (?) sediments.

The field season concluded in Elliot Lake and adjacent areas, where current drilling projects were visited.

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[1] Robinson, S.C.: Economic uranium deposits in granitic dykes, Bancroft district, Ontario; Can. Mineralogist, vol. 6, Pt. 4, pp. 513-521 (1960).

[2] Little, H.W.: Geology of Kettle River (west half), British Columbia; Geol. Surv. Can., Map 15-1961 (1961).

[3] Little, H.W.: Trail map-area, British Columbia; Geol. Surv. Can., Paper 62-5 (1962).

74. GEOLOGY OF CANADIAN LITHOPHILE METALS

Project 530014

R. Mulligan

Field work was directed mainly to the examination and sampling of molybdenum, tungsten, and other deposits known or likely to contain anomalous concentrations of tin and/or beryllium. In addition, two open-pit molybdenum mines were briefly studied in order that their geological makeup might be seen and appreciated at the most favourable stage of development. Localities visited included:

1. Canol Metal Mines (molybdenite). This is on the northern extrapolation of the Cassiar east flank group of molybdenite deposits.
2. Upper Boulder and Ruby Creeks, Atlin district, British Columbia. A number of wolframite-quartz-greisen deposits, some molybdenite-bearing, lie on a line through the Black Diamond deposit, a past minor producer of wolframite and by-product tin.
3. Endako molybdenum Mine, central British Columbia. This, the largest current molybdenite producer, is an open-pit operation in a granitic complex, and is considered a 'porphyry' type of orebody.
4. Christina Range, British Columbia. An area of pegmatitic granite where the occurrence of beryl has been suggested.
5. Red Mountain Mines, Ltd., Rossland, British Columbia. A major current producer of molybdenite from open-pit operations in Mesozoic volcanic and associated rocks.
6. Silver King Mine, Nelson, British Columbia. A former important silver-copper-lead producer in a tin province noted for numerous tin-bearing silver-lead-zinc-copper sulphide deposits.
7. Stannex Minerals Ltd., Revelstoke area, British Columbia. They have recently reopened and renovated the Regal-Silver-Snowflake Mine, a former producer of silver-lead-zinc-scheelite. A considerable amount of stannite was known to occur in the upper workings and scheelite is found locally in lower workings. There is a possibility of downward zoning into cassiterite-tungsten ore.

75. GEOLOGY AND DETECTION OF THE RARE-EARTH ELEMENTS CERIUM AND YTTRIUM

Project 670028

E.R. Rose

Chemical field tests developed for the detection of cerium and yttrium have been applied to a number of known rare-earth mineral occurrences in the vicinity of Ottawa and suggest that they may be of use in a study of the geology of Canadian rare-earth deposits. The tests developed to date are not without shortcomings, but they are neither time-consuming nor costly to perform, and they may prove to be of some assistance to those engaged in prospecting for deposits of rare-earth elements. A detailed report on this study is in preparation.

Cerium and yttrium were detected by means of the proposed chemical tests in a number of weakly radioactive pegmatite dykes located within a northeasterly-trending belt of Precambrian rocks from Verona, Ontario, to Glen Almond, Quebec. Traces of cerium and/or yttrium were also detected in some of the enclosing granite rocks and crystalline limestones, as well as in a number of weakly radioactive calcite-apatite – fluorite – pyroxene-phlogopite skarn zones, such as those of the old Yates uranium mine in Huddersfield Township, Quebec, and in several nonradioactive metamorphic pyroxenite-phlogopite occurrences in North Burgess Township, Ontario, all of Precambrian age.

Within these areas of eastern Ontario and western Quebec, traces of cerium and yttrium were also chemically detected in several samples of basal sandstone, arkose and limestone of Paleozoic age, as well as in widespread deposits of Pleistocene and Recent sand.

76. GEOLOGICAL STUDIES OF CANADIAN LEAD AND ZINC DEPOSITS

Project 650056

D.F. Sangster

As part of a continuing study of the geology of Canadian lead and zinc deposits, visits were made to 13 producing mines, 13 part producers, and 17 developed prospects in Newfoundland, Nova Scotia, New Brunswick, Quebec, Ontario, British Columbia, and Yukon Territory. Purpose of the visits was to become familiar with the geology of the deposits, document their major characteristics, study ore-host relationships, and discuss the mine and local geology with company and provincial geologists. In all cases, representative ore suites were collected for mineragraphic studies, sulphur isotopic and trace element analyses. In many instances wall-rocks were sampled for bedrock geochemical studies and, where local conditions permitted, specimens of wall-rock alteration and/or post-ore dykes were collected for possible K-Ar dating.

As a result of this examination of a large number and wide geologic variety of lead-zinc deposits, two major concepts have become apparent:

1. By far the majority of Canadian lead- and/or zinc-producing deposits are of the stratiform type (i.e. their longest dimension is conformable with layering in the host rock). Furthermore, these stratiform deposits are stratabound within distinct time-rock units which vary between geological provinces. In Canada, the most consistently-producing rock-units are: Archean volcanogenic series in the Shield[1], Upper Proterozoic through to Middle Cambrian sedimentary series of the western Cordillera, and Ordovician-Silurian volcanogenic series of the Appalachians (ref. 2, pp. 84-85).

2. The textural, structural, and mineralogical changes brought about by metamorphism must be regarded as important parameters in the exploration for and evaluation of stratiform, stratabound mineral deposits. Under suitable conditions, metamorphism can result in raising a mineralized zone from the protore category into potential ore. In general this can be brought about by one or any combination of the following metamorphic effects:

(i) Increase in grain size (thermal metamorphism) resulting in more efficient grinding, separation, and recovery of ore minerals. This point has been emphasized by Gross[3] in relation to metamorphism of iron-formation.

(ii) Folding (dynamic metamorphism) which results in a thicker ore zone, with little or no change in grade, by simply repeating an otherwise uneconomically thin sulphide layer.

(iii) Remobilization of ore constituents (dynamo-thermal metamorphism) into zones which are structurally and/or chemically receptive to sulphide deposition. A common example is the concentration of ore along structural lineations such as fold axes. Ore constituents such as Cu, Pb, and Zn generally appear to be more mobile than Fe and remobilization often results in an increase in grade in the fold axes with pyrite being left behind on the flanks of the fold or orebody.

In some cases, metamorphism results in mineralogical changes which may also materially affect exploration procedures. For example, pyrite is commonly altered to pyrrhotite during metamorphism. Because pyrrhotite is magnetic, the metamorphosed deposit will respond to magnetic as well as electrical geophysical exploration techniques. Furthermore, pyrrhotite is generally less stable than pyrite during weathering. This results in the more rapid release of acidic solutions to attack and disperse the ore constituents (Cu, Pb, Zn) and thus influence the secondary geochemical pattern of the deposit. This, in turn, will be reflected in the size and intensity of the resultant geochemical anomaly.

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[1] Goodwin, A.M.: Archean protocontinental growth and mineralization; Can. Mining J., vol. 87, No. 5, pp. 57-60 (1966).

[2] McCartney, W.D., and Potter, R.R.: Mineralization as related to structural deformation, igneous activity, and sedimentation in folded geosynclines; Can. Mining J., vol. 83, No. 4, pp. 83-87 (1962).

[3] Gross, G.A.: Metamorphism of iron-formations and its bearing on their beneficiation; Trans. Can. Inst. Mining Met., vol. LXIV, pp. 24-31 (1961).

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77. MINERAL PHASE RELATIONSHIPS IN STRATIFORM IRON DEPOSITS IN THE MICHIPICOTEN IRON-FORMATIONS (42C)

Project 680007

A. Sugaki

The mineral phase relationships of the carbonate, oxide and sulphide facies in Algoma type iron-formation were examined. Ore specimens and drill cores from the George W. Macleod, James and Lucy Mines in the Michipicoten area of Ontario were studied with the optical microscope. They are mainly composed of siderite, quartz, pyrite, pyrrhotite and some silicate minerals such as chlorite and muscovite. Occasionally associated with the above are magnetite, ilmenite, rutile, arsenopyrite, chalcopyrite, chloritoid, biotite, stilpnomelane, albite, ankerite, calcite and graphite.

The common mineral assemblages are:

(1) Siderite-quartz
(2) Siderite-quartz-pyrite
(3) Siderite-quartz-pyrite*-pyrrhotite
(4) Siderite-quartz-magnetite

(5) Siderite-quartz-magnetite-pyrrhotite-pyrite-arsenopyrite*-chlorite*-muscovite*-albite*
(6) Siderite-quartz-pyrite-pyrrhotite*-arsenopyrite*-chalcopyrite*-chlorite-ilmenite*-rutile*-graphite
(7) Siderite-quartz-pyrite-pyrrhotite*-arsenopyrite*-chlorite-chloritoid-muscovite-ilmenite*-rutile*
(8) Siderite-quartz-pyrite-pyrrhotite-chlorite-biotite

* Not always present.

Siderite, quartz and the iron sulphides are the most predominant minerals and occur in massive form or, occasionally, as stratiform bands and mutually crustified structures. Although they are generally recrystallized by metamorphism, they are sometimes found in their original form of spherical or spheroidal bodies (colloform texture), typical of many sedimentary deposits. From the facts mentioned above it is probable that the iron carbonate, oxide and sulphide facies in the Michipicoten iron-formation were of sedimentary origin with later low grade regional metamorphism.

PALEOECOLOGY AND QUATERNARY GEOCHRONOLOGY

78. TREE-RING CHRONOLOGY BUILDING IN EASTERN CANADA AND ALBERTA

Project 680026

M. L. Parker

Dendrochronological specimens, consisting of increment borings from living trees were collected in Alberta, New Brunswick, Ontario, Prince Edward Island, and Quebec. Most of this field work was undertaken in conjunction with peat and lake sediment sampling by J. Terasmae and R. J. Mott. The tree-ring specimens were collected for the purpose of constructing year-by-year master tree-ring chronologies that will provide chronological and climatological information required for the dating of postglacial events and the determination of past environments.

Tree-ring chronologies derived from living trees provide the foundation for: (1) dating dead tree-ring specimens which have ring series that overlap the living tree chronology in time; (2) comparing weather records with the tree-ring series to determine the relationships between climate and tree growth; and (3) evaluating the dendrochronological quality of ring series in order to determine the tree species and site conditions that are most likely to produce datable and climatically sensitive specimens. A tree-ring series is of high dendrochronological quality if it is sensitive (highly variable in ring width), long, free from undetectable false annual rings or absent rings, and can be crossdated with the other ring series in the area.

A sufficient number of specimens have been collected to construct tree-ring chronologies for the following species and locations: (1) white spruce (_Picea glauca_) and black spruce (_P. mariana_) near Athabasca, Alberta; (2) Engelmann spruce (_P. engelmanni_) and whitebark pine (_Pinus albicaulis_) near Peyto Glacier, Alberta; (3) Douglas fir (_Pseudotsuga menziesii_) near Banff, Alberta; (4) white spruce and lodge-pole pine (_Pinus contorta_) in the Cypress Hills of Alberta; (5) eastern hemlock (_Tsuga canadensis_) and eastern white cedar (_Thuja occidentalis_) at the Petawawa Forest Experiment Station, Ontario; (6) eastern hemlock near Owen Sound, Ontario; (7) eastern white cedar at the Sandbanks Provincial Park, Ontario; (8) eastern hemlock and eastern white cedar at Gatineau Park, Quebec; (9) eastern hemlock, eastern white cedar, and tamarack (_Larix laricina_) near St. Stephen, New Brunswick; and (10) eastern hemlock, eastern white cedar, and tamarack at the Acadia Forest Experiment Station, New Brunswick. A few increment cores of balsam fir (Abies Balsamea), alpine fir (A. lasiocarpa), white pine (Pinus strobus), red pine (P. resinosa), and jack pine (P. banksiana) have been taken, but the ring series of these specimens are too complacent (lacking in ring width variability) and too short to be used for constructing good quality tree-ring chronologies.

A cursory examination of the tree-ring material collected during the 1968 field season has led to the following tentative conclusions:

1. False annual rings are not expected to present a problem in the dating of any of the specimens collected, because these false rings occur infrequently and are easily recognized.

2. Of all the material collected, only the whitebark pine from the Peyto Glacier area has a high percentage of absent rings. No difficulties in dating due to a high frequency of absent rings is anticipated for most species from most areas.

3. The young age of the trees and the lack of ring width variability are two factors which often contribute to the poor quality of tree-ring series in many of the areas where samples were taken.

4. The old age (over 600 years), high sensitivity, and good cross-correlation of ring series of the Douglas fir trees from Banff make them the highest in dendrochronological quality of all trees sampled.

5. Eastern hemlock has the highest quality dendrochronological characteristics of all species that were sampled in Eastern Canada.

6. The samples taken from tamarack trees are sensitive and cross-date well with one another, but nearly all of the trees sampled are young (less than 100 years old).

7. Most of the eastern white cedar trees sampled are several centuries old and contain sensitive ring series, but are frequently difficult to cross-date.

79. QUATERNARY STRATIGRAPHIC PALYNOLOGY OF CANADA

Project 610042

J. Terasmae

Stratigraphic drilling in the buried Dundas Valley (Hamilton, Ontario) was completed in the spring of 1968. Borings reached bedrock at a depth of somewhat more than 400 feet and penetrated 5 glacial till layers, separated by sand, gravel and clay (according to preliminary examination of core samples). Water under pressure was encountered at Dundas at a depth of little over 200 feet. The ancient valley slopes toward Lake Ontario and was eroded to a depth of about 200 feet, or more, below present sea level.

Lake sediment cores for pollen analyses and radiocarbon dating were collected in the Athabasca district of Alberta, Cypress Hills area in Alberta and Saskatchewan, Kitchener area in Ontario, southwestern New Brunswick, and Prince Edward Island, for use in current Quaternary geology studies. Sampling in several areas was integrated with the collection of dendrochronological specimens by M. L. Parker.

Preliminary palynological and sedimentological study of cores collected in the Kitchener-Owen Sound area, Ontario, have indicated the presence of several late-glacial climatic oscillations and it is anticipated that radiocarbon determinations on basal organic deposits will provide dates older than those previously obtained in southwestern Ontario, possibly in the 12, 000 to 13, 000 years B. P. range.

PALEONTOLOGY

80. SILURIAN-ORDOVICIAN MACROBIOSTRATIGRAPHY, LAKE TIMISKAMING AND LAKE NIPISSING, ONTARIO AND QUEBEC (31L, M)

Project 680112

Thomas E. Bolton and M. J. Copeland

A combined macro-micropaleontological examination in August, 1968, of the Ordovician and Silurian rocks of the Lake Timiskaming outlier, Ontario and Quebec, has produced several fossils new to the area. Echinoderm faunas composed of Pleurocystites, Cremacrinus, and Cupulocrinus have been identified within the Middle Ordovician Farr Formation, Liskeard Group, and Hemicystites, Protaxocrinus, Dimerocrinus, and a new genus of Myelodactylidae within the Silurian Wabi and Thornloe formations.

Samples for micropaleontological examination were collected from a newly exposed section of the Ordovician Bucke and Farr formations in the Lake Timiskaming area. Closely related Middle Ordovician ostracod faunas are being studied from Manitou Islands in Lake Nipissing and Whitefish Falls-Little Current area of Manitoulin Island, Ontario. Zonation of the early Middle Silurian Wabi and Thornloe formations of the Lake Timiskaming area may be based on their contained zygobolbid and associated ostracods. Correlation of these faunas with those of southern Ontario and eastern Quebec is indicated.

81. CAMBRIAN BIOSTRATIGRAPHY (12H, 22A, 93H)

Project 650024

W.H. Fritz

Two weeks were spent with Dr. C. H. Kindle of City College, New York studying Late Middle Cambrian outcrops in Quebec and Newfoundland. Near Percé, Quebec, W. B. Skidmore of the Quebec Department of Natural Resources, gave assistance by helping to locate outcrops within the area of interest. New collections were made from the lower exposures of the Corner of the Beach Formation, and these were later reviewed with collections made by Skidmore in 1965 and P. Lesperance in 1962. Enough fossil material is now available to correct the dating of the Corner of the Beach Formation from its previously assigned[1] late Lower? Cambrian age. The lowest exposed beds (80 feet) belong to the late Middle Cambrian Bolaspidella Zone. The barren upper beds (85 feet) are of this age or younger. They cannot be younger than the early Upper Cambrian (Dresbachian) fauna known[2] from the overlying formation.

In west-central Newfoundland two outcrops were collected in the allochthonous Cow Head sequence. From the first outcrop on the White Rock Islets, boulders were collected that contained a Bolaspidella fauna. These fossils will be used for comparison with the Corner of the Beach fauna and with faunas collected by Rasetti[3, 4] (1948, 1963) from boulders at Grosses Roches and Metis, Quebec. The second outcrop collected contained boulders with a late Bathyuriscus-Elrathina fauna. Superficial examination suggests a very close faunal similarity between these trilobites and trilobites from the late Bathyuriscus-Elrathina Zone on Mount Stephen and Mount Field, British Columbia that are in the Burgess Project collections (1966, 1967).

Ten days were spent in the Northern Cariboo Range, British Columbia to assist R. C. Campbell. One continuous section near Dome Creek was found to have a measured thickness of 6, 920 feet and to contain Lower, Middle (?) and Upper (?) Cambrian trilobites. The measured thickness may not be a true thickness in the upper two-thirds of the section as that portion is highly cleaved. Across the Rocky Mountain Trench and 30 miles north of the Dome Creek section, Lower Cambrian strata were collected and Middle Cambrian strata observed. The only lithologic unit in common between this sequence and the Dome Creek section is the Lower Cambrian Mural Formation.

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[1] Kindle, C.H.: A Lower (?) Cambrian fauna from eastern Gaspé, Quebec; Am. J. Sci., vol. 240, pp. 633-641 (1942).

[2] Kindle, C.H.: Crepicephalid trilobites from Murphy Creek, Quebec, and Cow Head, Newfoundland; Am. J. Sci., vol. 246, pp. 441-451 (1948).

[3] Rasetti, F.: Middle Cambrian trilobites from the conglomerates of Quebec (exclusive of the Ptychopariidae); J. Paleont., vol. 22, pp. 315-339 (1948).

[4] Rasetti, F.: Middle Cambrian ptychoparioid trilobites from the conglomerates of Quebec; J. Paleont., vol. 37, pp. 575-594 (1963).

82. MESOZOIC AND TERTIARY STRATIGRAPHY OF NORTHERN VANCOUVER ISLAND (92E, 92L, 102I)

Project 670064

J. A. Jeletzky

About two and a half weeks in July, 1968 were spent in reviewing the principal previously studied[1, 2, 3] Mesozoic and Tertiary sections of northwestern part of Vancouver Island with J. E. Muller to facilitate his mapping of this area.

The remaining part of July, 1968 was spent in a detailed paleontological-stratigraphical study of the Mesozoic and Tertiary rocks of several areas of northern Vancouver Island. The following results were obtained.

Quatsino Sound

Volcanic division of Bonanza Subgroup at Quatsino village. A rich but indifferently preserved fauna of marine pelecypods and gastropods, and corals was found in interbeds of tuffaceous greywacke and grit at the top of the Waterlain breccia unit at the point about 300 feet east of Quatsino Hotel. A general Triassic age was suggested for this interesting fauna by E. T. Tozer because of the presence of representatives of Megalodontidae.

The at least 3,000-foot-thick Waterlain breccia unit of Quatsino Sound comprises the basal part of the Volcanic division of Bonanza Subgroup and corresponds to the Upper Triassic or Jurassic pyroclastic and tuffaceous rocks of the west coast of Vancouver Island[1, 2]. Like the latter unit, the Waterlain breccia unit overlies unconformably the late Upper Norian (upper Suessi Zone) Sutton limestone of the Sedimentary Division of the Bonanza Subgroup. This and the general Triassic affinities of the fauna suggest Rhaetian age for the Waterlain breccia unit and its equivalents.

The Waterlain breccia unit underlies, apparently conformably (contact not seen) an about 7,000-foot-thick unit of lavender to maroon coloured, acidic (dacitic to ? rhyolitic) and intermediate (andesitic?) pyroclastics and lavas. The acidic phases of this presumably basal Jurassic (Hettangian) unit are mostly rich in phenocrysts of meat-red to orange sodic plagioclase.

Jeune Landing Cretaceous outlier. The following most important, apparently continuous, gently inclined section of Mesozoic and? Tertiary rocks was observed at the southern end of the Cretaceous outlier mapped by Jeffery[4] in headwaters of Lippy and Kwokwesta Creeks, 2 to 3 1/2 miles north of Jeune Landing:

Unit	Lithology	Thickness (feet)
	Late Tertiary volcanic unit?	
1	Acidic, apparently rhyolitic lava, light blue to cream white, weathers maroon to rust-coloured, rich in phenocrysts of dirty white potassic? feldspar and quartz as well as in quartz- or chalcedony-filled amygdules and chalcedony?-lined vesicles; lower contact unconformable; top covered, probably underlies most or all of 200- to 250-foot high covered slopes above the section but is actually exposed for only	6
	Nanaimo Group (undivided)	
2	Arkosic? sandstone, mottled whitish grey or mottled buff, weathers bright to light orange, coarse-grained, partly gritty; unfossiliferous in this section but elsewhere has yielded Pterotrigonia evansana (Meek) fauna (GSC loc. 55086)	25
3	Pebble conglomerate, fine to very fine, mottled brown-grey, friable, pebbles poorly rounded; both contacts conformable	6
4	Greywacke, bluish grey, weathers chocolate brown, fine grained; locally contains: Baculites sp. indet., Inoceramus chocoensis Anderson, "Rhynchonella" suciensis Whiteaves etc., 8-foot wide covered interval at the base presumably conceals normal but unconformable contact with unit 5, visible	4.5
	Barremian variegated clastic unit	
5	Arkosic sandstone, whitish grey, beige or dull green, weathers buff or dull yellow, mostly fine grained; often replete with wood fragments and poor plant remains but locally contains Acroteuthis (Boreioteuthis) ex gr. impressa (Gabb); both contacts covered, visible	41
6	Pebble conglomerate, mottled grey, fine to very fine, mostly poorly rounded and often grades into a fine mixed (sedimentary and volcanic) breccia or?	

Unit	Lithology	Thickness (feet)
	very coarse, waterlain volcanic tuff, hard, massive; both contacts covered	17
7	Greywacke, bluish grey, weathers brown-grey, massive-looking, medium grained, hard; both contacts covered; visible	25
8	Grit, greenish grey, weathers brownish grey, fine to coarse and often pebbly; mostly massive-looking; numerous pods and lenses of pebble conglomerate and some interbeds of coarse-grained, gritty greywacke; has only yielded one poor, <u>Acroteuthis</u>-like <u>belemnite</u> in this section but elsewhere contains identifiable Barremian <u>Acroteuthis</u> cf. <u>pseudopanderi</u> (Sintsov) (GSC loc. 55100)	18
9	Pebble conglomerate, coarse to fine, mottled greenish grey, hard, tightly packed, matrix very fine pebbly to gritty; volcanic and sedimentary pebbles are mostly lithologically similar to the rocks of Bonanza Subgroup; no pebbles of Coast Intrusion seen; both contacts gradational	26
10	Greywacke, ash-grey, weathers brown to brown-grey, mostly medium- to coarse-grained; thinly but indistinctly bedded; basal 5-6 inches consist of mostly intensively orange-weathering (limonitic) but locally dark grey and coaly, sandy clay with scattered 1/4 to 1/2 inch, well rounded pebbles (fossilized late Mesozoic weathering crust ?); lower contact very sharp and at least erosionally disconformable (probably unconformable)	13
	<u>Volcanic division of Bonanza Subgroup (undivided)</u>	
11	Rhyolitic lava mineralogically and texturally closely similar to that of unit 1 except for an apparently larger ratio of quartz phenocrysts; weathers strongly spheroidally and pillow-like; upper 2 to 2 1/2 feet are bright-orange coloured, partly limonitized and friable presumably because of deep pre-Barremian weathering; upper contact conformable but abrupt	4.5

Unit	Lithology	Thickness (feet)
12	Andesitic? lava, dark- to dull grey, weathers light to dull brown or rust-coloured, fine- to medium grained, often trachytic but locally amygdaloidal; includes some similarly coloured, fine-grained volcanic tuff; invaded by intrusive dykes and sills of dark-green, medium grained, porphyritic and at the same time amygdaloidal gabbroic rock; base covered; visible	20?

Beneath this section are discontinuous outcrops of older beds of the Volcanic division including its Waterlain breccia unit. Greenish grey, waterlain volcanic breccia of the latter unit is underlain (contact covered) by some 75 feet of dark green, fine- to coarse-grained, medium- to thin-bedded greywacke of the upper part of Sedimentary division of the Bonanza Subgroup. This greywacke unit is lithologically similar to the Arenaceous member[1] but is locally rich in Monotis salinaria (Schlotheim) identified by E. T. Tozer. It is underlain conformably and apparently gradationally by 25 feet (base covered) of dark grey to black, more or less calcareous, thinly bedded argillite irregularly interbedded with an about equal amount of thinly bedded, more or less nodular, dark to medium grey impure limestone. This unfossiliferous (except for an indeterminate ammonite fragment) unit is lithologically similar and probably corresponds to the upper part of Thinly bedded member of the west coast[1].

The lava unit 1 is tentatively dated as of the late Tertiary age. This unit could, however, also be of late Upper Cretaceous (Upper Campanian or Maestrichtian) or early Tertiary age as it overlies unconformably sediments 2 to 4 comparable with the Santonian to Lower Campanian part of the Nanaimo Group.

Northern side of Vancouver Island

Lower Cretaceous outlier on the northern coast at Christensen Point. Because of stormy weather the study was limited to the marginal parts of this 3 1/2- to 3 1/4-mile wide outlier discovered by J. E. Muller and the writer. The outlier is a northwest-trending syncline locally strongly complicated by supplementary folding and faulting. Lower Cretaceous rocks are commonly invaded by dykes and sills of acidic to basic composition which were dislocated together with the sediments.

On the northeastern limb moderately southwest-dipping Lower Cretaceous rocks discordantly overlap Norian rocks (Thinly bedded member) of the Sedimentary division, with a well developed basal conglomerate rich in diorite porphyry pebbles and boulders. Their basal 90 to 100 feet consist of irregular interbedding of fine to more rarely medium pebble conglomerate with fine to coarse grained greywacke and grit. All rocks are rust- to orange-coloured and more or less strongly indurated. Conglomerate and grit predominate in the basal 30 feet and become less and less common higher up. Indeterminate inocerami are locally common in the calcareous greywacke interbeds in the uppermost 10 to 15 feet of the unit which grades upward into a more than 300-foot-thick unit (top was not reached) of predominantly fine grained, light to green-grey (except where hydrothermally altered and coloured rust to orange) mostly calcareous greywacke. Some thin, lenticular interbeds and pods of medium- to coarse-grained, pebbly and gritty, calcareous greywacke, fine to coarse, often more or less pebbly grit, and fine pebble conglomerate are scattered throughout the investigated part of the unit.

Numerous but mostly thin, lenticular interbeds and pods of fine- to coarse-grained, strongly calcareous greywacke and impure limestone rich in Inoceramus cf. colonicus Anderson and Inoceramus sp. indet. occur throughout the investigated part of the unit. Well preserved I. colonicus Anderson have been found in its highest investigated beds.

The above described clastics, including their unfossiliferous lower part are correlative with the presumably lower Barremian Inoceramus colonicus limestones of Quatsino Sound.

Similar but lithologically more varied clastics outcrop in a strongly faulted and contorted state on the western limb of the outlier at the eastern base of a nameless point situated about 1, 000 yards southwest of the mouth of Laura Creek. These clastics consist of dark to light brown, fine-grained, thinly bedded to laminated greywacke with some interbeds of similarly coloured, sandy siltstone. Considerable lenticular interbeds (up to 30 feet long and 6 feet thick) and pods of mostly fine pebble conglomerate and grit occur in the unit. It also includes a number of 2-inch to 3-foot, irregularly rounded concretions of impure limestone. These concretions often occur in clusters, are commonly rich in sandy, gritty and pebbly inclusions, and may show signs of abrasion. A few Inoceramus colonicus Anderson have been found in one of these concretions. The visible thickness of these presumably Lower Barremian clastics appears to be in the order of 30 feet. They appear to be faulted (contact covered) against the dark green, fine porphyritic to amygdaloidal lavas of the Karmutsen Group and to grade upward into a some 50-foot-thick unit of dark brown siltstone with rows of concretions of dark to dull grey impure limestone. The top of this unfossiliferous unit appears to be faulted (contact covered) against an at least 1, 000-foot-thick (top not reached) unit of ash to medium grey or dull brown, shale and siltstone with numerous rows of irregularly shaped concretions of dense, cryptocrystalline limestone 6 inches to 3 feet long, and rounded to discus-shaped concretions of hard, dark brown to dark grey calcareous siltstone 1 inch to 6 inches across. These small concretions tend to weather black. Minor 6- to 18-inch interbeds of dull brown to brownish grey, fine- to coarse-grained, greywacke and grit appear to be restricted to the basal 200 feet of the unit where siltstone and shale tend to be more or less sandy. Higher up shale predominates and tends to be pure to silty while siltstones are less common and tend to be pure. These mostly steeply northeast dipping, supplementary folded and strongly faulted rocks outcrop uninterruptedly to the mouth of Laura Creek and probably extend for at least another half a mile along the shore toward Christensen Point.

Except for a few poor plant fragments and those of Inoceramus sp. indet., no fossils have been found in the lower 450 feet of the unit. Very rare fossils found in the upper 550 feet of the unit include: Puzosia (Puzosia) aff. P. dilleri Anderson, Tetragonites? sp. indet., indeterminate desmoceratid ammonite and Inoceramus aff. I. incelebratus Pergament. This fauna appears to be Albian or (?) Cenomanian in age and indicates the correlation of shale unit concerned with the Haida Formation of Queen Charlotte Islands.

Cretaceous outlier on Hope Island. Well preserved Inoceramus vancouverensis Shumard and I. subundatus Meek have been found 20 to 25 feet above the base of the small sandstone outlier discovered by Dawson (ref. 5, p. 72B) on the east side of Hope Island (GSC loc. 82953). This predominantly coarse-grained, often gritty and pebbly greywacke discordantly overlying the Coast Intrusion is thus correlative with the Nanaimo Group.

I. vancouverensis and I. subundatus are uncommon beneath the early Upper Campanian Hoplitoplacenticeras vancouverense zone (ref. 6, p. 41). The Hope Island greywackes are therefore apparently not older than the Cedar District Formation of Nanaimo and Comox Basins (ref. 6, Table 2). If so, the Nanaimo sea covered the northeastern end of Vancouver Island considerably later than it did the latter areas (see also under Suquash Basin).

Northeast coast of Vancouver Island

Cretaceous rocks of Hardy Bay. No marine fossils have been found in the predominantly conglomeratic sedimentary rocks outcropping on the western side of Port Hardy Harbour between the mouth of Quatse River and that of Tsulquate River. The upper part of this apparently non-marine, at least 500-foot-thick unit includes considerable interbeds of coarse- to fine-grained, often gritty and pebbly greywacke and sandy siltstone. Both rock types are locally carbonaceous to coaly.

The Cretaceous rocks form a gentle, approximately west-trending synclinal structure complicated by supplementary folds and strongly disrupted by faults of several directions. The basal conglomerates of the unit overlap discordantly the volcanic rocks of Karmutsen Group on the northern side of Tsulquate River and in the bed of Quatse River.

As recognized by Dawson (ref. 5, p. 70B), these presumably Cretaceous rocks appear to be entirely separated by ridges of the Vancouver Group from the lithologically dissimilar Nanaimo rocks of Suquash Basin. It is not certain whether they are a piedmont facies of the latter rocks or are older and equivalent to the lithologically similar non-marine Lower Cretaceous (Barremian and Aptian) rocks of Coal Harbour.

Upper Cretaceous (Nanaimo) rocks of Suquash Basin. The study was restricted to the about 3-mile long stretch of the shoreline southwest of Thomas Point and to the lower 2 miles of Keogh (Ki-Uk) River. This area appears to represent the northern limb of a gentle (8°-15° dips) synclinal structure, commonly complicated by supplementary, equally gentle folds and strongly disrupted by a number of major faults of several directions. The inferred upward succession obtained by combination of several discontinuous, faulted partial sections appears to be as follows:

The basal unit of Nanaimo Group discordantly overlaps the volcanic rocks of Karmutsen Group about 3/5 mile southwest of Thomas Point. It consists predominantly of buff- to rust-coloured, coarse- to medium-grained, commonly gritty, intensively crossbedded and locally calcareous greywacke with some lenticular interbeds and lenses of fine to coarse grit and fine pebble conglomerate. Some poorly exposed interbeds of friable, fine-grained, locally carbonaceous to coaly greywacke and sandy siltstone occur in this unit. This basal unit appears to be more than 1,000 feet thick, barring its repetition by unrecognized major faults.

An about 13-foot-thick interbed of more or less calcareous, richly fossiliferous coarse-grained greywacke occurring in the middle part of the unit has yielded (GSC loc. 82952): Inoceramus subundatus Meek, I. aff. vancouverensis Shumard, Trigonia cf. tryonana Gabb and Pectunculus weatchii Whiteaves. This fauna cannot be any younger than the overlying late Upper Campanian Metaplacenticeras occidentale fauna and is unlikely to be any older than the nearly identical Inoceramus vancouverensis and I. subundatus fauna of the Hope Island outlier. This suggests the equivalence of the basal greywacke unit of Suquash Basin with the Cedar District Formation of Nanaimo and Comox basins.

About 3/4 mile west of the mouth of Keogh River the basal greywacke unit is conformably and gradationally overlain by an at least 500-foot-thick unit consisting of an irregular interbedding of the usually 10 to 30-foot-thick members of:

1. Greywacke, dull grey, medium to coarse grained, hard and weathering resistant, commonly more or less calcareous and ferruginous (weathers rust- to chocolate-coloured); and

2. Subgreywacke and(?) arkose light grey to pinkish grey, weathering buff to whitish grey, well sorted and rounded, mostly fine grained,

predominantly thinly bedded to laminated, mostly strongly and intricately crossbedded and ripple-marked. These sandstones are locally carbonaceous to coaly and contain a 1- to 2-foot-thick interbed of dark brown, coaly siltstone rich in poorly preserved plants in the middle part of the unit. An apparently lenticular 5 to 6-inch-thick interbed of impure coal occurs in this siltstone bed. No marine fossils have been found in this apparently deltaic unit which grades upward into an at least 35-foot-thick unit of ash to medium grey, sandy to very sandy siltstone rich in concretions and thin concretionary bands of impure limestone and calcarenite. This siltstone unit has yielded Metaplacenticeras occidentale (Whiteaves), Schluteria cf. selwyniana (Whiteaves) juvenile Pseudophyllites indra Forbes?, and various long-ranging, marine pelecypods and gastropods (GSC loc. 82962 and 82963). This fauna represents the late Upper Campanian lower part of Pachydiscus suciaensis zone (ref. 6, p. 41) and indicates the equivalence of the siltstone unit concerned with the lower Lambert and lower Northumberland Formations of Comox and Nanaimo basins (ref. 6, p. 45, Table 2).

Upper contact of Metaplacenticeras occidentale siltstones is invariably covered and probably faulted. However, they dip under and are believed to be older than an at least 400 feet thick unit of bluish grey to light grey coarse-to fine-grained, hard greywacke and(?) arkose with some interbeds of similarly coloured grit, and locally with large, rounded inclusions of calcareous, honeycombed greywacke. This arenaceous unit is locally carbonaceous to coaly and contains at least one 30-foot member of grey siltstone rich in wood-bearing clay ironstone concretions and bands. This siltstone member contains interbeds of black to dark brown coaly siltstone with 1- to 3-inch layers and pods of impure black coal. Base concealed and presumably faulted. Because of its inferred stratigraphic position this unfossiliferous unit is believed to be only slightly younger than the Metaplacenticeras occidentale siltstone and to correspond to the upper part of Northumberland Formation and the lower part of upper Lambert Formation.

At the point about 1 3/4 miles above the mouth of Keogh River the bluish grey greywacke unit is overlain conformably and apparently gradationally by an at least 250-foot thick unit of dull to dark grey sandy to very sandy, commonly thinly bedded to laminated, friable siltstone. This unit contains considerable bands and lenses of similarly coloured, predominantly friable, fine-grained, silty greywacke and lacks limestone concretions and bands. Numerous 3- to 8-inch cannon ball concretions of hard, fine-grained greywacke or sandy siltstone occur in the topmost 20 to 25 feet of the unit studied (top not reached). These concretions have yielded some long-ranging, marine pelecypods and gastropods of the general Nanaimo affinities (GSC loc. 82964) and some poor leaves. The unit cannot be dated any closer from these fossils. However, it could correspond to the early Lower Maestrichtian part of the upper Lambert Formation of Comox Basin (ref. 6, p. 45, Table 2) because of its inferred stratigraphic position well above the Metaplacenticeras occidentale siltstone.

[1] Jeletzky, J. A.: Stratigraphy of the west coast of Vancouver Island between Kyuquot Sound and Esperanza Inlet, British Columbia; Geol. Surv. Can., Paper 50-37 (1950).

[2] Jeletzky, J. A.: Tertiary rocks of the Hesquiat-Nootka area, west coast of Vancouver Island, British Columbia; with brief comments on adjacent Mesozoic formations; Geol. Surv. Can., Paper 53-17 (1954).

[3] Jeletzky, J. A.: Geological history of the west coast of Vancouver Island and Quatsino Sound; Bull. Geol. Soc. Am., vol. 65, No. 12(2) (1954).

[4] Jeffery, W. G.: Preliminary geological map, Alice Lake-Benson Lake; B. C. Dept. Mines Petrol. Resources (1962).

[5] Dawson, G. M.: Report on a geological examination of the northern part of Vancouver Island and adjacent coasts; Geol. Surv. Can., Ann. Rept. 1886, Pt. B (1887).

[6] Muller, J. E., and Jeletzky, J. A.: Stratigraphy and biochronology of the Nanaimo Group, Vancouver Island and Gulf Islands, British Columbia; Report of Activities: November 1966 to April 1967; Geol. Surv. Can., Paper 67-1, Part B (1967).

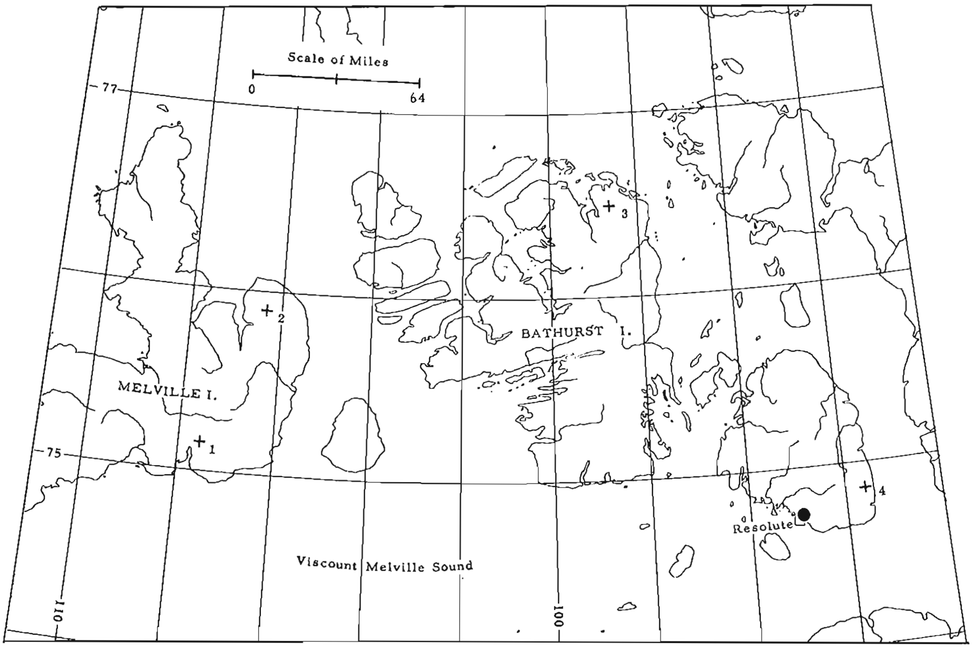
83. MID-PALEOZOIC BIOSTRATIGRAPHY OF THE ARCTIC ISLANDS (58F, 69A, 78H)

Projects 680101 and 680113

D. C. McGregor and T. T. Uyeno

Four measured sections of Late Silurian to Late Devonian age on Melville, Bathurst, and Cornwallis Islands were sampled (see Fig. 1). The objectives of the project are to set up zonal standards for palynomorphs and conodonts of the Canadian Arctic, to correlate the palynomorph and conodont zones, and to correlate the conodont zones with those already established in the classical areas of Germany and Austria. Further sampling will be made from other selected sections during two subsequent summers.

Sequential samples were obtained from the Read Bay (Late Silurian), Bathurst Island, Stuart Bay, Eids, Blue Fiord, Bird Fiord, Weatherall, Hecla Bay, and Griper Bay formations (Early to Late Devonian).



Location of sections sampled for spores and conodonts:

+1 – Weatherall, Hecla Bay, Griper Bay formations

+2 – Blue Fiord, Weatherall, Hecla Bay formations

+3 – Bathurst Island, Stuart Bay, Eids, Blue Fiord, Bird Fiord formations

+4 – Read Bay Formation (Members A, B, lower C).

Certain intervals within the latter five units are already known to contain spores[1]. In preliminary runs, conodonts have been found in the Stuart Bay, Blue Fiord, and Griper Bay formations.

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[1] McGregor, D. C.: Composition and range of some Devonian spore assemblages of Canada; Rev. Palaeobot. Palynol., 1:173-183 (1967).

PETROLOGY

84. ALKALINE ROCKS, CALLANDER BAY AND BRENT, ONTARIO (31 L/1, L/3)

Project 680071

K. L. Currie

Callander Bay

Callander Bay is an almost circular depression at the east end of Lake Nipissing, about two miles in diameter, and is surrounded on three sides by precipitous hills about 100 feet high. Around the edge of the bay a thin screen of alkaline plutonic rocks varying outward from shonkinitic to pulaskitic grades into variously fenitized, generally granitoid country rocks. Two islands near the centre of the bay expose carbonatite veins and breccias in intensely fenitized country rocks. Drilling results show that parts of the eastern portion of the bay are also underlain by carbonatite. The fenite zone is characterized by the development of abundant aegirine and riebeckite, in the body of the rock near the bay, and in cracks farther away. Calcite is present in intensely fenitized specimens. All strongly fenitized rocks are vuggy and porous, suggesting that fenitization was accompanied by loss of material. Rheomorphic shonkinitic red fenites locally cut and disturb the fenite zone.

A complex dyke system surrounds the bay, and extends outward approximately to the edge of the fenite zone (about 3/4 mile). The earliest dykes were breccia of alnoitic type, which are cut by spectacular porphyritic tinguaite dykes. The latest dykes are biotite lamprophyres of monchiquite type. A characteristic feature of all the dykes is their sinuous character both in plan and section. Two main systems of dykes are present; radial dykes that are short and lenticular and cone sheets that are much longer. Nepheline syenite cone sheets occur southeast of the crater. Monchiquite dykes also occur intermittently down Highways 11 and 17, following the boundaries of the Nippissing graben. There is a marked gap of about two miles between the edge of the central complex of Callander Bay and the commencement of these regional dyke swarms. The dykes are accompanied by fenitization and intense hematization extending several inches into the country rock. Exposure of the dykes is very poor, and for practical purposes they can only be examined in large rock cuts. In this way the dyke swarm has been traced east as far as Chalk River along Highway 17. The number and size of lamprophyre dykes decreases to the east, and the amount of carbonate in the occurrences increases, so that calcite veinlets are common east of

Mattawa. There is a notable intensification in the number of dykes, intensity of fenitization, and amount of carbonate just east of Deux Rivières. A central complex may be present in this area.

Brent

The Brent crater is a circular depression about two miles in diameter lying two miles north of the south boundary of the Nipissing graben. Previously drill cores from this structure revealed presence of alkaline aphanitic rocks and alnoite breccia dykes at depth[1]. Surface mapping revealed a shatter fenite zone surrounding the crater, slightly elongated to the northeast, and extending about 3/4 mile from the crater. Cone sheets of inclusion-rich alnoite breccia are present to the south and east of the crater. Carbonatite breccia outcrops along the west side of the crater. Abundant float of aphanitic red rocks identical to the material from depth, and to the rheomorphic dykes at Callander Bay, was found on the east side of the crater. The form of the boulder train suggests that it comes from a cone sheet. Moderate to intense fenitization occurs along a graben trending southwest from the crater to the main fault zone to the south. Along the main fault zone on the north shore of Cedar Lake dykes to alnoite breccia are occasionally found, and mild to intense fenitization occurs intermittently. Structural considerations suggest that the crater has been down-dropped several hundred feet with respect to its surroundings.

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[1] Currie, K. L., and Shafiqullah, M.: Carbonatite and alkaline igneous rocks in the Brent crater, Ontario; Nature, vol. 215, No. 5102, pp. 725-726 (1967).

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85. CHARLEVOIX STRUCTURE, QUEBEC (21 M/9)

Project 660547

K. L. Currie

The Charlevoix structure is elliptical, or semicircular about 23 miles by 15 miles in dimension formed in anorthosite and granulites of the Grenville Province. Structurally it is similar to Carswell Lake structure[1] with a large central mountain, and a relatively narrow surrounding moat. Lamellar features are present in quartz and plagioclase in the central mountain, and an extraordinary number of shatter cones occur in the surrounding moat, particularly in Ordovician outliers to the south. The orientation of the shatter cones is consistent at any one site, but varies radically, evenbetween closely spaced sites, and is difficult to reconcile with any simple hypothesis of origin. Tuffisite dykes with calcitic matrix and containing fluorite are abundant in the southern part of the structure. Carbonatite dykes with typical marginal fenitization occur in the west margin of the structure, and are exposed along the shore of the St. Lawrence River from La Malbaie (east edge of the structure) east at least as far as the Saguenay River. It is unknown whether these dykes only occur along the shore of the St. Lawrence, or are only exposed in this region.

Small masses of breccia occur near the central uplift, veined with rheomorphic material, and pseudotachylite occurs on the central uplift. Genuine igneous material appears only in one small plate of outcrop, which may be the remnant of a larger sheet.

Determination of the structural development of the Charlevoix structure is rendered difficult by the intense deformation along the St. Lawrence River. One hypothesis is that part of the structure has disappeared entirely by fault movement in the river. This idea is not supported by the zonation of the structure which appears to be continuous, though the widths of the zones vary. The similarity of Charlevoix to the Hicks Dome structure of southern Illinois in shape and petrography is striking.

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[1] Currie, K. L.: Geological notes on the Carswell circular structure; Geol. Surv. Can., Paper 67-32 (in press).

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86. GEOLOGY OF THE MISTASTIN LAKE STRUCTURE, LABRADOR (13M (PART OF))

Project 680070

K. L. Currie

Mistastin Lake lies in an elliptical northeast-trending depression 6 by 10 miles cut into hilly terrane of anorthosite, syenite, and augen-gneiss. A horseshoe-shaped island is centrally located in the lake with the open end of the horseshoe, about 2 1/2 miles across, facing east. A few small rocky reefs are located in the arms of the horseshoe, almost at the geometric centre of the lake. Igneous rocks, radiometrically dated at 202 m.y., outcrop in an almost continuous arc along the shore of the lake for 25 miles, from the northeast corner around the west end to the southeast corner, defining an elliptical area 7 by 9 miles, the eastern end of which is covered by the lake.

The volcanic feeders are exposed in creeks and on cliffs on the northern and western sides of the structure. A composite ring dyke from 25 to 100 feet wide is the lowest portion, widening upward to a steeply inward dipping trough, at the top of which the lavas spread out laterally. The lowest volcanic rocks are tuff-breccias, which line the walls of the feeders and form vesicular dykes and thin sheets. The main portion of the igneous rocks comprises basalt or andesite which is highly vesicular in the vents, but becomes rapidly dense and nonvesicular away from the feeders. In the areas of lava sheets the feeders can be readily recognized and traced by their vesicular character. The top unit, exposed along the north shore of the lake is a pale grey pumice with many fragments of andesite. The north side of the central island displays many dykes of tuff breccia, and rare andesite dykes. The Precambrian rocks show lamellar features in quartz and plagioclase, and local development of maskelynite. On the central reefs spectacular development of maskelynite is found, together with pseudotachylite, and numerous boulders of volcanic rocks.

Structurally, the ring dyke appears to occupy a fault along which the crater has subsided. Brecciation is strongly developed in the vicinity of this fault, particularly in the anorthosite.

This crater is strikingly similar to the Manicouagan structure[1]. It is neither circular nor equant, but irregularly elliptical. The igneous rocks originated from the boundary of the structure, not from the centre. The exposure and variety of the igneous rocks are such that a volcanic episode during the development of the crater cannot be denied. The shock metamorphic phenomena may indicate a hypervelocity impact, but this is not supported by any other evidence.

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[1] Currie, K. L., and Murtaugh, J. G.: A preliminary account of the Manicouagan structure, Quebec; Geol. Surv. Can., Paper 67-70 (in press).

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87. STRUCTURAL AND PETROLOGICAL STUDY OF PINNACLE PEAKS GNEISS DOME, BRITISH COLUMBIA (PARTS OF 82 L/1, L/8 AND 82 K/4)

Project 670278

J. E. Reesor and E. Froese

Mapping was continued in the metamorphic rocks of Pinnacle Peaks area during the past summer. Stratigraphic continuity, distinguished by two good marker horizons, has been established from Upper Arrow Lake to Monashee Creek, across the Shuswap Metamorphic Complex. A number of localities show a sharp transition from sillimanite-almandine-muscovite zone to staurolite zone rocks. Pelitic and semipelitic schists change rapidly in lithological aspect from one zone to the next. However, stratigraphic continuity can be followed along carbonate-bearing units that change little from one zone to another. Three stages of megascopic folding can be recognized. In the deepest zone, the culmination of Pinnacles dome is characterized by a large scale northward-verging east-west trending, isoclinal, recumbent fold that can be followed across the entire metamorphic complex. This fold is disharmonious and opens to a gentle east-west arch upward in the succession. In the upper levels of the complex north and northwest folds develop instead, they too are disharmonious, and show very little effect on the schists of the deeper zones. The latest major structural episode is an east-west, upright, isoclinal fold developed along the intrusive granite contact that trends westward along the south border of the map-area.

Each fold system is characteristically developed at a particular level in the metamorphic complex, with east-west folding at depth, northwest folds at shallower levels, and along the periphery. The large fold along the granite contact is superimposed upon both these structures.

PRECAMBRIAN GEOLOGY

88. PRECAMBRIAN SHIELD OF THE RIVIÈRE GATINEAU MAP-AREA, QUEBEC (PARTS OF 31NW AND 31F)

Project 680030

A. J. Baer

The writer and an assistant undertook a preliminary reconnaissance of the Grenville Province between longitude 76° and the Quebec-Ontario border. Most roads were traversed by jeep and the Ottawa River was navigated from Ville-Marie to Pembroke.

Lithologically, the area may be subdivided into three regions; one northeast of the Mont Laurier-Val d'Or highway, one between that highway and the Ottawa River, and one including the extreme eastern and southeastern regions.

Northeast of the Mont Laurier-Val d'Or highway, major lithological units are metagreywacke, biotite-garnet gneisses derived from them, and a group of brownish or greenish rocks characterized by garnet, green feldspar with or without pyroxene, and by the absence of biotite. Minor amounts of hornblende gneiss are present. These rocks have been followed across the Grenville Front into less metamorphosed greywacke in the Superior Province. They are in part equivalent to map-units (2) (3) and (4) of Wynne-Edwards et al. [1]. Most of the central, western and southern parts of the area are occupied by a lithologically distinct group of rocks. They include commonly well-layered white to pink, more rarely grey, quartzofeldspathic gneisses that, in the western part of the area, appear to grade into quartzite, micaceous quartzite and meta-arkose. They are interlayered with subordinate amounts of dark green feldspar-hornblende-garnet gneiss, and locally with grey biotite-garnet gneiss. Some of these rocks can be correlated with map-unit (1) and part of map-unit (2) of Wynne-Edwards et al. [1].

Rocks of the Grenville Group occur only in the eastern and southeastern parts of the area and are particularly abundant southeast of a line joining Pembroke to Reservoir Baskatong. Marble is the most common rock-type, but rusty-weathering biotite gneiss, quartzite and biotite-garnet-sillimanite gneiss also occur. Rocks included in the Grenville Group correspond to map-units (8) to (13) of Wynne-Edwards et al. [1].

Except for numerous gabbroic bodies in the southeastern part of the area, recognizable plutonic granitoid rocks are rare.

Two structural trends are evident in the area, a northwesterly trend that is particularly well developed between the Mont Laurier-Val d'Or highway and the Ottawa River and a northeasterly trend in the northeastern, eastern and southeastern parts of the area as well as along the Grenville Front. Preliminary observations indicate that northeasterly trending structures deform northwesterly ones and are presumably younger.

The Grenville Front was crossed northeast and southwest of the Mont Laurier-Val d'Or highway in La Verendrye Park, east and south of Belleterre, and south of Ville-Marie. In these five areas, it represents a metamorphic front with rapid but progressive increase in metamorphism from the greenschist facies or the lower part of the amphibolite facies to higher parts of the amphibolite facies. Conditions south of Ville-Marie are complicated by local and apparently late faulting in the region of the front, but the Grenville Front in that area is not essentially different.

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[1] Wynne-Edwards, H.R. et al.: Mont Laurier and Kempt Lake map-areas, Quebec; Geol. Surv. Can., Paper 66-32 (1966).

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89. VOLCANIC STUDIES IN THE SEAL LAKE AREA, LABRADOR (13 K, L)

Project 680096

W.R.A. Baragar

This summer's field work on the Seal Lake, Croteau, and Letitia Groups adds to the increasing knowledge of volcanic rocks of the Canadian Shield. The method of study was similar to that used in previous studies of this program[1, 2, 3]. Two sections across the Seal Lake Group and one each across a major part of the Croteau and Letitia groups were mapped in detail and the volcanic rocks sampled at close intervals. Section locations are shown in Figure 1. Lines 1 and 2 traverse the north limb of the regional east-west syncline involving the Seal Lake Group and span its entire preserved thickness. Line 3, along the axial plane of a gently-plunging fold in the Croteau Group and line 4 along its south limb, together provide a thick, nearly continuous sequence of Croteau volcanic rocks. Line 5 crosses part of the very limited exposures of Letitia Group rocks.

Each of the lines was chained and elevations recorded along it (by barometer) at intervals of 300 feet or less. The geology was mapped directly on the resulting profile at a scale of 400 feet to 1 inch. In addition, scintillometer readings were taken at intervals of 300 feet or less on lines 1, 3, and 5.

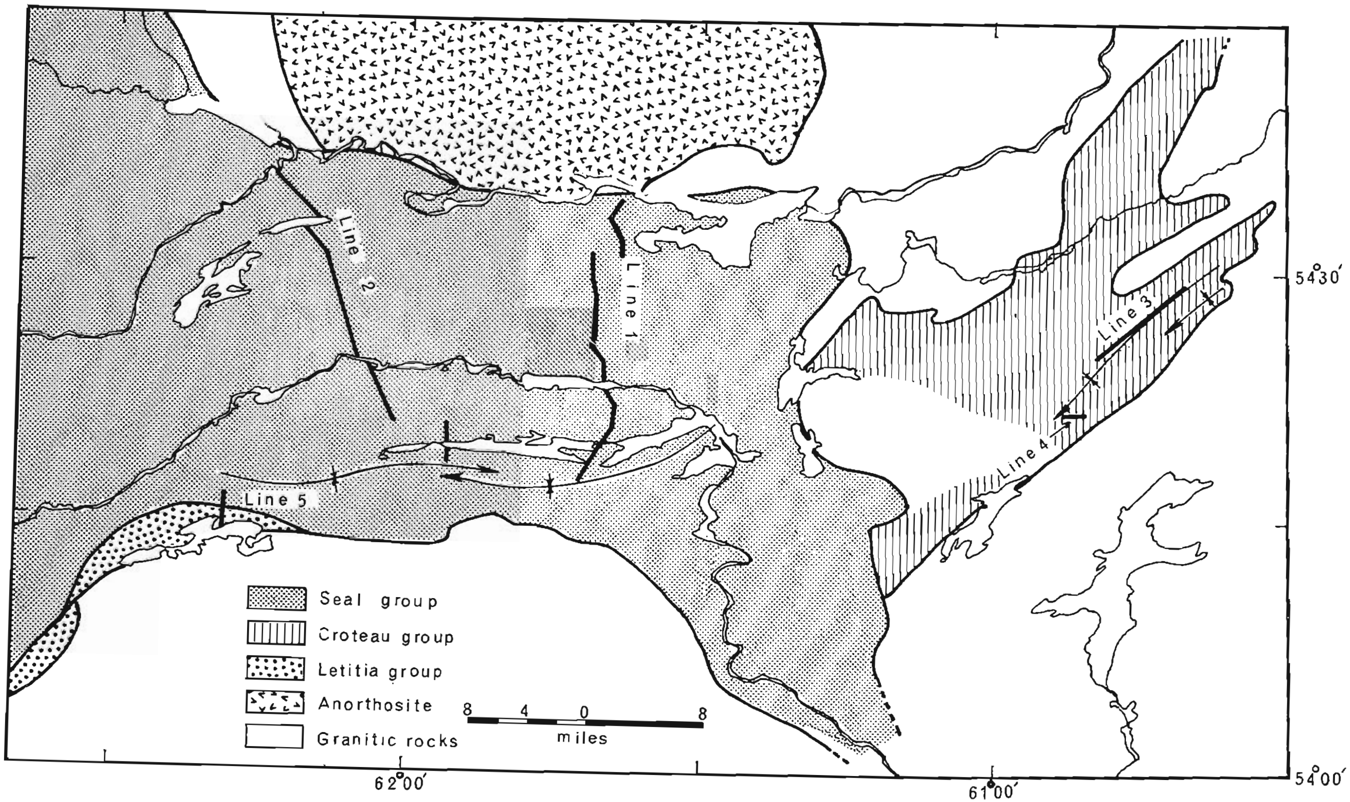

Figure 1. Seal Lake area, Labrador.

Chip samples for chemical analyses were collected in the volcanic parts of the sections at stratigraphic intervals of roughly 200 to 400 feet. These will be analyzed for the major and 13 minor elements.

For the geology of the region embraced by this report reference is made to the work of Fahrig[4], Roscoe[5], and Brummer and Mann[6].

A preliminary compilation of the geology of line 1 provides stratigraphic data on the Seal Lake Group as follows:

Unit	Name used in ref. 6	Thickness (feet)
Thick-bedded red quartzites, minor red shales and basalt	Upper red Quartzite Formation	1,500
Red shales, subordinate inter-bedded basalt flows and minor quartzite	Adeline Island and Salmon Lake Formations	4,500
Closely-spaced dolerite sills and minor intersill sediments, mainly red and grey siltstones and shales with locally some carbonate and limy shale beds	Wuchusk Lake Formation	7,000
Closely-spaced dolerite sills and minor intersill sediments, mainly red quartzites and arkoses, rare black shales	Wuchusk Lake Formation	2,500
Basalt flows with rare inter-bedded quartzite, arkose, and arkosic conglomerate	Majoqua Lake Formation	5,000?
Red arkose	---	800
Basement of anorthosite and granitic rocks		

The total preserved thickness of the Seal Lake Group according to this compilation is about 21,000 feet. The thickness of the main basalt formation is somewhat uncertain because of the presence within that segment of a presumed thrust fault. The thickness given is a minimum, however, even if there was no repetition due to the faulting the maximum thickness of the flows would not exceed 9,000 feet.

The part of the Croteau Group covered by lines 3 and 4 is composed entirely of volcanic rocks. A preliminary compilation of the stratigraphy is as follows:

Unit	Thickness (feet)
Felsic volcanic rocks, probably mainly rhyolite; rare bedded deposits of felsic ash	8,000
Mafic to intermediate volcanic flows and subordinate tuff	2,300
Rhyolite	200
Mafic lavas and subordinate mafic tuffs and lapilli tuffs	3,000
Felsic volcanic rocks, probably mainly rhyolite and dacite; in part fragmental	1,500
Purplish feldspar porphyry, probably mainly andesitic to dacitic composition	1,750
Mafic tuffs and lapilli tuffs; vaguely bedded in places	2,300
Quartzite and shale	25
Interlayered mafic volcanics and purplish feldspar porphyry of intermediate to acid composition	2,000
Total thickness	21,075

A sedimentary succession underlies this volcanic sequence at a stratigraphic interval of not more than a few hundred feet. Thus, much of the total volcanic succession is probably included in this section.

The Letitia Group is composed mainly of schistose acid volcanic rocks in which primary structures have been largely obliterated. Accordingly no reliable estimate of thickness is possible.

Scintillometer readings taken along the section lines varied with rock types but were remarkably constant within any one lithological category. Thus, measured in microrhoentgens/hour (μR/hr) basalts characteristically gave readings of 2-4, quartzites and arkoses 5-10, red shales 12-15, grey shales 16-20, and acid volcanic rocks 20-30. One arkosic conglomerate member interbedded with basalts near the base of the Seal Lake Group gave readings of up to 100 μR/hr. The high level of radioactivity enabled this member to be identified in three successive limbs of a pair of gentle folds that involve volcanic rocks of the north part of the Seal Lake Group and greatly aided correlation. Samples, which in outcrop gave readings of 100 and 30 µR/hr, were determined in the laboratory to have levels of activity equivalent to 0.015 per cent and 0.006 per cent U_3O_8 respectively. This is well below the range of values that might be of economic interest.

Rocks of the Seal Lake Group are believed to have been deposited mainly in a continental environment. The basaltic flows have the appearance of plateau basalts. They range in thickness from 10 to 150 feet and characteristically grade from a massive base to an oxidized, amygdaloidal flow top. Pillow lavas were observed at only 2 or 3 stratigraphic levels and pyroclastic rocks are rare.

The environment of deposition of the Croteau Group is less certain. No pillow lavas were observed and among the extensive deposits of pyroclastic and fragmental rocks present in the group, distinct bedding is rare. Thus the Croteau Group may also be of mainly subaerial deposition. Little can be said about the more altered rocks of the Letitia Group.

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[1] Baragar, W.R.A.: Volcanic studies: Coppermine River basaltic flows; in Report of Activities, May to October 1966, Geol. Surv. Can., Paper 67-1, Pt. A, pp. 26-28 (1967).

[2] Baragar, W.R.A.: Volcanic studies: Grenville Province, Ontario; in Report of Activities, May to October, 1967; Geol. Surv. Can., Paper 68-1 Pt. A, pp. 115-116 (1968).

[3] Baragar, W.R.A.: Major-element geochemistry of the Noranda volcanic belt, Quebec-Ontario; Can. J. Earth Sci., vol. 5, pp. 773-790 (1968).

[4] Fahrig, W.F.: Snegamook Lake, Newfoundland; Geol. Surv. Can., Map 1079A (1959).

[5] Roscoe, S.M.: East Kasheshibaw, Newfoundland; Geol. Surv. Can., unpubl. map.

[6] Brummer, J.J., and Mann, E.L.: Geology of the Seal Lake area, Labrador; Geol. Soc. Am., vol. 72, pp. 1361-1382 (1961).

90. STUDY OF THE HURWITZ GROUP IN THE EASTERN PART OF THE RANKIN-ENNADAI BELT, DISTRICT OF KEEWATIN (65H (EAST HALF), 65I (EAST HALF))

Project 670004

R. T. Bell

The study[1, 2] of the Hurwitz Group was continued in 1968 with work largely confined to the Hurwitz rocks in the Padlei belt (see Fig. 1 of Paper 91). Visits were made to the Kognak River area[3, 4] for the purpose of comparison. A two day visit was made to the Amer Lake area (66H) for the purpose of assessing the feasibility and scope of a study of presumed Aphebian rocks there and of comparison with the Hurwitz Group under study.

New information includes the following observations:

(1) The units underlying the ripple-marked orthoquartzites (Hurwitz C)[2] thicken and coarsen to the southwest.

(2) Sediment transport in the ripple-marked orthoquartzites remains consistently from the southeast, at least as far west as 97° west.

(3) Volcanic rocks in the upper part of the Hurwitz (Hurwitz Fa)[2] are exposed as far west as 97° west, but only the lower beds are present. There the gabbro sill (Hurwitz Fb)[2] is intruded above the volcanic rocks and therefore is not coeval with the earlier phase of vulcanism and possibly not coeval with any.

(4) Polymictic conglomerates, pyritic quartzites, and quartz-pebble conglomerates are exposed on the southeast flank of the padlei belt, but are largely absent from the northwest flank. These sedimentary rocks are probably separated from succeeding units by a gentle unconformity. It is highly likely that the lower succession is correlative with similar rocks near Montgomery Lake (unit 7, Eade[3]).

(5) Some of the pyritic quartz-pebble conglomerates mentioned above are mildly radioactive[1, 2, 5]. Using a type 1597A Rank Scintillometer readings of 15 to 40 μR/hr were commonly observed (at one locality a reading of 65 μR/hr was observed).

(6) Arkosic, conglomeratic and quartzitic metasedimentary rocks near MacKenzie and Victory lakes[1, 2, 6] continue into the Ferguson Lake area and are probably Archean in age (see following report).

(7a) At Amer Lake (66H) the succession of probable Aphebian rocks, from base to top comprises: about 700 feet of coarse and conglomeratic pink and white orthoquartzites; about 700 feet of grey mudstones, locally containing a pink dolomite member; about 2,000 feet of greenish grey massive volcanic rocks, locally containing pillowed volcanic rocks and pyroclastic rocks; a pink, grey, buff and white quartzite unit whose thickness may exceed 4,000 feet; about 800 feet of grey mudstones and siltstones; about 500 feet of grey limestones; and a succeeding very thick unit of grey and brown calcareous mudstones with minor arkosic siltstones. Another thick quartzite unit may stratigraphically overlie the upper mudstones. Small patches of friable, red, arkosic sandstone and red soils indicate that the Dubawnt Group (likely Thelon Formation) is locally present.

(7b) Exposure of the pre-Dubawnt succession is locally very good but preservation of primary sedimentary structure is extremely poor because of dynamic and regional metamorphism, thus making very difficult, if not impossible a comprehensive evaluation of the Amer Lake succession.

(7c) It is highly probably that the Amer Lake succession is Aphebian but direct correlation with the Hurwitz and Goulburn groups is not yet possible.

---

[1] Bell, R.T.: Study of the Hurwitz Group, District of Keewatin; in Report of Activities, May to October, 1967, Geol. Surv. Can., Paper 68-1A, pp. 116-120 (1968).

[2] Bell, R.T.: Preliminary notes on the Proterozoic Hurwitz Group, Tavani (55K) and Kaminak Lake (55L) areas, District of Keewatin; Geol. Surv. Can., Paper 68-36 (1968).

[3] Eade, K.E.: Kognak River area (east half), District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 64-27 (1964).

[4] Eade, K.E.: Kognak River area (west half), District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 65-8 (1966).

[5] Heywood, W.W., and Roscoe, S.M.: Pyritic quartz pebble conglomerate in Hurwitz Group, District of Keewatin; in Report of Activities, May to October, 1966, Geol. Surv. Can., Paper 67-1A, p. 21 (1967).

[6] Davidson, A.: Kaminak Lake (55L) map-area, District of Keewatin; in Report of Activities, May to October, 1967, Geol. Surv. Can., Paper 68-1A, pp. 122-126 (1968).

91. FERGUSON LAKE AND HENIK LAKES AREAS, DISTRICT OF KEEWATIN (65H (EAST HALF), 65I (EAST HALF))

Project 670004

R. T. Bell

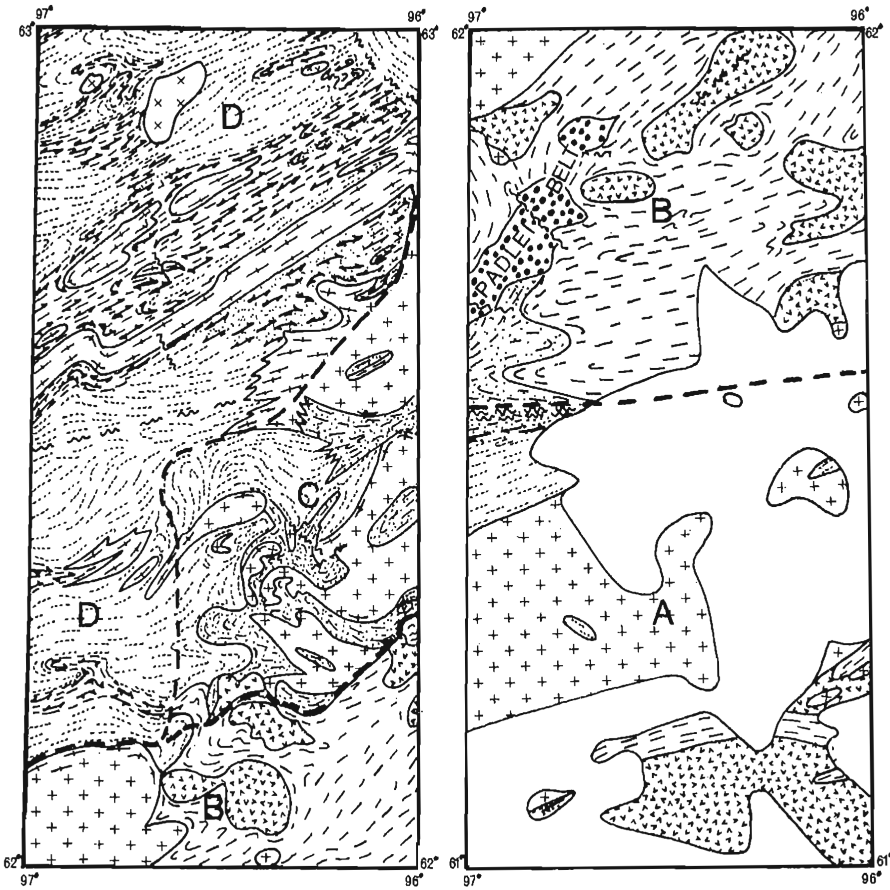
The centre of these contiguous areas lies about 250 miles north of Churchill, Manitoba. During late May, June, July, and August, 1968, reconnaissance mapping (for publication on a scale of one inch to four miles) in conjunction with a study of the Hurwitz Group was accomplished by combination of ground and helicopter traverses with light float-plane support. Ground traverses were concentrated in a band running the length of the centre of the east half of Ferguson Lake area and in the northern third of the east half of Henik lakes area. Professor J. L. Talbot of Lakehead University assisted the author in studying aspects of the structure of the area and made a notable contribution towards completion of the mapping.

The area has tentatively been divided into four regions (A, B, C, and D, Fig. 1) on the bases of structural style, and lithologic and metamorphic features.

Region A, an area of generally poor exposure, is characterized by leucocratic gneisses, greenstones, and biotite and amphibole schists, intruded by dioritic and granitic plutons. The diorites are intruded by a few northeasterly-trending diabase dykes, similar to those described by Davidson and accordingly the metasedimentary, metavolcanic, and dioritic rocks are interpreted to be Archean. It is very likely that the granitic rocks are also Archean.

Regions A and B are separated on the northwest side by a shear zone across which the metamorphic grade of the metasediments drops sharply.

Region B is underlain by a deformed assemblage of predominantly volcanic rocks cut by dioritic and granitic plutons. Greywacke containing iron-formation is exposed in the southwest corner of the region. The volcanic and sedimentary rocks are all of very low metamorphic grade except along the northern border where amphibole schists occur. The dioritic plutons have been intruded by diabase dykes similar to those in region A, thus permitting the same conclusions. Hurwitz sediments are exposed in the Padlei belt (Fig. 1, see also preceding report) and granitic pebbles are common in the lower polymictic conglomerates giving support to the view that the granites in this region are Archean. The dominant structural trend is northeasterly.



FERGUSON LAKE (east half) HENIK LAKES (east half)

LEGEND

- Drift covered areas
- Massive syenite, probably equivalent to the Martell Syenite (Dubawnt Group).
- Migmatite composed mainly of layered or homogeneous gneiss with pink granitic sheets and dykes.
- Relatively homogeneous granitic and dioritic gneiss, derived mainly from older plutonic rocks.
- Layered gneiss, derived mainly from volcanic and sedimentary rocks.
- Hurwitz Group and related rocks.
- Mainly massive, homogeneous pink granite or quartz monzonite, commonly with megacrysts of K-feldspar, in places foliated.
- Older plutonic rocks; gabbro, diorite, quartz diorite, and granodiorite.
- Metasedimentary rocks: mainly metagreywacke and biotite schists with garnet porphyroblasts; some metaquartzite, meta-arkose, metaconglomerate, and iron formation.
- Metavolcanic rocks; mainly greenstone or amphibole schist; minor intercalated felsic volcanic rocks, and greywacke in places.

Note - linear elements of map symbols indicate dominant structural trend.

Fault or fault zone

20 miles

GSC 1968

Metasedimentary rocks, mainly derived from greywackes and cut by granites, characterize region C. Arkosic, conglomeratic, and quartzitic metasedimentary rocks are present in the south and northeast. The metasedimentary rocks grade into a migmatite complex to the west and northwest. In the northeast the arkosic metasedimentary rocks, continuous with those of the Victory and MacKenzie lakes region of the Kaminak area[1] are cut by dykes of meta-diabase. If these dykes are equivalent to those previously cited then the arkosic, conglomeratic, and quartzitic metasedimentary rocks are older than the Hurwitz Group[2, 3]. In the east the structural trend is northeasterly, but becomes more complex in the west.

Region D is underlain by a gneiss complex apparently largely derived from rocks similar to the pre-Hurwitz rocks of regions B and C. New granitic material is restricted to sheets and dykes largely in the migmatite areas. It may be advisable to further subdivide this region on the basis of structural styles, but in general the structural trend is northeasterly to easterly and very steeply dipping.

Late undeformed andesitic and trachytic dykes with apparently no preferred trend cut the rocks in the northern half of region D. These dykes are probably related to the volcanic rocks of the Dubawnt Group.

Two bodies of relatively undeformed and uniform syenite are exposed in the northern part of region D. The syenites resemble the Martell Syenite of the Dubawnt Group.

Gossans are associated with the metavolcanic rocks. Magnetite-hematite iron-formation is associated with the greywackes. Very mildly radioactive pyritic quartz-pebble conglomerates are exposed in the Padlei belt.

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[1] Davidson, A.: Kaminak Lake (55L) map-area, District of Keewatin; in Report of Activities, May to October, 1967, Geol. Surv. Can., Paper 68-1A, pp. 122-126 (1968).

[2] Bell, R.T.: Study of the Hurwitz Group, District of Keewatin; in Report of Activities, May to October, 1967, Geol. Surv. Can., Paper 68-1A, pp. 116-120 (1968).

[3] Bell, R.T.: Preliminary notes on the Proterozoic Hurwitz Group, Tavani (55K) and Kaminak Lake (55L) areas, District of Keewatin; Geol. Surv. Can., Paper 68-36 (1968).

92. SEDIMENTOLOGICAL AND GEOCHEMICAL STUDY OF THE PAPASKWASATI BASIN, NORTH OF LAKE MISTASSINI, QUEBEC (32 P/10, PART P/7)

Project 680056

R.A. Boulay and J-L Caty*

A joint program was undertaken with the Quebec Department of Natural Resources in order to investigate the sedimentology and geochemistry of the Papaskwasati Basin previously mapped by Chown[1] and Neilson[2, 3]. This investigation was made possible through co-operation of the mining companies working in the area. Core totalling 32,000 feet, from 62 diamond-drill holes, was logged and sampled. The information collected is being used to outline the sedimentology, stratigraphy and possible geochemical trends in the basin.

The rocks of the Papaskwasati Formation are of Proterozoic age and unconformably overlie a paleosol derived from the Archean basement. The formation attains a maximum observed thickness of approximately 1,600 feet and consists of quartz-pebble conglomerate, arkosic grit, well-indurated quartz sandstone and thin argillaceous siltstone units, the preceding classification being based solely on field observations. From the information obtained it is possible to construct two generalized stratigraphic columns.

Directional primary structures are present and with further study it will be possible to outline transport direction.

In the central part of the basin the quartz-pebble conglomerate horizon attains a thickness of 120 feet and overlies the Archean basement. This unit is in turn overlain by thick (200-300 feet) units of well-indurated, medium-grained to granular quartz sandstone. These alternate with smaller units of arkosic grit, thin beds of argillaceous siltstone with desiccation cracks and, in places recurring units of quartz-pebble conglomerate which occur up to 700 feet above the base of the formation. Along the margins of the basin the quartz-pebble conglomerate is generally feldspathic and attains a maximum observed thickness of 220 feet. Above the conglomerate arkosic grit predominates and alternates with thin units of sandstone, argillaceous siltstone and recurring units of feldspathic quartz-pebble conglomerate.

Samples of drill core are being analyzed for Mn, Mg, Al, Fe, Ca, Ti, Cu, Co, Pb, Sr, and Ba, on a direct reading emission spectrometer under the direction of Dr. E.M. Cameron.

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* Quebec Department of Natural Resources

[1] Chown, E.H.: Preliminary report on the Papachouesati River area; Quebec Dept. Mines, Prelim. Rept. 415 (1960).

[2] Neilson, J.M.: Preliminary report on Takwa River area; Quebec Dept. Mines, Prelim. Rept. 254 (1951).

[3] Neilson, J.M.: Takwa River area; Quebec Dept. Nat. Resources, Geol. Rept. 124 (1966).

93. SOUTHERN INDIAN LAKE, MANITOBA (64 SE)

Project 680076

W. L. Davison

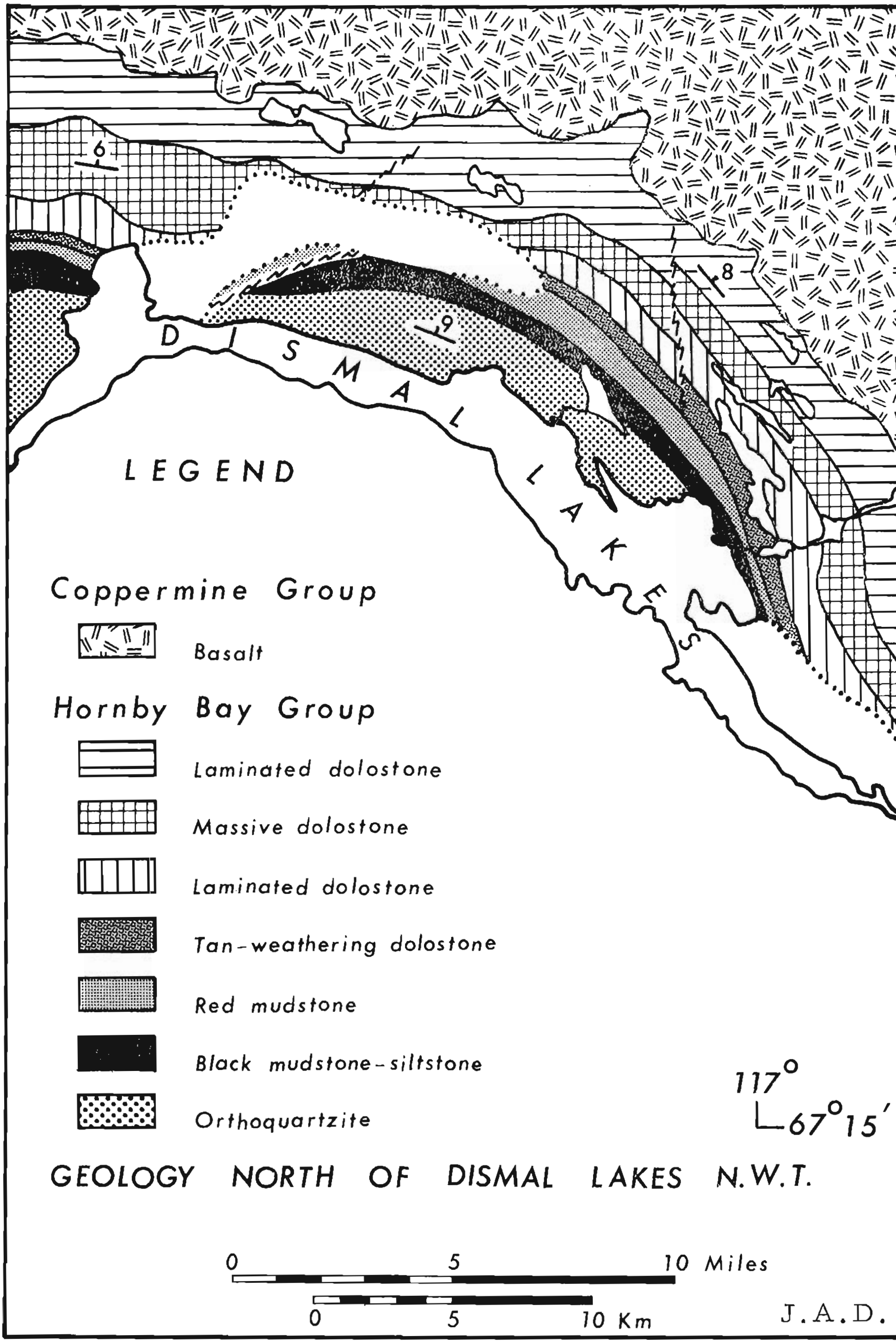
A helicopter, available for about four weeks, was used to traverse Big Sand Lake (64G) and Northern Indian Lake (64H), together with some adjacent parts of Uhlman Lake (64B) and Split Lake (64A) map-areas. In the north and east, exposures are essentially confined to shores of lakes and larger streams. In many places, continuous forest cover made landings impossible although outcrops were observed from the air. W. W. Heywood provided welcome assistance in the helicopter work.

The remainder of the field season was spent in the immediate vicinity of Southern Indian Lake, where extensive flooding will follow building of dams on the Churchill River. The work mainly involved re-examination of previously mapped features, with particular emphasis on sulphide occurrences.

On the whole, results agree with those of previous workers. In the southeast part of Big Sand Lake area, however, considerable amounts of granulite and metasediments have not been separated from younger granitic bodies in the published map[1]. Here, and in the adjacent area to the east[2], more volcanic and metasedimentary rocks are present than is suggested by available maps. In the east half of Northern Indian Lake map-area, sparse exposures in thick drift suggest that a mass of granulite extends from Freeman Lake to the northwest, and that the granulite is surrounded by porphyritic granite, with some granite gneiss.

[1] Quinn, H.A.: Big Sand Lake, Manitoba; Geol. Surv. Can., Map 45-1959 (1960).

[2] Kretz, R.: Northern Indian Lake, Manitoba; Geol. Surv. Can., Map 2-1959 (1959).


6
8
9
D I S M A L L A K E S
LEGEND
Coppermine Group
Basalt
Hornby Bay Group
Laminated dolostone
Massive dolostone
Laminated dolostone
Tan-weathering dolostone
Red mudstone
Black mudstone-siltstone
Orthoquartzite
117°
67°15′
GEOLOGY NORTH OF DISMAL LAKES N.W.T.
0
5
10 Miles
0
5
10 Km
J.A.D.

94. STRATIGRAPHY AND SEDIMENTOLOGY OF THE HORNBY BAY GROUP, DISTRICT OF MACKENZIE (PARTS OF 86J, K, L, M, N, AND O)

Project 680057

J.A. Donaldson

A preliminary investigation of the Hornby Bay Group was undertaken as an extension of earlier work on similar, and possibly correlative, sequences of Middle Proterozoic rocks in the western Shield. The group has been previously mapped on a scale of 8 miles to 1 inch[1].

Regional study of crossbedding in sandstones that compose the bulk of the Hornby Bay Group indicates that westward-directed paleocurrents predominate, although there is a distinct swing in crossbedding azimuths towards the north in stratigraphically higher beds.

Detailed field work in the Dismal Lakes area revealed that substantial stratigraphic subdivision of the upper part of the group is possible. Figure 1 shows the distribution of 7 units, several of which can be traced for considerable distances along eastward and westward extensions of the belt. Primary structures are abundant, and some of them are diagnostic of specific units.

Crossbedding and ripple-marks characterize both the orthoquartzite and the overlying mudstone-siltstone unit. The contact is gradational, and desiccation structures are abundant in the black mudstones. The red mudstones contain abundant mudcracks and casts of halite crystals; some possible pseudomorphs after gypsum crystals occur sparsely. Thin planar bedding and fine grain size characterize the unit of tan-weathering dolostone. The lower laminated dolostone contains beds of stromatolites, oncolites, oolites, chert lenses and nodules, black shale, intraformational conglomerate, and 'molar tooth' structure. The massive dolostone is characterized by vague swirly structures that may be of organic origin, and by a lack of most structures typical of the laminated dolomites. One variety of stromatolite locally occurs, however, and appears to be exclusive to this unit. The unique stromatolites form close-packed unbranched columns with conical laminations (Figs. 2, 3), the inclinations of which typically range from 65 to 80 degrees. In one locality (67°34'N; 114°12'W), the columns are as much as 10 m in diameter and 15 m high. Similar conical stromatolites occur in dolostone of the Parry Bay Formation on Kent Peninsula, more than 200 miles east of Dismal Lakes. Because the Parry Bay Formation is possibly correlative with the Hornby Bay dolostones, this correspondence of distinctive 'Conophyton-like' stromatolite is intriguing. The upper laminated dolostone is similar to the lower laminated unit, but contains a greater variety of

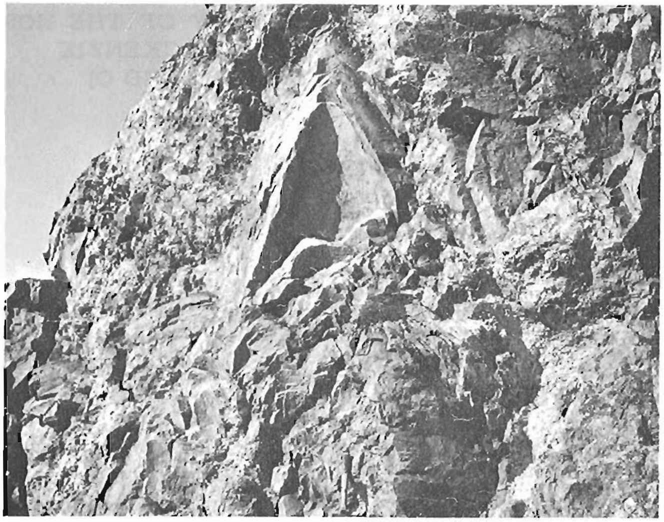


Figure 2. Conical-laminated columnar stromatolite in massive-bedded dolostone unit. Hammer at lower centre indicates scale.

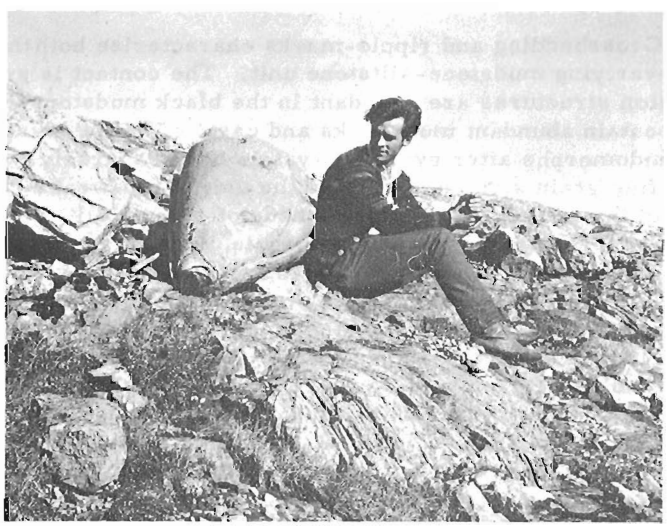


Figure 3. 'Nose cone' weathering form derived from core of a conical-laminated stromatolite.

stromatolites, both branched and unbranched. In transverse section, some stromatolites show elongation parallel to inferred current direction, identical to the relationship reported by Hoffman[2] for stromatolites in the East Arm of Great Slave Lake.

[1] Fraser, J.A.: Geology, north-central District of Mackenzie, Northwest Territories; Geol. Surv. Can., Map 18-1960 (1960).

[2] Hoffman, P.F.: Algal stromatolites: use in stratigraphic correlation and paleocurrent determination; Science, vol. 157, No. 3792, pp. 1043-1045 (1967).

95. PALEOMAGNETIC STUDY OF PROTEROZOIC ROCKS, GREAT BEAR LAKE, DISTRICT OF MACKENZIE (86K)

Project 680012

J.A. Donaldson

This field work initiates a program, in collaboration with E. Irving, Dominion Observatory, and J.C. McGlynn of the Survey for paleomagnetic study of Proterozoic red bed basins in the western Canadian Shield. In a period of three weeks, 134 oriented specimens of sandstone, siltstone, and associated diabase and volcanic rocks were collected at 48 sites in the Echo Bay-Cameron Bay belt that flanks the east side of Great Bear Lake. Laboratory measurements will be carried out by Dr. Irving, and the resulting data should provide magnetic pole positions for comparison with results for other red bed basins (Kazan, Nonacho, Et-then, Martin) to be studied subsequently.

96. ENNADAI LAKE MAP-AREA, DISTRICT OF KEEWATIN (65C)

Project 680085

K.E. Eade

A study of stratigraphic and structural problems was begun in this area which has been mapped previously during a helicopter-supported reconnaissance survey[1]. The map-area is heavily drift-covered and outcrops occupy less than 8 per cent.

Sedimentary rocks of probable Aphebian age, conglomerate, quartzite, dolomite-argillite, and greywacke, occur in two main localities, one in the west bordering the southwest side of Ennadai Lake and the other in the east in the vicinity of Poorfish, Kiyuk, and Windy lakes. In both areas a major unconformity exists within the sedimentary sequence marked by angular discordance and a thick, widespread, conglomerate unit. The sedimentary rocks are folded along northeast-trending axes and are cut by many faults. Plutons of coarse-grained porphyritic biotite granite to granodiorite, commonly fluorite-bearing, intrude the sedimentary rocks but contact effects due to these high level intrusions are slight.

In the northwest corner of the map-area, on the northwest side of Ennadai Lake, basic volcanic and metavolcanic rocks, andesite to dacite in composition, accompanied by medium-grained rocks of similar composition, are intruded by medium-grained granodiorite and both volcanic rocks and granodiorite are cut by small plutons of medium-grained gabbro.

Some prospecting has been carried out in the basic volcanic rocks[1] and during the present work some small pyrite-bearing gossan zones were observed. A scintillometer was used from time to time during the summer to check the sedimentary rocks but no significant results were obtained.

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[1] Lord, C.S.: Geological notes on southern District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 53-22 (1953).

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97. REGIONAL STRUCTURAL STUDY IN THE ELLIOT LAKE AREA, ONTARIO (41 J/7)

Project 680025

G.H. Eisbacher

The major structural features of Archean and Proterozoic rocks in the Elliot Lake region have been documented in maps and reports by Collins[1], Roscoe[2], and Robertson[3].

The present project was initiated in collaboration with the Mines Branch to assess the use of regional tectonic fabrics in understanding residual stress fields in areas of economic interest. Underground stress measurements carried out by the Mines Branch at Elliot Lake suggest the existence of unreleased tectonic stress components within the mine environment[4].

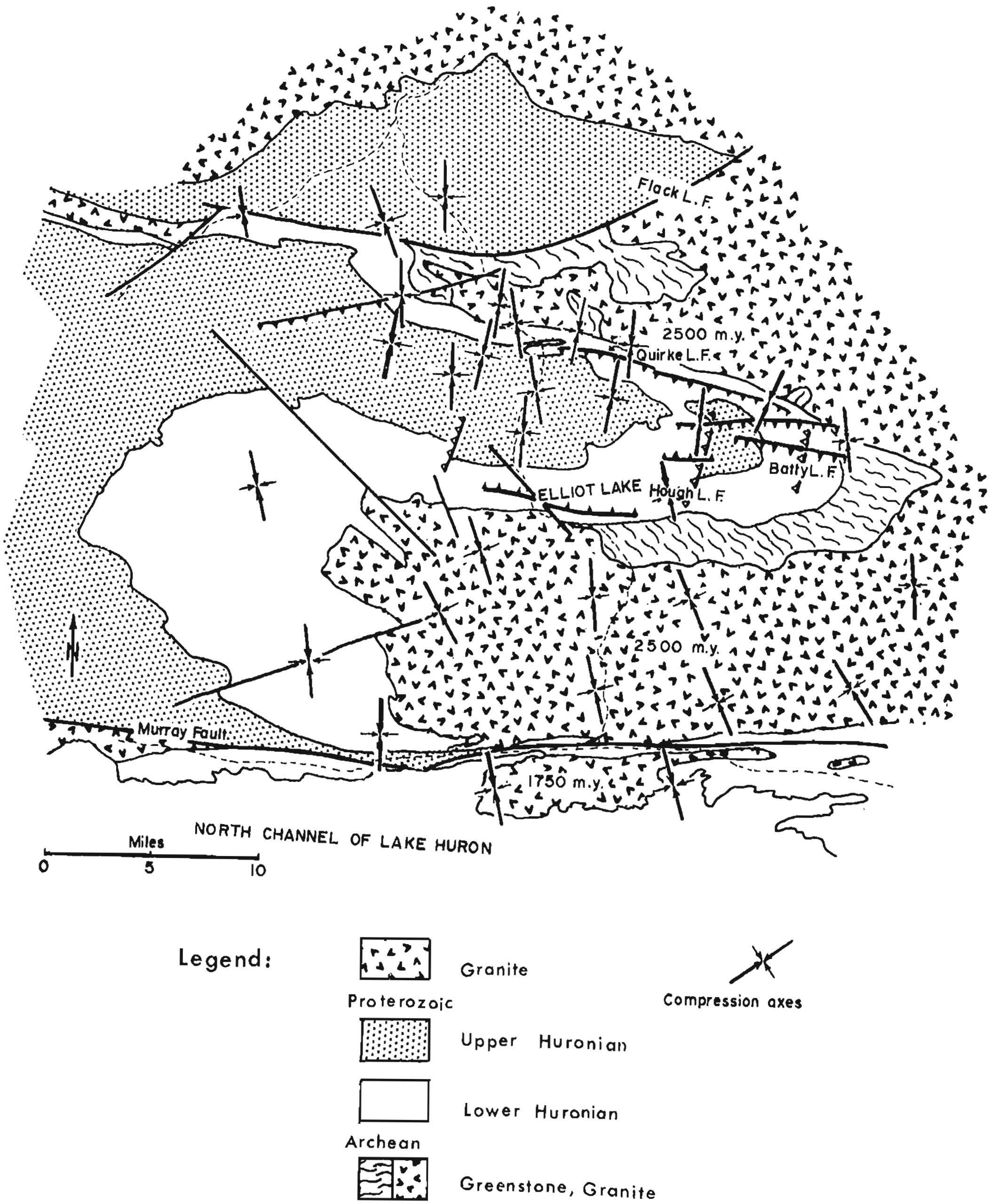

Figure 1. Dynamic sketch map of the Elliot Lake region.

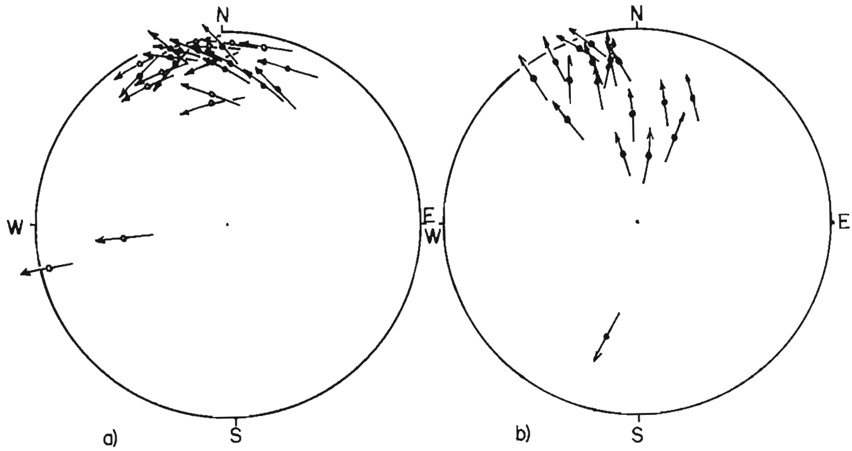

Figure 2. Right-lateral strike-slip linears
(a) in the Murray Fault zone, superimposed onto older up-dip slip linears
(b) on bedding and shear surfaces.

During the field season of 1968 tectonic fabric was systematically analyzed in Archean basement and the Proterozoic sedimentary cover. The basement complex consists of greenstones and greywackes intruded by granitic rocks (2,500 m.y.)[5], the Proterozoic succession contains conglomerates, quartzites, and minor limestone.

It is possible to document five steps in the post-Archean tectonic evolution of this region:

(1) Basin subsidence and syndepositional faulting, accompanied by intrusion of clastic dykes and sills along northerly trending fractures.

(2) Basement controlled steep-angle flexuring along north-northeasterly trends (Hough Lake Fault, Batty Lake Fault), locally developing into thrusts and creating a first set of cleavage in pelitic sedimentary units (Fig. 1).

(3) Intrusion of Nipissing diabase sills and dykes (2,150 m.y.)[5].

(4) Vertical motion on easterly trending basement faults (Flack Lake Fault, Quirke Lake Fault, Murray Fault) and concordant thrusting, bedding plane slip or local décollement in Proterozoic cover rocks, imprinting a penetrative easterly-trending cleavage on pelitic units.

Compression axes for this deformation could be derived by detailed kinematic analysis of slickensided fractures in granitic basement rocks, and bedding-slip, mesoscopic contraction faults, and matrix-clast displacements in sedimentary units. Orientation of compression axes within the area analyzed is shown in Figure 1. Granitic rocks of Hudsonian age (Cutler Granite – 1,750 m.y.)[5] were involved in the deformation: it is therefore likely that the dominant post-Archean displacements in the Elliot Lake region occurred between 1,750 m.y. (Cutler Granite) and 1,200 m.y.[5] (relatively undeformed olivine diabase).

(5) Late oblique right-lateral movements along the Murray Fault zone (Fig. 2a); superposition of subhorizontal slip-linears onto older, steeply pitching slip-linears (Fig. 2b) could be observed at several localities along the Murray Fault.

Basement propagated extension fracturing along easterly to southeasterly trends greatly reduced stress components with northerly to northeasterly directions. Unreleased stress components parallel to these dominant fracture sets, on the other hand, probably contribute significantly to residual rock stresses in the area.

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[1] Collins, W.H.: The north shore of Lake Huron; Geol. Surv. Can., Mem. 143 (1925).

[2] Roscoe, S.M.: Geology and uranium deposits, Quirke Lake-Elliot Lake, Blind River area, Ontario; Geol. Surv. Can., Paper 56-7 (1957).

[3] Robertson, J.A.: Recent geological investigations in the Elliot Lake-Blind River uranium area, Ontario; Ont. Dept. Mines, Misc. Paper 9 (1967).

[4] Coates, D.F., and Grant, F.: Stress measurements at Elliot Lake; Can. Mining Met. Bull. Trans., vol. 69, pp. 182-192 (1966).

[5] VanSchmus, W.R.: The geochronology of the Blind River-Bruce Mines area, Ontario, Canada; J. Geol., vol. 73, pp. 755-780 (1965).

98. GRAVITY INVESTIGATIONS OVER THE MORIN INTRUSION, QUEBEC (PARTS 31G, H, I, J)

Project 640039

R. F. Emslie

In collaboration with the Observatories Branch, a number of gravity profiles were measured over different parts of the Morin anorthositic intrusion. The profiles were located principally to assist interpretation of the shape of the intrusion at depth and consequently most of them cross the contacts at high angles. Samples of bedrock were collected along the profiles and their densities measured to assist the gravity interpretation. Together with sample collections made during previous geological mapping, these provide a total of nearly 1, 300 sample densities.

Reduction of the gravity data is not yet complete but it is clear that in general the anorthositic intrusion coincides with a substantial gravity low and that gravity gradients across the contacts vary from steep to nearly zero at different localities. The reasons for such different gradients are not everywhere readily apparent from surface rock densities or structure.

99. HECLA-CARROLL LAKE MAP-AREA, MANITOBA-ONTARIO (62P (EAST HALF), 52M (WEST HALF))

Project 680020

I. F. Ermanovics

The Hecla-Carroll Lake map-area, bounded by 51-52°N, 95-97°W, is chiefly underlain by granodioritic and monzonitic rocks in the north and by a narrow belt of Archean greenstones in the south. The region is part of a large area of Precambrian plutonic rocks bearing small zones of granitized, relict, Archean metavolcanic and sedimentary rocks. Such zones may be used to trace out the structure of the oldest Archean deposits.

The Archean greenstones of the Rice Lake Group consist of volcanic flows, tuffs and gabbroic rocks near the base, with quartz-rich sediments towards the top. The group forms a tightly folded belt, two to four miles wide, trending 110 degrees.

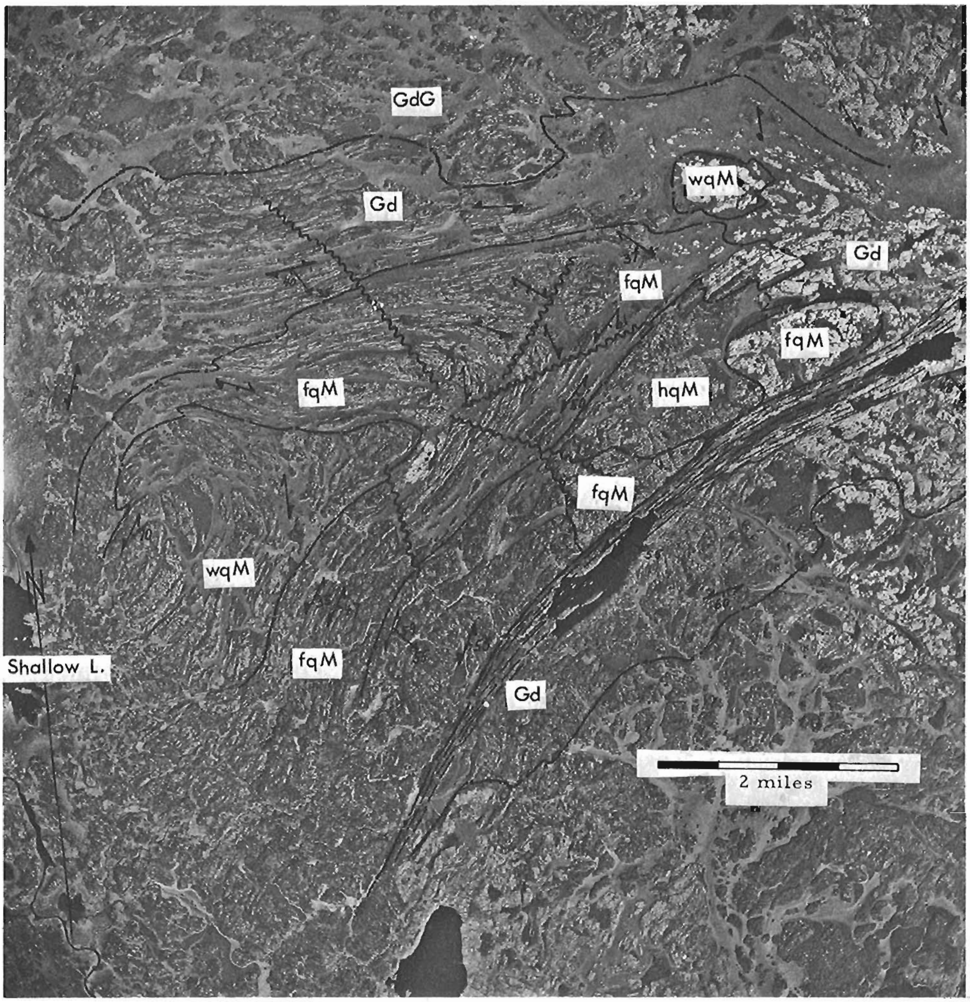


FIGURE 1: Folded orthogneisses of Shallow Lake.

Explanation of Symbols.

- Geological boundary (gradational)
- Foliation (inclined, dip unknown)
- Gneissosity (banding inclined, unknown)
- Lineation (inclined)
- Fault
- Shear zone

wqM	Weakly foliated quartz monzonite
fqM	Foliated (biotite and quartz fabric) quartz monzonite
hqM	Hornblende gneiss and quartz monzonite gneiss
Gd	Hornblende gneiss and granodiorite gneiss
GdG	Banded granodiorite gneiss, mixed with granite

Coarse-grained, foliated, commonly porphyritic granodiorites and diorites (orthogneisses) are intruded by granitic quartz monzonite; inclusions of foliated granodiorite locally occur in the latter. This mixture is intruded by, and included in, a coarsely grained, occasionally porphyritic, monzonite with minor associated phases of diorite and granodiorite which in turn is intruded by alaskite. The northern monzonitic and granitic rocks are mainly massive in texture and typically show gradations from diorite to granodiorite, to porphyritic granodiorite, porphyritic monzonite or granite and alaskite. Here and there these compositions occur as gently dipping, vertically gradational, layers; elsewhere they outcrop as a mélange. All contacts between igneous rocks are gradational and locally, as at Carroll Lake, four magmatic events are recorded from compositionally and structurally distinct inclusions - occassionally recognized on the same outcrop.

Plutonic rocks and their orthogneisses adjacent to the greenstones of the Rice Lake Group are folded parallel with the greenstones. In other areas recrystallized greenstone inclusions, adjacent orthogneisses and weakly foliated plutonic rocks seem to trace out like folds (Fig. 1). Rocks of the Rice Lake Group and the plutonic rocks are re-oriented along the shore of Lake Winnipeg in a zone two miles wide striking 140 degrees and extending from Hole River Bay 50 miles northwestward to Bloodvein Bay. Metamorphic differentiation of plutonic rocks during shearing appears to have been the chief cause for the formation of stratiform gneisses along the shore of Lake Winnipeg. Stratification gradually diminishes away from this shear zone. Elsewhere, massive igneous rocks change to orthogneiss along great linear zones; where the originally massive rocks bear angular inclusions of paragneiss these inclusions, together with their host, are partly transformed to banded gneisses.

Gold was mined from quartz veins in fissures within the greenstones at San Antonio Mine. This mine, the only recently worked deposit in the area, closed June, 1968.

100. DIABASE DYKES OF THE CANADIAN SHIELD

Project 610044

W.F. Fahrig

Approximately two weeks were spent visiting Operation Northwest River. During this time basic dykes and sheets of various ages in N.T.S. blocks 13I and J were sampled in co-operation with I.M. Stevenson.

Operation Bylot in Baffin Island was also visited for a period of 4 weeks and diabase dyke swarms within the boundaries of that operation were sampled in co-operation with G. D. Jackson.

101. PRELIMINARY RECONNAISSANCE OF THE FLIN FLON VOLCANIC BELT; MANITOBA AND SASKATCHEWAN (PARTS OF 63K AND L)

Project 680072

A. M. Goodwin

Introduction

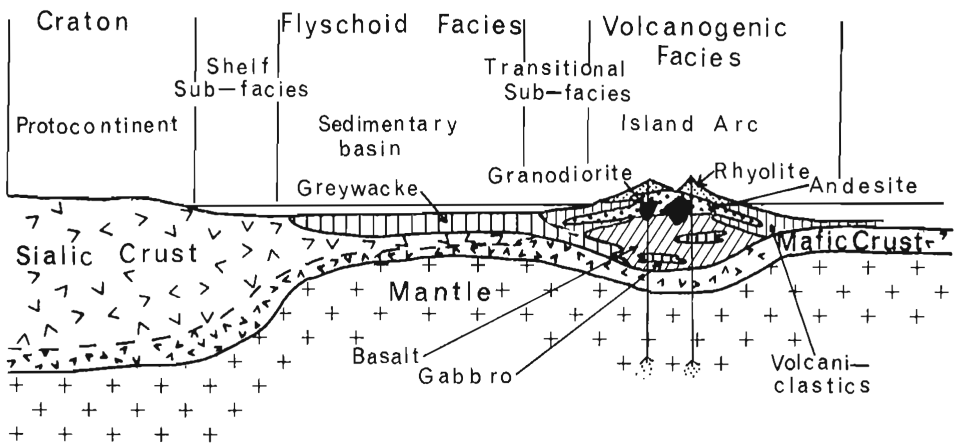
During part of the 1968 field season a regional traverse was made across certain Archean volcanic-rich and sedimentary-rich belts in the southern part of the Superior Province. The purpose was to examine and review in a broad way their lithofacies construction and relationships. The route taken crossed, in order, parts of the Pontiac sediments, Noranda-Timmins and Michipicoten volcanics, Couchiching sediments, Rainy Lake-Lake of the Woods volcanics, and the southern margin of the English River metasedimentary-gneiss belt. Thus parts of five major supracrustal belts of the Superior Province were briefly examined. The crustal model presented below (Part A) is intended to illustrate first-order relationships as presently known and interpreted in these belts. The model is offered as a stimulant to further Archean crustal studies. Dr. J. Holubec of the Geological Institute, Czechoslovakian Academy of Science who recently completed structural-stratigraphic studies of the Pontiac sediments in Quebec, accompanied me. I am indebted to him for stimulating discussion.

In addition a preliminary reconnaissance of the Flin Flon-Wekusko Lake volcanic belt and southern margin of the adjoining Kisseynew gneiss belt was made to appraise the region for possible future crustal studies (Part B).

Part A: Archean Crustal Model

The main Archean supracrustal lithofacies in the southern part of the Superior Province are lithologically distinctive and geographically persistent over large areas. Both the volcanic-rich and the sedimentary-rich lithofacies display predominantly orogenic affinities. Adjoining lithofacies where not in faulted contact are mutually gradational or stratigraphically superimposed. The main Archean lithofacies appear to represent products of

ARCHEAN LITHOFACIES



LITHOFACIES CHARACTERISTICS

Shelf sub—Facies:	Qte, arkose, conglomerate; well sorted; cross—bedding, ripple marks. Not positively identified in the Canadian Shield.
Flyschoid Facies:	Gwke., argillite; uniform bedding and lithology; graded bedding; some cross—bedding; moderately thick (5,000—10,000 feet).
Transitional sub—Facies:	Gwke., tuff, conglomerate, iron-formation; abrupt facies changes; graded bedding, disrupted bedding, penecontemporaneous slumping; unconformities. Some mineralization.
Volcanogenic Facies:	Basalt—andesite—rhyolite associations; gwke., tuff, bxia., iron—formation; granodiorite and gabbro; very thick (20,000—30,000 feet); abrupt facies changes; graded bedding; disrupted bedding, unconformities. Gold, nickel, iron and base metal deposits.

Increasing tectonic instability ↓

commonly repeated orogenic cycles of events resulting in uniform Archean crustal patterns. The following model is intended to depict in simplified form development of some main lithofacies during Archean crustal growth.

According to the model (Fig. 1) the three main facies, arranged in lateral succession, are, (a) sialic craton, (b) flyschoid facies, and (c) volcanogenic facies. Two transitional subfacies intervene. The characteristic orogenic affinities of the main supracrustal facies point to their accumulation in mobile belts corresponding to thin-crustal zones such as occurred at the margins of, and particularly between, expanding sialic cratons.

The main supracrustal lithofacies characteristics are listed in Figure 1. The sialic cratons are identified only on the basis of widespread clastic detritus of sialic composition contained in Archean sediments. The exact nature and degree of stability of the presumed cratons (or tectonic lands) is conjectural beyond their function as a source of sialic detritus. The shelf subfacies has not been positively identified but may be preserved locally in the Shield.

Flyschoid facies – the common quartz-feldspar-mica schist assemblage of the Superior Province – represents orogenic detritus apparently derived by rapid weathering of sialic provenances and deposited in the manner of classical flysch. The facies is moderately thick (about 10,000 feet as determined by Holubec for the Pontiac sediments); it tends to be lithologically uniform and stratigraphically continuous.

The flyschoid facies is transitional through a subfacies to the volcanogenic facies, the principal volcanic-bearing Archean facies. The volcanogenic facies, commonly called 'greenstone', is very thick (about 30,000 feet). It typically comprises basalt-andesite-rhyolite assemblages, assorted volcaniclastics, and numerous intrusions. Evidence of tectonic instability during accumulation is widespread. In particular the rocks of this facies are structurally deformed at or near the transitional subfacies where shear zones, faults, and evidence of local unconformities are common. Normally the grade of metamorphism is lower in the volcanogenic facies (greenschist) than in the flyschoid facies (amphibolitic).

During their development Archean lithofacies were subject to interruptions and disruptions in response to prevailing tectonic instability. As a result varied local facies relationships are to be expected including facies telescoping, abbreviation, superposition and omission. However considering the Superior Province at large, lithofacies uniformity and continuity suggest substantial persistence and repetition of formative processes during long periods of crustal growth.

Conceivably the volcanogenic facies as depicted in the model (Fig. 1) may be transitional in turn either, (a) to oceanic crust thereby implying the presence of a protocontinental-oceanic interface during Archean time, or, (b) to another flyschoid facies, itself marginal to a second sialic craton, thereby implying intracratonic relationships within an essentially thin, continuous Archean crust. The latter interpretation is preferred in the absence of identified oceanic crust in the Archean lithic record.

Part B: Flin Flon Region

A brief reconnaissance of the Flin Flon region was made. Certain key parts were examined in a region 110 miles long and 30 miles wide extending between Flin Flon on the west and Wekusko Lake on the east and Cranberry

Portage on the south and Kisseynew Lake on the north. The purpose was to gain an appreciation of rock types present, style of deformation, state of metamorphism, and stratigraphic relations with possible volcano-stratigraphic studies in mind. Any geological work in this region is greatly facilitated by availability of one mile geological map coverage.

Based on field examination, volcanic rocks of the region appear to be similar to those present in the Superior Province. Structural relations are comparatively complex. However stratigraphic successions have been unravelled by earlier workers in certain map-areas and a regional stratigraphic framework may be decipherable. Chemical relations of volcanic rocks may be determined by systematic sampling along appropriate stratigraphic sections followed by whole rock analyses as previously done in other parts of the Shield. Amphibolitic facies of metamorphism is common in contrast to prevailing greenschist facies in some previously studied volcanic areas in the Superior Province. This may obscure original chemical relations. On the other hand it may provide opportunity to study the effects of regional metamorphism upon bulk rock composition. A substantial number and range of mineral occurrences including gold, copper-nickel, copper-zinc, and zinc-lead provide intriguing possibilities for regional metallogenic studies. A variety of sediments, both volcaniclastic and others, offer substantial sedimentological challenge.

The south margin of the Kisseynew Complex to the north comprising metasediments, gneiss, migmatite and other foliated to massive granitic rocks was examined briefly. The grade of metamorphism is variable but predominantly high. Structural and stratigraphic relations along the Kisseynew 'front' in contact with recognizable Amisk-Missi rocks to the south are obscure. A wide range of sedimentological, stratigraphic, structural, and metamorphic problems are present.

Viewing the Flin Flon-Wekusko Lake-Kisseynew region within the framework of the crustal model described in Part A, it is apparent that a volcanogenic facies on the south is in contact with metamorphosed and deformed flyschoid facies on the north. The validity and adaptability of the model to the region-at-large may be tested by integrated crustal studies.

Geological studies logically would be directed to establishing volcano-stratigraphic, sedimentary-stratigraphic, structural, metamorphic and metallogenic relationships. Geophysical studies including magnetic, seismic and gravity presumably would be directed to establishing crustal relations at depth especially at the Kisseynew 'front'. Radiometric age dating support would be essential.

In conclusion, on the basis of this field examination, perusal of literature, and discussion with geologists who have mapped there, the region appears to be well suited to systematic, broadly integrated crustal studies.

102. SEDIMENTOLOGY OF THE YELLOWKNIFE GROUP, YELLOWKNIFE, DISTRICT OF MACKENZIE (85 J/8, 9, I/14, P/3)

Project 670006

J.B. Henderson

The sedimentological study of the Archean Yellowknife Group started in 1967 was completed during the past field season.

The stratigraphy of the Archean section was found to require revision (Fig. 1). At Yellowknife, the A Division volcanics of Jolliffe[1, 2] at the base of the section found along the west shore of Yellowknife Bay are never found in normal contact with the C Division turbidites on the east side of the bay. Throughout the section the vertically standing C Division turbidites all top generally to the north except at the end of the section north of Yellowknife River where the sediments, here much more thinly bedded and containing a higher proportion of slate, are tightly isoclinally folded with, in some cases, top reversals in less than 100 feet. Up section south of Walsh Lake is a zone of volcanics (predominantly tuffs and agglomerates) previously assigned to Division B that was originally thought to be between Divisions A and C. Stratigraphically above this zone of volcanics are more turbidites in which the sand proportion is greatly reduced over that seen in the lower part of the section. These sediments were also previously assigned to Division B. Unconformably overlying the volcanics of Division A is a sedimentary unit consisting of basal, predominantly volcanic conglomerate, locally with granite cobbles, overlain by shallow water, extensively crossbedded arkoses and subgreywackes with thin lenses of conglomerate. The relationship with the other sediments in the section is not exposed due to faulting. These sediments were originally described as the basal unit of Division B.

Paleocurrent directions were measured through the turbidite section using the foreset lamination of ripples in the ripple division of the turbidite cycle as an indicator of current direction. Due to the nature of the outcrop it was impossible to measure any reliable sole markings. Preliminary analysis indicates that sediment transport into the basin was from the west.

In addition some time was spent at Gordon Lake 50 miles northeast of Yellowknife on the opposite side of the 'basin'. Several detailed sections were measured in the turbidites in the central part of Gordon Lake for comparison with similar sections measured at Yellowknife. The sediments in this area are very similar to the turbidites at Yellowknife, commonly being made up of thick units of greywacke with a relatively small proportion of slate at the top of each unit. In this area the contact between the underlying volcanics and the turbidites appears to be conformable.

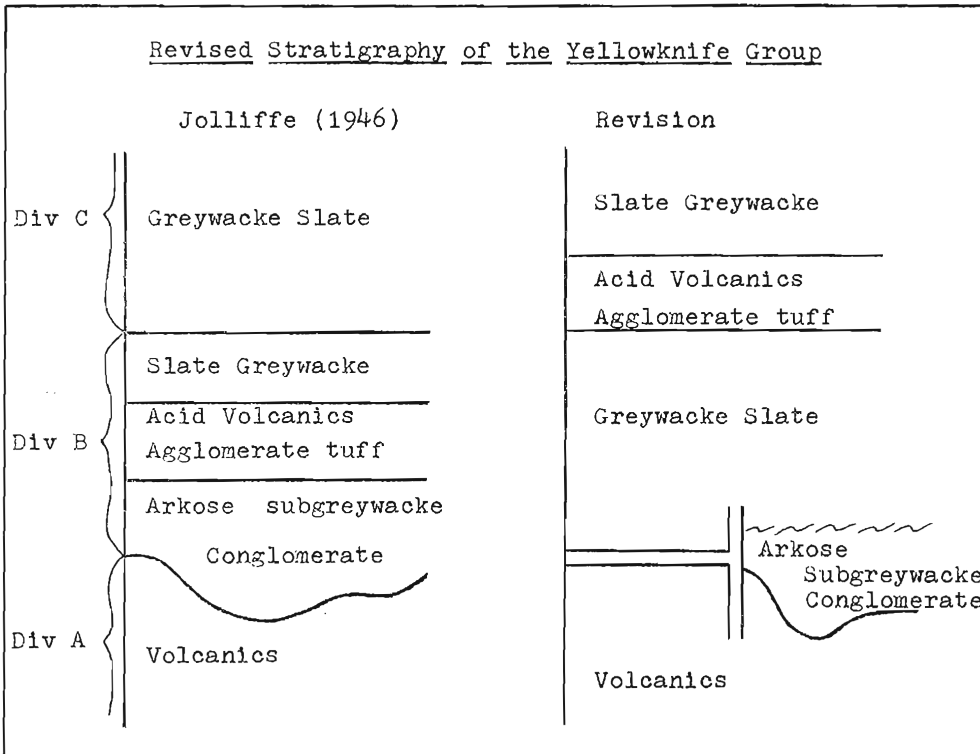


Figure 1

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[1] Jolliffe, A. W.: Yellowknife Bay; Geol. Surv. Can., Map 709 A (1942).

[2] Jolliffe, A. W.: Prosperous Lake; Geol. Surv. Can., Map 868 A (1946).

103. SOUTHAMPTON ISLAND, DISTRICT OF KEEWATIN (45M TO P, J, PART OF I; 46A TO C, F, PARTS OF D, E, G)

Project 680092

W. W. Heywood

A preliminary examination of Southampton Island was undertaken in August in preparation for Operation Southampton, a future reconnaissance mapping project. Few landings were possible near outcrop areas due to the shallowness of lakes in many lowland areas, and ice in upland lakes and on the northeastern coast.

Hill-exposed sections of Paleozoic limestone and dolomitic limestone outcrop in river valleys and along the coastal areas. Paleozoic outliers occur on the northeastern coast, and, at Donovan Beach about 700 feet of nearby horizontal sediments are exposed. Light to dark weathering Precambrian granitoid gneisses and paragneisses underlie the northeastern half of the island and occur as inliers east of the Bay of Gods Mercy. Massive granitic rocks are locally present. On Bell Peninsula well-layered gneissic rocks are intensely folded.

The Paleozoic-Precambrian contact between South Bay and the Duke of York Bay appears to be a fault scarp although in part it may be a fault-line scarp. Movement on some of the faults has occurred after post-glacial uplift.

104. RECONNAISSANCE OF NORTH-CENTRAL BAFFIN ISLAND (27C-G, 37C-H, 38A-C, PARTS OF 48A)

Project 670002

G. D. Jackson

This project completed the reconnaissance bedrock geological mapping of Bylot Island and that part of Baffin Island north of 69°N and east of 80°W, an area of approximately 53,000 square miles (Fig. 1). Two Bell helicopters, one 47G4 and one 47G4A, were used for geological traversing. Support was provided by a De Havilland Otter equipped with oversize wheels. Field observations were placed on prepared forms to enable the data to be fed

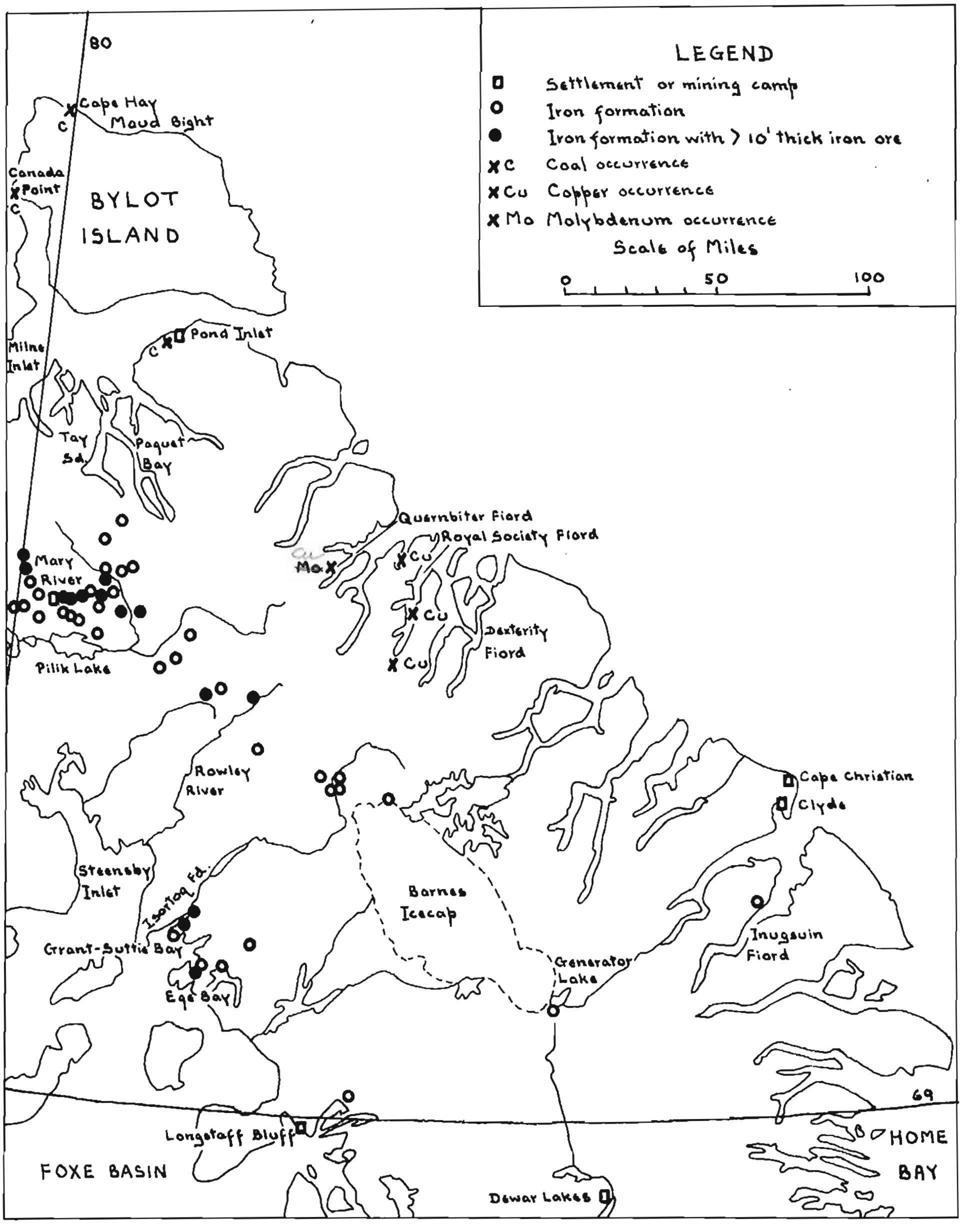

Figure 1. Sketch map showing location of iron formation and mineral occurrences in north-central Baffin Island.

into computers. The writer was assisted by S. L. Blusson, A. Davidson, and W. C. Morgan of the Geological Survey; and by W. J. Crawford of Tacoma Community College.

Metamorphosed and intensely deformed volcanic and sedimentary rocks occur as remnants in granitoid migmatites and gneisses throughout most of the map-area, and may include rocks of more than one age. The rocks in the larger remnants may be of Aphebian age and represent continuations of the Prince Albert Group[1] on Melville Peninsula. These rocks outcrop south of Tay Sound, in the Mary River area[2], east of Pilik Lake, near Grant-Suttie and Eqe bays, at Generator Lake and around the north end of the Barnes Ice Cap. At all of these localities iron-formation, and basic pillowed volcanics or derived amphibolite are present (Fig. 1). Lenses of porphyritic anorthosite outcrop in the Mary River area and east of Eqe Bay.

Migmatites, gneisses and massive to foliated granitoid rocks underlie most of the map-area. Variable amounts of amphibolite and paragneiss occur within these rocks. Granulites underlie an irregular northeastward-trending belt up to 25 miles wide that extends across Baffin Island from Steensby Inlet to Dexterity Fiord. Granulites also underlie part of central and eastern Bylot Island. Both areas display variations in metamorphic grade and the granulites probably are prograded equivalents of adjacent rocks. Some charnockitic and mangeritic rocks are associated with the granulites. South of the map-area granulites, and possibly charnockitic rocks underlie much of the region from Dewar Lakes south to Nettilling Lake. The granulites on Melville Peninsula[1] may be an extension of these rocks.

A few small gabbroic bodies outcrop southwest of Quernbiter Fiord. Metamorphosed basic dykes and sills outcrop along most fiord walls and throughout much of the area. Serpentinite is most abundant in a discontinuous belt of metavolcanics and metasediments that extends from the Mary River area southeast to the headwaters of Rowley River.

Highly folded, metamorphosed Aphebian sediments outcrop mainly in an eastward-trending belt up to 80 miles wide that extends from Longstaff Bluff on the west, to Home Bay on the east. These rocks may be correlative with the Penrhyn Group[1] on Melville Peninsula, and may also be an extension of similar rocks on southern Baffin Island[3] and in northeastern Labrador-Ungava[4]. Metamorphosed orthoquartzite, arkose, limestone and chert comprise the lower members of this group in the map-area. These are overlain by a thick, uniform succession of metamorphosed pelites and greywackes. Graphite-rich and rusty iron sulphide-rich zones are abundant in the lower part of this succession. Pegmatites and <u>lit-par-lit</u> migmatite are particularly abundant in and adjacent to antiforms and gneiss domes along the north side of this metasedimentary belt. Similar relationships occur south of the map-area along the south side of the belt.

Unmetamorphosed, gently folded, Helikian strata underlie an area that extends southeast from Milne Inlet to east of the head of Paquet Bay, and two smaller areas in western and northern Bylot Island. These rocks have been correlated with those of the Eqalulik Group and the lower part of the Uluksan Group that outcrop west of the map-area[5, 6]. Rock types include basic volcanic rocks, quartzite, conglomerate, calcareous and graphitic shales, limestone and dolomite.

Subhorizontal, locally faulted Ordovician-Silurian strata outcrop along the western edge of the map-area from the Mary River area[2] south to Steensby Inlet, on the islands and peninsulas in Foxe Basin, on Wollaston Islands and on northwestern Bylot Island. Rock types include: sandstone, conglomerate, limestone and dolomite. Most of these areas were mapped by H. P. Trettin this past summer and are described by him elsewhere in this publication.

Subhorizontal poorly consolidated Mesozoic strata underlie southwestern Bylot Island, a few small areas on the north side of Bylot Island and outcrop in several places near Pond Inlet. Lithologies include: sandstone, conglomerate, siltstone, claystone, mudstone, carbonaceous shales, and a few coal seams[7].

Iron-formation outcrops at numerous localities throughout much of the map-area (Fig. 1). Iron-formation and showings of nearly pure magnetite-hematite outcrop discontinuously along a 400-mile belt extending from north of Adams Sound[8] southeast as far as Inugsuin Fiord. Serpentinite occurs along this belt from Milne Inlet to Inugsuin Fiord. This iron-formation and associated rocks are lithologically similar to the rocks of the Prince Albert Group[1] which have been traced for about 200 miles to the southwest from Hall Lake (160 miles southwest of Eqe Bay). These rock lenses may at one time have formed a continuous belt that extended across several hundred miles of the northeastern District of Keewatin and Baffin Island.

Within the map-area, the maximum observed thickness of the iron-formation is about 500 feet. Oxide, silicate-oxide and silicate facies rocks predominate, although rocks of silicate-carbonate and carbonate facies are present locally. Most of the iron-formation contains layers up to 3 feet thick composed almost entirely of magnetite-hematite, and comprising up to 30 per cent of certain sections within the iron-formation. A few areas contain significantly greater concentrations of pure magnetite-hematite. Those within the Mary River area have previously been described[2, 9].

A zone of magnetite 90 feet thick has been reported from south of Isortoq Fiord[10]. This zone was not examined although a similar band 10 feet thick (69°45'N, 77°12'W), another band 40 feet thick (69°54'N, 77°2'W) and several bands about 30 feet thick were mapped in this general area (Fig. 1). Aeromagnetic data are not yet available for this area.

Iron-formation also outcrops near the southeast corner of Grant-Suttie Bay (Fig. 1). Several small topographic knobs are capped by iron-formation and by massive magnetite-hematite which may be equivalent in thickness to the bands south of Isortoq Fiord. The iron-formation in the eastern part of this area (ca. 69°42'N, 76°45'W) contains a 200-foot section of high-grade iron-formation, that is not, however, pure magnetite-hematite. Iron-formation was reported previously from this area[10], although the high-grade occurrences were not mentioned. A very high aeromagnetic anomaly is centred over this area (Geol. Surv. Can., Map 4728G).

Several zones of massive magnetite-hematite in iron-formation outcrop in a small area on the north side of the Rowley River near its headwaters (70°56'N, 76°18.5'W). The largest zone is about 100 feet wide and 2,000 feet long; another lens has a maximum width of 80 feet and is 330 feet long. The rock-formations in this area have been repeated by folding, and the number of separate magnetite-hematite horizons present is uncertain. Another pod of magnetite-hematite, 50 feet in diameter and 15 feet high, is located about 17 miles to the west (70°53'N, 77°2'W). Aeromagnetic information is not yet available for these two areas.

Thinly-layered quartz-magnetite iron-formation outcrops for about one mile along an eastward-trending ridge south of the west end of Generator Lake[11]. This iron-formation is contorted, has an exposed width of 200 feet, and where examined contains about 30 per cent iron. A high aeromagnetic anomaly (Geol. Surv. Can., Map 4774G) is centred over this dominantly drift-covered area.

Traces of disseminated sulphide minerals were observed at many localities. Rusty-weathering zones in the metasediments contain abundant pyrite, pyrrhotite, and in places trace amounts of chalcopyrite. Malachite stain was observed both south of the head and on the east wall of Royal Society Fiord, on the east wall of Drever Arm, and on the west wall of Quernbiter Fiord (Fig. 1). A few blebs of molybdenite are present along the north side of Clyde River (69°47.3'N, 70°45'W).

73°03'30"W, 71°14'00"N

Crystals of blue cordierite, up to 6 inches long and possibly of gem quality occur on the east side of Dexterity Fiord (~~69°47'N, 70°45'W~~). Tourmaline crystals up to 3 feet long occur in a pegmatite dyke near Generator Lake. Columbite has also been reported at this locality[11].

Layers of graphite-rich schist up to several feet thick are locally abundant in metasediments in the southern part of the map-area. The graphite may be of organic origin. Carbonaceous shales are present in Helikian strata in the northern part of the map-area. Several coal seams outcrop in Mesozoic strata southwest of Pond Inlet. One seam along the Salmon River five miles southwest of Pond Inlet is approximately 5 feet thick. Coal has also been reported from Canada Point and Cape Hay on Bylot Island[7].

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105. WILSON ISLAND-PETITOT ISLANDS AREA, EAST ARM GREAT SLAVE LAKE (85 H/10, 11, 15 (SOUTH HALF))

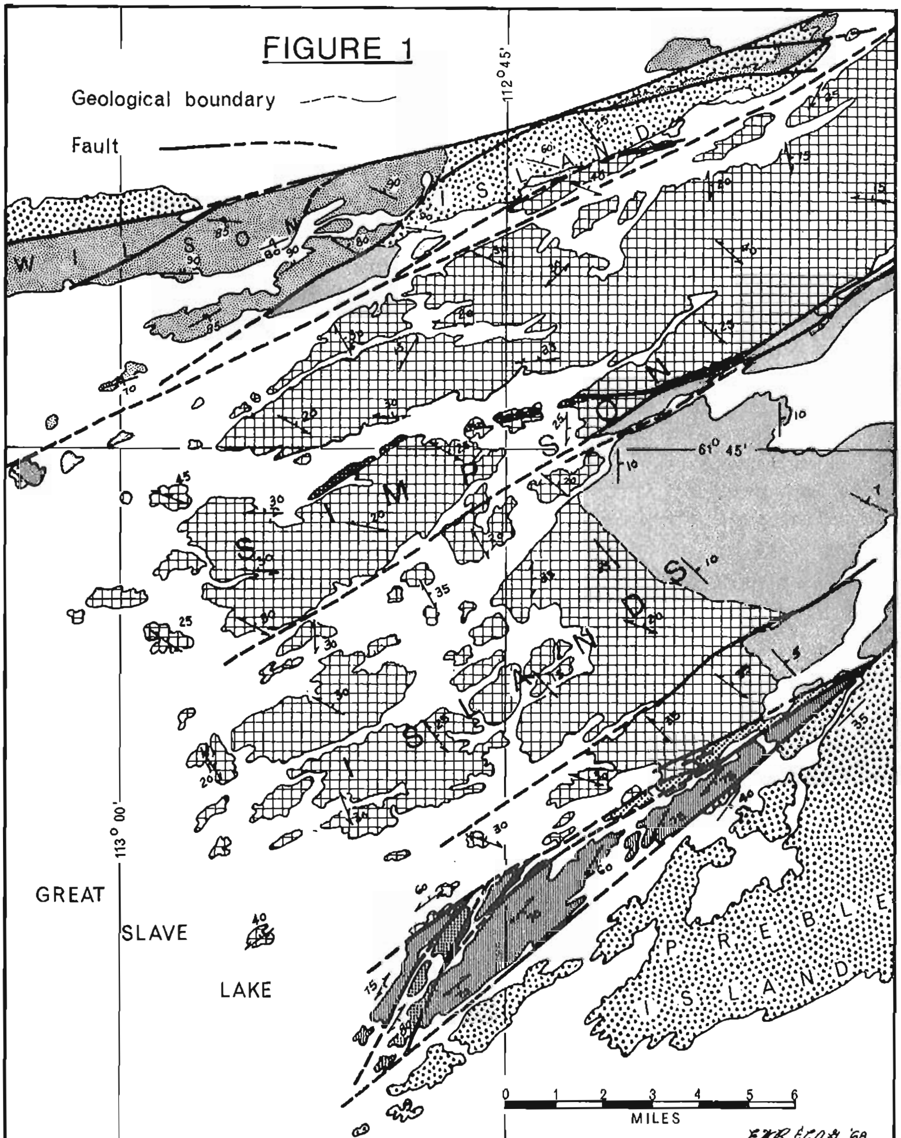
Project 650009

E. W. Reinhardt

Geological mapping of 85 H/10 and the south half of 85 H/15 was completed this summer in continuation of field investigations[1, 2] carried out in 1965 and 1966. The current component of this project was principally concerned with comparing deformation as related to tectonic movements along the McDonald Fault System in the Slave Structural Province, on the north, with equivalent deformation in the Churchill Structural Province to the south. The study also involves a re-examination of age relationships of the Great Slave Supergroup[3], Wilson Island Group[3], and Archean gneisses and granites occurring on Simpson and Petitot islands. The interpretation of the complex history of Precambrian rocks in the area will require assessment of structural data in conjunction with radiometric dating of rocks and minerals whose field and petrographic settings are now known in greater detail. Figure 1 shows the generalized geology of most of the area examined during the past season.

Unit 1 comprises a heterogeneous assemblage of Archean metasedimentary gneisses, migmatites, and granitic rocks which form most of the bedrock in the central part of the area. The gneisses are dominantly well-layered, ferromagnesian-rich pelitic metasediments containing biotite, cordierite, garnet, and sillimanite as typomorphic metamorphic minerals. Minor amounts of amphibolite are locally interlayered with the pelitic gneisses. All stages of migmatization are present within the map-area, and there is ample evidence that at least some of the granitic components were derived through partial melting of the metasedimentary strata. Stringers and lenticular bodies of granite are ubiquitous in mafic-rich paragneiss, and light and dark gneisses are often intimately interlayered. Large outcrops of gneissic granite commonly contain disconnected strands of gneiss, mafic schlieren, and randomly-oriented aggregates of ferromagnesian and aluminous minerals, notably cordierite and garnet. The high-grade metamorphic mineral associations observed in the gneisses, along with evidence for local mobility of the granitic components, indicate that these rocks attained their present aspect in a plutonic environment.

Migmatite (2) on Petitot islands (northwest of Preble Island) may be equivalent in age to migmatitic rocks of unit 1, but differs in having amphibolite as the dominant metamorphic component and shows less evidence for the development of the granitic component in situ. Furthermore, these migmatites (2) display pronounced shearing and widespread mylonitization



LEGEND

PRECAMBRIAN

8	ET-THEN GROUP: sedimentary rocks
7	Carbonate, siltstone, sandstone (Great Slave Group?)
6	GREAT SLAVE GROUP: sedimentary rocks
5	WILSON ISLAND GROUP: volcanic and sedimentary rocks
4	Metaquartzite, biotite schist (Wilson Island Group?)
3	Syenodiorite
2	Migmatite: granite, amphibolite, hornblende gneiss
1	Metasedimentary gneiss, migmatite, granite

accompanied by retrograde metamorphism. They resemble certain granitic migmatites occurring in the Thubun Lakes area[2] and elsewhere[1] south of the McDonald Fault.

The syenodiorite (3) occurs as a dyke which has intruded rocks of unit 1 but nowhere could this dyke be found cutting the Sosan Formation (Great Slave Supergroup). Baragar[4, 5] has described this dyke from one locality within the map-area. Biotite is a persistent minor constituent and available K-Ar dates from this mineral yield ages of 2, 170[5] and 2, 200[6] m. y.

Unit 4, comprising quartzite, biotite(-chlorite) schist, and lesser chloritic amphibolite may be part of the Wilson Island Group[3]. These rocks are typically schistose and locally appear to have been affected by shearing and retrograde metamorphism. In most places they dip steeply southeast. The quartzite has a minimum apparent thickness of about 1, 000 feet, measured normal to its stratiform foliation, but the true thickness may have been significantly modified by tectonic movements. Rocks of unit 4 are faulted against the adjacent migmatites along all observed contacts so that age relations with the latter rocks are obscure.

Rocks of the Wilson Island Group (5) occurring on Wilson Island and nearby islands to the south are roughly divisible into three subunits for mapping purposes. The lowermost subunit consists of intimately intercalated basic to acidic volcanics, coarse arkose, and fine-grained sediments probably of pyroclastic origin. Vesicules, amygdules, and rare pillows are preserved in the basic flows despite the presence of low-grade metamorphism and fine fissility. The acidic and intermediate volcanics weather pink to orange and probably include both flows and tuffs. Crossbedding and local pebble horizons are notably present in the arkoses. The middle subunit consists mostly of coarse arkose with numerous beds of conglomerate. The conglomerate pebbles and cobbles were derived mainly from the underlying volcanics and arkoses and a large proportion are flattened transverse to bedding. The uppermost subunit of the Wilson Island Group is a well-bedded sequence of subarkose, arkose, and orthoquartzite. Numerous interbeds of brown dolomite as well as occasional thin beds of phyllite and conglomerate also occur in this section. The sediments appear to become progressively more arkosic towards the upper part of the subunit. Marked tectonic thickening and thinning were observed in the central part of Wilson Island, and precise thickness determinations are therefore difficult to arrive at. Both the upper and lower part of the original section appear to be faulted off and no field observations were made beyond the major fault which lies along the north side of Wilson Island (see Fig. 1).

The Great Slave Supergroup (6) is represented almost entirely by the Sosan Formation which within the map-area consists mainly of pebble subarkose[7]. Other formations may be locally present towards the east end of Wilson Island where rocks of various ages have been brought into contact by a complicated network of faults. In the east-central part of the area, the unconformity between the Sosan and the underlying rocks of unit 1 is not exposed. However, this unconformity outcrops on an island along the west boundary of the area; here beds of carbonate, conglomerate, and siltstone form the base of the formation. Carbonate, siltstone, and sandstone (unit 7) of similar aspect occur north of Preble Island in what appears to be a long, narrow fault slice. Deformation of these rocks within the slice has been extreme, and the mixing of large blocks of contrasting lithology precluded systematic mapping and correlation. Similarly chaotically disposed large blocks of carbonate and siltstone and irregular zones of exotic breccia occur in Sosan subarkose in the central part of Simpson Islands.

The Murky Formation of the Et-then Group (8) reaches estimated thicknesses of up to 5,000 feet on the east half of Wilson Island where the dominant lithology is massively bedded boulder conglomerate[7]. The Preble Formation on Preble Island was not examined except where it is in fault contact with migmatites of unit 2.

A preliminary and tentative interpretation of the overall structural pattern in the map-area suggests that northeastward-striking faults have had a long history of Precambrian activity similar to that proposed[2] for rocks in the Churchill Structural Province to the south. Earlier movements appear to have been mainly transcurrent, and have produced penetrative deformation in the migmatitic rocks of unit 2, and to a lesser degree in the Wilson Island Group and rocks of unit 1; rocks of the Great Slave Supergroup and Et-then Group do not record this style of deformation. All map-units shown in Figure 1 were involved in later block faulting, probably of more than one age, and this is reflected by the present juxtaposition of rocks belonging to different groups. Furthermore, faulting may have significantly influenced sedimentation in the Great Slave Supergroup and especially in the Et-then Group as also suggested by Hoffman[7]. Probably the most important zones of faulting with respect to both degree of deformation and scale of movement are those which essentially define the northern and southern boundaries of known Archean gneisses and granites (unit 1). Late north-northwestward-striking minor faults with offsets up to several hundred feet, were also noted.

Rocks of the Great Slave Supergroup and Wilson Island and Et-then groups have been involved in folding of different intensities from place to place, and even strata belonging to the Et-then are locally overturned. Some folds in the two older groups have complex geometry which may reflect successive patterns of faulting. Further interpretations must await the analysis of data at hand, and in some places the fold history appears to be too involved to decipher without additional information.

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106. TUADOOK LAKE MAP-AREA, NEW BRUNSWICK (21 J/15)

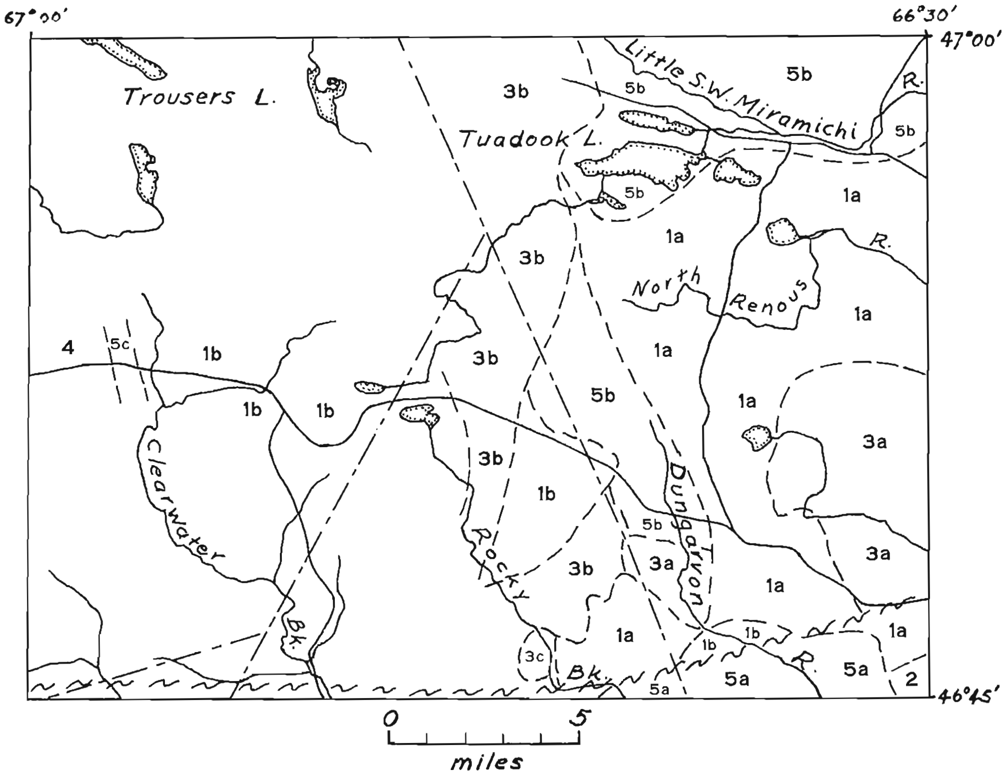
Project 680078

R. Skinner

Geological mapping of the bedrock of Tuadook Lake map-area, for publication scale of 1 inch to 1 mile, was started during 1968 and the east half was completed.

Metamorphic rocks of map-unit 1 (see Fig. 1) are tightly folded on mainly northwesterly trending axes. The strata are continuous with similar rocks of Cambrian and/or Ordovician age in adjoining areas[1, 2, 3].

Map-unit 2 contains red manganiferous slate, graptolitic black graphitic slate and chert, basalt and rhyolite about 2 miles to the east on the South Renous River in the McKendrick Lake map-area, and is very similar to Middle Ordovician strata to the south in the Hayesville map-area (ref. 3 and W.H. Poole, pers. comm. 1968).



DEVONIAN

5 5a Red to pink granite
5b Grey biotite granodiorite
5c Pink and red granite

SILURIAN AND/OR DEVONIAN

4 Rhyolite, minor grey mudstone and argillite

UPPER ORDOVICIAN(?)

3 3a Pink to grey biotite granite and granodiorite
3b Pink leucocratic and biotitic granite
3c Diorite

MIDDLE ORDOVICIAN (?)

2 Greenstone, minor rhyolite

CAMBRO-ORDOVICIAN

1 1a Metasiltstone, phyllite, quartzite, minor paragneiss
1b Paragneiss, schist, amphibolite, quartzite

Figure 1. Sketch map of Tuadook Lake map-area.

Map-unit 3 contains deformed and altered granitic rocks. In most, biotite has altered to chlorite, and the rocks have been subject to cataclasis. The granites are believed to be the same age as those in Hayesville map-area to the south[3] (W.H. Poole, pers. comm. 1968). Unit 3a consists of pink to grey, medium-grained granite and granodiorite, commonly with a well-developed foliation resulting from cataclasis. In places they contain zoned feldspar phenocrysts as much as 1 1/2 inches long. Unit 3b contains fine- to medium-grained, pink, leucocratic, sugary textured granite, and greenish pink, medium-grained, distinctly foliated, biotite granite; unit 3c is greenish grey, medium-grained, massive diorite.

Map-unit 4 comprises pink, red and grey, commonly porphyritic rhyolites with minor intercalated grey mudstone and argillite of probable Siluro-Devonian age.

Presumed Devonian granitic bodies of map-unit 5 comprise non-cataclastic massive rocks in which biotite is relatively little altered. Unit 5a consists of red to pink, medium- to coarse-grained, massive granite; that of unit 5b is a grey, medium-grained, massive granodiorite with abundant unaltered biotite; and that of unit 5c, a pink and red, massive biotite granite.

The most prominent structural feature in the map-area is an easterly trending major fault that extends across the southern part of the map-area and east-northeasterly for 20 miles or more across the adjoining McKendrick Lake map-area[2, 3].

No significant mineral occurrences are known within the map-area.

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107. RIGOLET AND GROSWATER BAY MAP-AREAS, NEWFOUNDLAND-LABRADOR (13I, J)

Project 650046

I. M. Stevenson

Geological reconnaissance mapping of map-areas 13I and J was completed during the 1968 field season, thus terminating the field work of Operation Northwest River, a helicopter-supported operation begun in 1965. Preliminary geological maps of 23A[1], 13C[2], and 13F[3] have been published, and preliminary maps of 13D and E[4] are in press.

The major part of the area lies within the Grenville Province and south of the Grenville Front[5]. The precise position of the Grenville Front in this part of Labrador has not been definitely established because of lack of age determinations, but it is probably marked by a zone of parallel shears rather than by a single fault.

The oldest rocks in the area are those of the Aillik 'series', a succession of Archean sedimentary and volcanic rocks which has been folded and metamorphosed to varying degrees. In addition, the Aillik 'series' has been practically everywhere intruded by granite, the resulting granitized rocks forming resistant ridges and hills over which the advancing ice sheets tended to ride. The east-trending Benedict Mountains are of such origin, and remnants of granitized Aillik rocks are readily identifiable in the intrusive granitic bodies.

The central part of the map-area south and southeast of Benedict mountains is of subdued relief, being underlain mainly by grey to brown paragneiss and meta-quartzite which are readily susceptible to erosion. Because of thick drift few outcrops are exposed compared to the Benedict Mountain area to the north. The origin of these metasedimentary rocks is in doubt, but they may form part of the Aillik 'series'. Biotite-hornblende 'Domino' gneisses[6], intensely folded and containing abundant granitic intrusive material outcrop as distinct east-trending ridges along the southern portion of the map-area.

Reddish brown conglomerate, grit, arkose, and sandy shale of the Double Mer Formation[8], of probable late Proterozoic age, underlie an area north of Double Mer. Except near the contact with the 'Domino' gneisses dips in the Double Mer Formation are gentle, rarely exceeding 20 degrees. The Domino-Double Mer contact was not seen, but vertical dips, shearing, and epidotization in basal Double Mer conglomerate within a few feet of the contact indicate that it is apparently a fault.

Plugs, sills, and dykes of gabbro and related basic and ultrabasic rocks outcrop as ice-rounded hills and ridges throughout most of the area. Basic dykes of at least four different ages were found cutting all rocks with the exception of those of the Double Mer Formation. One spectacular dyke, several hundreds of feet wide and more than 500 feet high is exposed as a sinuous ridge over a distance of about 20 miles north of Hamilton Inlet.

Structural trends in the bedrock vary from northeast in the western part of the map-area through west to southeast in the eastern region. This structural trend is readily apparent in the foliation of the gneisses as well as in the folds of the sedimentary and volcanic rocks of the Aillik 'series'. Faults, everywhere present in the area, are best exposed in the areas of greater relief in the north and northwest parts of the map-area. Here two sets of intersecting faults, a major northeast-trending set and a secondary northwest-trending set are well exposed in rocks of the Aillik 'series'.

Most of the gneisses and granites lie well within the epidote-amphibolite facies of metamorphism, but mineral assemblages representative of the granulite facies were recognized in a few localities. The relatively unmetamorphosed sedimentary rocks of the Double Mer Formation are low in the greenschist facies, as are some of the metaquartzites in the flat-lying central part of the map-area.

No mineralization of economic significance was recognized. Slight radioactivity was noted at various localities in rocks of the Aillik 'series', and a few minor showings of chalcopyrite, arsenopyrite, and galena were investigated. Much of the central part of the area is drift covered, and could best be prospected by geochemical, geophysical, and electro-magnetic methods.

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QUATERNARY GEOLOGY: REGIONAL AND STRATIGRAPHIC STUDIES

108. QUATERNARY GEOLOGY, COLUMBIA RIVER PROJECT RESERVOIRS (PARTS OF 82 E, F, K, L, M, 83 C, D)

Project 650020

R.A. Achard

The mapping of the Quaternary deposits of the Columbia River valley was completed from Johnston Creek, near the middle of Lower Arrow Lake, to Revelstoke.

This project, begun by R.J. Fulton, is intended to record data pertinent to engineering, forestry, agriculture and Quaternary history, and was scheduled in advance of flooding of the valley bottom by the Arrow Dam in the spring of 1969. The part of the valley studied is occupied by the Columbia River and by Upper Arrow Lake and Lower Arrow Lake.

The valley is from 1 mile to 4 miles wide, with adjacent mountains rising to 8,000 feet above the valley floor. From Revelstoke to its mouth at Arrowhead, the Columbia River scribes large meanders on a flat valley fill, bordered by steep walls. Rocky slopes dominate Upper Arrow Lake, but thick Quaternary deposits occupy major tributary valleys. These deposits are mainly of glacial and fluvioglacial origin. In some valleys, they have been cut and eroded by postglacial streams building alluvial terraces and deltas. The narrow section between Upper and Lower Arrow lakes is characterized by thick silt and sand deposits terraced by the river. Glaciolacustrine silt and clay locally overlain by sandy and gravelly shoreline materials, are the major Quaternary deposits lying along the northern half of Lower Arrow Lake.

Evidence of higher lake levels was found throughout the valley. Although the highest shore lines cannot be precisely correlated, it appears possible to tie lower features into single strandlines. At least one of these levels can be traced from Revelstoke through to Lower Arrow Lake. Altimetry of the numerous shore features and radiocarbon dating of organic materials discovered in older lake deposits will permit reconstruction of the sequence and age of former lake levels.

109. SURFICIAL DEPOSITS AND GEOMORPHOLOGY, CENTRAL RESEARCH FOREST, ONTARIO (31 G/S, H)

Project 680098

M.J.J. Bik

At the request of the Forest Management Research and Services Institute, Department of Forestry and Rural Development, a detailed survey of the Central Research Forest was initiated during the 1968 field season. This forest comprises approximately 1,000 acres of the Greenbelt between the Canadian Pacific Railway tracks near Blackburn on the north, Anderson Road on the east, and Borthwick Ridge Road on the south. A smaller, L-shaped segment extends east from Anderson Road along Dolman Ridge Road, and south along the eastern fence of the Geomagnetic Laboratory.

Fieldwork for this project comprises: (1) collection of data for a stratigraphic section parallel to Anderson Road to a depth of 16 feet (completed during 1968) and (2) mapping of the surficial deposits at a scale of 1:2400 (50 per cent completed during 1968) on the basis of auger holes 4 feet deep and with a density of about 1 hole per 0.6 acre. Mapping at this scale permits further subdivision of the stratigraphic units defined previously[1].

The near-surface deposits in the valley to the north of Dolman Ridge indicate a lacustrine environment. A thin cover of silty clay and loam (usually less than 1 foot) overlies a sensitive heavy clay in which scattered shells were found to within 4 feet of the present surface. Shoestring bodies of silty sand located between the sensitive clay and the silty clay are thought to mark former shorelines. Bog growth occurred before as well as after the deposition of the silty clay, as the latter was found intercalated with peat deposits.

The sand cover of Dolman Ridge contains three subunits. A very fine sand to silty sand, presumably of eolian origin, forms a rather uniform cover, approximately 2 feet thick, over the entire area of the ridge. This unit usually rests on a less uniform sand body which although generally of medium grade contains thin beds of coarse sand, gravel, clayey sand and silty clay, and is presumably of fan, terrace, or outwash origin; it may be up to 8 feet thick. Neither unit is calcareous. Locally 1 foot to 2 feet of medium, grey calcareous sand overlies marine clays and silty clays that form the base of Dolman Ridge.

The floor of Borthwick Valley contains two channels that are up to 7 feet deep and mainly filled with peat. In addition to large shoestring sand bodies covered by silty clay, also found to the north of Dolman Ridge, a sand ridge between the two peat-filled channels consists of a sequence of deposits similar to those described for Dolman Ridge, but resting on up to 6 feet of medium sand that is well sorted, well rounded, and rich in shell fragments and thought to be Champlain Sea sand (unit 6)[1].

Except for several rotational slumps, the escarpments of Dolman Ridge appear to be almost stable. Colluvial deposits occur at the foot, but are thin and of small extent. Degradation of Dolman Ridge was mainly by means of several streams that formed sandy fans at the escarpment foot, particularly in Borthwick Valley between Anderson Road and the city garbage dump.

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[1] Gadd, N.R.: Surficial geology of Ottawa map-area, Ontario and Quebec; Geol. Surv. Can., Paper 62-16 (1963).

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110. GLACIAL GEOLOGY AND GEOMPROHOLOGY, SOUTHEASTERN ELLESMERE ISLAND AND COBURG ISLAND, DISTRICT OF FRANKLIN (PARTS OF 38G, 39B, C, 49A, D)

Projects 670031, 680065

W. Blake, Jr.

The 1968 field season was devoted to studies of glacial geology and geomorphology in southeastern Ellesmere Island and on Coburg Island. The work was an extension of the 1967 program in northwestern Devon Island and southwestern Ellesmere Island[1]. As in 1967 W. Blake, Jr. concentrated on studying postglacial marine deposits, collecting samples for radiocarbon dating, and recording fluctuations in the marginal positions of glaciers. R.A. Souchez, University of Brussels, continued his studies of frost shattering and slope development and also investigated moraines at several localities in order to determine their mode of formation. Base camp was at the settlement of Grise Fiord, and support was provided by a Piper Super Cub equipped with low-pressure tires. Thanks to the Polar Continental Shelf Project a Sikorsky S-55 helicopter was made available for two days to reach localities inaccessible by fixed-wing aircraft.

In general the limit of marine submergence at the mouths of the fiords is lower in southeastern Ellesmere Island than farther west along the north coast of Jones Sound, as it rarely exceeds 300 feet. The marine limit also decreases in altitude northward toward the heads of the various fiords.

Pumice was not found on raised beaches in southeastern Ellesmere Island, on Coburg Island, or at the few localities visited on reconnaissance flights along the north coast of Devon Island. However, three additional localities were discovered west of longitude 85°, confirming the results obtained in 1967 and showing that the level at which the pumice occurs rises northward up the fiords as well as rising westward along Jones Sound.

Measurements were made of the amount of debris occurring as fans and scree on top of the highest beach deposits in the vicinity of Grise Fiord settlement. It is hoped that by radiocarbon dating of the highest beaches it will be possible to estimate the rate of accumulation of material at the base of the slopes, and hence of slope retreat above the beaches, since general deglaciation. These measurements in an area of gneiss will contrast with similar measurements, carried out in 1967, in an area of dolomite at Cape Storm, southwestern Ellesmere Island.

Studies of moraines were carried out for the most part adjacent to the Jakeman Glacier. This glacier, of the expanded foot type, has advanced into an area of raised beaches, creating a series of push moraines. Shear moraines are also well developed in several places along the margins of this glacier and the ice cap from which it debouches.

As noted in 1967 most outlet glaciers are at present close to their maximum extent since general deglaciation more than 8,000 years ago. Slight retreat of numerous glaciers has occurred only within the last decade or last few decades.

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[1]Blake, W., Jr.: Glacial geology and geomorphology, southwestern Ellesmere and northwestern Devon Islands, District of Franklin; in Report of Activities, May to October, 1967; Geol. Surv. Can., Paper 68-1, Part A, pp. 154-155 (1968).

111. SURFICIAL GEOLOGY, PORT STANLEY MAP-AREA, ONTARIO (40 I/11 (West Half))

Project 680043

A. Dreimanis

The western half of the Port Stanley map-area was mapped during the summer of 1968. Main surface deposits of this area are the heavy textured Port Stanley Till and the lacustrine and littoral deposits of the proglacial lakes, ranging from Lake Maumee to Lake Grassmere.

The most conspicuous topographic feature is the St. Thomas moraine (Fig. 1). It consists mainly of sinusoidal sand and till ridges (crevasse fillings, formed between blocks of stagnant ice), 0.1 to 0.6 mile long, 100 to 200 yards wide and 10 to 30 feet high, low round or irregular till hummocks, and shallow kettle depressions. The stagnant ice topography ends abruptly at the southwest end of the St. Thomas moraine near Wallacetown where the general land elevation is 710 to 720 feet above sea level. If the St. Thomas moraine was formed during the Lake Maumee II time[1] this lake was more than 100 feet deep south of Wallacetown, but only 20 to 80 feet deep along the moraine towards the north-northeast. As a result the thinning ice margin was grounded and could stagnate north of Wallacetown; to the south it was afloat and had a calving edge. In the area around Tyrconnell lacustrine silt and fine sand was deposited instead of an end moraine.

Lacustrine deposits 3 to 60 feet thick, in places interbedded with waterlaid till, were deposited in the rising water of Lake Maumee and occur on the Port Stanley Till in the eastern part of the area. The Erie glacial lobe retreated southeastward from the St. Thomas moraine into an area where the till surface is several tens of feet lower than along the moraine. During that time lake levels had probably risen about 30 feet from Lake Maumee II to Lake Maumee III and the ice margin was afloat because of the deeper water, and stagnation could not take place. Subsequently the area was covered also by the Lake Arkona and Lake Whittlesy waters, except for crests of some of the highest crevasse fillings.

Discontinuous sand and gravel beaches were formed along the St. Thomas moraine during Lake Warren time, and sand bars were deposited offshore in the shallow lake to the south and southeast. Some of the offshore bars were modified into beaches during the lowering of the lake level.

Several sections expose involutions, extending to a depth of 5 to 15 feet, and small frost wedges cut through the lacustrine deposits and filled by gravelly beach sands.

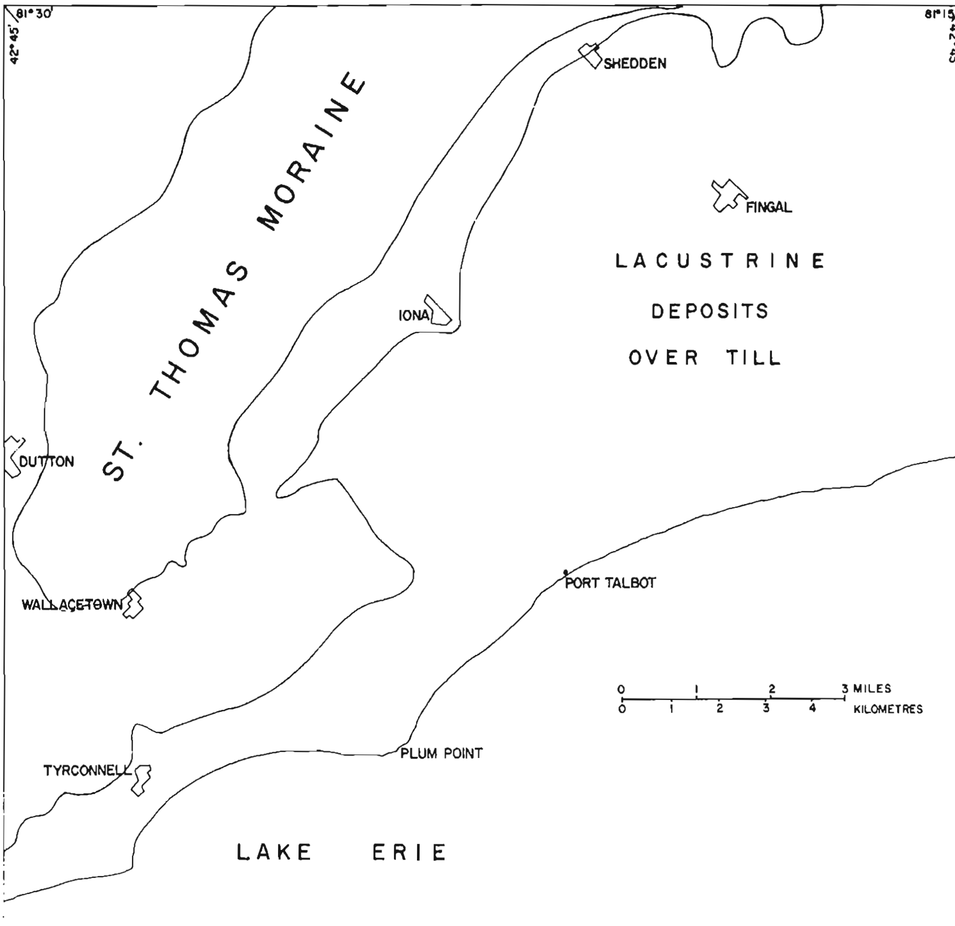

Figure 1. The St. Thomas moraine and main area of the glaciolacustrine deposits, Port Stanley West sheet (40 I/11).

During recent time the area has been severely dissected by stream erosion, and Lake Erie waters have cut steep bluffs along its shore.

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[1] Dreimanis, A.: Pleistocene geology of the London-St. Thomas and Port Stanley areas; Ont. Dept. Mines P.R. 1963-2, pp. 33-34 (1963).

112. GEOMORPHOLOGICAL INVESTIGATIONS, BEAUFORT PLAIN, DISTRICT OF FRANKLIN (98)

Project 640004

H.M. French

Investigations of the nature of slopes, slope processes, slope development, and valley history were concentrated in the Ballast Brook area, northwest Banks Island. Brief studies on western Prince Patrick Island provided comparative information on valley development.

On northwestern Banks Island, the lower part of the Ballast Brook valley system was mapped, including study of abandoned, meltwater channels and of terraces and related deposits in the valleys. Slope profiles were measured in 84 localities in valleys cutting into the Beaufort Formation. The varying lithology of the Beaufort Formation exerts an important influence over slope forms. Many of the valleys are asymmetrical, possessing steeper slopes facing southwest than in other directions. This asymmetry is thought to be the result of differential solifluction pushing the basal stream to one side of the valley to thus undercut and steepen that slope. Rectilinear slope forms are widespread and vary from 2-7° in angle. To gain information on solifluction deposits and the importance of solifluction processes in fashioning the landscape a number of sections through solifluction slopes and solifluction lobes were excavated with a high pressure fire pump. In general, the materials exposed in these sections indicate that the solifluction is laminar and nonturbulent. The relationship between the efficiency of solifluction and the marked asymmetry of the landscape was investigated through microclimatological measurements. Using electrical resistance techniques, the temperature and moisture characteristics of the active layer were examined on slopes of varying orientations. A provisional conclusion is that the slopes facing northeast appear to be the most suited to solifluction activity because they retain the highest moisture content throughout the summer.

113. QUATERNARY GEOLOGY, NORTHWEST DISTRICT OF MACKENZIE

Project 680032

R.J. Fulton and R.W. Klassen

Reconnaissance of the Quaternary geology in the area covered by 'Operation Norman' (120° to 132°W. and 65°N. to the Arctic Coast) was carried out by R.J. Fulton and R.W. Klassen. Field work was concentrated on Quaternary stratigraphy, pattern of deglaciation, and levels of glacial lakes in the Great Bear Lake Basin.

Glacial deposits and landforms are widespread in this region, but certain areas such as the Precambrian uplands of the Melville Hills, higher parts of the Smoking Hills and the lowlands drained by the Ontaratue and Ramparts rivers lack distinctive glacial landforms.

Quaternary deposits predating the last glaciation are exposed in several river valleys. Till overlies sand and gravel in the Mackenzie River valley between longitudes 131° and 132°, in the lower Hare Indian River valley, and in the Wolverine River valley, indicating that these valleys were cut prior to the last glaciation. At that time the Mackenzie River apparently was as far as eight miles east of its present course in the vicinity of the lower Hare Indian River. Wood was found in 'Mackenzie River Type' gravel relating to this earlier course. Wood was also collected from the base of the till within Mackenzie River valley at 67°29'N., 131°00'W.

A section which appears to record much of the Quaternary history of the coastal part of the area is exposed on a tributary of the Horton River (69°13'N., 127°03'W.). This section, containing at least 3 tills, lies outside the moraines built by the last ice advance. Sand and gravel at the base of the sequence may possibly be equivalent to the Beaufort Formation of late Tertiary or early Quaternary age[1]. This unit lies between till and bedrock, contains clusters of well-preserved wood, and is characterized by abundance of black chert and quartzite pebbles. A peat bed, above the lower two tills and below at least one till, appears to be in the same stratigraphic position as a peat bed in a nearby section dated as greater than 38,100 years B.P. (GSC-576 unpublished).

The regional direction of ice flow during the last glaciation was to the west and north away from the Great Bear Lake Basin. The Melville Hills, on the Arctic Coast, do not appear to have been overridden by ice during a glacial event that left moraines around their flanks. Large tracts of these hills are covered by autochthonous Precambrian rubble and only scattered patches of thin drift were seen. Subdued glacial grooves nearly at right angles to the fresh ice-flow features on the flanks of the upland were noted in several localities.

Ice retreat in this region was punctuated by stillstands or readvances that produced well-defined end moraines. The magnitude of these breaks in retreat is not known.

Evidence for at least three relatively well marked high lake levels of ancestral Great Bear Lake are present on the north shore of Great Bear Lake Basin. The highest of these was probably controlled by flow through the Hare Indian River valley; the others may be levels of Glacial Lake McConnell[2]. The raised shorelines are tilted upward towards the east[3].

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[1] Craig, B.G. and Fyles, J.G.: Pleistocene geology of Arctic Canada; Geol. Surv. Can., Paper 60-10 (1960).

[2] Craig, B.G.: Glacial Lake McConnell, and the surficial geology of parts of the Slave River and Redstone River map-areas District of Mackenzie; Geol. Surv. Can., Bull. 122 (1965).

[3] Craig, B.G.: Surficial geology north-central District of Mackenzie, N.W.T.; Geol. Surv. Can., Paper 60-18 (1960).

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114. NORTHWESTERN BANKS ISLAND, DISTRICT OF FRANKLIN (98)

Project 640004

J.G. Fyles

Field work on northwestern Banks Island in 1968 had three components: (1) stratigraphy and paleobotanical sampling of the Beaufort Formation, by L.V. Hills; (2) determination of mode of development and history of valleys entrenched into the Beaufort Formation, by H.M. French; and (3) delineation of glacial features, by both of the above and J.G. Fyles. Logistic support by the Polar Continental Shelf Project included the use of two Nodwell tracked vehicles.

Northwestern Banks Island consists of the Beaufort Plain, underlain by the Beaufort Formation, west of longitude 122 degrees, and a dissected hilly region underlain by a variety of sedimentary formations east of longitude

122 degrees. A moraine system, comprising a discontinuous belt of ridges of loamy, sandy, and bouldery drift up to 4 miles wide and a few feet to several hundred feet high, follows the north coast, both in the dissected region and the Beaufort Plain.

Investigations along the moraine from Castel Bay westward beyond Ballast Brook have provided abundant evidence that the moraine marks the southern margin of a glacier lobe that flowed westward along McClure Strait, presumably during the maximum stand of the Wisconsin Laurentide ice sheet. The lower reaches of many of the valleys presently draining northward through the moraine contain sandy to silty terrace deposits, extending several tens of feet above present river level, which constitute eroded remnants of fluvial and locally lacustrine infillings that apparently originated when the valleys were blocked to the north by glacier ice and/or the moraine. In the valley east of Ballast Brook, valley fill deposits containing local moss layers are deformed as if by overriding glacier ice. In other valleys, the valley fill terraces extend northward through the moraine and thus are younger than the moraine.

Forms and deposits attributable to marine levels higher than present appear to be entirely lacking within the area traversed, but drowned valley mouths resulting from recent submergence are present along the western part of the north coast.

115. ST. STEPHEN, NEW BRUNSWICK (21 G/3)

Project 670037

N.R. Gadd

Mapping at the scale 1/50, 000, commenced in the St. George map-area (21 G/2) in 1967[1], was completed and extended westward to cover the St. Stephen map-area (21 G/3) in the southwest corner of New Brunswick. Reconnaissance mapping at the scale of 1/250, 000 of the Fredericton map-area (21 G) was almost completed.

A new radiocarbon date of 13, 000 $\pm$ 240 years B.P. (GSC-882) for marine shells from clay that probably forms bottom-set beds of the Pennfield glaciofluvial delta[1] along with a similar date of 13, 235 $\pm$ 500 years B. P. (I(GSC)-7)[2] from the St. John Harbour area indicate that the Bay of Fundy was ice free 13, 000 years ago. However, a new radiocarbon date of 12, 300 $\pm$ 160 years B. P. (GSC-886) from raised marine deposits near Benson's Corner along with an identical date (GSC-795)[1] on marine shells from Sandy

Point near St. Andrews suggest that a lobe of ice persisted in Passamaquoddy Bay for some 700 years after marine water had invaded the Bay of Fundy. In addition, crossed striations and bevelled flutings in the St. George and St. Stephen areas lend further support to this suggestion.

Massive moraines and outwash fans at St. George and St. John associated with the fossiliferous clays dated at 13,000 years B.P. suggest that these ice-front features are of similar age or slightly older. Although the moraines are similar in physical characteristics to a system of moraines in the Cherryfield-Eastport area of eastern Maine that extends as far as St. John[3, 4, 5] a correlation between the two has not been made.

General reconnaissance of the area between St. Stephen and Fredericton, New Brunswick reveals that there are several indistinct belts of low-relief hummocky terrain underlain by ice-contact sediments, characterized by heavy surface accumulations of boulders and blocks and containing short eskers; these interrupt the pattern of outwash and in places formed distinct 'heads of outwash'. This regional pattern suggests a rapid northwesterly retreat of the ice margin with a number of minor halts. The lack of strong moraines, but the presence of belts of hummocky ice-contact terrain, suggests to the writer a very weak residual southeasterly flow of the ice during rapid melting, rather than the general stagnation of the ice in the period of time following exposure of the Fundy and the Maine coasts, as has been proposed by various previous workers in the region.

At the request of the New Brunswick Department of Natural Resources the writer made a very short reconnaissance of a triangular area between Sussex, Moncton, and Hillsborough, New Brunswick, to assess the feasibility of prospecting in that region for sand, gravel and silica sand. A separate report to the New Brunswick Department of Natural Resources indicates the presence of these three commodities in glacial ice-contact, glaciofluvial, and bedrock sources.

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[1]Gadd, N.R.: St. George map-area, New Brunswick; in Report of Activities, Part A: May to October, 1967; Geol. Surv. Can., Paper 68-1, p. 161 (1968).

[2]Lee, H.A.: Late glacial and postglacial Hudson Bay sea episode; Science, vol. 131, No. 3413, pp. 1609-1611 (1960).

[3]Borns, H.W., Jr.: Late glacial ice-wedge casts in northern Nova Scotia, Canada; Science, vol. 48, No. 3674, pp. 1223-1226 (1965).

[4]Borns, H.W., Jr.: The geography of paleo-Indian occupation in Nova Scotia; Quaternaria, vol. 8, pp. 49-57 (1966).

[5]Swift, D.J.P. and Borns, H.W., Jr.: A raised fluviomarine outwash terrace north shore of the Minas Basin, Nova Scotia; J. Geol., vol. 75, No. 6, pp. 693-710 (1967).

116. SURFICIAL DEPOSITS LAKE MELVILLE AREA, LABRADOR (13 F and G)

Project 680086

D.R. Grant

The purpose of the study was to produce a geomorphological map annotated as to surficial materials for the Labrador Pilot Project of the Canada Land Inventory, Department of Forestry and Rural Development, which acknowledges as the basis of its Bio-physical Land Classification the controlling influence of landscape 'geo-units' on all ecological patterns. Fieldwork endeavoured to confirm the composition and sequence of deposits inferred from photo-mapped geomorphology and to collect data relating to glacial history.

The area comprises two land 'systems': A portion of the Mealy Mountains Plateau consisting of bare fractured rock surface, locally obscured with till which only rarely has a moulded form, and a broad apron of coastal plain bordering the Melville Plain. Except for certain broad arcuate swells and recent dissection, the latter is relatively featureless, but the combination of low relief and gradient brings the water table near the surface such that even the most subtle topographic features are marked by contrasting vegetation patterns. Thus the vegetative cover is of prime importance for the interpretation of materials and landform elements.

The following sequence of late and postglacial events is inferred from observed features and deposits, ice retreat up the Melville Plain and southward onto the Mealy Mountains followed by incursion of high-standing marine levels that left benches, terraces and beaches as high as 400 to 450 feet. Spasmodic retreat produced ice-marginal kettled terraces and ridges underlain by a stony silt that grades upward into gravelly glaciofluvial units intertonguing with deep-water concretionary shell-bearing pelite. The ridge pattern includes interlobate segments apparently related to the various tributary sublobes of the Melville glacier.

Because of falling relative sea level due to isostatic rebound, a mantle of littoral, deltaic, and nearshore sand up to 100 feet thick was deposited. Shells were not found in this unit, but were present in the offshore pelites, perhaps because the early high 'marine' levels were then, as now, fresh in the upper part and saline only at depths corresponding to the offshore pelite environment. The spacing of emerged deltas and paired alluvial terraces may reflect sea level pauses. At present, a relative submergence appears to be in progress.

Possible evidence of postglacial faulting was noted in the form of regular up-to-the-south displacements of roches moutonnées surfaces in the Mealy Mountains.

In view of the accelerated road building in the area it is noteworthy that, although the sand mantle is ideally suited to embankment-type roads, a real hazard exists near natural and artificial cuts where abrupt hydrologic changes initiate and propagate sliding of the sand over the pelite. Extensive spatulate flow-slides now extend a mile or more inland from rivers.

117. SURFICIAL DEPOSITS, MANITOUWADGE, ONTARIO (42 F/4 (West Half))

Project 670097

D.R. Grant

A brief examination of surficial deposits in the vicinity of Manitouwadge, Ontario was made in connection with geochemical investigations of till in the vicinity of mineral deposits by R.G. Garrett.

The four most common surficial materials are two tills exposed mainly on hills, glaciofluvial sand and gravel largely restricted to the smaller valleys, and glacial-lake sediments comprising an upper sand-silt unit and a lower varved clay unit, both underlying extensive flat tracts below 1,000 feet. The upper limit of lake action is perhaps 50 feet higher.

In the sampling area proper, although only the tills are present, the usual stony, Shield-type, locally-derived till is unfortunately almost entirely lacking, except in protected locations. Instead, a fine-grained highly calcareous till of predominantly Paleozoic lithology (the minus 170 micron fraction alone averages more than 40 per cent CO_3) thinly veneers much of the bedrock. This cream-coloured, pasty material, deposited by ice that moved at 205 degrees, was seen to overlie the Shield till phase in two places.

The topographic setting, and mechanical properties of the till were such that glacial erosion could not prevail over the orebody. Instead, the limestone-till was plastered, with a lenticular structure, onto the orebody. For this reason, the usual geochemical anomaly from glacial dispersion could not, and apparently did not, develop.

More than just a local curiosity, this till occurs over a considerable area, but was indistinguishable 25 miles south of Manitouwadge. Although there is evidence that it was constituted during a glacial readvance over proglacial lake sediments, which may in part account for its fine texture, the composition and areal extent suggest that the till originated through the wholesale glacial transport of easily erodable material from the Paleozoic terrane some 50 miles to the north. While such voluminous transport is not common, it has occurred elsewhere, notably in Nova Scotia, and it, therefore, seems preferable to suggest this simple explanation, than to invoke the proximity of a hypothetical limestone outlier.

118. RECENT SUBMERGENCE IN NOVA SCOTIA AND PRINCE EDWARD ISLAND (11, 20, 21)

Project 660036

D.R. Grant

Reconnaissance mapping of submergence phenomena was completed. The latest detailed stratigraphic study and sampling of selected sites was aimed at confirming two apparently distinct regional submergence trends: about one-half foot per century for the Atlantic coast and Gulf of St. Lawrence, and one foot per century for the Bay of Fundy.

Since even the slower rate is fully three times faster than that for the stable part of the Atlantic coast, negative land movements are indicated. In fact it can be shown that the anomalous rate is not so much due to a rise of sea level as to a subsidence of the land, in this case, caused literally by the weight of water on the continental shelf.

The much greater rate in the Bay of Fundy on the other hand, cannot be accounted for by subsidence and is believed attributable instead to a differential rise of the high tide datum, that is, to a general increase in tidal range over the past 5, 000 years. As might be inferred from the large vertical changes in postglacial relative sea level, the bay must have had a complex history of changing tidal range. Theoretical reconstruction of tidal character reveals an initial low range, an intermediate series of fluctuating highs and ultimately a gradual decline. These inferences are largely borne out by stratigraphic evidence. It is hoped that the major events may be dated and described through the application of a newly developed and proven mathematical model.

119. NORTH BAY - MATTAWA REGION, ONTARIO (31 L/2, L/3, L/6, L/7)

Project 680067

J.E. Harrison

Reconnaissance of a 1,500-square-mile area in the North Bay - Mattawa region of Ontario was completed and approximately 600 square miles of the area was mapped at a scale of 1:50,000.

While the general ice flow direction over the region was from north-northeast, the western part of the margin of the ice within the map-area retreated more rapidly than the eastern portion of the front during deglaciation. This pivoting of the ice front uncovered three progressively lower routes through the Fossmill Channel[1] at 1,175, 1,140 (Chapman's Fossmill) and 1,125 feet above present mean sea level, which served as outlets for the Great Lakes. The ice front during the last of these stages stood across Mattawa Valley near Rutherglen, where it built a north-south trending moraine system which can be traced from the scarp bordering the north side of the Mattawa River to the uplands south of the Great Desert, a distance of seven miles. Retreat from the position marked by this moraine allowed water to flow south down the Amable du Fond valley and over the Mink Lake sill at 1,100 feet above present mean sea level.

Further retreat of the ice allowed water to escape down the Mattawa River valley lowering Lake Algonquin below the Mink Lake sill and reversing the drainage of the Amable du Fond River. A log found in gravel, that overlies varved clays formed during the Mink Lake sill stage, and underlies alluvium, may give a radiocarbon date of the reversal.

Potholes found in an abandoned channel west of Mattawa and about 100 feet above present river level may mark the last drainage of Lake Algonquin through Mattawa Valley. Small pieces of wood mixed with sand were found interspersed with the rounded boulders at the bottom of an 11-foot deep pothole. Radiocarbon dating of this wood may pinpoint the time of emergence of the North Bay sill and termination of drainage of the Upper Great Lakes into the Ottawa drainage system.

Strong beach scarps developed on a hill west of the town of Powassan at elevations 985, 1,005, 1,046, 1,102, and 1,123 feet, and scarps cutting into the moraine at Rutherglen at 956, 988, 1,022, and 1,038 feet were surveyed in by instrument. The Powassan beaches are probably related to drainage through the Fossmill outlets. No marked channels have, as yet, been found in Mattawa Valley that can be related to the Rutherglen scarps.

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[1] Chapman, L.J.: An outlet of Lake Algonquin at Fossmill, Ontario; Proc. Geol. Assoc. Can.; vol. 6, Pt. III (May 1954).

120. QUATERNARY GEOLOGY OF THE TASEKO LAKES MAP-AREA BRITISH COLUMBIA (92 O)

Project 680129

J.A. Heginbottom

This project is intended to provide general areal information regarding Quaternary deposits and landforms, particularly for forestry and agriculture, and was initiated this year to meet a request from the British Columbia ARDA Committee. This season the northeast quarter of the area was mapped from airphotos and on the ground at a scale of 1:250, 000.

The field area comprises three contrasting terrain regions. The most widespread is rolling plateau, generally based on Tertiary volcanic rocks and covered with a layer of ground moraine and outwash gravel. The plateau surface has a general elevation of 3, 000 to 3, 500 feet. Rising above this are a number of hill areas, all less than 6, 500 feet in altitude. These are formed of older rocks projecting through the volcanics, and are covered by thin, patchy ground moraine. Many have meltwater and overflow channels cut in their sides. The third terrain region comprises the valleys of the Fraser and Chilcotin rivers, incised deeply (1, 500 feet) below the plateau level. These valleys are marked by series of terraces, locally known as benches, along the sides. The upper benches appear to be the remnants of a Pleistocene valley fill, originally more than 1, 000 feet thick, which has since been incised by the rivers. The lower benches are remnants of alluvial fans, graded to a high river level. Several sections of the Pleistocene fill were examined; it is formed of various layers of till, silt and glacial diamictite. No evidence of more than one glaciation was found. The general direction of ice movement was from the southwest.

121. LIMIT OF CHAMPLAIN SEA, EASTERN ONTARIO LOWLAND (PARTS OF 31 B, C, F, G)

Project 650040

E. P. Henderson

Four weeks were spent in the Smiths Falls - Prescott area of eastern Ontario searching for marine shore deposits generated by the Champlain Sea at its maximum or near maximum western limit. These marine features formed when the continental ice sheet had retreated sufficiently from the St. Lawrence valley to allow drainage of proglacial lakes and invasion of the area by the sea. Altitude of selected beach features was determined by levelling. Though marine shells in this region had hitherto not been found within 60 feet of the altitude of the assumed marine limit[1], Macoma fragments at Yule Station 5 miles southeast of Jasper appear to be only 35 feet below the highest marine level.

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[1] Henderson, E. P.: Mallorytown-Brockville Area, Ontario; in Report of Activities, May to October, 1967; Geol. Surv. Can., Paper 68-1, Pt. A, p. 167 (1968).

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122. QUATERNARY GEOLOGY, KINGSTON (North Half), ONTARIO (31 C (North Half))

Project 680062

E. P. Henderson

This project has been undertaken to devise and test a reconnaissance method for mapping the unconsolidated deposits and landforms on shield terrain. Because of the complexity of the topography and the intricate pattern of distribution of the surficial materials, mixed mapping units are required to portray the features at a reconnaissance scale.

Over most of the area, striae and other associated ice-flow features indicate ice movement slightly south of southwest. A later movement to the south is recorded north and south of Smiths Falls, and lobation of the ice margin is suggested locally by striae divergent from the main ice direction.

Glacial deposits are the most widespread unconsolidated materials in the area and characteristically are thin and discontinuous. Locally, however, the sandy till attains a thickness of more than 10 feet, particularly on the flanks of hills or in morainic areas. In the southwest corner of the region southwest of Tichborne an area of 5 or 6 square miles underlain by limestone is almost completely covered by stony knobs and ridges of the Dummer moraine[1]. Although this appears to represent the eastern extremity of this major moraine system the morainic topography is well developed with relief of up to 40 feet and till deposits that in places almost certainly exceed 50 feet in thickness.

Glacial-fluvial sediments are generally present as small isolated kames or short esker segments, but in a few places they cover much larger areas. A major esker system begins as two tributary eskers 5 miles northeasterly from Snow Road Station, which join to form a single esker-kame complex near Sharbot Lake and extend west of south for a further 8 miles. Although this unit has been extensively exploited for sand and gravel, it is still a large reserve of commercial materials. A kettled mass of deltaic sand and gravel north of Plevna may mark the most northerly shore feature associated with Glacial Lake Iroquois in this area.

The area north and a few miles south and west of Smiths Falls lies below the marine limit and was inundated for a short time during an early stage of the Champlain Sea. Short beaches and bars are common and deposits of marine sand and gravel may exceed 10 feet in thickness. Shells in deposits close to the marine limit are rare or absent, but a few fragments and two nearly complete shells of Macoma balthica were found at Yule Station, five miles southeast of Jasper, in a gravel bar only 35 feet below the presumed maximum altitude reached by the Champlain Sea. A radiocarbon date of 11,800 $\pm$ 150 years B.P. (GSC-1013) on shells collected from marine gravel near Mailland, east of Brockville, along with a similar date of 11,600 $\pm$ 150 years B.P. (GSC-842) on shells collected[2] north of Ottawa near Meach Lake indicate the approximate time of the maximum marine invasion in the western part of the Champlain Sea basin.

Surface clay and sand below the marine limit are mostly of marine origin, but probably include some lacustrine material deposited in proglacial-lake waters that preceded the marine phase.

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[1] Chapman, L.J. and Putnam, D.F.: The Physiography of southern Ontario; Univ. Toronto Press (1951).

[2] Buckley, Jane T.: Geomorphological map of the Gatineau Park; in Report of Activities, May to October 1967; Geol. Surv. Can., Paper 68-1, Pt. B, p. 79 (1968).

123. BEAUFORT FORMATION, NORTHWESTERN BANKS ISLAND DISTRICT OF FRANKLIN (98)

Project 640004

L.V. Hills

A detailed stratigraphic study of the Beaufort Formation during July and August concentrated on the Ballast Brook area where the formation is well exposed. The general distribution of the formation on Banks Island is given by Thorsteinsson and Tozer[1].

The Beaufort Formation is underlain to the east by the Eureka Sound Formation. The base of the Beaufort is not exposed along the lower part of Ballast Brook, but it was studied at one locality east of the head of Ballast Brook north of location 7 (Fig. 1). Here the Beaufort can be differentiated from the Eureka Sound Formation by its: relatively unconsolidated character; yellow to orange colour; coarser sediment (sand and gravel as compared to shale, siltstone, and lignitic coal); the presence of only slightly altered wood rather than coal and silicified wood; and the absence of concretions which are relatively common in the latter formation.

The Beaufort Formation in the Ballast Brook area has been subdivided into two units (X and Y, Figs. 2, 3) separated by an erosional unconformity. The lower unit (X, Figs. 2, 3) ranges up to 130 feet in thickness and is composed of fine- to coarse-grained white quartz sand, silt-clay, clay, woody peat, and minor interbeds of coarse pebble gravel. Except for the woody peat bed, which reaches 12 feet in thickness, wood is relatively scarce and is commonly flattened and altered. Only a single spruce cone was found in this unit.

The upper unit (Y, Figs. 2, 3) ranges up to about 200 feet in thickness and is composed of coarse-grained, dark coloured sand and pebble to cobble gravel. Uncompressed and unaltered wood occurs in lenses throughout the unit. Cones of Picea, Larix, Pinus, and Alnus are common. Sands infilling the channel illustrated in Figure 2 differ from typical unit Y sediments in that they are light coloured medium- to coarse-grained quartz rich sands. Like unit Y, however, they contain an abundance of uncompressed and unaltered wood.

Both units can be further subdivided. Unit X can be subdivided into five discrete subdivisions (A-E, Figs. 2, 3) and unit Y into two (F, G, Figs. 2, 3). Table 1 gives the characteristics of the two units and of their subdivisions.

Table 1: Subdivision of Beaufort Formation

Unit	Subdivision and thickness	Characteristics
Y	G (90-120 feet)	Pebble to cobble gravel and coarse sand. Commonly cross-stratified, paleocurrent west to southwest. Light grey to dark grey in the western part of the area, but has an orange limonitic coating in the eastern part. Contains numerous lenses of uncompressed wood 1 foot-3 feet thick and 2-300 feet in length, containing cones. Conformable with F below.
	F (10-90 feet)	Medium- to coarse-grained, cross-stratified light coloured quartz rich sands. Wood lenses uncommon. Commonly contains blocks of peat apparently derived from subdivision C below. Subdivision F cannot be differentiated outside the channel. Cross-stratification and distribution of sands indicates paleocurrent flow west southwest. Contact with units A to E below is erosional.
X	E (0-20 feet)	Light coloured clay, silty clay with sand lenses. Removed by erosion to the east (Fig. 3); conformable contact with D below.
	C (0-12 feet)	Dark brown to black, altered macerated and compressed woody peat. Contains some wood fragments 6 inches in diameter. Eroded from the eastern part of the area. Conformable with the underlying subdivision.
	B (0-20 feet)	Light grey, laminated clay to silty clay. Contains abundant altered flattened wood fragments. Removed from the eastern part of the area prior to the deposition of unit Y. Conformably overlies subdivision A.
	A (90+ feet)	Light grey medium- to coarse-grained quartz sand with common wood lenses in some areas. Cross-stratification indicating paleocurrent flow to the west or southwest common. The lower half of this unit contains numerous interbeds of clay up to 10 feet in thickness. The upper half of this subdivision was removed (loc. 6, Fig. 3) by erosion prior to deposition of unit Y. The base of this subdivision not exposed. North of location 7 undivided sediments belonging to unit X overlie the Eureka Sound Formation.

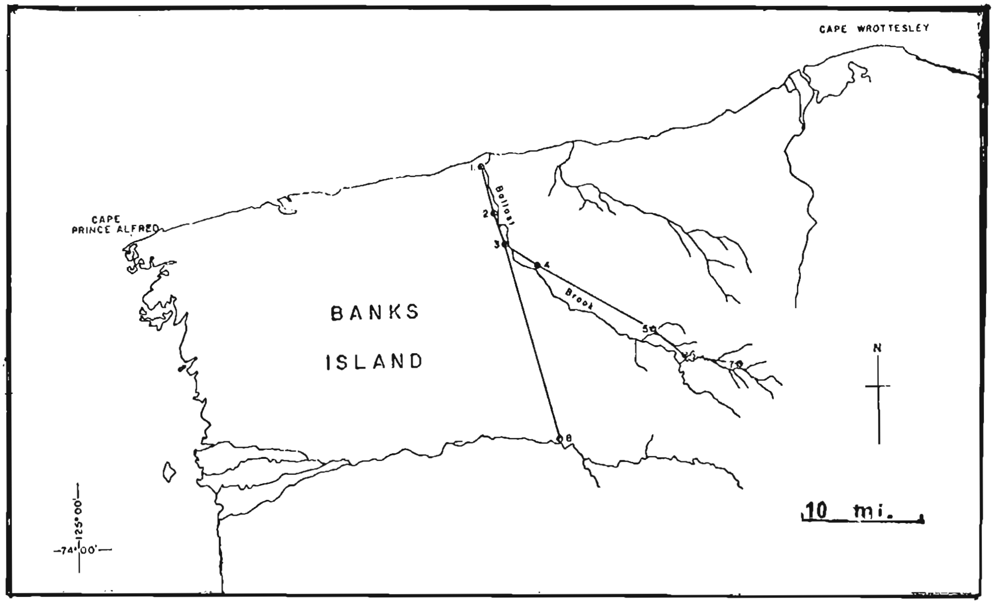

Figure 1

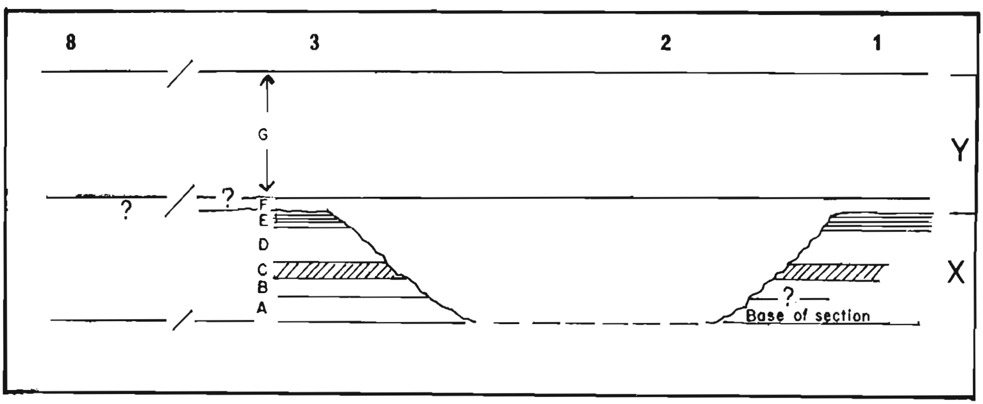

Figure 2

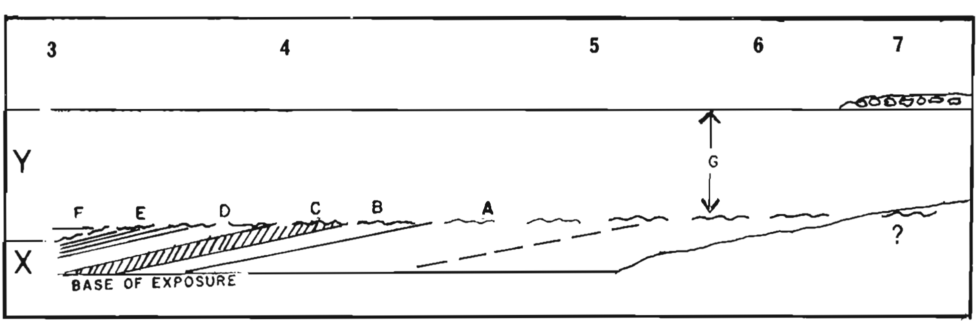

Figure 3

At location 7 (Fig. 3) the Beaufort is overlain by 20 to 30 feet of coarse clastic material which probably is a remnant of till. The phenoclasts range up to 6 feet in diameter and are composed predominantly of angular quartzite, quartz sandstone and diabase, and are commonly striated.

The significance of the unconformity between units X and Y is uncertain. However, the contrast between the compressed and altered wood from unit X and the unaltered and uncompressed wood of unit Y and the angular discordance (Fig. 3) between the two units suggests that a considerable time interval may be represented by the unconformity.

Examination of a single section of the Beaufort between locations 3 and 5 might result in the impression that the two units (X and Y) are conformable. However, the angular relationship which can be mapped in the field is good evidence of the unconformable relationship. To the east of location 5, such features as channels, reworked clay balls, and coarse gravels over clay are good evidence of the erosional nature of the contact.

Fyles[2] suggested that the Beaufort Formation on Ellef Ringnes and Borden islands couldbe subdivided into two units; a lower unit consisting of brown silt with peaty (lignitic?) layers and an upper unit of sand, pebble gravel, minor amounts of silt, and driftwood. This similar sequence of strata suggests that these units are correlative with those mapped on Banks Island. In contrast, the entire Beaufort Formation on Prince Patrick Island is lithologically similar to unit Y.

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[1] Thorsteinsson, R. and Tozer, E.T.: Banks, Victoria, and Stefansson Islands Arctic Archipelago; Geol. Surv. Can., Mem. 330, pp. 69-70 (1962).

[2] Fyles, J.G.: Surficial geology, Western Queen Elizabeth Islands; in Jenness, S.E., Rept. of Activities: Field 1964, pp. 3-5 (1965).

FIGURES 1, 2, 3, opposite

Figure 1. Index map indicating position of diagramatic cross-sections.

Figure 2. Diagramatic cross-section 1-8.

Figure 3. Diagramatic cross-section 3-7. Note angular relationships grossly exaggerated because of vertical exaggeration.

124. QUATERNARY RECONNAISSANCE, NORTHEAST BAFFIN ISLAND (37G, H, 38A, B, C, PART OF 48D)

Project 680044

D.A. Hodgson and G.M. Haselton

Reconnaissance field work was carried out to the east and north of the interior upland plateau, with limited helicopter and fixed-wing aircraft support. As no surficial deposits apparently pre-date general deglaciation of this area, the investigations concentrated on tracing end moraines and collecting samples for radiocarbon dating from the limit of marine submergence along the fiords and coast.

The Cockburn end moraine system[1] can be clearly traced across the heads of the major fiords, and represents the last stillstand or readvance of a regional ice sheet in this area. An older and more complex series of lateral moraines and drainage channels from throughgoing ice parallels the fiords where they transect the eastern highlands.

Ice from Buchan Gulf moved seawards in a deep submarine trough; to the north the outlet glacier from Coutts Inlet extended over the coastal foreland and continental shelf as a piedmont lobe. Similar outlet glaciers extended through Pond Inlet and north from Navy Board Inlet at an as yet undetermined date. Lateral drainage channels on northeast Bylot Island indicate an ice surface at least 250 metres above present sea level.

The upper limit of marine submergence rises inland from 50 metres on the outer coast to a maximum of 85 metres at the distal side of the Cockburn system. The northeast coast of Bylot Island exhibits two broad wave-cut platforms, and is currently in equilibrium with the eustatic rise in sea level.

Local ice caps in the eastern highlands have contributed to but not significantly altered the regional pattern of glaciation. A neoglacial expansion of these ice caps, probably reaching a maximum in the 18th or 19th centuries, has forced outlet glaciers down to sea level and created a number of proglacial lakes.

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[1] Falconer, G., Ives, J.D., Løken, O.H. and Andrews, J.T.: Major end moraines in eastern and central Arctic Canada; Can. Dept. Mines Tech. Surveys, Geog. Bull., vol. 7, No. 2, pp. 137-153 (1965).

125. PLEISTOCENE STRATIGRAPHY, PORCUPINE AND OLD CROW RIVERS, YUKON TERRITORY (116 O, N (east half) 117 A, B)

Project 680031

O. L. Hughes

Field work in 1968 was devoted mainly to study of Pleistocene sections along Old Crow and Porcupine rivers. New observations from an exposure on the south bank of Porcupine River near Old Crow, from which two radiocarbon dates have been reported previously (GSC-121[1], GSC-199[2]), permit amplification of the interpretation that accompanied announcement of the dates. The lower part of the section, which was partly to wholly covered when examined in 1962, was freshly eroded this year, exposing Unit 1 and the lower part of Unit 2 and providing a much better exposure of Unit 3 (Table 1).

In comment accompanying GSC-199 the writer inferred two glacial stages when Laurentide glaciers advanced against the east flank of Richardson Mountains and onto Peel Plateau, discharging meltwater northward down Eagle River and/or westward through McDougall Pass into the Porcupine River drainage. Unit 6 was judged then to be of glaciolacustrine origin, but now Unit 3 is also interpreted as glaciolacustrine. L.D. Delorme has examined samples collected from Unit 6 in 1962, and samples, judged from lithology and stratigraphic position to be Unit 3, collected by C.R. Harington in 1967, and found them to be devoid of ostracods or other fauna except for a single specimen of *Cytherissa* lacustris from Unit 3. Samples collected by the writer and others collected by C.R. Harington from Units 4 and 5, and from marl at the base of peat Unit 8 (at the upstream end of the section) yielded moderately abundant to abundant lacustrine and fluvial forms (Delorme, pers. comm., 1968). According to Delorme, the near absence of ostracods in Units 3 and 6 is compatible with interpretation of the sediments as having been deposited in a rather deep, cold turbid lake into which glacial meltwater was being discharged.

TABLE I

Unit	Description	Thickness (feet)
9	Silt, probably eolian	1.5
8	Peat, wood, mostly unhumified	3
7	Silt, grey-brown, with twig and wood lenses, thin peaty layers; probably fluvial	17.5
6	Clay, silty, dark grey (moist), pale grey (dry); sediments slumping and flowing and poorly exposed; glaciolacustrine	10.5
5	Silt and very fine-grain sand, dark grey to grey-brown (moist), yellow-brown (dry); gravel lens 1-foot thick in middle of unit: lacustrine and fluvial	37
4	Silt, grey-brown (moist), yellow-brown (dry), lenses of gravel and of twigs and wood; bedding in upper 3 to 4 feet highly convoluted by cryoturbation	20.5
3	Silt, dark brown-grey (moist) medium brown-grey (dry); massive; markedly jointed with oxidized joint surfaces; glaciolacustrine; overlies Unit 2 disconformably	41.5
2	Silt, sand, fine gravel bedded, grey brown to yellow brown; twig and wood layers abundant in lower 25 feet; upper 4 feet highly convoluted by cryoturbation, with convolutions truncated at contact with Unit 3; overlies Unit 1 disconformably	40
1	Sand, coarse, and fine gravel, with a few thin silt layers, grey, in part oxidized to dull red brown; very compact cf. Units 2, 4 and 5; abundant logs (spruce) with diameter to 20 inches.	12
	Total	183.5

Unit 6 is exposed intermittently along Porcupine River from 8 miles east of the mouth of Driftwood River to the head of 'The Ramparts' near the Alaska border, and along Old Crow River at least as far upstream as Timber Creek. Shorelines occur at elevations up to 1, 160 feet around the periphery of Old Crow basin in Porcupine River valley near Old Crow. The shorelines probably relate to the glacial lake stage during which Unit 6 was deposited, and indicate a vast glacial lake occupying Old Crow basin and Porcupine River valley from 'The Ramparts' to beyond Driftwood River, and draining westward to Yukon River across a bedrock threshold at 'The Ramparts'. Much of Bell basin is below 1, 160 feet, suggesting that it too may have been inundated. Clay similar to Unit 3, and underlying sediments similar to those of Units 4 and 5, are exposed at several localities along Old Crow River, but require further study. However, it is probable that the glacial lake in which Unit 3 was deposited was approximately coextensive with the later one described above.

Briefly, the inferred history is as follows:

1. Tertiary or early Pleistocene downwarping and/or faulting to produce Old Crow basin, another basin now crossed by Porcupine River from above Driftwood River to 'The Ramparts', and Bell Basin, with drainage eastward through Richardson Mountains at McDougall Pass (present divide is at ca. 1, 050 feet).

2. Aggradation of the basins by fluvial, deltaic and probably lacustrine sediments (represented in part by Units 1 and 2). The cryoturbate horizon of Unit 2 indicates that the sediments were at least in part subaerial and subjected to intense cold.

3. Damming of the eastern outlet by advancing Laurentide ice, formation of a (probably) single glacial lake in the basins with westward drainage at 'The Ramparts', and deposition of Unit 3.

4. Retreat of Laurentide ice, re-establishment of eastward drainage, and resumption of filling of the basins by normal lacustrine, deltaic and fluviatile sediments (Units 4 and 5).

5. Readvance of Laurentide ice, re-establishment of the glacial lake and deposition of Unit 6; erosion of the western outlet to below the level of McDougall Pass.

6. Retreat of Laurentide ice and cessation of the meltwater discharge into Porcupine River drainage.

7. Local deposition of fluvial and shallow water lacustrine sediments (including marl) followed by widespread deposition of peat.

8. Erosion of Porcupine River and tributaries to their present levels.

Deposition of Unit 5 began more than 41, 300 years ago (GSC-199). Deposition of Unit 6 was followed by peat deposition beginning 10, 740 $\pm$ 180 years ago (GSC-121). The glacial lake stage represented by Unit 6 is probably of classical Wisconsin age, and that represented by Unit 3 of preclassical Wisconsin or older age.

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[1] Dyck, W. and Fyles, J.G.: Geological Survey of Canada Radiocarbon Dates III; Geol. Surv. Can., Paper 64-40 (1964).

[2] Dyck, W., Fyles, J.G. and Blake, W., Jr.: Geological Survey of Canada Radiocarbon Dates IV; Geol. Surv. Can., Paper 65-4 (1965).

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126. GLACIAL GEOLOGY, STRATFORD-CONESTOGO, ONTARIO (40 P/7, P/10)

Project 650038

P.F. Karrow

Although most till boundaries have now been defined, the identification of several till bodies must await the results of analyses. Indeed, in view of the presence of many relatively thin till sheets in the area, identification of tills has had to depend to an unusual degree on analyses rather than field recognition. There are several clay tills of different stratigraphic position and/or lobal origin; the same is true of silt tills. Sandy tills are relatively unusual and are generally identifiable.

To facilitate identification and tracing of the till bodies about 500 till samples have been collected and most have been analyzed in terms of grain-size distribution and carbonate content. Till fabrics have been determined at many sites and pebble counts have been made for over 100 samples.

127. QUATERNARY GEOLOGY OF THE DUCK MOUNTAIN AREA, MANITOBA (62 N)

Project 640029

R.W. Klassen

Mapping of the surficial deposits in the Manitoba part of the Duck Mountain area was begun and the south half completed. The writer was assisted by Mr. G. Burwasser, a graduate student at the University of Saskatchewan.

The area mapped includes part of the Lake Agassiz basin in the southeast and ground moraine plains in the southwest separated by an interlobate hummocky disintegration moraine and end moraine complex. The interlobate moraine belt is continuous with the hummocky disintegration moraine of the Duck Mountain and Riding Mountain Uplands.

The drift is thin (generally less than 40 feet) in the Lake Agassiz Basin and on the slopes leading up to the Riding Mountain Upland, but it thickens gradually toward the morainal areas to the west and northwest. The greatest known drift thickness (585 feet) was recorded from a testhole east of Roblin (GSC Roblin 2-68).

Multiple tills and intercalated stratified sediments of significant areal distribution comprise the drift in the western part of the area[1, 2]. The stratigraphic relationships of fine and coarse lacustrine deposits within the Agassiz basin record marked fluctuations in the levels of Lake Agassiz.

The western limit of a surface till high in Paleozoic carbonate rock deposited by glacier flow to the west (Valley River Sublobe[3], p. 126) between the Duck Mountain and Riding Mountain Uplands is marked by a prominent north-trending end moraine in townships 24 and 25, range 25. The surface till in the western part of the area is high in Cretaceous shale and was deposited by glacier flow to the southeast (Northwestern Lobe[3], p. 121). In the interlobate belt the till is transitional in composition between these two types. Present evidence suggests these ice lobes were essentially contemporaneous and formed during general deglaciation in late Wisconsin time, although the Valley River Sublobe remained active after the Northwestern Lobe had retreated northward.

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[1] Klassen, R.W.: Stratigraphy and chronology of Quaternary deposits of Assiniboine River Valley and its tributaries; *in* Report of Activities November 1966 to April 1967; Geol. Surv. Can., Paper 67-1, Pt. B, p. 55 (1967).

[2]Klassen, R.W.: Quaternary geology and geomorphology of Assiniboine Valley and its tributaries, Manitoba and Saskatchewan; in Report of Activities, May to October 1967; Geol. Surv. Can., Paper 68-1, Pt. A, p. 172 (1968).

[3]Klassen, R.W.: The surficial geology of the Riding Mountain area, Manitoba-Saskatchewan, unpubl. Ph.D. thesis, Univ. of Saskatchewan, Saskatoon (1966).

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128. POSTGLACIAL MARINE LIMIT AT PITZ LAKE, DISTRICT OF KEEWATIN (65 P)

Project 660030

B.C. McDonald and R.G. Skinner

The Pitz Lake basin, 30 miles southwest of Baker Lake settlement, is situated on the former Keewatin ice divide. Nine days were spent studying features of the Tyrrell Sea episode there. Several collections of marine shells were made, and they will provide C-14 dates relating to disappearance of the ice sheet.

Distinctive wave-cut terraces occur at the top of well developed flights of beaches and mark the contacts between till above and beach gravel below. These terraces were considered to represent marine limit. Altitudes were measured with altimeters and by levelling from Pitz Lake; the terraces vary between 410 and 520 feet above present sea level. Although the marine limit generally rises southeastward within the basin, irregularity in the altitudes may have resulted from residual glacier ice having caused the marine limit to be significantly time-transgressive.

129. QUATERNARY STRATIGRAPHY, MACKENZIE DELTA-ARCTIC COAST, DISTRICT OF MACKENZIE (107 D)

Project 650011

J.C. Ritchie

Between 1 May and 4 May, 3 sections of lake sediment were recovered from 3 small lakes on the morainic ridge immediately north of Eskimo Lakes. The lakes are at 69°03'N., 133°27'W.; 69°07'N., 133°16'W.; 69°18'N., 132°38'W. The cores were recovered with a piston sampler (the Square Rod modification by Wright) - operated through the ice. The cores will be analyzed for pollen and larger plant remains, thus providing information on late Pleistocene vegetation and climate supplementing the data already on hand from samples collected in 1967 and earlier.

130. SURFICIAL GEOLOGY ALONG THE BOW RIVER VALLEY IN THE VICINITY OF CALGARY, ALBERTA (82 O)

Project 670061

N.W. Rutter

An integrated program of drilling, side-wall sampling, and single point electro-logging was carried out within or near the Calgary city limits during the fall of 1967. The results from nineteen boreholes were used to provide stratigraphic information which could not be obtained by conventional observational techniques. This is an outgrowth of earlier field work completed to the west along the Bow River valley[1, 2]. This drilling has demonstrated that outwash gravel underlain by till occurs beneath the Spy Hill till of Tharin[3]. It is suggested that the till, and possibly the outwash, date from a glacial advance earlier than and separate from the Spy Hill glacial activity. In the course of the drilling, till was found beneath Glacial Lake Calgary sediments in several places and, in contrast, till was discovered over lake deposits near the eastern boundary of the city. The latter relationship possibly records westward encroachment of ice into Lake Calgary.

Further drilling was carried out in September and October, 1968. As of 1 October, seventeen boreholes had been completed within a triangular-shaped area extending northwestward from Calgary to Cochrane on the north side of the Bow River, from Cochrane eastward to Airdrie, and from Airdrie southward to Calgary. Preliminary results indicate that in most of the area thin till covers bedrock, thickening locally in areas of hummocky dead ice moraine. Side-wall sampling and electro-logging indicate more than one till unit present.

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[1]Rutter, N.W.: Surficial geology along the Bow River valley between the Kananaskis River and Cochrane; in Report of Activities, May to October; 1966; Geol. Surv. Can., Paper 67-1A, p. 113 (1967).

[2]Rutter, N.W.: Surficial geology along the Bow River valley in the vicinity of Calgary, Alberta; in Report of Activities, May to October 1967; Geol. Surv. Can., Paper 68-1A, p. 181 (1968).

[3]Tharin, J.C.: The glacial geology of the Calgary area, Alberta; unpubl. Ph.D. thesis, Univ. Illinois (1960).

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131. SURFICIAL GEOLOGY OF THE PEACE RIVER DAM AND RESERVOIR AREA, BRITISH COLUMBIA (PARTS OF 93 N, O, 94 B, C, E)

Project 660031

N.W. Rutter

The geological study and mapping (1/50,000) of glacial deposits and geomorphology of the Peace River dam (W.A.C. Bennett Dam) and reservoir (Lake Williston) area were completed. During previous seasons, mapping and stratigraphic studies were carried out by the use of boats along the major rivers - the Parsnip, Peace and Finlay. This summer, to facilitate mapping of the broad Rocky Mountain Trench and bordering mountains beyond the banks of the navigable rivers, a helicopter was used. Over two hundred stops were made in order to check airphoto interpretation maps with ground observations. Aspects of the stratigraphy and surficial deposits have been reported previously[1, 2].

An objective of this year's field work was to determine the glacial flow pattern in the area, and particularly to determine whether ice at any time flowed across the Rocky Mountain Trench as an ice sheet, from the west or east, or whether it has always followed the natural drainage directions. Pebble orientation studies were made in several till units but have not as yet been analyzed. Preliminary information suggests, however, that at least the latest advances followed the natural drainage. The paucity of glacial erratics from sources west of the Rocky Mountain Trench and the poor preservation of striated and fluted surfaces on or near mountain summits in the Rocky Mountains, suggest that only early and extensive glaciations have crossed drainage routes and penetrated deeply into the Rocky Mountains. No evidence was found that ice from the east flowed across or into the Rocky Mountain Trench.

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[1]Rutter, N.W.: Surficial geology of the Peace River dam and Reservoir area, British Columbia; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1A, p. 87 (1967).

[2]Rutter, N.W.: Surficial geology of the Peace River dam and Reservoir area, British Columbia; in Report of Activities, May to October, 1967; Geol. Surv. Can., Paper 68-1A, p. 182 (1968).

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132. QUATERNARY GEOLOGY AND GEOMORPHOLOGY OF THE WHITECOURT AND TAWATINAW AREA, ALBERTA (83 I, J)

Projects 660032, 680027

D.A. St-Onge

The Quaternary stratigraphy of the region as exposed along several sections in the Fort Assiniboine area was re-examined in detail. The most significant find was a large piece of wood in a gravel unit, between the two tills which outcrop in the Freeman section (sec. 18, tp. 62, rge. 6, west of 5th). The wood has yielded a C-14 date of > 40,000 (GSC 1019). In the light of this new data, it will be necessary to re-examine the significance of the dates obtained on organic material in a section located a few miles to the north[1].

Systematic mapping of landforms and surficial deposits was started in the Tawatinaw area. The southwestern third of the map-area has been completed. Glacial landforms are particularly well-developed in this region, notably flutings, hummocky moraines, pitted outwash, crevasse fillings and meltwater channels. Gravel pits in river terrace deposits have yielded numerous bones. The highest terrace on the north side of the Athabasca River near the town of Athabasca is exceptionally rich in organic remains.

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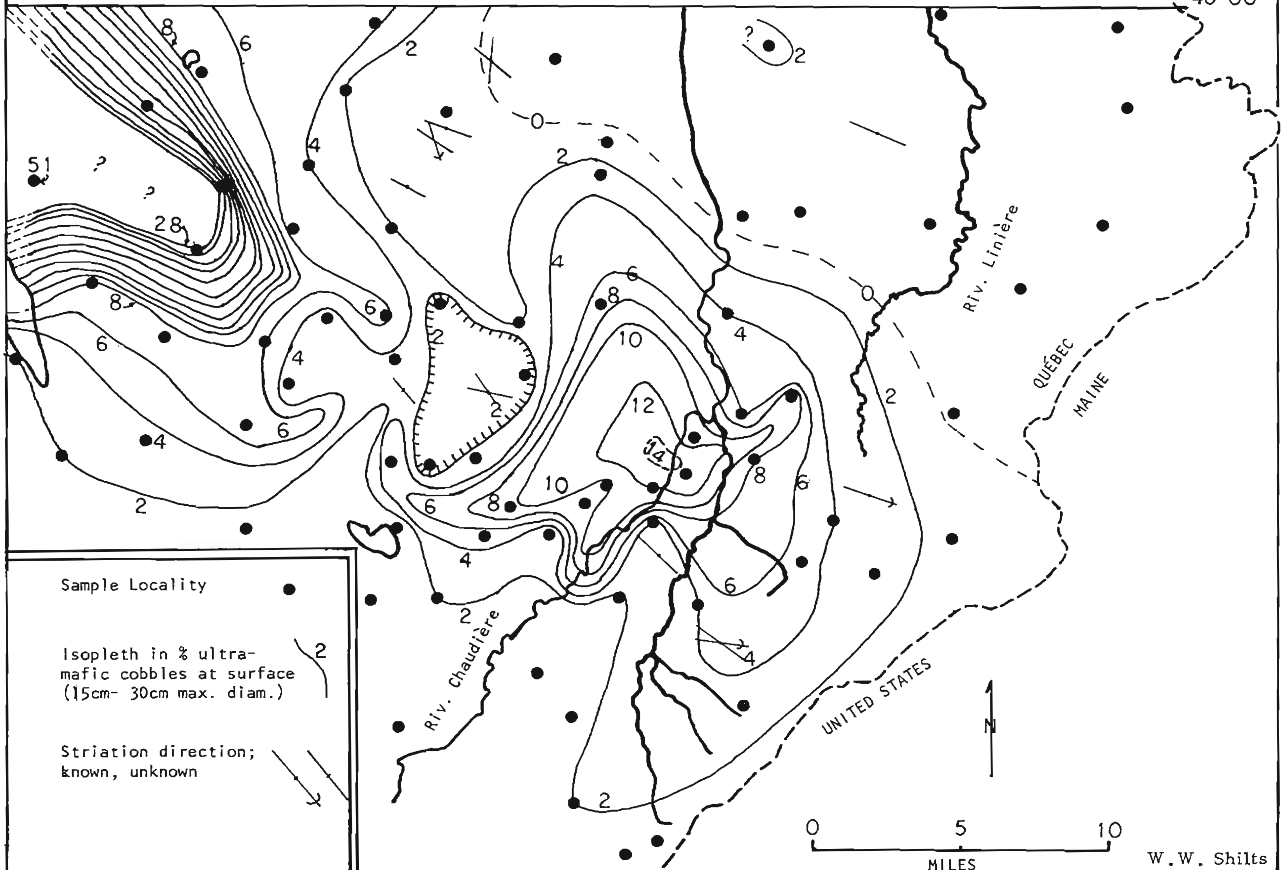
[1]St-Onge, D.A.: Quaternary geology and geomorphology, Whitecourt map-area, Alberta; in Report of Activities, May to October 1967; Geol. Surv. Can., Paper 68-1, Pt. A, pp. 186-187 (1968).

Figure 1. Isopleths of Ultramafic Cobbles; Chaudière River, P.Q.



133. QUATERNARY GEOLOGY OF THE UPPER CHAUDIÈRE RIVER DRAINAGE BASIN, QUEBEC, (21 E, (east half))

Project 660035

W.W. Shilts

Reconnaissance mapping of the surficial deposits of the Quebec portion of the eastern half of Sherbrooke map-area (21 E) was completed. Mapping has outlined a system of moraines and meltwater channels which mark former ice front positions at halts during the retreat of an active ice sheet. The highest and oldest of these systems is represented by discontinuous ridges of till and gravel and by meltwater channels which are preserved at altitudes of 1,600 feet to 1,800 feet on the west and north-facing slopes of the Boundary Mountains and on the east and north flanks of Mount Megantic. Prominent northeast-trending, ice-contact gravel and sand moraines through Ditchfield and gravel-till moraines near Marsboro and Moose Lake mark halts of backwasting ice or readvance positions.

A broad, lobe-shaped area of chlorite-rich clay till and associated chlorite-rich silt till seems to represent a southerly glacier readvance from St. Ludger to or south of Lac Megantic. Abundant north-south striae north of the study area[1] and similarly oriented weakly developed striae north of St. Ludger, suggest that the readvance may have been much more extensive. A thin till unit overlying ice-contact gravel and thin lake sediment in several places north of St. Ludger may be correlative with the clay till farther south.

In the vicinity of Drolet, extensive slumping of thick Pleistocene sediments has been studied. Relief of pressure by the removal of easily erodible lake sediment has caused large and small scale slumping along the Chaudière River and its tributaries. Some large slump blocks with apparent vertical displacements of over 150 feet are displaced away from Drolet River and cannot readily be explained by response to river erosion. Postdepositional compaction and/or plastic flow of the thick (180 feet) laminated clays, which commonly occur below 1,400 feet in this region, are possible mechanisms for producing this large-scale faulting. Fault or slump scarps form the steep sides of asymmetric gullies and streams and are the loci of many small mudflows. Extreme care should be taken in planning and construction and in any modification of natural river channels in this area as even slight loading of slopes, or alteration of stream grade or position with respect to valley walls, has initiated and may cause further slumping, mudflows, and severe gullying.

Detailed study of surface boulder distribution has delineated anomalously high concentrations of pyroxenite and serpentinized peridotite between St. Ludger and the junction of the Samson and Chaudière rivers (Fig. 1). The high concentration does not fit the general down-ice decrease in ultrabasic boulder frequency from the source area in the vicinity of Caribou Mountain. The anomaly could be related to a slight magnetic high southeast of Lake No. 2 and Douglas Lake[2]. Brief reconnaissance of the magnetic high failed to show either boulder concentration or outcrop of ultrabasic rocks.

[1] Gadd, N.R.: Surficial geology, Beauceville map-area, Quebec; Geol. Surv. Can., Paper 64-12 (1964).

[2] St. Evariste, Frontenac and Beauce Counties, Quebec; Geol. Surv. Can., Aeromagnetic Map No. 153 G (1954).

134. QUATERNARY STUDIES IN THE SOUTHWESTERN PRAIRIES, ALBERTA

Project 650027

A.M. Stalker

Field work in 1968 in the main continued the Quaternary stratigraphy and vertebrate paleontology studies of previous years. Dr. C.S. Churcher, Department of Zoology, University of Toronto, continued his association with the writer on this project as vertebrate paleontologist, although he was able to spend only a short period in the field, in the autumn. The writer had the privilege of having as archeological consultants Mr. B. Reeves and Mr. C. Eyman, both from Department of Archeology, University of Calgary. An archeological party under direction of Mr. Reeves participated in the excavations.

Much of the study consisted of intensive examination of interglacial (Sangamon?) deposits at Mitchell Bluff, on the south side of South Saskatchewan River north of Medicine Hat, in NE 1/4 sec. 32, tp. 13, rge. 5, W. 4th mer. (50°7'45"N.; 110°38'40"W.). This study entailed removal of 8,000 cubic yards of material to reach a 5-foot-thick gravel band that in other years had supplied numerous vertebrate fossils and what apparently are poorly-formed artifacts. That gravel band again surpassed expectations, yielding several hundred bones and additional chipped cherts and worked pieces of bone. In addition, deposits along the river, both older and younger, but particularly the basal gravels, yielded many bones.

The worked cherts and bone fragments are being studied at the Department of Archeology, University of Calgary, and the vertebrate fossils at the University of Toronto by Dr. Churcher. In neither case will results be available for some time.

The studies in 1967 added several animals to the faunas previously reported. Dr. Churcher (written communication) sums up some of the results as follows:

"The Medicine Hat Buried Valley, Alberta, has been further investigated and identification of four additional animals obtained. These are a ground sloth (? Nothrotherium sp.), two horses (Equus scotti, either E. cf. lambei or E. cf. niobrarensis), and caribou (Rangifer tarandus). The ground sloth was obtained from the lowest Quartzite Gravels from which Equus scotti has been recognized. The presence of E. scotti implies a Kansan age for this level which directly overlies the bedrock at Low, Blindman and Island Bluffs. The caribou has been obtained from the Artifact Band at both Mitchell and Island Bluff and is associated with a partial tooth that can be identified as Mammuthus jeffersoni. Together with the remainder of the fauna in the Upper Sands and Gravels a date of Late Sangamon-Early Wisconsin may be suggested.

"The Wellsch Valley fauna from north of Swift Current, Saskatchewan, has yielded definite evidence of camel, mammoth, peccary, carnivore, antilocaprid and two horses. .... the two horses can be tentatively identified as Equus pacificus and E. complicatus, both of which are considered to be of Kansan age ..... .

"Correlation between the Medicine Hat Buried Valley's lowest faunal level with that from Wellsch Valley is not yet possible. It may be hoped that some comparison will be possible between the camelid species as the equids appear different at the two localities."

135. BEDROCK TOPOGRAPHY AND QUATERNARY STRATIGRAPHY, VIRDEN, MANITOBA (62 F)

Proiect 670034

J.E. Wyder

During July and August of 1968, forty-seven drillholes were completed into bedrock within the Manitoba section of the Virden area. These holes were drilled to evaluate the interpretation of surface DC resistivity surveys conducted in the area during June. The surface resistivity traverses were chosen so as to check a bedrock topographic contour map constructed from the results of the 1967 drilling program[1].

Two discoveries of some possible importance to future ground-water development in the area were made:

(1) The existence of a deep (greater than 250 feet), narrow (less than 4, 000 feet) northeast-trending channel, containing mainly colluvium and gravel, has been confirmed at points approximately one to one and one-half miles northwest of Waskada, one mile southwest of Medora and at a point midway between the two villages. This channel may be of particular importance to the village of Waskada which is presently without a dependable water supply. The presence of this channel was first indicated by the results of surface resistivity surveys.

(2) The existence of thick gravel deposits up to 5 miles wide and 100 to 200 feet thick extending westward from a point about 8 miles west and 3 miles north of Melita. These deposits were detected and, to a certain extent, delineated with the aid of surface resistivity surveys. These deposits may be of some significance for future industrial water supplies in the area.

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[1] Klassen, R.W. and Wyder, J.E.: Drift stratigraphy and bedrock topography, Virden area, Manitoba in Report of Activities, May to October, 1967; Geol. Surv. Can., Paper 68-1, Part A, pp. 171-172 (1968).

STRATIGRAPHY AND STRUCTURAL STUDIES

136. OPERATION NORMAN, DISTRICT OF MACKENZIE (86D, E, L, M, 87B, C, 96, 97A, B, C, D, F, 106A, B, G, H, I, J, O, P, 107A, D, E)

Project 670068

J. D. Aitken, C. J. Yorath, D. G. Cook, and H. R. Balkwill

Operation Norman, a regional geologic study of the lower Mackenzie River area (Fig. 1) carried out, under the direction of J. D. Aitken, combines reconnaissance bedrock mapping, stratigraphic studies, and investigation of surficial Quaternary deposits. The bedrock program is being carried out by the Institute of Sedimentary and Petroleum Geology; Quaternary studies are by the Division of Quaternary Research and Geomorphology. The operation will cover about 145, 000 square miles, most of the area between 64 degrees north and the Arctic Ocean, and between 119 and 132 degrees west (Fig. 1).

Field studies during 1968, the initial year of the operation, were confined mainly to the plains area north and east of the Mackenzie Mountains. A main party under J. D. Aitken operating to the south, and a smaller coastal party led by C. J. Yorath to the north, completed examination of about two thirds of the total project-area (Fig. 1). Much of the remaining area is in the Mackenzie Mountains where field work will be more time consuming owing to much better exposure and more complex structure. Maps of the area in which field work is completed will be published at scales of 1:500,000, and where justified by geologic detail at 1:250, 000 (Fig. 1). The main party was supported by two helicopters, the coastal party by one; a Cessna 206 fixed-wing aircraft was shared. Field work was preceded by airphoto interpretation of all areas to be investigated.

Detailed stratigraphic and paleontologic studies carried out in conjunction with mapping, provided stratigraphic control between localities in spite of lateral facies changes within formations. Individual reports by stratigraphers, paleontologists, and Quaternary geologists appear elsewhere in this publication. Discussions of the broader findings of each of the two parties are presented below.

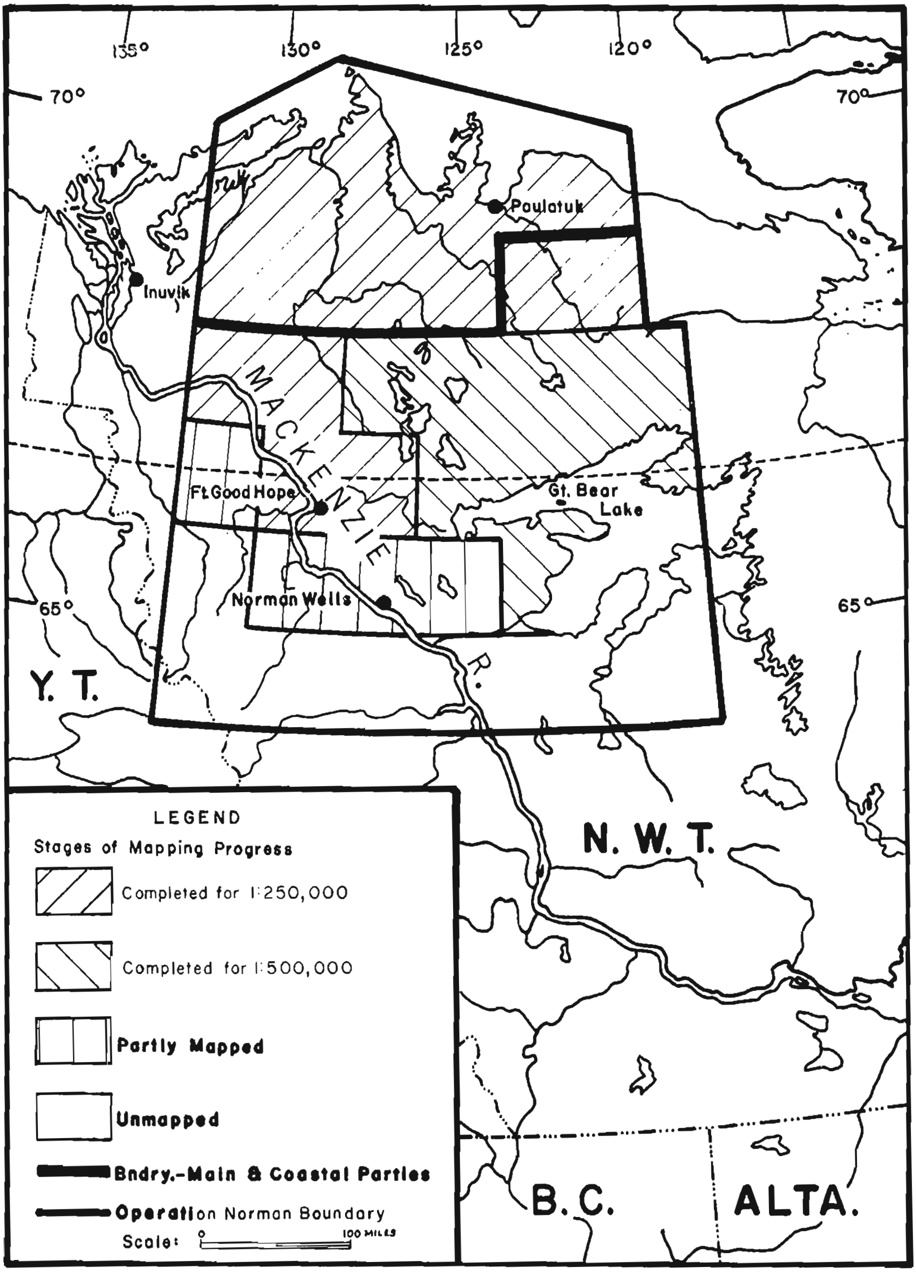

Figure 1. Stages of mapping - Operation Norman.

Table 1

Table of Stratigraphic Units

	Mapped by Main Party		Mapped by Coastal Party	
	Unit	Thickness in feet	Unit	Thickness in feet
Quaternary	unconsolidated surficial deposits		unconsolidated surficial deposits	
	regional unconformity		regional unconformity	
Quaternary or Tertiary			Beaufort Formation equivalent	5-10
			unconformity	
			Pale Shale zone Bituminous zone	610 100-325
Cretaceous			disconformity	
	Shales Basal sandstone	 75	Bentonitic zone Silty zone	500-750 1200?
	regional unconformity		regional unconformity	
Upper Devonian	Imperial Formation Canol Formation	2000 425	Imperial Formation Canol Formation	2000 125
	disconformity		disconformity	
Middle Devonian	Ramparts-Kee Scarp Formation Hare Indian Hume Formation Bear Rock Formation	0-360 800 400 700	Hare Indian Formation Hume Formation Bear Rock Formation	600 150 700
	disconformity		disconformity	
Ordovician or Silurian	Ronning Group (3 mappable units)	1200-1400	Ronning Group (2 mappable units)	1100-1300
Cambrian or? Ordovician	Macdougal Group (2 mappable units) Basal Paleozoic sandstone	400 200	Macdougal Group (1 mappable unit) Basal Paleozoic sandstone	300 200
	regional unconformity		regional unconformity	
Proterozoic	Diabase sills and dykes Gypsiferous unit Orange weathering dolomite unit Quartzite unit Lower dolomite and shale unit		Diabase sills and dykes Gypsiferous unit Orange weathering dolomite unit Quartzite Lower dolomite and shale unit Green shale unit	

Main Party

J. D. Aitken and D. G. Cook

Reconnaissance mapping and the regional structural investigation were done by J. D. Aitken, D. G. Cook, and M. E. Ayling (University of Calgary graduate student). The reconnaissance program was augmented by stratigraphic and Quaternary studies by R. W. Macqueen (Cambrian, Ordovician and Silurian stratigraphy), W. S. MacKenzie (Devonian stratigraphy), A. E. H. Pedder (Devonian biostratigraphy), and R. J. Fulton (Quaternary geology). These geologists operated from either the main or coastal party depending on availability of suitable rock exposure. During the final two weeks of the field season C. J. Yorath and H. R. Balkwill from the coastal party joined the main party. This permitted Yorath to carry out preliminary investigation of Cretaceous stratigraphy between the west bank of the Mackenzie River and the mountain front, in preparation for the 1969 field season.

Nineteen stratigraphic units (Table 1) were mapped in the area examined by the main party (approximately 68,000 square miles, Fig. 1). The stratigraphy of the area is dominated by pronounced regional sub-Cretaceous and sub-Paleozoic unconformities. These are made obvious by regional truncation of the underlying units and, in the case of the sub-Paleozoic unconformity, by angular discordance with the underlying Proterozoic units. Disconformities, apparent from local relief on the underlying unit, occur at the base of the Bear Rock Formation and at the base of the Canol Formation.

Structurally, the rocks examined in the plains area during 1968 form large expanses of generally flat-lying sediments interrupted by enigmatic linear, anticlinal ridges of high relief, occurring along three principal trends, namely, northwest-southeast, east-west, and north-south. These are commonly asymmetric anticlines or faulted anticlines with intervening, broadly synclinal plains areas. Reversals of asymmetry are common. Moreover, such reversals and diverging trends are frequently displayed along a given range. These structures are best developed east of Mackenzie River and, north and east of Norman Wells, but also occur in the Colville Lake area and north of Smith Arm on Great Bear Lake. There is clear evidence of shortening and hence compression of the stratigraphic sequence overlying the Cambrian Macdougal Group shales. There is no evidence that rocks older than the Macdougal Group are affected by deformation in the central plains area. This suggests the existence of a décollement in the Macdougal Group, presumably in the gypsum and/or salt beds of that group. Tectonic activity appears to have extended more than 100 miles to the east of the main Mackenzie Mountain front. A thrust fault with at least a quarter mile of displacement, observed in flat-lying strata north of Fort Good Hope, supports the concept of compressive deformation across most of the plains area.

In addition to compressional structures, north to northwest trending normal faults, with throws measured in hundreds of feet, are prominent in some areas. High angle normal and reverse faults offset Precambrian and Paleozoic sediments in the eastern part of the area. Some of these appear to be Precambrian faults reactivated during or after Paleozoic time.

No metallic minerals of economic significance were noted. Precambrian sediments, intruded by basic igneous dykes and sills in the northeast part of the area, appear to constitute the only rocks for potential base metal exploration. Gypsum occurs, and salt deposits may also be encountered, in the Cambrian Macdougal Group. The area's greatest economic potential is for oil and gas. Highly bituminous shales in the Cretaceous sequence and in the Devonian Canol Formation are obvious potential source rocks for hydrocarbons. Potential reservoir rocks are basal Paleozoic sandstone, porous Ordovician and Silurian dolomites (locally containing solid hydrocarbons), Devonian Bear Rock Formation breccia, Devonian Ramparts-Kee Scarp Formation limestone (producing horizon in the Norman Wells field), and Cretaceous sandstone (locally oil saturated). Unfortunately from the point of view of productive potential, these formations are widely exposed.

Coastal Plains Party

C. J. Yorath and H. R. Balkwill

The responsibilities of the Arctic Coastal Plains subparty were to carry out stratigraphic studies and to complete the mapping of the mainland sedimentary rocks north of latitude 68 degrees and between 120 and 132 degrees west, an area of approximately 32, 000 square miles (Fig. 1). All units older than the Cretaceous were mapped by H. R. Balkwill. Stratigraphic studies of lower Paleozoic rocks were made by R. W. Macqueen; and of Devonian rocks by W. S. MacKenzie. The lithostratigraphy and mapping of Cretaceous and Tertiary rocks were the responsibility of C. J. Yorath. T. P. Chamney described and sampled the Cretaceous succession for biostratigraphic studies of the microfauna. Quaternary studies were made by R. W. Klassen.

Bedrock exposures are found principally in the valleys of the Anderson, Kugaluk, Carnwath, Wolverine, Horton, Hornaday, Brock and Roscoe rivers. Between these rivers there is little outcrop and large areas are masked by Pleistocene and Recent deposits.

The oldest rocks are Proterozoic clastic and carbonate strata, intruded by diabase dykes and sills, and exposed as a structurally and topographically prominent arch in the northeastern part of the area. The dykes and sills have yielded dates between 705 and 770 million years[1]. Lower Paleozoic (Cambrian and Ordovician-Silurian) clastic and carbonate rocks flank the eastern and western limbs of the arch. The sequence of lower

Paleozoic and Devonian rocks dips gently toward the northwest, with local structural interruptions, from Hornaday River to Kugaluk River. This succession is similar to, and in mappable continuity with, the succession mapped by the main party, except that the Kee Scarp-Ramparts Formation appears to be undeveloped.

The principal exposures of Cretaceous strata occur in the broad valleys of the Anderson, Kugaluk, Horton, Hornaday and Brock rivers, where they unconformably overlie rocks of Devonian, Ordovician-Silurian, Cambrian and Proterozoic ages. The Cretaceous succession is divisible into four mappable units. The basal 'Silty Zone' in the region of the Horton, Hornaday and Brock rivers can itself be subdivided into a lower sandstone-coal division and an upper siltstone-mudstone division. To the west in the vicinity of the Anderson River the basal sandstone-coal division is undeveloped and here the 'Silty Zone' is represented by shales, mudstones and siltstones.

Overlying the 'Silty Zone' with apparent conformity is the 'Bentonitic Zone' which consists of a monotonous sequence of dark, soft and plastic shales with many ironstone concretionary beds containing poorly preserved ammonites. No lateral changes in facies occur within this unit.

Unconformably overlying the 'Bentonitic Zone' is a sequence of black bituminous shale, yellow jarosite and locally dark maroon earthy hematite. The hematite occurs where the unit has undergone oxidation. Active burning of the 'Bituminous Zone' is evident at several localities, including those in the Smoking Hills on the west side of Franklin Bay. The unconformity at the base is marked by an irregular contact and an ironstone- and shale-pebble conglomerate.

The 'Pale Shale Zone' overlies the 'Bituminous Zone' with apparent conformity. It consists of a sequence of light grey-weathering shales of notably low specific gravity. The uppermost beds of this unit are iron-rich and weather medium to dark brown.

The foregoing names were applied to these units by geologists employed by J. C. Sproule and Associates Limited and have been used informally by oil companies since 1959.

A thin, unconsolidated gravel and sand unit containing wood fragments and beds of dark organic material, and forming flat, planar surfaces was found capping the Cretaceous beds on both sides of the Horton River. This unit may be the equivalent of the Beaufort Formation on Banks Island where it is believed to be of Late Tertiary and Early Pleistocene age[2].

The Cretaceous succession thickens and dips gradually toward the northwest in a normal offlap sequence. If fold structures are present, they are so broad and gentle that documentation by ordinary field methods is impossible.

The economic potential of the region depends mainly on the possibility of hydrocarbon accumulation. The Devonian Bear Rock Formation is porous in some areas and is a potential reservoir. The black bituminous Devonian Canol shales are potential source rocks. Similar economic potential may be associated with the Cretaceous sandstones and shales respectively. The sandstones at the base of the Cretaceous sequence contain coal beds which have been used for fuel by trappers and the Roman Catholic Mission at Paulatuk[3]. Metallic minerals were not found in the region.

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[1] Wanless, R.K. et al.: Age determinations and geological studies, Part 1, Isotope ages; Geol. Surv. Can., Paper 64-17 (1965).

[2] Thorsteinsson, R., and Tozer, E.T.: Banks, Victoria and Stefansson islands, Arctic Archipelago; Geol. Surv. Can., Mem. 330 (1962).

[3] Mackay, J.R.: The Anderson River map-area, Northwestern Territories; Can. Dept. Mines Tech. Surv., Geograph. Br., Mem. 5 (1958).

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137. UPPER DEVONIAN TO UPPERMOST CRETACEOUS STRATIGRAPHY OF ANDERSON PLAINS, DISTRICT OF MACKENZIE (107A, D, 97A, B, C)

Project 670068

T.P. Chamney

Stratigraphic sections from the Upper Devonian to the uppermost Cretaceous exposed along the Anderson and Horton rivers on the Anderson plains were measured and described, and sequential ten-foot samples were collected for microfossils. Only three sampled sections have been processed in the laboratory for the extraction and picking of Foraminifera (as of October 1968) but good correlation between these sections has been obtained. Foraminiferal study of these sections demonstrates possible overlapping so that no unexamined sections are represented by covered intervals. Therefore, the isopachous interpretation for Operation Norman should show somewhat thinner, major rock units than previously reported. The paleoecological interpretation of the microfauna is one of a relatively shallow, shelf environment on the continental edge which would suggest a low regional dip. Field observations along the south to north river valleys indicate much higher angles of dip which are accounted for by both slumping (high montmorillonite clay) and gentle warping along general northeast-southwest axes.

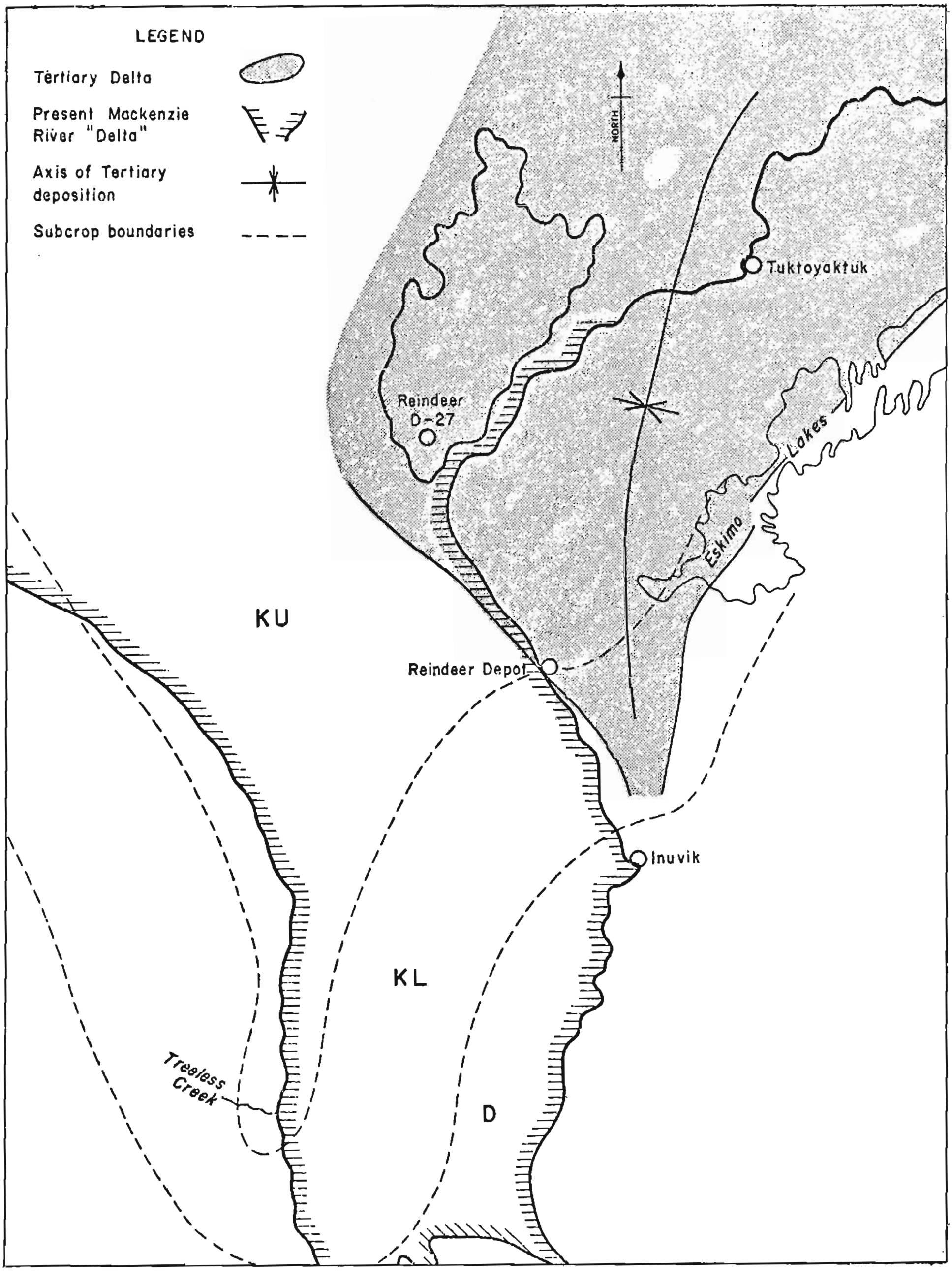


Figure 1. Tertiary deposition in Mackenzie River Delta.

The geometry of the Tertiary deposits deserves considerable attention as a result of data obtained from Operation Porcupine (1962) on the Caribou Hills, and from the examination of subsurface samples in the Operation Norman I area from Reindeer D27 (location 69° 10'N., 134° 30'W.), Nicholson G-56 (location 69° 55'28.8"N., 128° 58'34"W.) and Nicholson N-45 (location 69° 54'59"N., 128° 56'18.8"W.) wells. The configuration is a fan-shaped delta skewed to the northeast consisting of Tertiary deposits that spread from a point some fifteen miles northeast of Inuvik (Fig. 1). The main axis of deposition appears to be from this point of origin at the south end of the Caribou Hills (about 1, 000 feet thick) along an arcuate trend north and east into the Tuktoyaktuk Peninsula, passing east of the Reindeer D 27 well (about 3, 000 feet thick). Micropaleontological evidence from the continental land area to the east and west of this delta fan has shown very little or no Tertiary beds to be present. This large Tertiary delta deposit was formed by a pre-existing Mackenzie River drainage channel which appears to have cut through to the northeast at the point of intersection of the present channel and the chain of lakes trending through Campbell Lake. The present Mackenzie River channel has migrated westward and could be a relatively young drainage system depositing only a veneer of Quaternary alluvium without a true delta build-up; the present 'drowned' topographic expression of the land and water pattern is not a deltaic signature. The alluvium of the present river bed covers a sequence overlying, successively northwards, Middle Devonian, Upper Devonian, Lower Cretaceous and Upper Cretaceous strata.

Tertiary strata are either absent or very thin under the present Mackenzie River Delta. Thick Tertiary deposits occur about 100 miles east of the present Mackenzie River and this deep axis forms an arcuate linear trend from the Caribou Hills to Tuktoyaktuk Peninsula. From here it probably extends farther to the northeast under the present Arctic Ocean.

138. EASTERN DEVON ISLAND AND SOUTHEAST ELLESMERE ISLAND, DISTRICT OF FRANKLIN; (38F, G; 39B, C, F, G, H; 48E, F, G, H; 49A, B, D)

Project 680015

R. L. Christie

A program of reconnaissance mapping and stratigraphic studies was conducted in these regions, the stratigraphic studies carried out in co-operation with Dr. J. W. Cowie of Bristol University, England. Geological reconnaissance of the Precambrian crystalline rocks exposed along the coasts and in the valleys of eastern Devon Island was carried out by dog sled in the late spring season. Stratigraphic sections were visited during the summer using chartered STOL aircraft. Travel by sledge was considerably hampered by open water after late April, and the east and southeast coasts of the island were not visited.

The Precambrian rocks of the north coast of Devon Island are mainly quartz-feldspar-biotite-gneisses; the gneissic foliation being variously faint to strong. Garnet is present in places. The foliation and gneissic banding trend generally east but southeast trends occur between Cape Sparbo and Ward Point (Fig. 1).

The gneisses west of Cape Sparbo are in part granitoid but also contain well-banded garnetiferous rocks that have a metasedimentary appearance. Metamorphism, cataclasis and migmatization, with segregation of lighter fractions to produce pegmatitic dykes and veins, appears to have occurred. At Cape Sparbo, xenoliths of a wide assortment of dark to light gneisses lie within mobilized granitoid rocks; the gneisses are mainly quartz-feldspar-biotite rock containing five to ten per cent garnet. The granitoid rock is medium- to coarse-grained and contains both grey and pink feldspar, the latter occurring as phenocrysts. The granitoid rock, predominant between Cape Sparbo and the east side of Sverdrup Glacier, is massive to foliated and, in places, contaminated with schlieren and inclusions of darker rock. Some very coarse pegmatite veins and masses were observed at Cape Hardy. East of Sverdrup Glacier the rather uniform, brown-weathering granitoid rocks give way to a mixture of grey, well-foliated to banded rocks and possibly younger brown-weathering less-foliated rocks. The latter are, possibly, but not certainly, related to the granitoid rocks to the west.

Light grey, strongly foliated gneisses appear at the coast west of Belcher Point; these rocks are very variable with grey granitoid and lighter coloured foliated rocks interbanded. Dyke-like diabasic and dioritic bodies, a few of which were observed east of Sverdrup Glacier, are here abundant. These bodies, evidently synkinematic in nature, both conform with and cut across the gneissose banding.

A zone of mixed, interbanded quartz-feldspar-garnet rock resembling quartzite, and grey granitoid gneiss lies south and east of Belcher Point. The bands conform to the easterly trend of foliation as do numerous synkinematic dykes.

The Precambrian gneisses of the south coast of Devon Island west of Cape Warrender are varied and the types are intermixed. The gneissic banding and foliation generally trend easterly to northeasterly with, however, local variations. Locally, a well-developed lineation plunges north about perpendicular to the strike of the foliation. Predominant on the south coast are garnetiferous quartz-feldspar gneisses; the gneissic minerals generally occur only in small amounts and the rock is characteristically marked by a cataclastic texture to produce prominent augen of garnet and feldspar. A

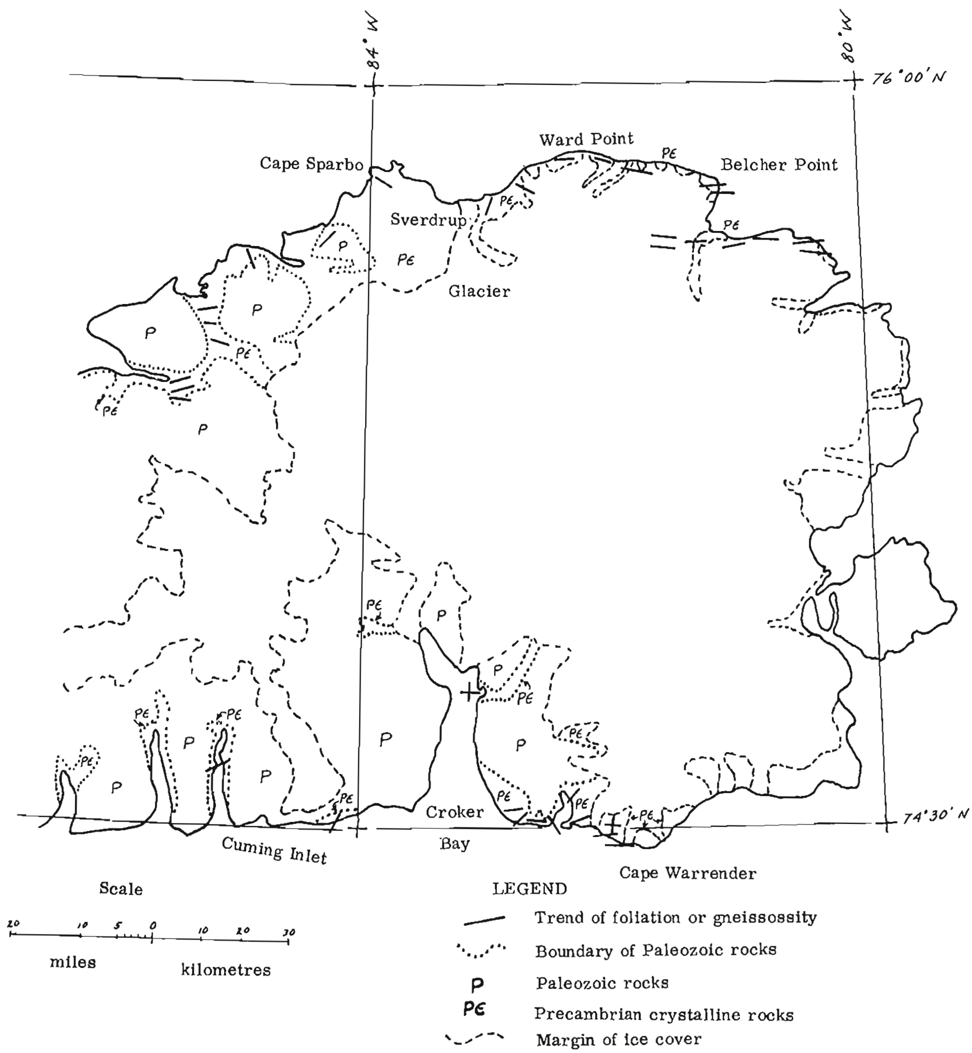


Figure 1. Sketch-map showing trends of foliation in some of the Precambrian crystalline rocks of Eastern Devon Island, District of Franklin.

variation of this gneiss is a garnet free, thinly laminated quartz-feldspar gneiss with some biotite. Bands and lenses of darker rock are present in varying, generally small, proportions. Widespread, but less abundant than the garnetiferous quartz-feldspar gneisses, are darker variegated quartz-feldspar gneisses that are generally garnet free. These vary in colour from grey to nearly black and in texture from coarse to fine. The mafic minerals are often very fine grained. Structures such as boudins, ptygmatic folds, and breccia zones are abundant. Some of the dark bands in the variegated gneiss may be relict dykes and sills, but synkinematic bodies such as those observed on the north coast of Devon Island were not found on the south coast. On the other hand, at least one post-kinematic or younger diabase dyke was observed on the south coast.

Stratigraphic studies and paleontological collecting on Devon and Ellesmere islands

Sections of Paleozoic rocks were measured in the vicinity of Croker Bay and Cuming Inlet on the south coast of Devon Island, and sections of the same rocks in the vicinity of Grise Fiord, measured in a previous field season, were restudied. Fossils from presumed Cambrian beds on Devon Island were collected by Cowie, who also made further collections from Cambrian beds on Southern Ellesmere Island. The well-known section behind the abandoned police post on Bache Peninsula was revisited by Cowie and the author with the intention of collecting further from the lower Cambrian Police Post Formation. Material obtained from the Police Post Formation was disappointingly meagre but productive trilobite-bearing beds were discovered in the Cape Wood Formation, higher in the section, and collections of good material were obtained from them. The Cambrian collections are presently being studied by Cowie.

Post-Paleozoic Structural Features

The Paleozoic beds are nearly flat-lying throughout the area studied, with a gentle regional dip to the west or northwest. These beds overlie the crystalline gneisses with a profound unconformity. The Paleozoic and older rocks are transected by numerous east-trending faults, many of them branching or occurring as subparallel swarms. Southeast-trending faults form a second prominent group. Many tributary valleys are evidently fault-controlled and the trends of major topographic features may also be due to faulting. The vertical component of movement on the faults, evident from the displacement of Paleozoic beds, is about 3, 000 feet on certain faults.

139. TRIASSIC STRATIGRAPHY OF THE ROCKY MOUNTAIN FOOTHILLS, NORTHEASTERN BRITISH COLUMBIA (93O, 94B, G)

Project 680084

D. W. Gibson

Field work in 1968 consisted of measuring and sampling in detail, several stratigraphic sections between the Sikanni Chief River, and the John Hart Highway of northeastern British Columbia. This work, part of Operation Smoky, represents the initial phase of a regional investigation of the Rocky Mountain foothills, between Sikanni Chief and Smoky rivers of British Columbia and Alberta.

In the foothills of the study area Triassic strata are tentatively divided into five mappable units, which are, in ascending order: (1) the Toad-Grayling Formation, (2) the Liard Formation, (3) the 'Grey Beds', (4) the Pardonet Formation, and (5) the 'post-Pardonet Beds'. In all easterly sections these units may be further divided into distinct members.

Unit 1

The Toad-Grayling Formation comprises a sequence of dark, brownish grey-weathering, calcareous to dolomitic siltstone, silty limestone, shale, and minor sandstone. At most western sections the Toad Formation contains scattered nodules and lenses of phosphate in a stratigraphic interval ranging between 100 and 200 feet thick. Unit 1 disconformably overlies the Permian Fantasque Formation, and is overlain conformably by the Liard Formation.

Unit 2

The Liard Formation, here considered equivalent to the 'Flagstones', 'Dark Siltstones', and the Halfway Formation, consists of a resistant to recessive sequence of sandstone, siltstone, sandy limestone, and calcareous shale. The contact between the Liard Formation and the 'Grey Beds' in the central and eastern part of the foothills is conformable and transitional. However, at sections in the western part of the foothills near Mount Laurier, the contact is disconformable.

Unit 3

The 'Grey Beds' in the central and eastern foothills north of Peace River, and the entire foothills between Peace River and the John Hart Highway can be divided into two distinct lithologic units. The lower unit, here considered equivalent to the subsurface Charlie Lake Formation and possibly part of the Halfway Formation, comprises a variable sequence of light grey- to buff-weathering, sandstone, siltstone, dolomite, and minor limestone. The upper unit, equivalent to the subsurface Baldonnel Formation, consists of a resistant, light grey-weathering, conchoidal fracturing, dense to bioclastic limestone. In the western foothills the 'Grey Beds' consist of a single unit of medium to light grey, platy-weathering, calcareous sandstone, siltstone, and sandy limestone. The contact with the overlying Pardonet Formation is generally sharp and conformable.

Unit 4

The Pardonet Formation consisting of dark greyish brown, platy-weathering, silty limestone, bioclastic limestone, and calcareous siltstone, generally forms the upper unit of the Triassic succession in the foothills. North of Peace River the Pardonet Formation is disconformably overlain by the Jurassic Fernie Group. However, between Peace River and the John Hart Highway, the Pardonet Formation is overlain by a dense, white-weathering limestone, provisionally considered Triassic in age.

Unit 5

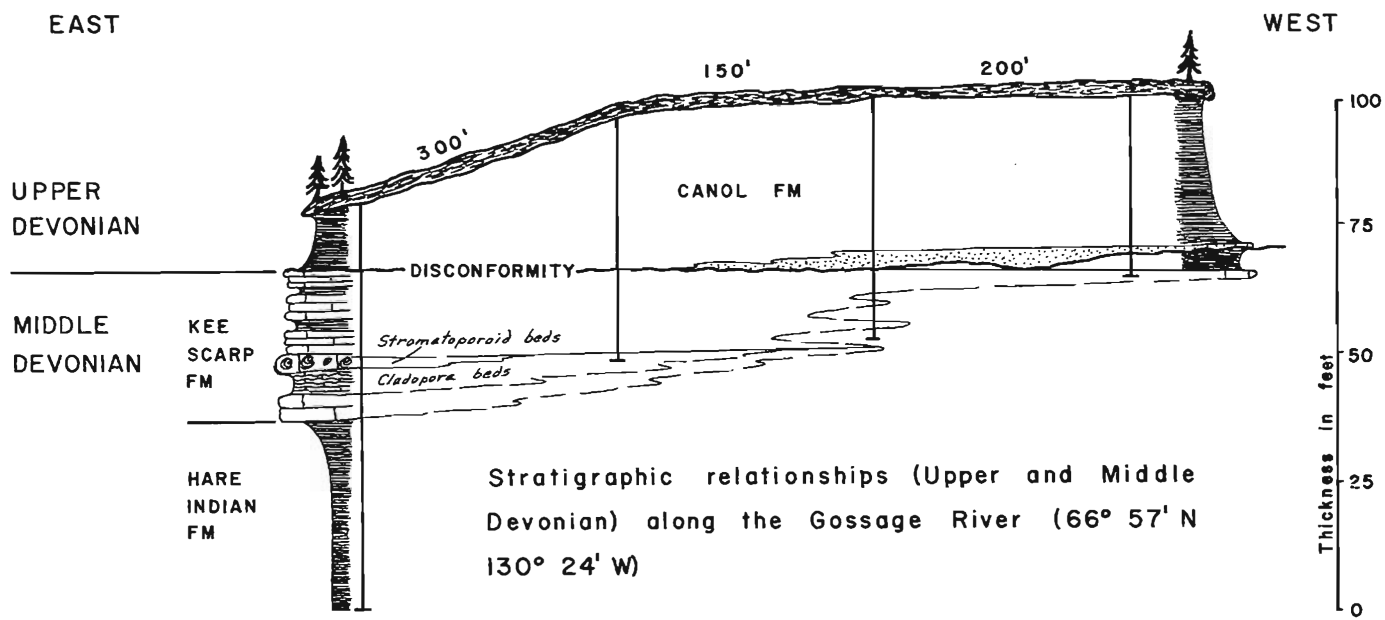
Between Peace River and the John Hart Highway, the Pardonet Formation is overlain by a light grey- to white-weathering, cliff-forming, limestone facies up to 200 feet thick. It is tentatively classified as post-Pardonet and Triassic in age, although no identifiable fossils were collected. Near Bocock Peak the limestone is partly porous, medium- to thick-bedded, and consists of encrinite and finely crystalline limestone. However, near Clearwater Lake to the west, the carbonate facies is siliceous, dense, and displays a prominent conchoidal fracture. The 'post-Pardonet Beds' are disconformably overlain by typical black, recessive weathering Jurassic shales. The lower contact with the Pardonet Formation is abrupt and is thought to be disconformable.

140. LOWER MACKENZIE RIVER, DISTRICT OF MACKENZIE

Project 670068

W.S. Mackenzie

Middle and Upper Devonian strata were examined in outcrop areas lying north of 65 degrees north and east of 132 degrees west (Operation Norman) (see Aitken, Yorath, Cook and Balkwill, this publication).



Stratigraphic relationships (Upper and Middle Devonian) along the Gossage River (66° 57' N 130° 24' W)

Vertical scale: 1 inch = 25 feet

FIGURE 1

Typical brecciated dolomites of the lowermost Devonian Bear Rock Formation become less conspicuous northward from their type locality on Bear Rock and from similar outcrops in the mountains to the west. Laterally equivalent strata at Hume River, Lac Belot and the Anderson and Horton rivers to the north, for example, consist largely of grey and dark grey bedded limestone (Gossage Formation).

The overlying Hume Formation, in the vicinity of Normal Wells, can be subdivided into a lower unit of bedded limestone, a middle unit of argillaceous nodular limestone, and an upper unit of light-coloured bedded limestone. At the most northerly occurrence examined on the Anderson River the formation consists of about 125 feet of nodular, argillaceous limestone and shale.

Small patch reefs, about fifteen in number, and up to 45 feet in diameter by 30 feet thick, were observed in calcareous shales of the Hare Indian Formation in outcrops along the Carnwath River. Such isolated developments of small 'reefs' enhance prospects for future recovery of hydrocarbons from similar larger 'reefs' in correlative subsurface beds to the northwest.

More widespread, laterally equivalent carbonates (Ramparts-Kee Scarp formations) are also prospects for future oil and gas production.

Overlying Upper Devonian strata (Canol and Imperial formations) rest disconformably on the Middle Devonian beds (Fig. 1). They occur in the western part of the report area.

141. LOWER PALEOZOIC STRATIGRAPHY, OPERATION NORMAN, 1968

Project 670068

R. W. Macqueen

Two months of field work were spent on this project, in association with Operation Norman (see Aitken, Yorath, Cook, and Balkwill, this publication). Prior to study of the widespread Cambrian, Ordovician, and (?) Silurian rocks of the plains, useful background data on these rocks were obtained in the Norman Range (Franklin Mountains) and at Dodo Canyon in the Mackenzie Mountains. Excluding the Mackenzie Mountains, exposures of lower Paleozoic rocks in the western part of the Operation Norman area (Fig. 1, Aitken *et al.*, ibid) are found in narrow outcrop belts including (a) the Norman Range, and (b) north-trending anticlinal ridges to the north and east of the Norman Range within the plains proper. Over the remainder of this western area, surface bedrock exposures consist of Devonian and Cretaceous rocks. In the eastern part of the area, lower Paleozoic rocks reappear at the surface, and form a broad, northward-trending outcrop belt from Great Bear Lake to Parry Peninsula on the Arctic coast. Exposures of the flat-lying rocks in this eastern plains belt are for the most part confined to major river valleys. A high degree of uniformity characterizes these lower Paleozoic shelf sediments across the entire area; facies changes appear to be minimal. The following remarks exclude the limited observations made in the Mackenzie Mountains except as noted.

Basal Paleozoic Sandstone

This unit, which overlies Precambrian sedimentary and intrusive rocks with angular unconformity and crops out only in the eastern broad belt of lower Paleozoic rocks, is a medium- to locally coarse-grained, light grey-weathering orthoquartzite, about 200 feet thick. Planar and trough cross-stratification are widespread; limited paleocurrent data were collected. The presence of numerous weakly cemented intervals makes the unit very porous, distinctive, and a potential reservoir within the subsurface.

Macdougal Group

At its type section at Dodo Canyon in the Mackenzie mountains[1], the Macdougal Group may be subdivided into three informal units: a lower recessive, red and green shale unit with thin dolomite and micritic limestone beds (250 feet); a middle, resistant, predominantly glauconitic sandstone and shale unit (200 feet); and an upper, poorly exposed gypsum, dolomite, and shale unit (up to 500 feet in thickness). Olenellid trilobites (Lower Cambrian), collected during the 1968 field season from thin micritic limestone beds within the middle glauconitic sandstone unit at Dodo Canyon, rule out the previous age assignment of Middle or Late Cambrian to the lower part of the Macdougal Group[1]. Only the uppermost gypsum-bearing unit of the Macdougal is found within the Norman Range.

A similar three-fold division of Macdougal strata is evident within the eastern broad belt of lower Paleozoic outcrop. In this eastern area, however, the lower unit is largely composed of siltstone and dolomite (200 feet); the middle glauconitic sandstone unit is in part an orthoquartzite (100-150 feet); and the upper gypsiferous and argillaceous dolomite unit is much reduced in thickness (100-150 feet). The age of the eastern Macdougal Group has not been established, but the unit appears to be similar to Thorsteinsson and Tozer's map-unit 10a (?Cambrian) of Victoria Island[2] to the northeast of the Operation Norman area.

Ronning Group

Three units were mapped within the Ronning Group (Aitken et al., ibid), which has a cumulative thickness of about 1,200-1,400 feet, over much of the plains area. The lowest of these, which sharply overlies gypsiferous shales of the Macdougal Group, is a distinctive, pale yellowish orange-weathering dolomite unit containing about 20 or more separate lithic cycles. In the Norman Range, where the unit is about 200 feet thick, single cycles average about 5 feet in thickness, and contain, most commonly, the following lithologic types in ascending order from the base: (a) olive-grey argillaceous dolomite; (b) pale yellowish orange, very finely crystalline dolomite; (c) conglomeratic dolomite composed of rounded and wafer-like, elongate, flat pebbles showing random orientation; and (d) stromatolitic (domal, columnar, and digitate[3]) dolomite. Units (c) and (d) are less commonly interchanged. Although the cycles are less distinct and the unit is less than 100 feet thick in the northernmost part of the broad eastern outcrop belt, the unit is easily recognized over its entire area of outcrop in the plains.

Overlying the cyclic unit is a 500-foot-thick (approximately) sequence of predominantly grey-weathering, thick-bedded, slightly porous dolomite, generally lacking in chert. The lower part of this unit over the plains area contains rhythmic alternations of very finely crystalline, light brownish grey to greyish orange, silty dolomite, and fine- to medium-crystalline, brownish grey dolomite, although these rhythms are much less distinct in the plains and Norman Range than at Dodo Canyon in the Mackenzie mountains. The Dodo Canyon rhythms, which consist of alternations of about two- to five-foot-thick beds of each lithology, impart a distinctive banding to this part of the Ronning Group. There, also, many of the brownish grey dolomites contain several types of stromatolites, and a few contain oolites. In the Norman Range and the plains, the remainder of the middle Ronning unit is composed predominantly of fine- to medium-crystalline dolomite, lacks obvious rhythms, and rarely shows local red or green mottling on fresh surfaces.

The uppermost unit mapped by Aitken et al. (ibid) is about 500-700 feet thick over much of the area, and consists of light grey-weathering, thick-bedded, finely to predominantly medium and coarsely crystalline dolomite characterized in the plains region by an abundance of silica occurring as drusy quartz and chert, and with rare, floating quartz sand grains. Drusy quartz is very abundant in many beds, and occurs most commonly as linings within vugs, many of which are subhorizontal and up to one foot long. The chert, which is white and yellowish grey-weathering, is mostly confined to beds of probable stromatolites (large-scale stacked hemispheroids) from two to ten feet thick. There are as many as 10 separate widespread stromatolitic chert beds present in the plains, although only 3 have been found in the Norman Range. Some stromatolites are overlain by flat-pebble chert conglomerates. The only fossils found in most of this silica-rich unit are small, silicified, planispiral gastropods associated with the stromatolitic chert zones. Certain stromatolites at several different levels are set in a matrix of silicified oolites. In the Norman Range, and in exposures to the north near Lac à Jacques and along Hare Indian River, the uppermost beds of this highest Ronning unit consist of finely crystalline, brownish grey, recessive weathering dolomite carrying a silicified coral fauna but generally lacking in chert. These beds are missing, probably owing to erosion, over most of the eastern belt of lower Paleozoic outcrop.

Together, these three units are similar to at least part of Thorsteinsson and Tozer's map-unit 10b, which is widespread on Victoria and Stefansson islands, and ranges in age from Middle Ordovician to Middle Silurian[2].

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[1] Hume, G. S.: The lower Mackenzie River area, Northwest Territories and Yukon; Geol. Surv. Can., Mem. 273 (1954).

[2] Thorsteinsson, R., and Tozer, E. T.: Banks, Victoria, and Stefansson islands, Arctic Archipelago; Geol. Surv. Can., Mem. 330 (1962).

[3] Aitken, J. D.: Classification and environmental significance of cryptalgal limestones and dolomites, with illustrations from the Cambrian and Ordovician of Southwestern Alberta; J. Sed. Petrol., vol. 37, No. 4 (1967).

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142. STRUCTURAL STUDIES IN EASTERN AND NORTHERN CORDILLERA OF CANADA (82G, H, J, O; 106, 107, 116, 117)

Projects 640025 and 660020

D. K. Norris

Structural studies in the Cascade coal area of the eastern Cordillera led directly to the discovery, development and exploitation of significant reserves of strip coal in the lower part of the Jurassic and Lower Cretaceous Kootenay Formation in the Canmore area, Alberta. Advantage was taken of numerous trenches and prospects as well as of drillhole and underground data to document the structural style of the coal measures between Canmore and Stewart creeks on a scale of 100 feet to one inch. Maps and cross-sections arising from these investigations suggest that major revisions of economic significance are necessary to existing geological maps of the area. Of prime importance is the recognition of fold-pairs trending across the regional structural grain that shift the surface trace of coal seams and, until now, have led to difficulties in correlation and traceability of seams from one part of the area to another. These studies, moreover, forecast the presence of thick, mineable coal seams higher in the succession on the near-vertical to overturned, southwest flank of the Mount Allan syncline, a forecast subsequently proven to be correct by drilling and trenching.

The structural habit of the Mackenzie Mountain front was investigated between Keele and Arctic Red rivers in western District of Mackenzie. Forty-eight mesoscopic fabric stations were established in Middle Devonian and older formations and samples of basic intrusions for paleomagnetic and radiometric age determinations were collected to supplement data gathered in 1966. Structural and stratigraphic control was acquired for the production of a geologic strip map on a scale of four miles to one inch connecting areas at the southern and western extremities of the Mackenzie Mountains. Data are therefore in hand for a preliminary assessment on a mesoscopic and megascopic scale of the origin, style and tectonic significance of the Mackenzie deflection.

143. STRUCTURAL-STRATIGRAPHIC STUDIES IN THE SOUTHERN FOOTHILLS OF ALBERTA (82 O/6; 82 O/7W; 82 O/11; 82 O/14)

Projects 620024; 640026; 660021; 660486

N. C. Ollerenshaw

Field work during 1968 consisted of several excursions of from one to eight days duration into the southern Foothills of Alberta, between the Ghost and Clearwater rivers. The objective of the field work was to supplement and extend earlier studies made by the author in this region.

Several stratigraphic sections were measured and described, including the lower part of the Brazeau Formation, the lower part of the Blairmore Group and the Nordegg Member of the Fernie Group. Fabric studies were made on several exposures of Cretaceous conglomerate, to provide data on the depositional environment, source areas and tectonic background.

144. SUBSURFACE DATA FROM MESOZOIC ROCKS OF HUDSON BAY LOWLANDS

Project 670014

L. L. Price

Sparse outcrop data from Mesozoic rocks encountered in the Onakawana area, Ontario, during Operation Winisk in the 1967 season were supplemented in 1968 by subsurface samples obtained during exploratory drilling in this area for coal reserves. The supplementary work yielded material for clay mineralogy and palynology studies and much data on Quaternary overburden in the prospective mining area.

145. GEOLOGICAL OBSERVATIONS; POTASH MINE SHAFTS, SASKATCHEWAN (62L, K; 72O, P; 73B)

Project 640420

L. L. Price

A program for preserving geological data uncovered during sinking of shafts for potash mining was continued in co-operation with the Province of Saskatchewan and various potash companies. The project was extended to cover a new shaft begun by Sylvite of Canada near Rocanville which is expected to yield new information on the southeast extremity of the belt of current exploitation.

Work at the Potash Company of America site east of Saskatoon and at the Noranda site near Colonsay is continuing. Observations at the Duval and nearby Cominco shafts are complete and relative proximity of the sections exposed provides material for a close study of some environmental trends in the carbonate rocks.

146. SUBSURFACE STUDIES OF THE PALEOZOIC

Projects 580159 and 680092

B. V. Sanford

During the summer of 1968 field work was conducted at three widely separated localities of the St. Lawrence and Hudson platformal regions of eastern Canada.

1. The writer made a reconnaissance flight across the northern part of the Hudson Bay Basin. The lower Paleozoic rocks were briefly examined on Mansel, Coats, and Southampton islands, as a preliminary to a more comprehensive study of Southampton Island.

2. On the west coast of Newfoundland, Cambrian, Ordovician and Lower Devonian rocks were examined to provide a preliminary comparison to those of Ontario.

3. A stratigraphic study of the Devonian rocks of southwestern Ontario was completed. Each of the key outcrop and quarry sections varying from Lower, through Middle to Upper Devonian age were studied and measured. This information will be coordinated with the subsurface geology for a report in preparation entitled: 'Devonian of Southwestern Ontario'.

147. JURASSIC AND CRETACEOUS ROCKS OF PEACE RIVER FOOTHILLS, ALBERTA AND BRITISH COLUMBIA (83E, L, 93I, O, P, 94B, G)

Project 680084

D. F. Stott

Stratigraphic studies of Jurassic and lowermost Cretaceous rocks were made in the foothills between Sikanni Chief River at latitude 57° 15' and Pine River at latitude 55° 30'. The investigation forms part of Operation Smoky and is part of a regional study[1] of those rocks in outcrop between Prophet River at latitude 57° 40' and Smoky River at latitude 53° 30'.

The succession, unconformably overlying the Triassic Pardonet Formation, has a maximum thickness of more than 7,000 feet along the western foothills between Pine and Peace rivers but decreases eastward and northward to an erosional edge. The sequence is bevelled by a major regional unconformity and throughout the region is overlain unconformably by the Lower Cretaceous Cadomin or Gething Formation of the Bullhead Group.

The Jurassic Fernie Formation, comprising phosphatic, calcareous, and sideritic shales with some siltstone and sandstone, can be subdivided into the Nordegg Member and other informal lithologic units equivalent to the Paper Shales, Rock Creek Member, Grey Beds, Green Beds, and Passage Beds of southwestern Alberta. The Fernie Formation ranges in thickness from about 400 feet in eastern exposures near Halfway River to possibly as much as 1,000 feet in the western foothills between Peace and Pine rivers.

The Minnes Group, predominantly marine in this region, has a maximum thickness of about 6,000 feet. It includes the Monteith, Beattie Peaks, and Monach formations, and an overlying unnamed succession of interbedded sandstone and shale. The Monteith Formation, of latest Jurassic to earliest Cretaceous age, comprises flaggy to massive, fine- to coarse-grained sandstones with some mudstones and thin conglomerates. It decreases from 1,800 feet in westerly sections near Pine River to about 500 feet near Halfway River. The occurrence of abundant coarse, conglomeratic, quartzose sandstones in western sections near Peace River is strongly indicative of a western source and suggests the presence of an ancient major drainage system in that vicinity. The early Valanginian Beattie Peaks Formation of the southern part of the region is 1,200 feet thick and contains a succession of interbedded silty mudstones and siltstones with many channel sandstones. The middle Valanginian Monach Formation, about 400 feet thick, comprises flaggy to massive, fine-grained sandstones overlain by a quartzose sandstone. Sandstones similar to those of the Monach occur within the upper unnamed unit and contain marine pelecypods. The Monach Formation is mapped within the Carbon Creek basin but elsewhere may grade laterally into sediments similar to those of the Beattie Peaks Formation and be indistinguishable. The upper unit is about 1,300 feet on the east side of Carbon Creek basin and equivalent beds may be over 2,000 feet thick in more westerly exposures.

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[1] Stott, D. F.: Fernie and Minnes strata north of Peace River, Foothills of northeastern British Columbia; Geol. Surv. Can., Paper 67-19 (Parts A and B) (1967 and 1968).

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148. DEVONIAN STRATIGRAPHY, NORTHEAST BRITISH COLUMBIA (94B)

Project 680084

G. C. Taylor

Devonian rocks exposed in the Halfway River area provide a link between the surface and subsurface stratigraphic successions. Southward from the British Columbia-Yukon boundary successive carbonate fronts exposed at the surface mark the introduction of facies units that are prominent in the adjacent subsurface of northeastern British Columbia and Alberta.

The older Devonian platform carbonates of the Muncho-McConnell, Wokkpash, and Stone formations can be recognized from the Yukon border to south of the Peace River. The first of the younger carbonate units, the Dunedin (Hume/Nahanni correlatives) Formation, appears immediately south of the British Columbia-Yukon border and marks the top of the carbonate succession as far south as Keily Creek. South of Keily Creek, the biostromal Pine Point Formation overlies a thin Dunedin equivalent. Between Needham Creek and Nabesche River the Watt Mountain and Slave Point formations of the Elk Point Group first appear at the surface. South of the Nabesche River thin carbonate units in the argillaceous succession allow a subdivision of the strata into the Muskwa, Fort Simpson, Tetcho, and Banff-Kotcho formations, equivalent to subsurface usage.

149. GEOLOGY AND PETROLEUM POTENTIAL OF LOWER PALEOZOIC SEDIMENTS-FOXE BASIN, NORTHEASTERN MELVILLE PENINSULA AND PARTS OF NORTHERN AND CENTRAL BAFFIN ISLAND (PARTS OF 36O, N; 37A, B, C, D, F, G; 46O, 47A, D, E; 48A, C)

Project 670018

H. P. Trettin

Introduction

The objectives of this project were: (1) to establish the stratigraphy, regional structure, and petroleum potential of the lower Paleozoic sediments in Foxe Basin and the adjacent parts of Baffin Island and Melville Peninsula; (2) to clarify some stratigraphic problems left over from Operation Admiralty in 1963[1, 2].

Parts of the project-area had earlier been investigated by the Fifth Thule Expedition[3], Burns, C.A.[4], Blackadar, R.G.[5, 6, 7], and Heywood, W.W.[8] whose work was of considerable help during the present study. This is the first comprehensive study dealing specifically with the lower Paleozoic geology.

The party of three was based at Igloolik, and the field work was done by the writer by means of a Piper Super Cub airplane on balloon tires chartered from Bradley Air Services Limited. The localities visited are shown in Figure 1; they extend over a belt about 450 miles long and 180 miles wide. The writer camped at seventeen of these localities.

For hospitality and technical help, the party is indebted to the following officers of the Department of Indian Affairs and Northern Development; H. Bartels, J.B. Haining, D. Nygard, W. Paterson, and J. Wemiwang. Pilot Hemby contributed to the success of the field work by his competent and willing performance, often under difficult weather conditions.

Stratigraphy

Investigations within the area adjacent to and covered by Operation Admiralty

Admiralty Group. The age of this unit, whether Early and Middle Cambrian or early Early Ordovician, is still in doubt. Samples of shaly sediments were collected from several sections for paleobotanical analysis. A zone of brecciation and solution observed at several localities at the top of the group, suggests that it may be separated from the overlying Ship Point Formation by a significant hiatus.

The isopachs of the Gallery and Turner Cliffs formations (ref. 1, Figs. 3, 4) were extended eastward. The isopachs of the Turner Cliffs Formation indicate a southward extension of the depositional basin, toward Steensby Inlet.

In the adjacent Erichsen Lake map-area[9], the Admiralty Group extends farther south than previously recognized, but it is thin and poorly exposed.

Ordovician-Silurian contact. Early Silurian (early Llandoverian) fossils had not been found in the operation area, nor had they been reported from Foxe Basin or the Hudson Bay Lowlands. Re-examination of a key section on Brodeur Peninsula, however, showed that there is probably no hiatus between the Ordovician and the Silurian, and that the Ordovician-Silurian boundary probably lies within a massive unit of biomicrite that represents a relatively deep submergence.

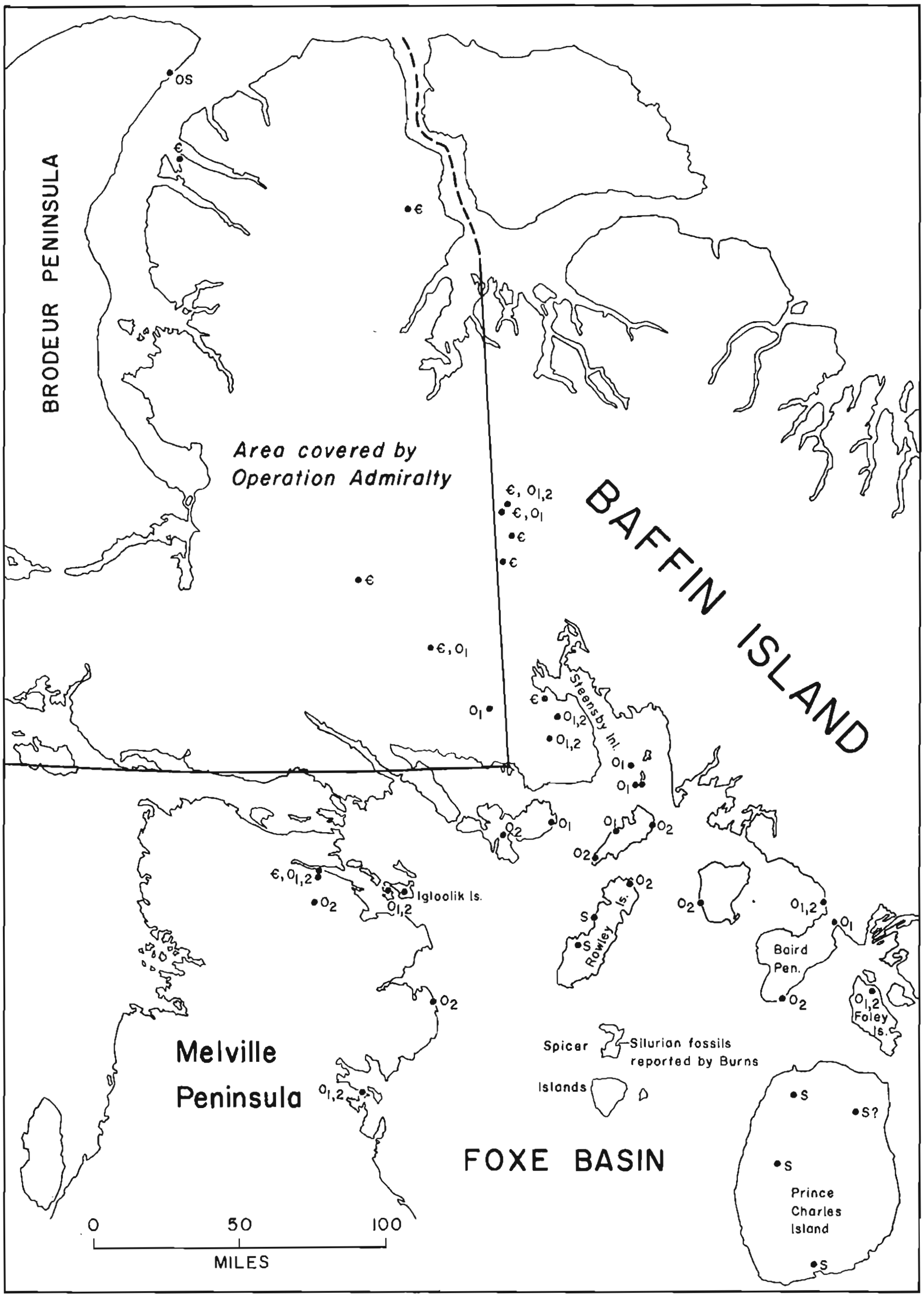

Figure 1. Localities visited and units examined; for designation of units see text.

Lower Paleozoic stratigraphy of Foxe Basin and adjacent parts of Melville Peninsula and Baffin Island

Owing to the low topographic relief of the region and the horizontal attitude of the strata, there are few satisfactory stratigraphic sections. The beds have, furthermore, been reworked by the postglacial sea, resulting in extensive complexes of raised beaches and lagoons. It is possible, however, to distinguish four stratigraphic units that can be correlated with units in the Admiralty Inlet area.

Cambrian or Lower Ordovician Admiralty Group (unit C, Fig. 1): Sandy and dolomitic sediments lying stratigraphically between the Precambrian basement and the Ordovician carbonate succession are correlated with the Admiralty Group. On northeastern Melville Peninsula this unit is about 40 feet thick and west of Steensby Inlet the thickness is between 70 and 100 feet. On the southeastern side of Foxe Basin, at Foley Island, the strata are not exposed and are either very thin or absent.

Lower and Middle Ordovician Ship Point Formation (unit O_2): The Ship Point Formation, which so far has yielded Arenigian to Middle Ordovician fossils[1, 2, 7, 10] is widely exposed and probably once covered the entire region . It consists mainly of dolomite with small amounts of interstratified shale, and a few units of quartzose and dolomitic sandstone that represent channel fillings. The dolomite is generally well stratified, and partly stromatolitic. Resistant, pure or sandy dolomite units alternate with recessive argillaceous dolomite. Measured sections range from 240 feet on Foley Island to about 400 feet west of Steensby Inlet.

Upper Middle and/or Upper Ordovician (unit O_2): The Ship Point Formation is overlain by cliff-forming limestones that are cryptocrystalline, bituminous, and partly dolomitized in the lower few feet of the section. These strata contain an abundant and varied Arctic Ordovician fauna probably mainly of Red River age. There are several indications that the contact with the Ship Point Formation is disconformable, but the time interval represented by the inferred hiatus would represent only a fraction of Middle to Late Ordovician time. The strata of unit O_2 are correlative with and lithologically similar to the lower part of member B of the Baillarge Formation[1, 2]. Exposures are commonly as much as 100 feet in stratigraphic thickness and bounded at the top by the present-day erosion surface; the contact with the Silurian strata described below has not been observed.

Silurian (unit S): The Silurian is represented mainly by interstratified limestones and dolomites containing fairly abundant brachiopods and corals, and by poorly exposed calcareous shale. The bituminous and cryptocrystalline limestones are partly dolomitized, and the dolomites are commonly calcareous. The strata are similar to and probably correlative with the upper part of the Baillarge Formation and the Cape Crauford Formation[1, 2], although sediments of late Wenlockian and Ludlovian age, a

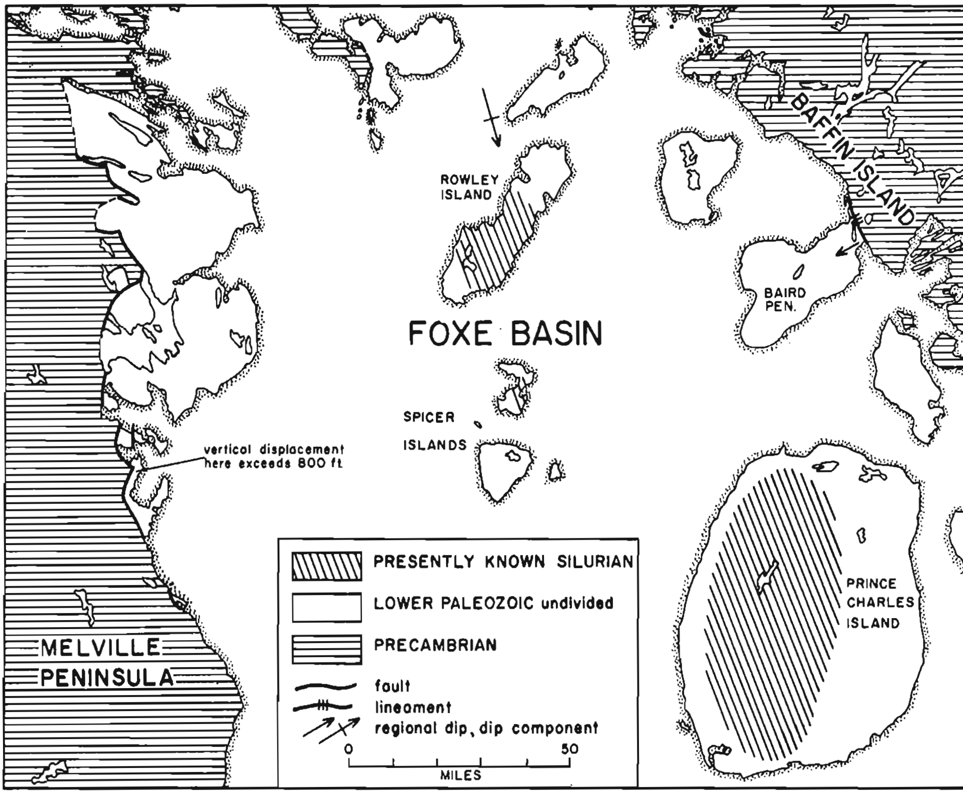

Figure 2. Geological sketch map of Foxe Basin.

little younger than the Cape Crauford Formation, also may be represented. A breccia similar to the evaporite solution breccias of the Cape Crauford Formation was observed on Rowley Island. Exposures of the Silurian rocks are at best a few tens of feet in stratigraphic thickness and the total thickness of the unit cannot be determined by surface geology.

Structure of Foxe Basin

Foxe Basin, a present-day physiographic depression, is a post-Silurian structural feature. This is inferred from the fact that the lower Paleozoic sediments become progressively younger toward the centre of the basin, and that Silurian rocks are confined to Prince Charles Island, southern Rowley Island, and the Spicer islands (Fig. 2).

Is this depression a gentle flexure, or is it a downfaulted segment of the crust? On northeastern Melville Peninsula the lower Paleozoic sediments are mainly in fault contact with the Precambrian rocks, and the vertical displacement locally exceeds 800 feet (Fig. 2). These faults, presumably normal faults, are complex and curving, and locally coincide with the coast line. On the east side, at the foot of Baird Peninsula, the Paleozoic-Precambrian contact is covered by drift, but marked by a lineament that may indicate a fault. The structure of the islands in Foxe Basin has not been determined because the rocks are poorly exposed.

Preliminary Notes on Petroleum Potential

On Melville Peninsula and Baffin Island, the lower Paleozoic sediments are too deeply incised by erosion to have any petroleum potential but, in Foxe Basin, this may not be so. As pointed out above, Foxe Basin was depressed relative to the surrounding Precambrian terranes in post-Silurian time; whether it also subsided during the early Paleozoic and received relatively thick sediments cannot be deduced from the surface geology.

Potential reservoir rocks are abundant. The friable sandstones of units C and O_1 have a high porosity, and most dolomites of unit S have a fair or good intercrystalline porosity. The intercrystalline porosity of the pure and sandy dolomites of the Ship Point Formation is judged to be only fair.

The bituminous limestones of unit O_2 and S, and the bituminous calcareous shales of unit S are potential source beds of petroleum[11], but noncalcareous marine shales have not been seen.

Potential stratigraphic traps are formed by pinchouts of the basal clastic unit C, by local sandy lenses within the Ship Point Formation, and by variations in the degree of dolomitization in the Silurian succession, but these types of traps would be difficult to predict in the subsurface. Potential structural traps have not been recognized.

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[1] Trettin, H. P.: Lower Paleozoic sediments of northwestern Baffin Island, District of Franklin; Geol. Surv. Can., Paper 64-47 (1965).

[2] Trettin, H. P.: Lower Paleozoic sediments of northwestern Baffin Island, District of Franklin; Geol. Surv. Can., Bull. 157 (1968).

[3] Teichert, C.: Ordovician and Silurian faunas from Arctic Canada; Rept. Fifth Thule Expedition 1921-24, vol. 1, No. 5.

[4] Burns, C. A.: Geological notes on localities in James Bay, Hudson Bay, and Foxe Basin visited during an exploration cruise, 1949; Geol. Surv. Can., Paper 52-25 (1952).

[5] Blackadar, R. G.: Fury and Hecla Strait, District of Franklin, Northwest Territories; Geol. Surv. Can., Map 3-1958 (1958).

[6] Blackadar, R. G.: Foxe Basin North, District of Franklin, Northwest Territories; Geol. Surv. Can., Map 4-1958 (1958).

[7] Blackadar, R. G.: Additional notes to accompany Map 3-1958 (Fury and Hecla Strait map-area) and Map 4-1958 (Foxe Basin North map-area); Geol. Surv. Can., Paper 62-35 (1963).

[8] Heywood, W. W.: Geological notes northeastern District of Keewatin and southern Melville Peninsula, District of Franklin, Northwest Territories (parts of 46, 47, 56, 57); Geol. Surv. Can., Paper 66-40 (1967) (W. W. Heywood kindly supplied field notes, fossil reports, and a sketch map covering the area immediately to the north of his published report).

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GENERAL

150. COMPUTER-ORIENTED RESEARCH ON MINERAL DEPOSITS

Project 640417

F.P. Agterberg

The Caribou Project near Bathurst, New Brunswick, was visited in September. Information, including assay plans and diamond-drill hole logs, was provided by staff members of the Anaconda American Brass Ltd. A statistical study of the spatial distribution of the elements Cu, Pb, Zn, Au, and Ag will be made in collaboration with the Applied Mathematics Section, Mineral Sciences Division, Mines Branch.

151. GEOLOGICAL INVESTIGATIONS, MID-ATLANTIC RIDGE

Project 660063

F. Aumento

Twenty-eight successful dredge stations were taken over the Median Rift Valley, Crest Mountains, and the High Fractured Plateau of the Mid-Atlantic Ridge at 45° N during the Hudson 22-68 Geophysical Expedition. These bring to 40 the number of successful dredge stations in the area. The stations were closely co-ordinated with the activities of other scientific parties on board; these included bathymetric, gravimetric and magnetic surveying, bottom photography, piston coring, seismic profiling, seismic refraction studies and oceanographic investigations. The positions of the dredge stations were fixed to an accuracy of better than 0.1 nautical mile using an U.S. Navy Satellite Navigation System. In addition, the dredges carried instrumentation to record the actual depths sampled and their locations relative to the ship.

A total of 440 samples (hand specimens or larger) were collected (see Table I); these were cut, described, classified and catalogued. In addition, over 100 thin sections and 5 polished sections were prepared on board. Fission track dating measurements were made on the latter. Sixty-one rock cores were extracted from the specimens for paleomagnetic and other

TABLE I

CRUISE B.I. 22-68 HUDSON

F. Aumento
GSC
Ottawa

PHASE IV

DAY	STATION #	LATITUDE N	LONGITUDE W	DEPTH OF DREDGING fms	MAX.LOAD ON CABLE, Tons.	RECOVERY CONDITIONS	YIELD	THIN SECTION-ED	CORED	FOR DOM.OBS.	FOR CHEM.AN.	FOR OXYGEN ISOTOPES
211	103	45° 52'	28° 05'	1380 - 1300	4	shears gone bent leading edge	1 granulite block several basalt & tuff chips in mud	1	1x2	1	-	-
212	105 106	45 22	28 12	585 - 500	3	shears gone bent leading edges	4 basalts 1 greenschist 5 erratics 2 foram lot	8	4x2 1x1	5	3	2
212	108	45 50	28 18	1348 - 1300	3	shears gone bent leading edge	2 serpentinites 1 amphibolite 2 erratics	4	1x1	1	3	1
215	112	45 29	28 17	1230 - 1170	4.5	shears gone severe bending of leading edges & 3½ ton weak link stretched	1 serpentinite 4 greenschist 1 amphibolite 2 limestones 10 gallons mud	8	1x1	1	3	3
216	116	45 46	27 58	1100 - 1020	2.5	additional bending of leading edges	4 basalts 2 volcanic aggloms 1 quartzite erratic many chips 15 gallons mud	7	1x1	1	3	2
218	118	45 44	28 56	1053 - 1450	2.5	O.K.	Few chips 10 gallons mud	-	-	-	-	-
219	120	45 42	28 56	1380 - 1273	5	extreme bending of whole bucket	3 basalts 3 volc. aggloms. 2 tuffs 3 greenstones 2 brucitized volcs. 7 erratics many bits 10 gallons mud	8	1x2	1	3	6
220	123	45 45	29 15	1234 - 1160	4.5	further bending	1 large basalt many bits 10 gallons mud	1	1x2	1	1	1
222	128	45 44	29 14	1518 - 1290	2.5	O.K.	1 basalt 1 tuff 1 limestone 1 gneiss many bits 10 gallons mud	3	-	-	2	1
227	133	45 31	29 34	1560 - 1450	4	O.K.	8 basalt + glass 32 pieces manganese with basalt chips 8 assorted erratics	3	1x1 1x1	2	3	3
228	134	45 16	29 26	1510 - 1400	5	O.K.	16 basalts + mangan. much manganese 24 assorted erratics	3	1x1	1		1

PHASE V

237	143	45° 30'	28° 36'	1310 - 1000	3.9	2 teeth sheared others bent	1 basalt 1 manganese crust 2 limestones 4 erratics (gneiss)	2	-	1		1
238	147	45 29	28 36	1200 - 1050	6.0	depth recorder mounting shear	3 basalts 1 limestone bag of mini-bits	3	-	-		1
241	156	45 48	29 07	1350 - 1160	5.3	teeth bent on one side, [illegible] leading edge bent	6 basalts 8 volc. aggloms. 6 serpentinites 6 erratics		3x1 1X3	5		6
241	159	45 46	28 59	1498 - 1300	4.3	dredge bent teeth bent & sheared	9 basalts 12 serpentinites 18 cummingtonite amphibolites 17 erratics		Nil	6		37
242	165	45 13	29 52	1390 - 1230	3	dredge bent teeth bent	26 serpentinites 3 basalts 7 limestones 6 greenstones 7 erratics		1x5	6		21
243	188	45 23	27 35	1260 - 1150 in hidden trench	2.8	O.K.	11 basalts/greenst. minibits & mud	10	2x1	2		5
244	173	45 37	27 43	1300 - 1140	4.3	teeth bent	57 basalts 9 erratics		3X2	4		9
249	182	45 18	27 23	1516 - 1300	4	teeth bent	1 serpentinite 3 erratic gneisses		-	-		1
250	187	45 30	27 20	1402 - 1000	4.8	very bent teeth & leading edge	3 basalts much coral		2x2	2		2
251	190	45 21	27 10	1294 - 1000	4.8	teeth bent	4 basalts 1 erratic		2X1	3		3
252	192	45 35	27 03	1350 - 1150	2.5	O.K.	8 serpentinites 2 amphibolites		Nil	Nil		1
252	193	45 36	27 15	1340 - 1100	4.9	O.K.	5 basalts		Nil	Nil		1
253	197	45 40	27 47	1906 - 1800	5	O.K.	14 basalts		Nil	7		7
254	198	45 38	27 44	1574 - 1460	5.1	O.K.	5 basalts/greenst.		1x3 2x1	3		5

TOTAL NUMBER OF DREDGE STATIONS :-	31	
DREDGES LOST :-	1	(= 3%)
BROKEN WEAK LINKS :-	2	(= 6%)
TOTAL NUMBER OF NEGATIVE YIELDS :-	5	(= 16%)
TOTAL NUMBER OF PETROLOGICALLY SATISFACTORY YIELDS :-	24	(= 78%)

M/V THETA DREDGE DATA

199	5	45° 14'	29° 48'	1500 - 1200	3.5	shear pins gone	1 tuff 2 basalts 2 amphibolites 1 metam.gabbro 3 acid met.erratics.	6	3x2	3	3	
	6	45 14	29 50	1500 - 1200	3.5	shear pins gone	6 serpentinites 2 gabbros 1 greenstone 2 acid erratics	7	3x2	3	3	
	8	45 45	29 14	1250 - 1050	-		4 basalts 3 erratics				2	

TOTAL NUMBER OF DREDGE STATIONS (including N of Azores) :- 9

DREDGES LOST :- 1 (= 11%)

TOTAL NUMBER OF NEGATIVE YIELDS :- 5 (= 55%)

TOTAL NUMBER OF PETROLOGICALLY SATISFACTORY YIELDS :- 4 (= 45%)

TOTAL NUMBER OF NUMBERED SPECIMENS FROM HUDSON AND THETA :- 440

LOCALLY DERIVED SPECIMENS :- 310 (= 70%)

DEFINITELY ERRATIC :- 103 (= 23%)

DOUBTFUL ORIGIN :- 27 (= 7%)

F. Aumento
F. Aumento
C.S.S. Hudson At Sea.
12th Sept. 1968

investigations. Over 120 specimens were prepared for oxygen isotope studies at the Enrico Fermi Institute, Chicago, and a preliminary batch of 22 crushed samples was flown to the Geological Survey of Canada in mid-summer for chemical analysis.

Preliminary observations indicate that:

(a) The occurrence of thick ferro-manganese coatings on specimens can be used to distinguish erratics from locally derived rocks. The thickness of the coating is also a function of the distance of a sample from the axis of the Mid-Atlantic Ridge. Indeed, a sudden and marked increase in this thickness at about 55 km from the axis can be correlated to a corresponding increase in the sediment thickness in the valleys, to an increase in the ages obtained from basalts collected from the seamounts, and to a marked change in topography (the transition between the Crest Mountains and the High Fractured Plateau).

(b) Basalt is the predominant rock of the Median Rift Valley and the adjacent Crest Mountains; it also forms the cappings of the more distant seamounts. However, on the lower slopes of the inner rift walls of the Median Rift Valley, basalts show various stages of alteration to greenstones.

(c) Serpentinites and serpentinized mafic rocks are extremely common in the area, but are absent in the Median Rift Valley and adjacent mountains. Serpentinites occur both on the slopes of shield-type volcanic seamounts, and on elongated seamounts of possible block-faulted origin. These diversified occurrences indicate that depth of burial is not a necessary criterion for serpentinization to occur.

(d) Two elongated, block-faulted seamounts yielded, in association with basalts and serpentinites, large quantities of in situ cummingtonite-bearing amphibolites. These occurrences are a further indication that considerable metamorphism, block faulting and uplift has taken place on the Mid-Atlantic Ridge.

(e) Glacial erratics are completely absent in the Median Rift Valley, suggesting that the valley is younger than the last major glaciation. A study of the spatial distribution of the erratics may reveal further chronologically recognizable zones.

152. SUBSURFACE AND REGIONAL STUDIES IN EASTERN CANADA AS RELATED TO OIL AND GAS

Project 600456

R. D. Howie

Collected oil and gas well data from the provincial Mines Departments in Quebec and the Atlantic provinces. He also logged 5,800 feet of core, 13,000 feet of cable tool samples, examined outcrop areas as related to subsurface drilling; and obtained samples for 45 core and rotary wells drilled in New Brunswick and Nova Scotia.

153. STUDY OF MINERAL COLLECTING AREAS OF INTEREST TO ROCKHOUNDS AND TOURISTS

Project 640048

Ann P. Sabina

About 380 mineral and rock occurrences were investigated in the Maniwaki-Ottawa-Peterborough area. The occurrences are accessible by automibile and are within 50 miles of Highway 11 (Hull to Maniwaki) and Highway 7 (Ottawa to Peterborough). The purpose was to obtain up-to-date information on the occurrences of interest to tourists, collectors and mineralogists. A guide-book describing the localities, and giving detailed information on reaching them, is being prepared.

Localities on both sides of the Gatineau River from Hull to Maniwaki were examined. Included are formerly-worked mica, apatite, brucite, iron, molybdenite, feldspar, asbestos and barite mines. A quartz mine at Baskatong Lake and a Hull limestone quarry were the only operating mines in the area. Between Ottawa and Peterborough most of the mines, except for the nepheline, iron, talc and marble mines, are no longer in operation. Abandoned mines which include iron, gold, mica, apatite, calcite, feldspar, fluorite, actinolite, pyrite, copper, lead, uranium and limestone occurrences are easily accessible and yield a variety of mineral and rock specimens.

Of particular interest to collectors are the following occurrences: marble (Madoc, Tatlock, Kaladar); serpentine (Madoc, Wakefield); feldspar (Wakefield); tourmaline (Wakefield); graphic granite (Blue Sea Lake); cancrinite (Nephton); tremolite (Madoc, Peterborough); fluorescent calcite (numerous localities); kornerupine (Kazabazua); talc, fluorite (Madoc).

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