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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 68-1
Part A

REPORT OF ACTIVITIES,

Part A: May to October, 1967

MANUSCRIPT AND CARTOGRAPHY
JAN 5 1968
SECTION

Released 3rd Jan 1968.

Price, $2.00

1968

Technical editing and compilation

R. G. Blackadar

Layout

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Dervorguilla Snowden

CANADA

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ROGER DUHAMEL, F.R.S.C.
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ABSTRACT

This report presents 145 brief papers on field work undertaken in 1967 by members of the Geological Survey of Canada and 8 additional statements on mineralogical and palaeontological collecting projects.

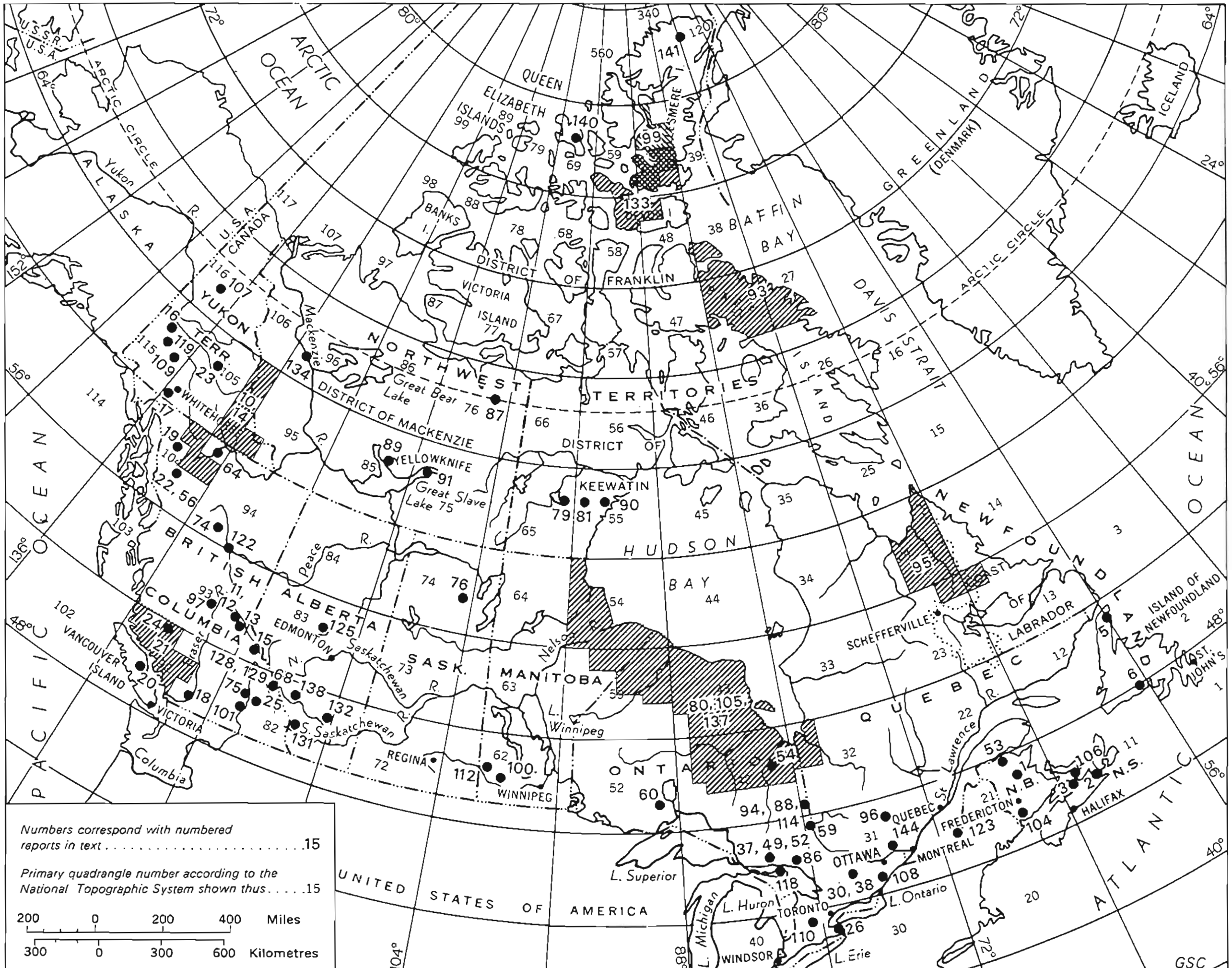


Figure 1. Distribution of most of the 1967 Geological Survey field parties

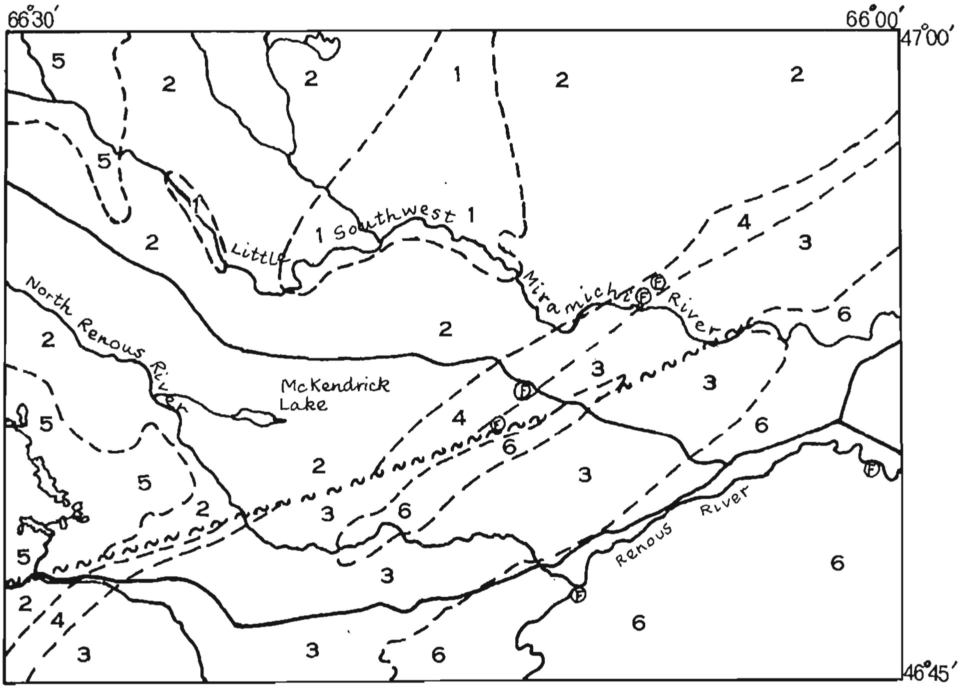
INTRODUCTION

In 1967 almost 100 full-time field parties of the Geological Survey conducted investigations on a wide variety of subjects designed to continue the systematic geological investigation of Canada. In Canada the Geological Survey is the major organization engaged in this form of research and as the following reports and Figure 1 show, its studies ranged from coast to coast and far into the arctic. This systematic investigation is supported by research into many aspects of geoscience including geochemistry, geophysics, geomorphology, mineralogy, palaeontology, petrology, and related subjects. The Survey had more than 75 part-time projects during the 1967 field season – most were engaged in collecting support-data for other research.

This report is based on brief accounts submitted by field officers upon their return from the field, and in order to expedite publication it has been given minimum editorial attention and uses illustrative material as submitted by the authors. It is designed for the earliest possible release of information that may be useful to those engaged in the search for and development of metallic and non-metallic mineral deposits, fuels, and construction materials. It comprises 144 reports arranged by scientific discipline. An index to geographic locations (arranged by province, territory or district) and an authors index follow the text. Where possible the reports are keyed to the National Topographic System as revised in 1960. All statements contained in this report are subject to confirmation by office and laboratory studies.

Details of many of the activities mentioned in this report will form the basis for more detailed maps and reports of the Geological Survey, the release dates of which are announced from time to time by postcards mailed free-of-charge to those requesting this service. Requests for announcement cards, geological reports, and maps, or information on specific areas or topics, should be addressed to: The Director, Geological Survey of Canada, Department of Energy, Mines and Resources, 601 Booth Street, Ottawa 4, Ontario.

This report (Paper 68-1, Part A) describes activities of the Geological Survey carried out between May and October, 1967. Paper 68-1, Part B will include work carried out from November, 1967 to April, 1968 and will be published later in the year. This report, together with the reports on isotopic and radiocarbon dating, the annual index of publications, and the compilation of abstracts of papers published by Geological Survey personnel in non-Survey publications, collectively provide an annual accounting of most of the scientific work of the Geological Survey.



McKENDRICK LAKE MAP-AREA

LEGEND

0 4 8 12
miles

CARBONIFEROUS

6 Sandstone, siltstone, conglomerate

DEVONIAN AND EARLIER

5 Granite

UPPER SILURIAN

4 Basic volcanic rocks, minor slate and siltstone

ORDOVICIAN AND SILURIAN

3 Siltstone, greywacke, slate, minor volcanic rocks

CAMBRO-ORDOVICIAN

2 Phyllite, quartzite, slate

1 Paragneiss and schist

APPALACHIAN GEOLOGY

1. McKENDRICK LAKE MAP-AREA, NEW BRUNSWICK (21 J/16)

F.D. Anderson

Geological mapping of the McKendrick Lake map-area, for publication on a scale of 1 inch to 1 mile was completed.

Metamorphic rocks of unit 1 (see Fig. 1) occupy the core of a large domal structure and are conformably overlain by rocks of unit 2. Rhyolite and quartz-feldspar augen-schist are associated with the phyllites of unit 2 in the northeastern part of the map-area. Minor structures in units 1 and 2 indicate that the rocks have undergone at least three periods of deformation. The age of the strata is unknown, however, they are structurally similar to pre-Middle Ordovician rocks in southwestern New Brunswick[1], and are continuous with metasedimentary and metavolcanic rocks of Cambrian and/or Ordovician age in adjoining areas[2,3,4,5].

Overlying the metamorphic rocks with apparent unconformity (in the central part of the map-area the contact is possibly a fault) is a sequence of basic volcanic rocks and minor interbedded siltstone and slate. Graptolites collected from the siltstone have been identified as Upper Silurian (Lower Ludlovian) in age. These rocks are contiguous with strata mapped in adjoining areas as Middle Ordovician[3,4,5].

Sedimentary and minor basic volcanic rocks that form map unit 3 are a continuation of Middle Ordovician to Middle Silurian strata to the south[4,5]. The contact with map-unit 4 is unknown.

Near-horizontal Carboniferous (6) strata unconformably overlie Ordovician and Silurian units. Fossil flora collected are correlative with the Pennsylvanian Clifton Formation.

---

[1]Ruitenberg, A.A.: Stratigraphy, structure and metallization, Piskahegan - Rolling Dam area; Leidse Geologische Mededelingen, pp. 81-120, Doctoral dissertation (1967).

[2]Anderson, F.D.: Geology, Big Bald Mountain, New Brunswick; Geol. Surv. Can., Map 41-1960 (1961).

[3]Dawson, K.R.: Geology, Sevogle, New Brunswick; Geol. Surv. Can., Map 1092A (1961).

[4]Poole, W.H.: Geology, McNamee, New Brunswick; Geol. Surv. Can., Map 20-1960 (1960).

[5]Poole, W.H.: Geology, Hayesville, New Brunswick; Geol. Surv. Can., Map 6-1963 (1963).

---

2. ANTIGONISH MAP-AREA, NOVA SCOTIA (11 F/11, F/12, F/13, F/14)

D.G. Benson

Geological field work was limited to the coastal area around George Bay and a few miles inland. Previously mapped areas to the north and east[1,2,3] were briefly examined to complete a general understanding of the geology on all sides of George Bay. Particular attention was paid to structural features such as faults, folds and unconformities which would influence the extrapolation of bedrock geology beneath the bay.

An attempt was made to examine the bedrock in six selected areas of George Bay in water depths of 50 to 100 feet but was unsuccessful because of poor weather conditions. The methods of sampling the bedrock and of determining the altitudes of strata were tested and found to be satisfactory.

The geology of the Antigonish map-area consists essentially of a thick Carboniferous sequence, mainly alternating red and grey non-marine and marine sedimentary rocks. The formations are generally conformable but fault contacts and local unconformities are common. There is a thick section of Windsor limestone and evaporites in the Antigonish Basin.

Pre-Carboniferous rocks of the Antigonish Highlands extend into the northwest corner of the Antigonish map-area. The bedrock exposures are mainly laminated argillite, greywacke and minor andesite of the Ordovician Brown's Mountain Group. Pale red Devonian or older granite is exposed on the east side of Antigonish Harbour where it is unconformably overlain by calcareous Windsor sediments. In the interior of Williams Point, pale red granodiorite underlies Windsor limestone.

[1]Ferguson, S.A. and Weeks, L.J.: Mulgrave, Nova Scotia; Geol. Surv. Can., Map 995A (1950).

[2]Kelley, D.G.: Whycocomagh, Nova Scotia; Geol. Surv. Can., Map 17-1957 (1957).

[3]Norman, G.W.H.: Lake Ainslie map-area, Nova Scotia; Geol. Surv. Can., Mem. 177 (1935).

[4]Sage, N. McL. Jr.: The stratigraphy of the Windsor Group in the Antigonish Quadrangles and the Mahone Bay-St. Margaret Bay area, Nova Scotia; N.S. Dept. Mines, Mem. 3 (1954).

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3. COBEQUID MOUNTAINS, NOVA SCOTIA (11 E/11)

D.G. Kelley

During the field season of 1967, part of the area of the Cobequid Mountains between Moose River and the western end of the mountains was examined (approximately between 64°10' and 64°55'W). This part of the Cobequids consists of argillitic-phyllitic sedimentary rocks with minor volcanic rocks, granitic rocks, rhyolitic rocks and minor highly sheared intermediate(?) igneous rocks. Except for the sedimentary strata, whose age is unknown, the rocks are probably a westward continuation of those encountered last year[1].

The lithology of the sedimentary rocks is similar throughout the area from north of Parrsboro to Advocate Bay. These rocks consist mainly of light to dark grey phyllites, phyllitic slates, argillites, quartzites and minor calcareous beds. They are partly similar to Silurian rocks in the area to the east[1,2,3]. The phyllitic aspect of the rocks west of Parrsboro may be due to metamorphism associated with late movement on the Cobequid Fault. A K-Ar, whole rock age determination on phyllite from 3,000 feet north of the Cobequid Fault scarp gave an age of 280 $\pm$ 34 m.y.[4].

The relationship of the sedimentary rocks to the other rock units is uncertain due to incomplete coverage and scarcity of outcrop in critical areas. Within all rock units, crushed zones and shear zones are common and present indications are that the rock units are in fault contact. One exception is the contact between granitic and rhyolitic rocks, which in places appears gradational.

[1]Kelley, D.G.: Cobequid Mountains, in Report of Activities, May to October, 1966, edited by S.E. Jenness; Geol. Surv. Can., Paper 67-1, Part A, pp. 175-176 (1967).

[2]Kelley, D.G.: Cobequid Mountains, in Report of Activities, May to October, 1965, edited by S.E. Jenness; Geol. Surv. Can., Paper 66-1, pp. 172-173 (1966).

[3]Kelley, D.G.: Cobequid Mountains, in Report of Activities: Field, 1964, compiled by S.E. Jenness; Geol. Surv. Can., Paper 65-1, pp. 125-127 (1965).

[4]Wanless, R.K., Stevens, R.D., Lachance, G.R. and Edmonds, C.M.: Age determination and geological studies; K-Ar Isotope Ages; Report 7; Geol. Surv. Can., Paper 66-17, p. 104 (1967).

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4. STRUCTURAL STUDY OF THE FLEUR DE LYS GROUP, BURLINGTON PENINSULA, NEWFOUNDLAND (2 E, L, 12 H, I)

M.J. Kennedy

Field work between Baie Verte and White Bay has been completed[1].

Major structures, formed by the first deformation D_1, have not been recognized, but three major F_2 folds occur in the coastal sections from south of Pigeon Island to Slaughter House Cove. These folds plunge steeply to the north-northeast or south-southwest, and, on evidence of tops of the beds, face north. The south-southwesterly plunging folds face downward. The folds cause the repetition of the Birchy Schist Formation (separated by semi-pelitic and psammitic schists with an impure limestone) at Coachman's Cove. The limestone has been cut out along a minor tectonic slide at Birchy Cove and Little Bay Head Cove.

S_2 schistosity, formed during the second deformation D_2, is the axial plane fabric of the F_2 folds and north of Fleur de Lys dips gently. There, the F_2 folds are recumbent and plunge from the northwest clockwise to the east. The steep attitude of S_2 and the steep plunge of the F_2 fold axes farther south are the result of later (post-D_3) downwarping along the junction with the Baie Verte Group. A coarse strain-slip schistosity or fracture cleavage, S_4, may be related to this structure.

Late recumbent crenulations, demonstrably younger than D_3 deformation, are probably of D_5 age. Kink bands, the youngest fold structures in the area probably result from a further deformation D_6.

The metasedimentary rocks exposed at Slaughter House Cove and in Slaughter House Cove Brook, shown on earlier maps as members of the Baie Verte Group[2,3] and mapped partly as meta-diorite, can be demonstrated to be part of the Fleur de Lys Group on evidence of similar structural sequence, geometry, and metamorphism. The metasediments, rich in graphitic schists with impure limestone bands, are probably the oldest rocks in this part of the area and occupy the core of an F_2 fold. They are surrounded (flanked) in turn by calc-silicate schists and actinolite-chlorite schists of the Birchy Schist Formation. The axial trace of this fold has been displaced dextrally by two east-trending faults, which have been intruded by serpentinite.

The two serpentinite bodies at Fleur de Lys show complex relationships with the Fleur de Lys Group. Where they are in contact with amphibolite, the amphibolite has been altered to an actinolite-chlorite-albite rock; actinolite forms a well-developed mineral lineation of D_2 age, and has been crenulated by D_3 structures. Furthermore, the margin of one serpentinite body shows mesoscopic structures identical in orientation and form to the D_2 and D_3 structures of the metasediments. This is suggestive of an early, pre-D_2, phase of ultrabasic intrusion, possibly associated with metasomatic alteration of the bounding amphibolites and much older than the ultrabasic intrusions associated with the Baie Verte Road fault zone. Careful textural studies of these rocks may reveal further information on the nature and age of these ultrabasic bodies at Fleur de Lys.

Although an insufficient stratigraphic thickness of the Fleur de Lys Group is exposed in the study-area for definite conclusions to be drawn, the strata and their sequence closely resemble the upper part of the Islay Succession of the Scottish and Irish Dalradian. Fleur de Lys rocks farther south are probably not exposed well enough to obtain the necessary stratigraphic details.

---

[1]Kennedy, M.J.: Structural study of the Fleur de Lys Group, Newfoundland; Geol. Surv. Can., Paper 67-1A, pp. 180-182 (1967).

[2]Neale, E.R.W. and Kennedy, M.J.: The relationship of the Fleur de Lys Group to younger rocks in the Burlington Peninsula, Newfoundland; Geol. Assoc. Can., Special Paper No. 4, in press.

[3]Neale, E.R.W.: Fleur de Lys, Newfoundland; Geol. Surv. Can., Map 16-1959 (1959)

5. TACONIC KLIPPEN OF WESTERN NEWFOUNDLAND, (2 L, M)

R.K. Stevens

A study of the two major Taconic Klippen[1] of western Newfoundland was undertaken during the 1967 field season. A geological map of the northern klippe (Hare Bay klippe) is being prepared for publication on a scale of 1 inch to 2 miles.

Rocks of the Hare Bay klippe[2,3,4] comprise three sequences:

(1) The Northwest Arm Formation[3,5] consisting of Tremadocian and Arenigian (?) black and green shales with some impure carbonate and arenite beds and blocks.

(2) The Canada Head[6] and Maiden Point[5] Groups consist of greywacke, shale and volcanic rocks. The age of these rocks is problematic; some resemble Cambrian rocks elsewhere in Newfoundland whereas others appear to be Arenig or later in age.

(3) The Goose Cove schists[5] and related rocks which are interpreted as an ophiolitic complex of Llanvirnian and earlier age.

The Northwest Arm Formation occurs as a mélange between the autochthon and the allochthonous Canada Head and Maiden Point Groups. The ophiolites form the highest structural slice and consist of a basal greenschist unit showing polyphase deformation and low grade metamorphism, overprinted by thermal metamorphism bordering ultrabasic intrusions. The roof of the intrusions consists of an assemblage of pillow lavas, black shale and chert with a structural and metamorphic history less complex than that of the greenschists.

Several different sedimentary sequences are recognized in the southern klippe[7,8] (the Humber Arm klippe), which may be described in terms of the type section along Humber Arm[7]. New fossil discoveries have, for the most part, confirmed previous age assignments[7,8].

An upper clastic unit, represented at Humber Arm and at Port-au-Port Peninsula, is best interpreted as a fan which spread from the east across the various sequences of the Humber Arm klippe before emplacement during Arenig and Llanvirn times.

Relationships at the base of the Humber Arm klippe form a consistent pattern. The autochthonous carbonate sequence gives way to an internally derived flysch sequence of Llanvirnian to Caradocian age (an external facies of the clastic fan described above). Lime breccias intercalated near the base of the flysch, mark a westwards migration of the carbonate shelf edge but should be distinguished from the older Cow Head breccias of similar facies. The upper part of the flysch, where preserved, contains sedimentary breccia derived from the klippe. The top of the flysch, however, is usually incorporated into the basal mélange of the klippe developed by the mingling of soft autochthonous and allochtonous rocks under high water-pressure in the movement zones.

Phacoidal cleavage is extensively developed in the mélange zones of both klippen and its relationship to the regional cleavage suggests that the mélange was dewatered during or immediately after its formation. The mélange zones can be distinguished from mudflows which are not dewatered until the development of the regional cleavage.

Folds within the mélange zones and in rocks immediately adjacent to them, are commonly recumbent and isoclinal. The fold axes generally lie at right angles to the inferred direction of movement of the klippen and parallel the long axes of 'blocks' in the mélange and the lens-shaped segments resulting from the phacoidal cleavage.

Final emplacement of the klippen is dated by newly discovered fossil localities as early Caradocian.

An almost unbroken transition between the autochthon and neoautochthon exists along the western shore of Port-au-Port Peninsula and this marks the original western edge of the Humber Arm klippe.

A preliminary survey of Lower Cambrian shales in northern Newfoundland was conducted at the suggestion of A.G. Darnley of the Geological Survey using a scintillation gamma ratemeter. The purpose was to determine whether some shales are rich in potassium similar to some Lower Cambrian shale of the Furoid Beds of northwest Scotland. One sample from the Fortean Formation[9], found to be anomalously radioactive, assayed 7% K_2O by gamma-ray spectrometer. Potassium feldspar was detected by X-ray diffractometer.

---

[1]Rodgers, J. and Neale, E.R.W.: Possible "Taconic" Klippen in western Newfoundland; Am. J. Sci., vol. 261, pp. 713-730 (1963).

[2]Gillis, J.W.: Great Northern Peninsula, Newfoundland; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 179-181 (1966).

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[7]Stevens, R.K.: The geology of the Humber Arm area, western Newfoundland; unpubl. M.Sc. thesis, Memorial Univ. Nfld.

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[9]Schuchert, C. and Dunbar, O.: The stratigraphy of western Newfoundland; Geol. Soc. Am.; Mem. 1 (1934).

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6. BURGEO (EAST HALF) MAP-AREA (11 P (EAST HALF))

H. Williams

Geological mapping of the Burgeo (East Half) map-area was completed suitable for publication on a scale of 1 inch to 4 miles. This completes the 4-mile mapping program throughout central Newfoundland.

The north part of the map-area is underlain mainly by granite intrusions and the south by a low- to medium-grade metamorphic terrane. The granitic rocks are medium- to coarse-grained, massive, biotite granite which include large amounts of garnetiferous muscovite leucogranite, syenite, and monzonite. Within the regional metamorphic terrane, relatively unmetamorphosed rocks of the Ordovician (?) Baie d'Espoir Group[1] are included to the east and undated siltstones, micaceous sandstones, and quartz-pebble conglomerates toward the northwest. Associated metamorphic rocks are almost entirely of metasedimentary origin. Bedding, foliation, direction of fold axes, and the trend of mylonitic zones throughout the southerly metamorphic terrane form an arcuate pattern across the map-area that is concave toward the north. The rocks comprising this arcuate salient are sharply truncated by massive biotite granite between Hare Bay and Devil Bay and they are cut by granites toward the north.

West of La Hune Bay, green amphibolites and chloritic schists with quartzitic interlayers are truncated by granites. These metamorphic rocks continue westward to Grey River where they form the host rocks for a tungsten prospect that is presently being developed by American Smelting and Refining Company. Similar rocks occur 12 miles toward the east at Devil Bay.

Unmetamorphosed plutonic pebble conglomerate, limestone, and silicic volcanic rocks that are deformed only by tilting occur at Cape La Hune. These rocks although cut by granites are probably no older than Devonian[2] and they are thought to be the youngest layered rocks in the map-area.

---

[1]Jewell, W.B.: Geology and mineral deposits of the Baie d'Espoir area: Nfld. Geol. Surv., Bull. 17, 29 pp. (1939).

[2]Williams, H.: Island of Newfoundland: Geol. Surv. Can., Map 1231A (1967).

COAL RESEARCH

7. CARBONIFEROUS PALYNOLOGY, JOGGINS, ANTIGONISH AND PORT HOOD-MABOU, NOVA SCOTIA

M.S. Barss

Collecting of samples was carried out in the Joggins, Antigonish, and Port Hood-Mabou areas of Nova Scotia for a palynological study of the Canso and Riversdale Groups. These groups are considered to be Namurian A and Westphalian A age respectively. However, the many sequences of rocks that have been assigned to these groups have, in many instances, yielded few or insufficient fossils for accurate age determinations. It is hoped that the samples obtained may provide a basis for zonation and accurate age determination of the rocks assigned to these groups, which are widespread throughout the Atlantic Provinces.

In the Joggins area 21 samples were collected from the type section of the Boss Point Formation (Riversdale Group), providing excellent coverage from the bottom to the top of the formation. Sixteen samples were collected from the shore section near Bayfield and 35 samples from the Pomquet River section, near Antigonish, Nova Scotia. These two sections make up a sequence of rocks that have been assigned to the Riversdale and Canso Groups. Previous work on only a few samples has shown that four miospore zones may be present in these rocks. It may now be possible to delineate these zones more accurately with these additional samples.

In the Port Hood-Mabou areas four samples were obtained in the hope that the Riversdale-Canso boundary in that area can be determined when comparison with the Pomquet and Joggins samples is made.

8. RADIOACTIVITY OF LIGNITES, SOUTHERN SASKATCHEWAN

A.R. Cameron and T.F. Birmingham

Exposures of Tertiary lignite were checked for radioactivity with a scintillometer at 81 stations across southern Saskatchewan. These exposures were found in road-cuts, in strip mines and in cliffs along valleys and coulées. Station locations ranged from Estevan in the east to the area of Eastend in the Cypress Hills. At some stations as many as seven seams were checked; at others only one seam was exposed. Particular attention was paid to the highest seam in any given section, to their dirty seams and to the upper part of thick seams.

Readings on the scintillometer for most of the stations covered ranged from 0 to .016 milliroentgens per hour above a background which ranged from 0.008 to 0.013 milliroentgens per hour. However one station on a cliff south of Frenchman River near Eastend gave higher readings ranging up to 0.160 milliroentgens per hour above background.

Thirty-five samples were collected for chemical determination of uranium content. These data indicate low contents with the exception of some of the Eastend samples which show values of 350 and 650 parts per million U_3O_8 in the ash of two samples collected from the top of the highest seam in the section. A 10 x 35-mesh fraction prepared from one of these samples showed 1050 parts per million U_3O_8 in the ash.

In addition, an 8-foot column sample of lignite for petrographic analysis was collected in one of the active strip mines in the Eastevan area. This sample is presently under study.

9. COALFIELDS IN WESTERN CANADA

P.A. Hacquebard and J.R. Donaldson

The reflective index of coal, as determined from polished grain mounts, can be used to predict the stability of the resultant coke. The same index, it is hoped, can also be used to determine the rank of a particular coal. In the coalfields visited, samples were collected in stratigraphic sequence, in order to see if the reflective index, like the volatile matter content, follows Hilt's Law. Fifty-five coal seams were sampled from 11 different areas.

CORDILLERAN GEOLOGY

10. SEKWI MOUNTAIN (105P) AND NAHANNI (105I) MAP-AREAS, DISTRICT OF MACKENZIE AND YUKON TERRITORY

S.L. Blusson

As part of Operation Selwyn (see also H. Gabrielse and D.L. Dineley in this report) 2 weeks were spent examining selected stratigraphic sections and completing 4-mile reconnaissance mapping in the Sekwi Mountain (105P) and Nahanni (105I) map-areas.

A new section of Proterozoic clastic sedimentary rocks (unit 1 of Geol. Surv. Can. Maps 8-1967 and 6-1966), 8 miles east of Mount Pike in the Nahanni map-area is as much as 12,000 feet thick and contains the oldest strata yet recognized in Selwyn Mountains. A thin member of limestone-quartzite-boulder and cobble-conglomerate near the base, closely resembles part of the middle part of the Rapitan Group in the Mackenzie Mountains to the northeast.

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

R.B. Campbell

Field work in 1967 involved the continuation of work begun in 1966[1] and included in addition, a study of fold structures by A. Brown, and the initial phase of a stratigraphic study by F.G. Young. Results of each of the latter are reported separately below. E.W. Mountjoy provided much valuable advice and assistance with the work in Rocky Mountains and is solely responsible for the mapping north of McGregor River and Bastille Creek.

Fossils collected from the Greenberry Member of the Guyet Formation of the Slide Mountain Group have been tentatively identified as Lower Mississippian.

The new work has confirmed the stratigraphic succession of rocks in northern Cariboo Mountains and showed the validity of the correlation to strata in Rocky Mountains previously suggested by the writer[1].

The discovery of as much as 6,000 feet of strata comprising the Early Cambrian limestone (Mural) and the succeeding thick shale, siltstone, and limestone unit (map-unit 8) above the Midas Formation in Cariboo Mountains has important implications regarding the stratigraphy of the Cariboo Group established by Holland[2] and followed by Sutherland-Brown[3] and the writer[4,5].

The Snowshoe Formation has been regarded as the uppermost member of the Cariboo Group and was thought to lie directly above the Midas Formation. Thus the Snowshoe Formation, an assemblage of feldspathic arenaceous, pelitic, and minor carbonate rocks, was placed in precisely the stratigraphic position occupied by the very different post-Midas strata mentioned above, and is geographically separated from them by only 30 miles and from exposures of the Mural Formation by 12 miles or less. Possible explanations of these factors are: (1) the Snowshoe Formation results from deposition of material from a western source and represents a profoundly different facies than equivalent rocks to the east that have an eastern source; (2) the Snowshoe Formation lies above an unconformity and hence is younger than its apparent equivalents to the east; (3) the Snowshoe Formation does not lie stratigraphically above the Midas Formation, is older than other units of the Cariboo Group, and is separated from the Cariboo Group in part by undetected strike faults, and in part lies in its normal low stratigraphic position.

More field work and analysis of data at hand is needed to resolve the problem of the Snowshoe Formation, but the writer considers that the third possibility is correct, and that the formation is equivalent to the Kaza Group which it resembles in many respects. This conclusion is similar to the opinion reached by Wheeler (this publication) respecting the Broadview Formation of the Lardeau Group.

Within the map-area the Rocky Mountain Trench is not distinguished by any recognizably unique structure; that is, the structures within it do not appear to be different in nature or magnitude from those in the adjoining mountains. Though several faults may lie along the Trench none seem to be major thrust or strike-slip breaks.

Northeast of the fault along McGregor River and Bastille Creek, structures that are typical of much of Rocky Mountains, feature relatively unfolded, unmetamorphosed rocks cut by southwesterly dipping thrust or reverse faults. Southwest of the fault, folding is important and faults generally dip steeply either northeasterly or southwesterly. This structural regime is continuous from the western Rocky Mountains across the Trench and through the Cariboo Mountains. It features huge, generally northwesterly-plunging anticlinoria and synclinoria. In some of these major folds the style of deformation changes along the trend from structurally deep similar or composite folds in foliated metamorphic rocks, to structurally shallower faulting of essentially unmetamorphosed strata.

LEGEND

CARIBOO MOUNTAINS

CENOZOIC

QUATERNARY
PLEISTOCENE AND RECENT
- 16 — Glacial deposits and alluvium

MESOZOIC

TRIASSIC
UPPER TRIASSIC
- 14 — Black shale, slate, and phyllite

PALAEOZOIC

MISSISSIPPIAN AND (?) LATER
LOWER MISSISSIPPIAN AND (?) LATER
SLIDE MOUNTAIN GROUP (undivided)
- 11 — Antler and Guyet Formations

CAMBRIAN
LOWER CAMBRIAN AND LATER
- 8 — Black shale, siltstone, and limestone

LOWER CAMBRIAN AND EARLIER
CARIBOO GROUP (in part)
- 5 — Mural, Midas, Yanks Peak, Yankee Belle, and Cunningham Formations

PROTEROZOIC

WINDERMERE
- 3 — Isaac Formation; mainly argillaceous
- 2 — Kaza Group arenaceous and argillaceous

Note; for lithology of units refer to Sutherland Brown (1957 and 1963) and Young in this publication

ROCKY MOUNTAINS

QUATERNARY
PLEISTOCENE AND RECENT
- 16 — Glacial deposits and alluvium

CRETACEOUS
LOWER CRETACEOUS
- 15 — Mainly Nikanassin Formation

TRIASSIC
- 13 — Whitehorse and Sulphur Mountain Formations

PERMIAN AND CARBONIFEROUS
- 12 — Rocky Mountain and Rundle Groups and Banff Formation

DEVONIAN
- 10 — Palliser Formation and Fairholme Group

CAMBRO-ORDOVICIAN, ORDOVICIAN, AND (?) LATER
- 9 — Limestone, shale, and quartzite; greenstone dykes and sills west of McGregor River

CAMBRIAN
UPPER CAMBRIAN
- 7 — Lynx Formation

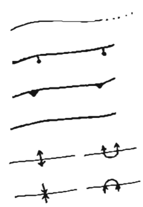
MIDDLE CAMBRIAN
- 6 — Arctomys, Pika, Titkana Formations and unnamed basal unit

LOWER CAMBRIAN
GOG GROUP
- 4 — Mahto, Mural, and McNaughton Formations

WINDERMERE
MIETTE GROUP
- 3 — Upper Miette Group; mainly argillaceous
- 2 — Middle Miette Group; arenaceous and argillaceous
- 1 — Lower Miette Group; mainly argillaceous

Note: for lithology of units refer to Slind and Perkins (1966) and Mountjoy (1962)

Geological contact ....
Fault (dots on downthrown side) ....
Thrust fault ....
Fault (undifferentiated) ....
Anticline (upright, overturned) ....
Syncline (upright, overturned) ....



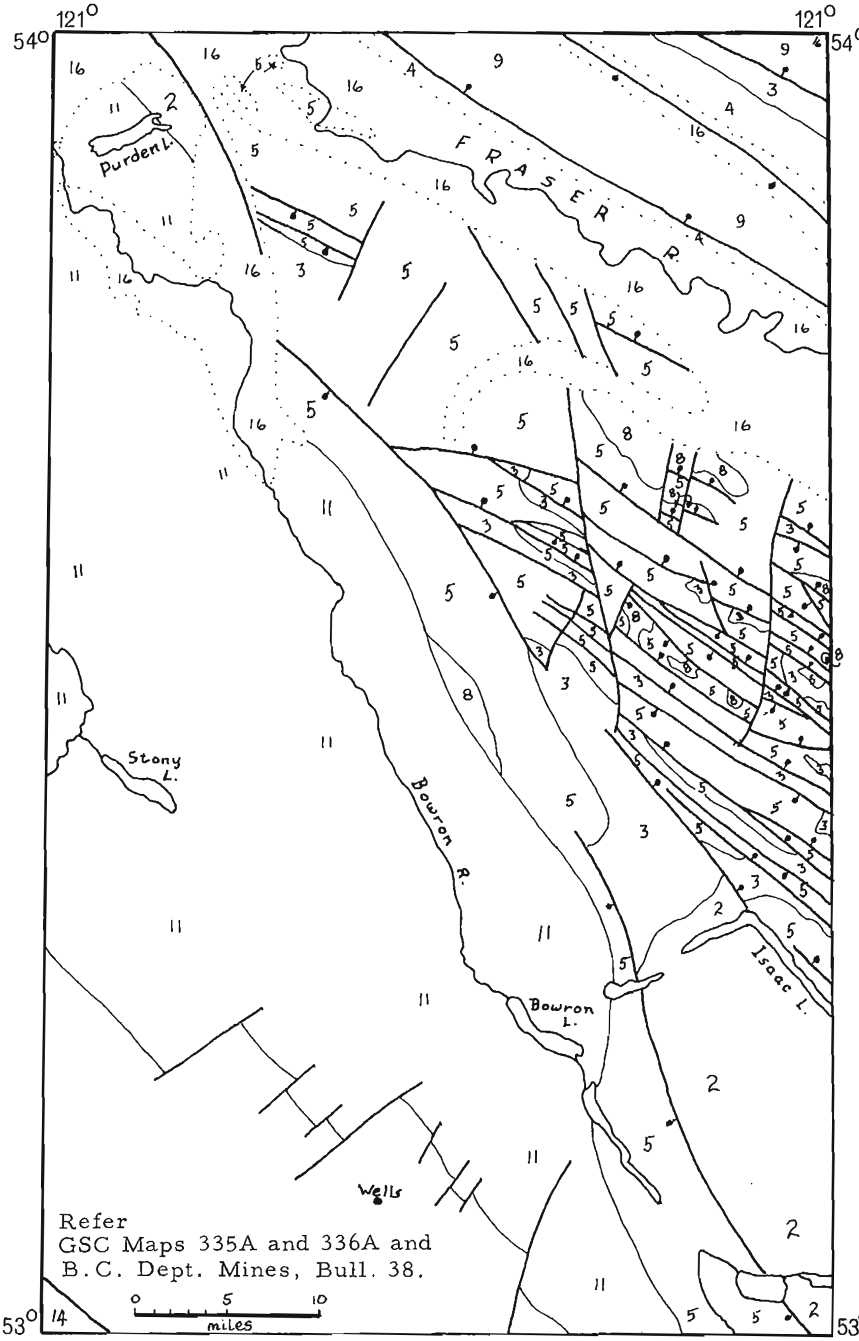


Figure 1. Geological sketch map of McBride map-area (west half).

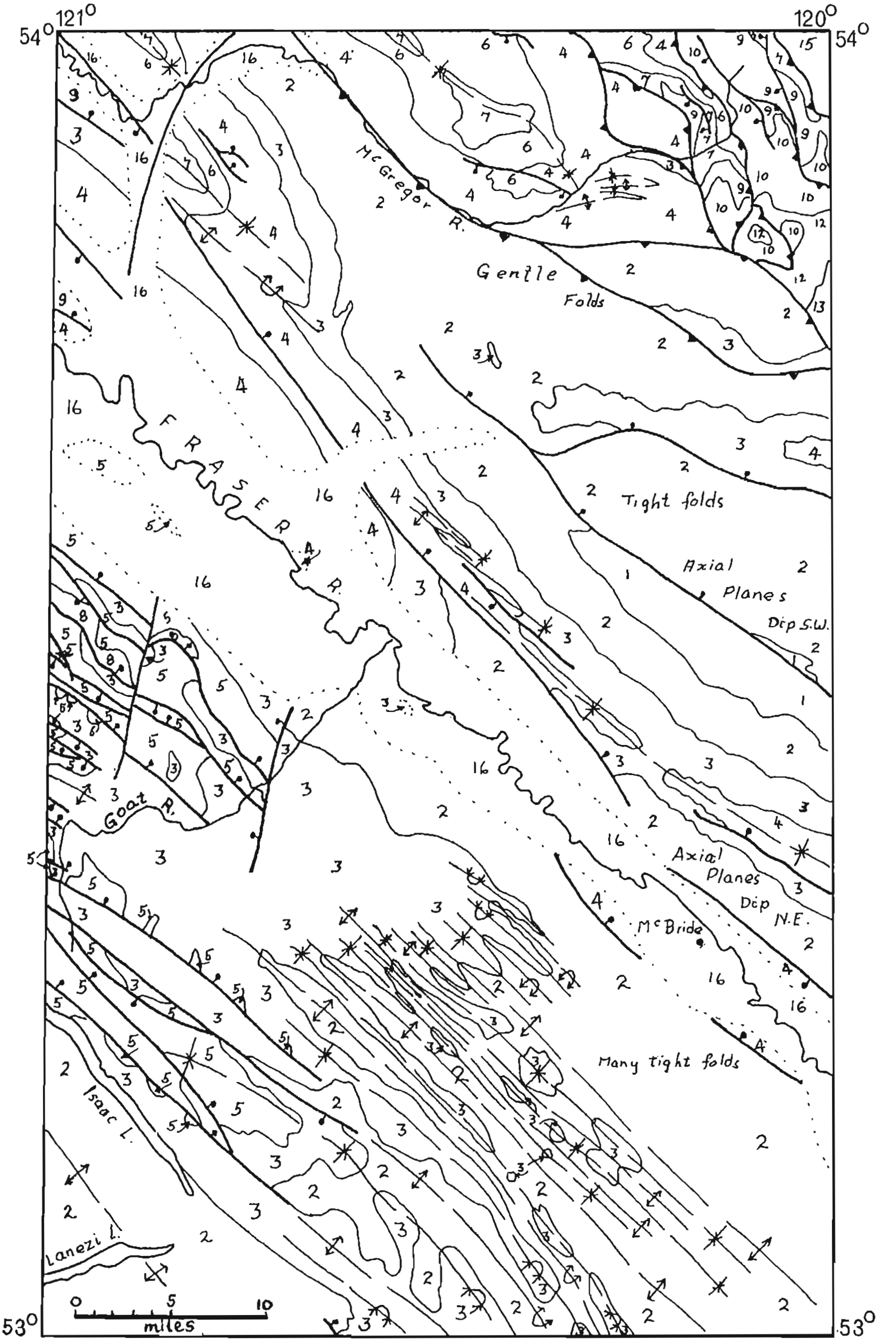


Figure 2. Geological sketch map of McBride map-area (east half).

The deformation in Cariboo Mountains, and by inference in at least part of Monashee and Selkirk Mountains (Wheeler[6,7] and Campbell[4,5]), cannot be separated in time from that of the Rocky Mountains. The former appears to grade into and to be the 'root zone' of the latter. Nothing was noted that supports the concept of distinct Nevadan and Laramide Orogenies.

The structural pattern in the western Rocky Mountains and particularly in Cariboo Mountains does not suggest to the writer that the deforming forces operated as a regional compression or couple, at least at the level of observation. Rather it suggests complex differential vertical movements whereby elongate ridges (anticlinoria) were uplifted relative to intervening troughs (synclinoria). Speculatively this zone may be regarded as one of near vertical movements overlying the site of a deep seated 'squeeze zone'.

The placer and lode gold deposits of the Barkerville-Wells district have been important producers in the past. The writer is not aware of other commercial mineral production from within the map-area. Copper mineralization from near Dome Creek has been reported and coal deposits near Bowron River are currently being explored. The coal is apparently of early Tertiary age and is found in rocks with little or no surface exposure. This deposit was not visited by the writer.

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[1] Campbell, R.B.: McBride (93H) map-area, in Report of Activities, 1966; Geol. Surv. Can., Paper 67-1, pp. 53-55 (1966).

[2] Holland, S.S.: Yanks Peak-Roundtop Mountain area, B.C.: B.C. Dept. Mines, Bull. 34 (1954).

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

[4] Campbell, R.B.: Quesnel Lake, west half; Geol. Surv. Can., Map 3-1961 (1961).

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

[6] Wheeler, J.O.: Big Bend map-area, B.C.; Geol. Surv. Can., Paper 64-32 (1965).

[7] Wheeler, J.O.: Rogers Pass map-area, B.C. and Alberta; Geol. Surv. Can., Paper 62-32 (1963).

12. McBRIDE AREA (93H) BRITISH COLUMBIA STRUCTURAL STUDY

Anton Brown

A reconnaissance survey of mesoscopic-scale structural fabric elements was undertaken while mapping the McBride map-area in order to test the similarity of structural symmetry through the different structural regimes of the area, and through rocks varying from Proterozoic to Early Mesozoic in age.

Over eight thousand readings have been grouped in thirty-six structurally homogeneous subdomains. These subdomains do not cover the entire area but are samples whose location has been partly dictated by the exigencies of mapping. Some localities are in the bordering map-areas of Mount Robson (83E), Canoe River (83D) and Quesnel Lake (93A).

Planar and linear elements were measured. The former consist of bedding, a micaceous foliation parallel to bedding, a micaceous foliation or fracture cleavage subparallel to the axial plane of some folds, a fracture cleavage fanned symmetrically about the axial plane of some folds, and minor fractures classified as either extensional or of unknown origin. The linear elements are fold hinge lines, boudins, mullion, and quartz-rod long axes, axes of crenulations and mineral elongation on the bedding or micaceous foliation surfaces, and the intersection of bedding and cleavage. Not all elements are present at each locality. At some stations bedding thickness around folds was measured or the folds photographed so that this can be done in the office.

The study suggests a continuity of deformation throughout the area, and that all the rocks from Proterozoic to Late Triassic reflect the same deformational history.

In the southern two-thirds of the map-sheet an early slip folding (F_1), on a west-northwesterly axis, has been rotated by a later composite folding (F_2) on a northwesterly axis; a third set of folds (F_3), generated by movement on a plane perpendicular to the F_2 axis, is thought to be due to squeezing and extension of the rocks due to differential uplift on the F_2 axis. The F_1 folding has a very local distribution even in areas where it is most commonly observed.

North of the Rocky Mountain Trench the F_1 folding is evident only in the Lower Miette Group, but a fourth folding (F_4) is found associated with thrust or reverse faults. The b-axis of the movement on these faults seems to be slightly oblique to the F_2 axis. Close to a thrust, slip folding has occurred; farther away, a complicated flexural slip has taken place between competent beds; forming a fracture cleavage and concomitant minor folds in the less competent beds. The attitudes of this cleavage extend over a quadrant, and are insufficiently sampled to define the complete geometric relation to the F_2 folds.

The extreme northeast of the map-sheet, which extends into the thrust fault regime of Rocky Mountains, has not been sampled.

Minor fractures proved useful in defining fold systems accurately where fold hinges and associated lineations are scarce. Strong concentrations of fracture planes are normal to both the west-northwesterly and northwesterly axes. Extensional fractures containing the F_2 axis in many localities are concentrated subparallel to the axial plane.

Massive volcanic rocks of the Slide Mountain Group have influenced the deformation of that unit. These rocks seem to have acted as dampers and to have formed blocks that were tilted to and fro by differential uplift on the northwest axis, presumably by movement on joints perpendicular to the fold axes. When data are plotted for a large area this gives an apparent and seemingly anomalous folding about northeast and southwest axes.

13. McBRIDE AREA, BRITISH COLUMBIA (93H) LOWER CAMBRIAN STRATIGRAPHIC STUDIES

F.G. Young

Field work consisted of measuring and describing stratigraphic sections of the Cariboo Group in the northern Cariboo Mountains. The thickness of the Cariboo Group from the base of the Isaac Formation to the highest beds recognized aggregates about 15,800 feet.

In the western Rocky Mountains west of Mount Sir Alexander, a single section was measured in strata in part equivalent to the Cariboo Group. This section, which is over 22,000 feet thick, is essentially continuous from the Middle Miette Group, through the Gog Group, to a Middle and Upper Cambrian carbonate sequence.

Figure 1 illustrates the lithologic characteristics, thicknesses, and correlation of the units on each side of the Rocky Mountain Trench about forty miles northwest of McBride. The archaeocyathid-bearing limestones of the Mural Formation serve as an excellent key to lithologic correlation, and probably also as an approximate chronostratigraphic datum. The unfossiliferous clastic units beneath the Mural may be correlated with less

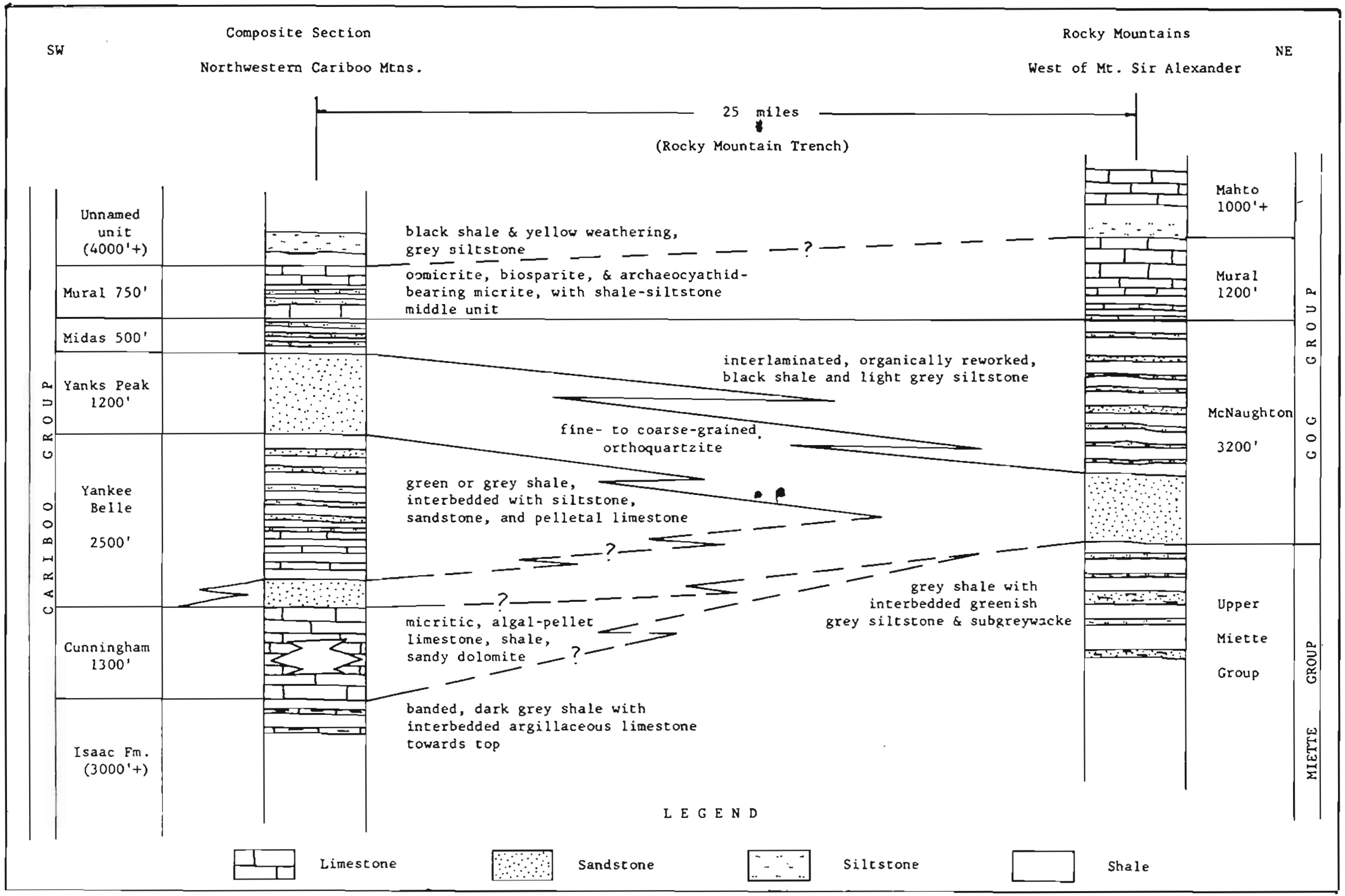

Figure 1. Tentative Correlation Diagram between Cariboo and Gog Groups east of Prince George, B.C.

certainty, but the close similarity of the Isaac-Cunningham and Upper Miette lithologic successions greatly aids in tying together the basal portions of the sequences.

Both the Isaac Formation and Upper Miette Groups are predominantly dark grey shale units and overlie thick successions of alternating subgreywackes and phyllites which comprise both the Kaza and Middle Miette Groups.

Lying in gradational contact over the Isaac, the Cunningham Formation exhibits interesting facies variations. From the interior of the Cariboo Mountains, where it is an ankeritic, algal pellet limestone, it grades northeastward into a dolostone-sandstone-shale unit along the western edge of the Trench, and thins abruptly to zero along the Rocky Mountain side where a few thin tongues of carbonate were noted beneath Gog quartzite.

The Yankee Belle Formation includes greenish grey to dark grey shales, siltstones, limonitic fine-grained sandstones, orthoquartzites, microcrystalline and pelletal limestones, and rarely, dolostone. These diverse, interbedded rock types probably represent the marine shelf facies of the McNaughton Formation orthoquartzite in the Rockies. Further studies should result in the subdivision of the Yankee Belle into members which would be mappable over local areas of the Cariboo Mountains. The orthoquartzite member shown in Figure 1 is known only in the Ptarmigan Creek area.

Yanks Peak Formation orthoquartzite exhibits the same characteristics as the Gog quartzite to the east, and the two units are thought to be correlative. If the thick sand body is continuous as illustrated (there is no evidence yet to the contrary) it represents a regressive, westward shifting of facies during the Lower Cambrian Epoch.

The originally disturbed black shales and laminated siltstones and sandstones of the Midas Formation thicken greatly towards the east within the McNaughton Formation. These fine-grained clastic rocks were possibly deposited in relatively quiet, shallow water in the lee of great offshore bars and barrier islands formed by the Yanks Peak orthoquartzite.

The Mural Formation maintains a tripartite character over most of central and eastern McBride area. A variety of shelf limestones and bahamites comprises the lower and upper members, whereas the middle member is a recessive, shaly unit having much the same characteristics as the underlying Midas Formation. The Mural apparently thins and 'shales-out' in the west by interfingering with black shales in the area of Wells, B.C.

Overlying the Mural is an unnamed formation of black shales, nodular limestones, and yellow-weathering siltstones. The limestones commonly bear olenellid trilobites, indicating an Early Cambrian age. The shales extend several thousand feet above the highest recognized Lower Cambrian beds and probably are equivalent to Middle Cambrian, and possibly to Upper Cambrian and Ordovician formations in Rocky Mountains.

14. OPERATION SELWYN, 1967 YUKON TERRITORY, DISTRICT OF MACKENZIE, BRITISH COLUMBIA

H. Gabrielse

During the field season reconnaissance mapping was completed in Coal River (95D), Jennings River (104O), Watson Lake (105A), Frances Lake (105H), Nahanni (105I), and Sekwi Mountain (105P) map-areas (see also S. L. Blusson in this report). Mapping was also completed in Dease Lake East Half (104J E 1/2) map-area and additional work was done in Cry Lake (104I) map-area.

Coal River map-area

The geology of bordering map-areas is shown on Geological Survey maps 35-1964 (Flat River, 95E), 32-1959 (La Biche, 95C), 19-1966 (Watson Lake, 105A), and 46-1962 (Rabbit River, 94M). Bedrock formations mapped in eastern Watson Lake map-area also underlie much of the area west of Coal River.

Westerly dipping strata between Coal and Rock Rivers near Camp Creek are cut by easterly directed thrust faults and are probably in part overturned to the east. The stratigraphic succession includes more than 1,000 feet of green, amygdaloidal volcanics of late Proterozoic (?) age; several thousand feet of phyllitic shale, siltstone, sandstone, feldspathic grit, and pebble conglomerate of Early Cambrian and (?) late Proterozoic age; 2,300 feet of fossiliferous Lower Cambrian limestone, siltstone, and sandstone; more than 2,000 feet (?) of Middle (?) and Upper Cambrian and Lower Ordovician, wavy-banded, silty limestone and calcareous phyllite; and several hundred feet of well-bedded dolomites of probable Middle Ordovician age.

The Middle Ordovician Sunblood Formation, widespread east of Rock River, is thin or absent south of a line running east-northeast from the mouth of Rock River to about latitude 60°15'N and longitude 126°W, presumably as a result of erosion prior to deposition of the Silurian Nonda Formation.

Silurian and Devonian carbonate rocks ranging in age from Late Llandovery to Couvinian change facies northerly into shales generally along an east-west line near latitude 60°15'N. However, a thin basal unit of sandstone and dolomite of the Nonda Formation, about 100 feet thick, is present beneath the Road River Formation between Coal and Rock Rivers and east of Rock River as far north as latitude 60°21'N.

More than 13,000 feet of stratified rocks ranging in age from late Proterozoic (?) to Carboniferous are exposed in a westerly dipping succession west of Toobally Lakes and north of Spruce Creek. In ascending order the mappable units include:

(1) Grey, green, and purple weathering, amygdaloidal volcanic flows and agglomerates with minor intercalated dolomite and sandy dolomite, as much as 2,000 feet thick and possibly of late Proterozoic age.

(2) Feldspathic sandstone, grit, and pebble conglomerate with interbedded maroon, brown, and green weathering shales and orange and buff weathering dolomites and sandy dolomites, about 7,500 feet thick and probably mainly or entirely of Early Cambrian age.

(3) Buff weathering sandy dolomite intercalated with amygdaloidal volcanic rocks in the upper part, more than 500 feet thick and of Early Cambrian age.

(4) Well-bedded dolomite and limestone probably less than 1,000 feet thick in easternmost exposures but thickening rapidly to the northwest; Middle Ordovician Sunblood Formation.

(5) Black, graphitic shale, dark grey and black chert and siltstone about 1,000 feet thick; Silurian to Carboniferous Road River and Besa River Formations.

(6) Well-bedded to massive, even-grained, sandstones with interbedded black shale; more than 500 feet thick; Carboniferous Mattson Formation.

Near Caribou River strata correlative with those described above are much thicker and the sequence includes an additional thick unit of wavy banded, silty limestone of Middle (?) and Late Cambrian and Early Ordovician age. Thickness are as follows:

1. Lower Cambrian volcanics; more than 500 feet.
2. Lower Cambrian sandy dolomite and dolomitic sandstone; 100 feet.
3. Middle (?) and Upper Cambrian and Lower Ordovician; more than 2,000 feet.
4. Middle Ordovician Sunblood Formation; more than 2,000 feet.
5. Ordovician to Devonian Road River Formation; possibly 1,000 feet.
6. Devonian and Carboniferous Besa River Formation; as much as 2,500 feet.
7. Carboniferous Mattson Formation; more than 500 feet.

East of Rock River and southwest of Caribou River the Sunblood Formation includes a member of blocky, green, amygdaloidal volcanics as much as 500 feet thick. Along and north of Beaver River near the eastern border of the map-area the Sunblood Formation is overlain by a distinctive, well-bedded sequence of sandstones, siltstones, dolomites, and shales several hundred feet thick. This assemblage is overlain in turn by Road River Formation containing Early Silurian graptolites near the base.

Two small stocks of biotite-hornblende quartz diorite outcrop in the northeasternmost part of the map-area.

Small smounts of chalcopyrite and malachite were noted in Proterozoic(?) volcanic rocks west of Toobally Lakes and north of Spruce Creek and in Middle Ordovician volcanic rocks east of the upper reaches of Rock River and west of Caribou River.

Jennings River map-area

Fusulinids collected by W.H. Poole from limestones east of Screw Creek in Wolf Lake map-area near the north boundary of Jennings River map-area have been assigned a Pennsylvanian age (Morrowan) by C.A. Ross. Strata, probably at least in part correlative with the Screw Creek rocks, outcrop near Klinkit Lake and were formerly assigned by the writer to the Mississippian[1]. The Klinkit Lake assemblage of greenstones, tuffs, cherts, limestones, and conglomerates is represented to the southeast by the regionally metamorphosed Oblique Creek Formation.

Dease Lake (E 1/2) and Cry Lake map-areas

Additional mapping in the Hotailuh and Three Sisters Ranges has shown that the southeastern part of the Hotailuh batholith extends southeasterly to McBride River and that a tongue of the batholith probably extends westerly to Stikine River where granitic rocks had been previously mapped in the Grand Canyon of the Stikine (see Geol. Surv. Can. Map 21-1962). Near the Cassiar-Stewart Road and westerly to 130°W the batholithic rocks are commonly mafic-rich hornblende diorites, locally foliated.

A south-southwest trending body of hornblende-biotite quartz monzonite, about 6 miles long and 2 miles wide, underlies a low lying area in Dease Lake map-area centred near 58°15'N and 130°15'W. This body and a protruberance of the Hotailuh batholith east of Thenatlodi Mountain appear to be barely unroofed and their contacts with topographically higher Triassic volcanic rocks are commonly gently dipping.

A previously unmapped area north of Turnagain River and southwest of Hard Creek (see Geol. Surv. Can. Map 29-1962) is underlain mainly by granitic rocks. Tertiary volcanic rocks outcrop along the lower part of Hard Creek.

A southwesterly dipping, remarkably fresh ultramafic body, locally displaying compositional layering parallel with its contacts, underlies an area of about 5 square miles on the southern part of the ridge north of the mouth of Hard Creek and extends southeasterly across Turnagain River. The enclosing strata, including black crenulated phyllite, meta-chert, meta-diorite, and minor limestone are believed to be of Carboniferous and/or Permian age and appear to form the northeasterly limb of a major syncline with its axis along or near Flat Creek.

Massive, tan to pale purple acidic (?) volcanic rocks were observed in two places west of Tucho River on Spatsizi Plateau but the abundance of these rocks relative to that of the associated Sustut Group is not known.

Disseminated copper minerals, including malachite and chalcocite, were noted in volcanic rocks east of McBride River on a northerly trending, western spur of a cirque near latitude 58°01 1/2'N and longitude 129°01 1/2'W. Chalcocite is associated with vein-quartz in a strong fracture zone on the crest of the ridge west of Kutcho Creek at 58°11 1/2'N and 128°35'W.

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[1]Gabrielse, H.: Operation Selwyn; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1, Part A, p. 48 (1967).

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15. STRUCTURAL STUDIES OF THE METAMORPHIC ROCKS ALONG THE ROCKY MOUNTAIN TRENCH AT CANOE RIVER, BRITISH COLUMBIA

C.A. Giovanella

Field investigations of the gneissic terrane which straddles the Rocky Mountain Trench (Canoe River valley) in this area[1,2,3] were completed during the past season. Contacts between the gneisses and contiguous metasedimentary rocks were mapped and locally examined in detail. Figure 1 shows the distribution of the units studied.

The gneissic terrane comprises a heterogeneous assemblage of layered gneisses and schists which range in composition from leucogranite to amphibolite. The major constituents are feldspar, quartz, biotite and hornblende. Homogeneous gneissic granites and augen-gneisses of meta-igneous aspect are commonly intermixed with the layered rocks. Preliminary petrographic studies indicate that the metamorphic grade is uniformly of middle amphibolite facies. Layering is commonly irregular and discontinuous, and relict sedimentary textures are totally absent.

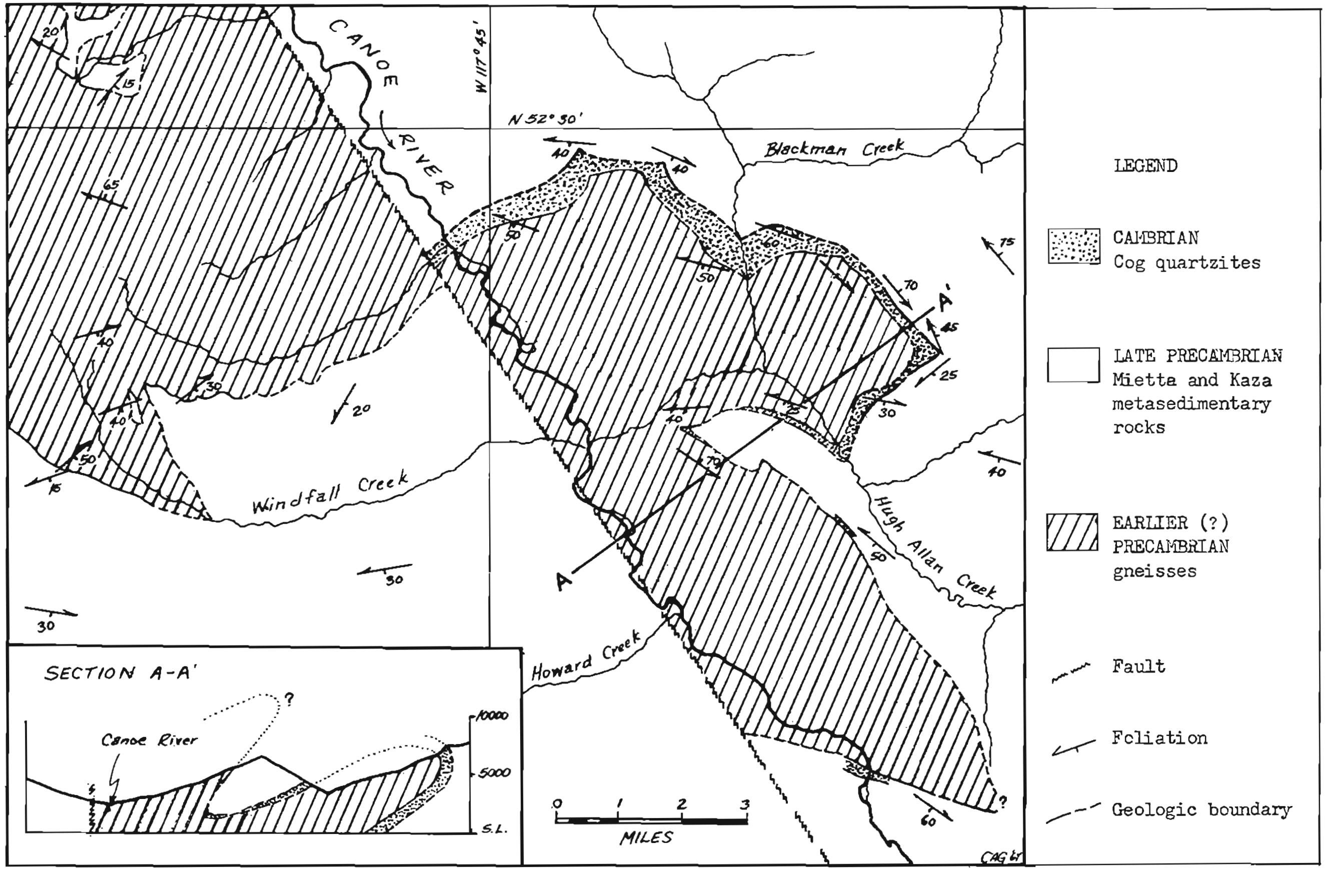

Figure 1. Generalized sketch map and section showing geology along part of Canoe River, B.C.

Late Precambrian Kaza rocks, dominantly pelitic schists and psammitic gneisses, lie structurally above and to the south of the gneissic terrane on the west side of the Trench. East of the Trench, an extension of the gneiss complex is surrounded by Cambrian Gog quartzites and late Precambrian Miette schists and phyllites. The Miette Formation, an equivalent of the Kaza and lithologically very similar to it, consists dominantly of interbedded pelitic and psammitic rocks with rare carbonate and conglomerate. Kyanite is commonly present in aluminous Kaza schists and occurs locally in the Miette rocks near contacts with the gneiss. To the northeast, the grade of metamorphism decreases to greenschist facies within a distance of 3 to 6 miles.

The eastern extension of the gneisses represents the inner zone of a large fold structure which plunges gently east-southeast. Gog quartzites form an incomplete envelope about the gneisses. The northernmost salient of the structure is well-exposed and appears to be an antiformal hinge in which the gneisses and quartzites plunge underneath Miette rocks. The southernmost hinge(?) is virtually unexposed and was not mapped.

All major boundaries between the gneiss complex and adjacent rocks appear to be tectonic. The contact between the Kaza and the gneiss is superficially concordant for much of its exposed length, but several sharp angular discordances (up to 45°) can be seen on cliffs southwest of Windfall Creek. East of the Trench, broad-scale discordance is indicated by the thinning, and locally complete absence, of the Gog quartzite envelope. Schistose mylonitic rocks were found along the contact at localities on both sides of Canoe River.

Several small bodies of metasedimentary (Kaza?) rocks occur within the western part of the gneiss complex. Contacts with the gneisses appear concordant at all localities examined. The metasedimentary rocks include pelitic schists, quartzites and calc-schists, and are thus lithologically distinct from the gneisses. The largest of these metasedimentary bodies (northwest part of Fig. 1) caps a ridge and may represent a remnant of the main Kaza mass. Other bodies are in contact with gneisses on both top and bottom, and may be totally isolated within the gneiss terrane. These appear to represent isoclinally infolded Kaza rocks or possibly tectonically detached lenses. Terminations on these metasedimentary bodies have not been found.

Minor structures in the gneisses have been outlined previously[2]. In general, mineral lineation, widely developed in the main body of the gneisses, is only locally present within the northern half of the eastern extension of gneiss. Near contacts with the Gog, mineral lineation is virtually absent and the gneisses are typically more schistose.

The absence of primary sedimentary features and the overall migmatitic aspect of the gneiss complex contrast sharply with the metasedimentary nature of the surrounding units. This strongly suggests that the gneisses have had a more complex history and are likely older than the adjacent rocks; in any case they appear to be exotic with respect to their present geologic environment. The supposition that the gneisses predate the Kaza-Miette rocks would require that the gneiss contact with the Gog represents a dislocation of major proportions.

The complex fault-fold relationship between the gneissic terrane and enclosing rocks (east of the Trench), together with the apparent intermixing of gneisses and Kaza rocks (west of the Trench) indicate that the tectonic history was highly complicated; several enigmatic problems relating to the emplacement of the gneisses are not fully resolved at present.

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[1]Campbell, R.B.: Canoe River map-area (83D); in Report of Activities; May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 51-52 (1966).

[2]Giovanella, C.A.: Structural relationships of the metamorphic rocks along the Rocky Mountain Trench at Canoe River; in Report of Activities, Part A; May to October, 1966; Geol. Surv. Can., Paper 67-1A, pp. 60-62 (1967).

[3]Price, R.A.: Operation Bow-Athabasca, Alberta and British Columbia; in Report of Activities, Part A; May to October, 1966; Geol. Surv. Can., Paper 67-1A, pp. 106-112 (1967).

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16. RECONNAISSANCE OF AISHIHIK LAKE (115H), SNAG (115J and K(East Half)), AND A PORTION OF STEWART RIVER (115N(East Half)) MAP-AREAS, YUKON TERRITORY

L.H. Green

During the 1967 field season on month of field work was done in preparation for a future helicopter-supported mapping project. Earlier reconnaissance mapping is available for a number of small areas within the overall project area and the major units established in this work appear applicable.

Metamorphic rocks, previously assigned to the Yukon Group, underlie much of the area and are locally overlain by sedimentary and volcanic rocks of probable Mesozoic age; all have been intruded by younger granitic rocks of probable Cretaceous age. Rocks that post-date the younger granitic rocks occur locally and include intermediate to basic volcanic rocks, intermediate to acidic volcanic rocks with some associated hypabyssal rocks, and sedimentary rocks, principally conglomerate, sandstone, and shale.

Throughout much of the project area the metamorphic rocks may be divided into four sub-units similar to those described by Cockfield[1] in part of the Stewart River area:

1. 'Pelly gneiss' – principally quartz-feldspar-biotite and feldspar-hornblende gneiss.
2. 'Klondike schist' – strongly foliated, white to light green, quartz-white mica schist.
3. 'Nasina series' – metamorphic rocks formed through the alteration of sedimentary rocks, especially quartzite, graphitic phyllite, and limestone.
4. 'Amphibolite' – amphibolite and related rock types; usually of very local extent.

Contacts observed between rocks assigned to these sub-units appear gradational and differences between them are believed to reflect differences in original composition rather than intrusive relationships as suggested by Cockfield and other earlier workers.

Little definite information is available concerning the age of metamorphic rocks of the 'Yukon Group' or the complementary 'Birch Creek schist' in Alaska. A field relationship suggesting a probable Precambrian age, made near the Alaska boundary about 70 miles northwest of Dawson, Yukon, is not valid[2] as the rocks compared lie on opposite sides of Tintina Trench, a major structural feature. In the Whitehorse map-area, immediately southeast of the Aishihik Lake map-area, metamorphic rocks are overlain[3] by Mesozoic rocks including conglomerates that carry clasts of granitic and, rarely, foliated metamorphic rocks. Available age determinations from metamorphic and granitic rocks range between 223 and 58 million years.

One silver-lead deposit is currently being explored in the Snag map-area and a few showings of silver-lead, copper, tungsten, and placer gold have been reported elsewhere.

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[1]Cockfield, W.E.: Sixtymile and Ladue Rivers area, Yukon; Geol. Surv. Can., Mem. 123 (1921).

[2]Green, L.H. and Roddick, J.A.: Dawson, Larsen Creek, and Nash Creek map-areas, Yukon Territory; Geol. Surv. Can., Paper 62-7 (1962).

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

17. WHEATON RIVER AND HOMAN LAKE, YUKON AND BRITISH COLUMBIA (105 D/5, 104 M/14)

M.B. Lambert

Volcanic rocks of the Skukum Group[1] lie within a circular area about 12 miles in diameter, near the head of West Arm of Bennett Lake. They are completely surrounded by granitic rocks of the Coast intrusions[1,2]. Mapping on a scale of 1:25,000 was confined to the eastern half of the area, where a pile of gently to moderately dipping pyroclastic and sedimentary rocks are exposed for a vertical distance of about 5000 feet.

Near the north end of Partridge Lake, a massive unit, which includes a variety of light coloured volcanic breccias and tuffs, overlies shattered and brecciated hornblende granodiorite. This unit is 1000 to 1500 feet thick. Tuffs at the top of the unit grade upward into pale green to dark brown weathering ignimbrites. The ignimbrite sequence has a maximum thickness of about 2000 feet. Individual units within the sequence are commonly separated by discontinuous beds of granitic boulder conglomerate.

The ignimbrites are overlain by 250 feet of distinctive granitic-fragment breccia in which angular granitic blocks, ranging from 1 foot to 3 feet across, are set in a matrix consisting of angular granitic and crystal fragments. This unit is overlain by 500 to 1000 feet of very coarse granitic conglomerate, consisting of 1- to 10-foot boulders with interstitial green pebbly sandstone.

Well-bedded, pale greenish grey weathering sandstones, tuffaceous sandstones and siltstones comprise the top of the section. Poorly preserved plant fossils were found in the upper part of this unit.

A nearly vertical, 300- to 1500-foot thick, arcuate shaped porphyritic rhyolite dyke, which is continuous for at least 10 miles, occurs around the eastern periphery of the volcanic rocks. This dyke was probably emplaced along a major ring-shaped fracture system.

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

[2]Christie, R.L.: Geology of the plutonic rocks of the Coast Mountains in the vicinity of Bennett, British Columbia; PhD thesis, Univ. Toronto (1958).

18. CHILLIWACK GROUP - HARRISON LAKE AREA, BRITISH COLUMBIA (92 H/5, H/12)

B.E. Lowes

Field work begun in 1966[1] was completed, but much laboratory study remains.

The rock units have been described previously and only additional data are mentioned here. The easterly sequence of alumina-rich, pelitic schists with minor amphibolite, designated unit 3[1], are poly-metamorphic rocks displaying marked schistosity with post-kinematic upgrading to the staurolite-kyanite zone, and locally to the sillimanite zone, from an earlier lower grade of dynamothermal metamorphism. The superposed thermal metamorphism is apparently controlled by proximity to intrusive masses. In places strong metamorphic differentiation has taken place with marked enrichment of dark layers in CaO, FeO, MgO and Al_2O_3.

A belt of strongly deformed gabbroic rocks along the east side of Garnet Creek, and extending across Old Settler Mountain to the northwest, marks the probable northward continuation of the Shuksan Thrust. Much of the gabbroic mass closely resembles rocks of the basement complex found along the root zone of the Shuksan Thrust in the Cascade orogen of northern Washington[2]. Detailed petrography is required in order to unravel the complexity of this belt.

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[1]Lowes, B.E.: Chilliwack Group, Harrison Lake area; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1A, p. 74 (1967).

[2]Misch, P.: Tectonic evolution of the northern Cascades of Washington State; in Tectonic history and mineral deposits of the western Cordillera; Can. Inst. Mining Met.; Special Volume No. 8 (1966).

19. ATLIN HORST, BRITISH COLUMBIA (104 J, K, N)

J.W.H. Monger

Investigation of the stratigraphy and structure of late Palaeozoic rocks in the Atlin Horst[1] was continued in 1967. Detailed studies were made in the four areas indicated in Figure 1. In addition, samples for petrographic and palaeontological studies were collected from Late Permian rocks at Blue River, and from Early Pennsylvanian rocks at Screw Creek and Klinkit Lake (Fig. 1, localities BR, SC and KL respectively).

In Area 1 (Fig. 1) a thick volcanic sequence, originally thought to overlie Late Permian limestone and to be the youngest Palaeozoic unit[2], is now believed to underlie the limestone and to be laterally equivalent to mid- to Late Permian volcanic rocks that outcrop elsewhere in the area. The predominantly micritic, fusulinid-bearing, Late Permian limestone was traced northwesterly for at least 40 miles. It has been mapped farther northwest in Jennings River map-area (104O) by Watson and Mathews[3], and H. Gabrielse (personal communication, 1967) and was found in Area 2 (Fig. 1) in Atlin map-area (104N).

Rocks in Area 2 are deformed into tight northwesterly trending folds with near-vertical limbs. The oldest unit, whose base was not seen, consists largely of thin-bedded chert with argillaceous partings, and minor interbedded argillite and volcanic greywacke. This unit is overlain conformably by as much as 500 feet of greenstone, green to maroon tuff and agglomerate, and breccia containing greenstone and limestone clasts, which grade upward and possibly laterally into limestone. The limestone has an apparent thickness of about 1,000 feet, contains abundant fusulinids of mid (?)- to Late Permian age, and, where non-crystallized, varies from locally laminated, algal (?) micrite to less abundant fusulinid coquina. It appears to be overlain by thin-bedded chert but the contact was not directly observed. Unconformably above the late Palaeozoic strata are volcanic rocks that closely resemble Late Cretaceous or Early Tertiary rocks elsewhere in the region.

Area 3 (Fig. 1) is underlain largely by Late and possibly Early Permian massive fusulinid and crinoidal limestone with an apparent thickness of at least 4,000 feet. The repetition of fusulinid faunas with the limestone and the variable orientation of locally recognizable bedding, indicates considerable internal deformation; however, the common obscurity of bedding prevents the direct observation of folds. This limestone is predominantly bioclastic, in contrast to the largely micritic limestone of the same age in Areas 1 and 2. It apparently overlies thin-bedded chert and argillite of unknown thickness and is itself conformably overlain by about 5,000 feet of thin-bedded chert, in places tightly and irregularly folded. The chert locally

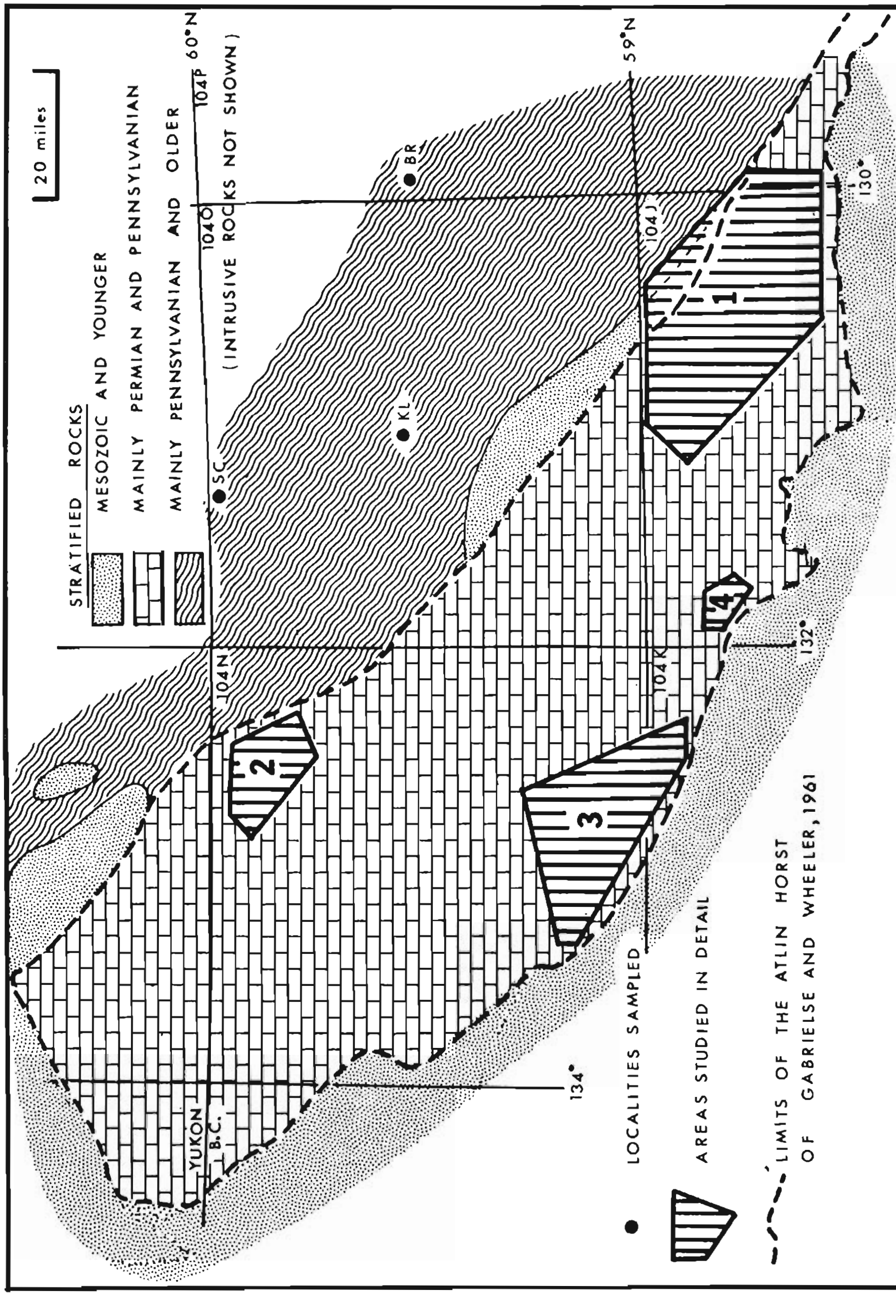

Figure 1. Location of areas of detailed mapping

grades into argillite and volcanic greywacke and contains lenses of shaly, cherty, and crinoidal limestone up to 100 feet thick. Above the chert is massive greenstone, evidently thousands of feet thick, that is the youngest Palaeozoic rock in this area. The greenstone contains scattered intrusions of serpentinite.

The massive bioclastic limestone, greenstone and chert of Area 3 extend southeasterly into Area 4.

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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, p. 2 (1961).

[2]Monger, J.W.H.: Atlin Horst Project; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1A, pp. 76-77 (1967).

[3]Watson, K. DeP. and Mathews, W.H.: The Tuya-Teslin area northern British Columbia; B.C. Dept. Mines, Bull. 19, p. 17 (1944).

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20. ALBERNI AREA, BRITISH COLUMBIA (92F)

J.E. Muller

Four weeks of field work were spent in the southwest quarter of the map-area (Tofino region) and two weeks on Texada Island. This completes mapping at 2 miles to the inch of the insular parts of the Alberni map-area.

Points of interest were: (1) the discovery, south of Kennedy Lake, of volcanic tuff and ignimbrite, lithologically similar to early Tertiary volcanic rocks elsewhere in British Columbia and Yukon, and (2) the finding south of Sproat Lake of sandstone and shale with marine fossils and plant remains, underlying reddish, light coloured volcanic breccia and tuff, and overlying Upper Triassic limestone (Geol. Surv. Can. Map 49-1963).

The beds contain poorly preserved pelecypods, several of which are probably referable to Trigonia (s.lato) ex gr. costata Sowerby. The species group is mostly characteristic of Lower and Middle Jurassic rocks in Europe and North America (H. Frebold and J.A. Jeletzky, personal communication).

These sediments could be correlative to beds of conglomerate and breccia with minor arenaceous and tuffaceous layers, underlying amygdaloidal or porphyritic bluish green lava and lilac red to green-grey tuff and breccia, at Mushroom Point on the west coast of Vancouver Island, reported by Jeletzky and assigned by him to the Bonanza Group. Jeletzky found no fossils in the Mushroom Point rocks but in 1954 he reported finding near Tatchu Creek sedimentary rocks, apparently overlying the Bonanza Group, and containing in the basal part also *Trigonia costata*, Sowerby.

21. COAST MOUNTAINS PROJECT, BRITISH COLUMBIA

J.A. Roddick and W.W. Hutchison

During the 1967 field season the initial reconnaissance of the Coast Mountains was extended south from 52°N, through Rivers Inlet (92M) map-area and into Alert Bay (92L) and Mount Waddington (92N) map-areas, a total area of more than 10,000 square miles (see Fig. 1). Shore exposures were examined in some detail and sampled at half-mile intervals; the inland terrain was covered mainly by spot examinations on the ridges and by a few ground traverses across metasedimentary belts.

Operational methods were mainly an outgrowth of those initiated in 1965. To improve specimen control, all specimens were photographed, normally in traverse lots. Specific gravity determinations were run routinely on all homogenous specimens. All specimens of granitoid rock were stained for K-feldspar content. Also, the initial etching by hydrofluoric acid greatly facilitated determinations of quartz content. To bring out textural relationships most specimens were sawn before staining.

For two months the operation was based on the VELELLA, a research barge kindly loaned by the Fisheries Research Board. A small tugboat was chartered for the season to move the barge. A flat-deck barge was used as a helicopter base and for storage of aviation fuel and excess gear. The party was supported by helicopter for about seven weeks.

Geological data of a definite nature ('hard' data) was coded and recorded on printed sheets (one per station) and later key-punched. Geological observations of a descriptive nature were recorded on small portable tape recorders, and the original tapes were filed after being transcribed on to large indexed master tapes. No written transcription was attempted.

For each specimen the location, rock type, specific gravity, estimated mineral composition (after staining), etc. were recorded on printed sheets and later key-punched. A separate card file for digitizing station coordinates is being attempted.

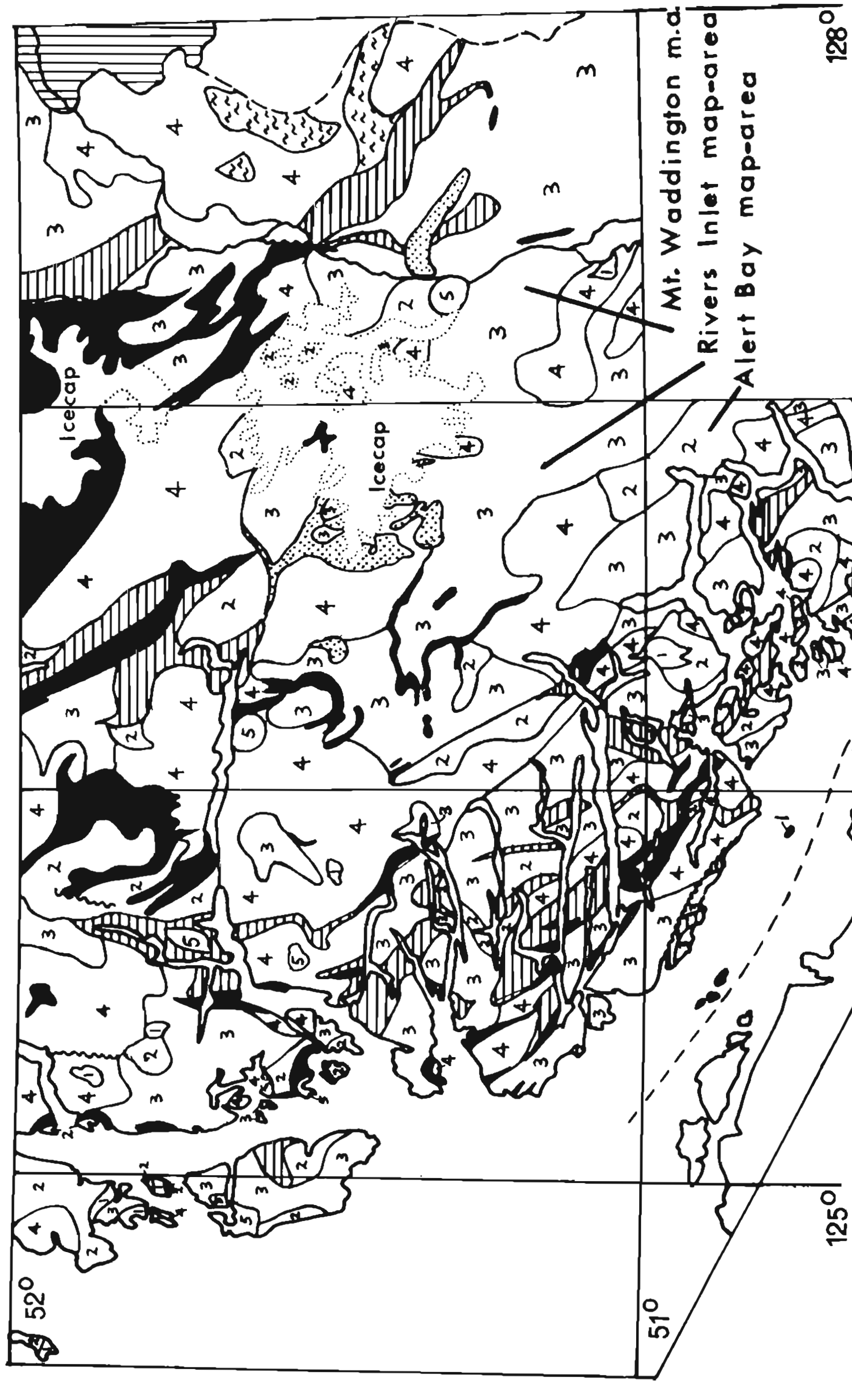

Icecap
Icecap
Mt. Waddington m.d.
Rivers Inlet map-area
Alert Bay map-area
52°
51°
125°
128°
40 miles

FIGURE 1.

L E G E N D

STRATIFIED ROCKS

QUATERNARY AND OLDER(?)

Dacitic and basaltic flows, tuffs, and breccias

MESOZOIC

Sedimentary and volcanic rocks

CRETACEOUS AND OLDER

Schists, gneiss, quartzite; crystalline limestone and volcanic rocks

MESOZOIC AND PALAEOZOIC(?)

Granitoid gneiss

Migmatite

PLUTONIC ROCKS

5 Mainly quartz monzonite

4 Mainly granodiorite

3 Mainly quartz diorite

2 Mainly diorite

1 Gabbro and diorite

limits of icefield

geological contact

limit of mapping

fault

Shore exposures are nearly continuous. On the outer coast especially, exposures are excellent, but in the fiords marine life (mainly kelp, mussels and barnacles) and a black surface scum hamper observations. On the ridges the best exposures are associated with ice-fields. Elsewhere lichen partly obscures the rock. Between the ridges and the shore, dense coastal rain forest limits outcrops to scattered cliffs and creek bottoms.

Northwest-trending structures which dominate the northern Coast Mountains, extend through the present project area. Both the central metasedimentary belt and the gneiss belt that lies east of it in the northern Coast Mountains, become fragmented in Rivers Inlet and Mount Waddington map-areas. Complex migmatites are more abundant along the west side of the project area, in contrast to the more easterly parts where large areas are underlain by comparatively homogenous plutonic rock.

The oldest rock in the region is thought to be the granitoid gneiss in the Mount Waddington map-area. From a distance the gneiss is indistinguishable from massive plutonic rock. Closer inspection, however, reveals complex nebulitic structures with variable but dominantly northwest trends and moderate to steep dips.

The metasedimentary rocks are mainly schists and fine-grained gneisses but the principal central belts are characterized by 200 to 300 feet of crystalline limestone. One of these bands appears to be offset about 18 miles left-laterally along Owikeno Lake, or possibly may pass beneath it. Near the coast many of the metasedimentary bands consist mainly of thin-bedded quartzite intercalated with crystalline limestone and skarn. In places these beds are associated with massive greenstones that locally exhibit pillows. High grade metamorphic minerals are rare in all of the metasedimentary rocks, and restricted to a few occurrences of sillimanite in the eastern half of the project area. Mineral assemblages in most of the metasedimentary rocks indicate temperatures no higher than amphibolite grade.

Underlying the northeast corner of Rivers Inlet map-area and the northwest corner of Mount Waddington map-area is a thick massive greenstone unit of probable Triassic age, overlain unconformably by slaty argillaceous and limy rocks of probable Lower Cretaceous age (see report of H.W. Tipper, this volume). These sediments are only gently deformed.

On Harbledown Island two sequences of thin-bedded black argillite are separated by a feldspar porphyry intrusive. One contains pseudomonotis of Upper Triassic age and the other large ammonites, probably of Lower Jurassic age.

The plutonic rocks in the project area range from gabbro to quartz monzonite. No mappable bodies of granite are present although local concentrations of K-feldspar in quartz monzonite results in rare specimens of granite composition. Quartz diorite is the most abundant plutonic rock, followed by granodiorite and then by diorite.

Hornblende gabbro normally grades into hornblende diorite in the project area. On the basis of a study of the specific gravity of the plutonic rocks in the northern Coast Mountains, diorite and gabbro were divided at a specific gravity of 2.905. Except for one body in southern Mount Waddington map-area, gabbro is restricted to the western quarter of the project area.

Diorite is similarly concentrated mainly in the west. Most of the dioritic terrane is very heterogeneous, containing numerous migmatitic zones, and thin bands of metasedimentary rocks and fine-grained gneisses. The dioritic rocks grade into surrounding rocks, and are rarely well-defined.

The largest masses of quartz diorite underlie southwestern Mount Waddington and southeastern Rivers Inlet map-areas. It commonly contains a high percentage of amphibolitic inclusions and numerous areas of migmatite and gneissic rock. Hornblende is the dominant mafic mineral in most of the quartz diorites.

Much of the granodiorite is concentrated across the northern part of the project area. Individual plutons, however, commonly trend northwest. Much of the granodiorite is a clean, light weathering, coarse-grained rock containing few inclusions. The central parts of granodiorite plutons are commonly massive.

Quartz monzonite appears in small homogeneous plutons with sharp contacts. They are smaller and less abundant than farther north.

The region is cut by many synplutonic dykes which are extensively altered by the plutonic rock they cut. Later dykes of basaltic, andesitic and dacitic composition are also abundant. In places they are concentrated in swarms, such as on the southwest shore of Broughton Island where they number about 100 per mile. They range in thickness from about 6 inches to 20 feet and trend about W20°N.

The Silverthrone volcanic complex overlies about 30 square miles of crystalline terrane in the east-central part of Rivers Inlet and adjacent part of Mount Waddington map-areas. A thick explosion breccia containing large granitic, metamorphic and volcanic blocks in a light coloured, welded tuff matrix forms a basal member that is several thousand feet thick. It is overlain by thick siliceous flows and minor fluvial material, which in turn are overlain in places by basaltic flows and tuff-breccia (see report by J.G. Souther, this volume). The siliceous flows are well-glaciated but some of the basalt overlies till in the valley of Pashleth Creek.

Rivers Inlet map-area has a pronounced east-west physiographic pattern. It may be attributed to strong jointing in the plutonic rock, but no reason for jointing developing in that direction is apparent.

22. CORDILLERAN VOLCANIC STUDY, 1967 BRITISH COLUMBIA (104 G/7, G/10, G/15, G/16)

J.G. Souther

As part of the continuing study of young volcanic rocks in the Canadian Cordillera three volcanic centres were visited during the field season: Mount Edziza, Mount Silverthrone, and the large shield volcanoes north of Anahim Lake.

Detailed mapping of Mount Edziza, begun in 1965, was completed and, in conjunction with D.T.A. Symons of the Exploration Geophysics Division, samples were collected for palaeomagnetic study. The latter work was carried out on three typical sections around the periphery of the main cone of Mount Edziza. Each section contains from 30 to 50 flows and spans an interval of time extending from mid-Tertiary to Recent. Oriented drill-cores as well as specimens for chemical and petrographic study were taken from each flow. Magnetic pole positions (to be determined by D.T.A. Symons from the cores) are expected to provide the absolute age of individual flows and hence a measure of the rate and duration of successive pulses of volcanic activity. A profile of normally and reversely magnetized units is also being prepared in an attempt to correlate the Edziza pile with Tertiary lavas in other parts of the Cordillera.

A brief visit was made to the Mount Silverthrone volcanic complex in Rivers Inlet map-area and specimens were collected for chemical and petrographic study. The complex underlies about 30 square miles in the central part of the Coast Crystalline Complex. The lowest unit is an explosion breccia containing large (up to 10 feet) angular and subangular clasts of granitic, metamorphic and volcanic rocks in a white to light grey matrix of welded chards. The breccia is exposed from the bottoms of the valleys through a vertical distance of at least 3,000 feet. Contacts with the older crystalline rocks of the adjacent peaks are steep, suggesting that the breccia may occupy a fault-bounded collapse structure. The breccia is overlain by thick lenticular flows of rhyolite and dacite (?) and locally by fluvial gravel and boulder beds. A thick sequence of basalt flows, scoria and palagonite tuff-breccia forms the upper part of the pile and rests on an irregular surface that cuts across the explosion breccia and the older, more acid, lavas. The explosion breccia is cut by a closely spaced swarm of highly irregular basalt dykes that probably form part of the feeder system for the overlying basalt flows and scoria. Although the poorly consolidated material near the centre of eruption is thoroughly dissected, the topography of the surrounding granitic rocks has been little altered since the basalt was erupted. Many of the basalt flows occupy existing valleys and are probably no older than early Pleistocene.

A helicopter reconnaissance of the Rainbow, Ilgachuz, and Itcha Ranges was made in connection with a study of the Plateau Lavas being undertaken jointly with H.W. Tipper. Each range comprises a large, moderately dissected shield volcano with a central core of rhyolite, dacite and andesite flows and domes, and an outer skin of basalt. The latter appears to spread over a vast area and constitutes at least the upper part of the Plateau Lava succession in Anahim Lake map-area. Oriented drill-cores were taken from various units within the ranges and from the adjacent Plateau Lavas. It is hoped that palaeomagnetic data from the cores can be used to establish the age relationship between the shield volcanoes and the adjacent Plateau Lavas.

23. GEOLOGIC SETTING OF THE FARO, VANGORDA AND SWIM BASE METAL DEPOSITS, YUKON TERRITORY (105 K)

D.J. Templeman-Kluit

A stratigraphic and structural study of the Anvil Range in Tay River map-area (105K) was begun in 1967 to provide geological data for assistance to mineral exploration and for assessment of mineral potential of the region including the Faro, Vangorda and Swim base metal deposits. The writer gratefully acknowledges the assistance given him by various mining companies and individuals operating in the area.

Anvil Range is underlain by a sequence of Proterozoic and Palaeozoic strata similar to that found over a wide area to the south and southeast. The sequence includes two unconformities of regional significance, one beneath Devono-Mississippian strata and another below late Palaeozoic volcanic sequence. The minimum aggregate thickness of Palaeozoic strata is about 20,000 feet. The area studied is bounded on the southwest by Tintina Trench, the locus of a regional transcurrent fault.

Gritty grey micaceous quartzites (unit 1; see Fig. 1) of unknown thickness and stratigraphic relations, constitute what is thought to be the oldest rock unit in the area. Unit 1 is lithologically correlated with the Proterozoic 'Grit Unit' that occurs extensively north and northeast of the map-area.

Unit 2 is a 2,000-foot thick sequence of argillaceous calc-silicate rocks that represents an originally limy, thin-bedded and fine-grained, dominantly sedimentary succession. The unit includes in its upper part (?) a 200- or 300-foot thick section in which beds of light grey marble, some as much as 50 feet thick, are prominent. Thin lenses of amphibolite, probably of volcanic origin, are common.

The phyllite of unit 3, probably about 3,000 feet thick, contains greenstone lenses as much as 50 feet thick that are probably tuffaceous; the phyllite itself may contain a considerable proportion of tuffaceous material.

Units 2 and 3 are similarly deformed and are pre-Ordovician; they show none of the distinctive lithologic characteristics of the Proterozoic 'Grit Unit' and are therefore assigned a Cambrian age. Unit 2 is similar to strata of Lower Cambrian age in southeastern Yukon. The stratigraphic relations between units 2 and 3 are uncertain; unit 3 may be older than unit 2.

Although the schists of unit 3a occur close to the Anvil batholith, changes in metamorphic grade bear no distinct relationship to distance from it, and their mineralogy suggests a regional metamorphic origin. Unit 3a is at least in part the metamorphic equivalent of unit 3, but it may also include older rocks. The presumed regional metamorphism of unit 3a is thought to be pre-Devonian.

The phyllite of unit 3 apparently grades upward into thinly laminated, ochre-coloured, calcareous siltstone (unit 4) which is lithologically correlated with Middle and Upper Cambrian strata in Frances Lake map-area. Unit 4 is at least 1,000 feet thick.

Dark graptolitic slates (unit 5), of probable Silurian age, are the oldest fossiliferous rocks in the area. They are believed to overlie the siltstones of unit 4 directly and are at least 400 feet thick.

Orthoquartzite (unit 6), about 100 feet thick, overlies the graptolitic slate conformably at one locality. Elsewhere orthoquartzite is associated with fossiliferous Middle Devonian carbonate rocks (unit 7). The rocks of units 6 and 7 are correlated with similar strata found to the southeast in other Yukon map-areas.

Unit 8, probably in the order of 10,000 feet thick, rests unconformably on rocks of units 3, 4, 5, 6 and 7. Though not investigated in detail rocks of unit 8 are known to range in age from Late Devonian to Mississippian[2], and are correlated with similar strata that occur extensively throughout this and adjacent map-areas.

L E G E N D
(for figure 1)

MESOZOIC

CRETACEOUS

12	12a. Medium- to fine-grained equigranular muscovite biotite granodiorite 12b. Medium-grained porphyritic (K feldspar) biotite quartz monzonite

PERMIAN OR YOUNGER

11	Massive cobble and pebble conglomerate with fragments of mica quartz schist (1), andesite (9a), chert (9b), limestone (?), serpentine (10).
10	Serpentine, serpentinized peridotite

PALAEOZOIC

PENNSYLVANIAN AND/OR PERMIAN
MIDDLE AND UPPER PENNSYLVANIAN (?)

9	9a. Massive, green andesitic volcanic rocks, commonly amygdaloidal; includes common pyroclastic and less common pillowed varieties. 9b. Grey, green and red argillaceous chert and chert pebble conglomerate.

DEVONIAN AND MISSISSIPPIAN
UPPER DEVONIAN AND MISSISSIPPIAN

8	Massive medium and dark grey chert; medium grey limy slate and argillaceous chert; chert pebble grit.

SILURIAN (?) AND DEVONIAN
MIDDLE DEVONIAN

7	7a. Medium to dark grey platy, thin-bedded, fetid limestone. 7b. Massive light grey dolomitic limestone.
6	Massive, medium to light grey orthoquartzite.

ORDOVICIAN (?) AND SILURIAN

5	Dark grey to black graphitic graptolitic slate.

CAMBRIAN AND/OR EARLIER (?)
MIDDLE AND UPPER CAMBRIAN (?)

4	Buff weathering, thinly laminated, ochre-coloured, calcareous siltstone and phyllitic siltstone.
3	Medium grey chlorite quartz phyllite, locally graphitic or calcareous; foliated green chloritic tuff: 3a garnet, staurolite, biotite, quartz schist.

PROTEROZOIC

LOWER CAMBRIAN (?)

2	Thinly laminated biotite-garnet-diopside-quartz-skarn: light grey marble; amphibolite.
1	Light grey, massive and thin bedded, muscovite quartz schist and micaceous quartzite, locally gritty; minor graphitic micaceous quartzite.

A	Stratigraphic position uncertain, probably Cambrian possibly equivalent to 4: white weathering, banded limy siltstone and phyllitic siltstone; hornfels.

Areas of little or no outcrop

Geological boundary (defined, approximate, assumed)

Limit of geological mapping

Bedding, inclined

Foliation, inclined

Fault (defined, assumed)

F Fossil locality

Mineral deposit

×87 Isotopic age determination with age in M.Y.

LEGEND
(for figures 3 & 4)

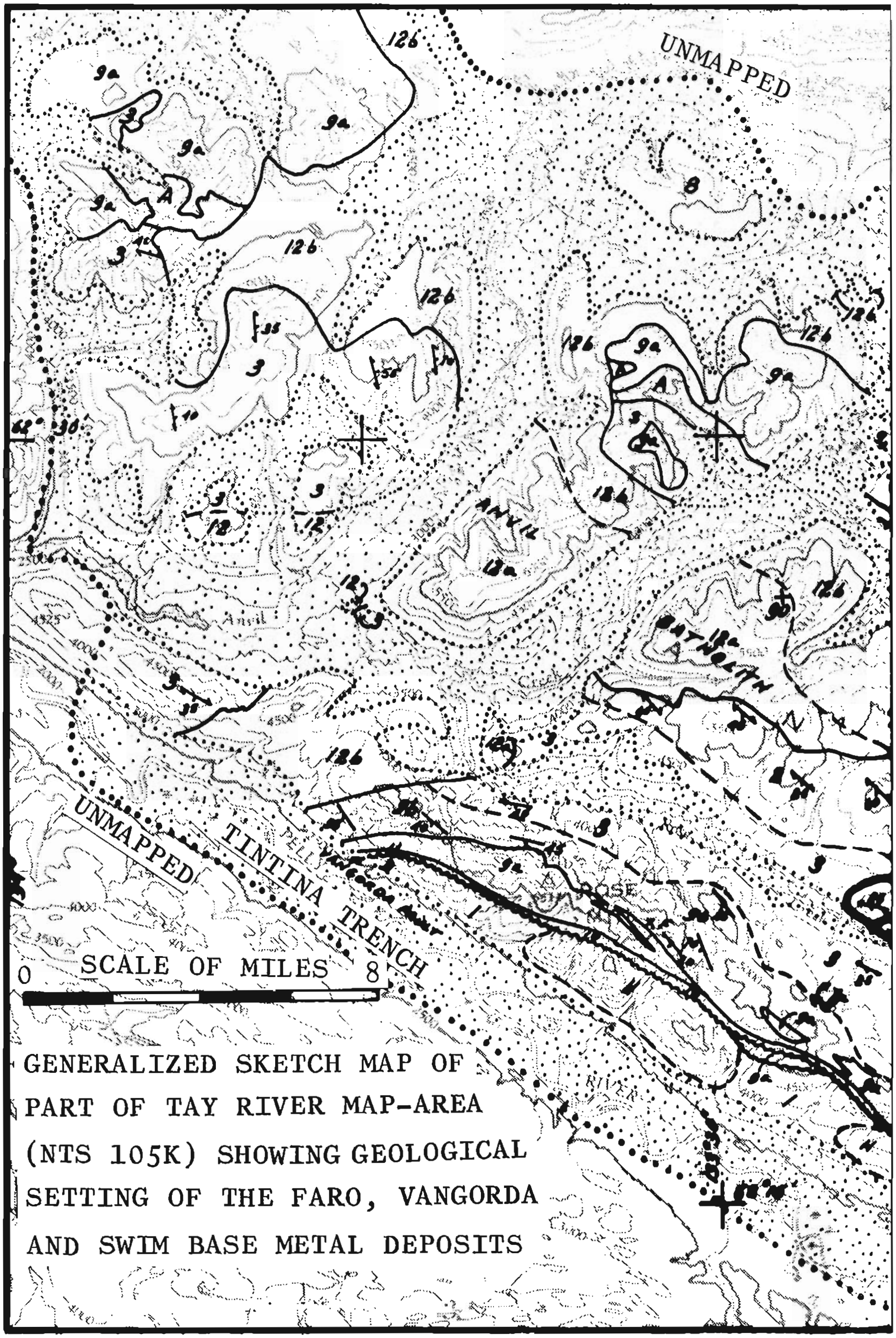
Locally graphitic chlorite quartz phyllite

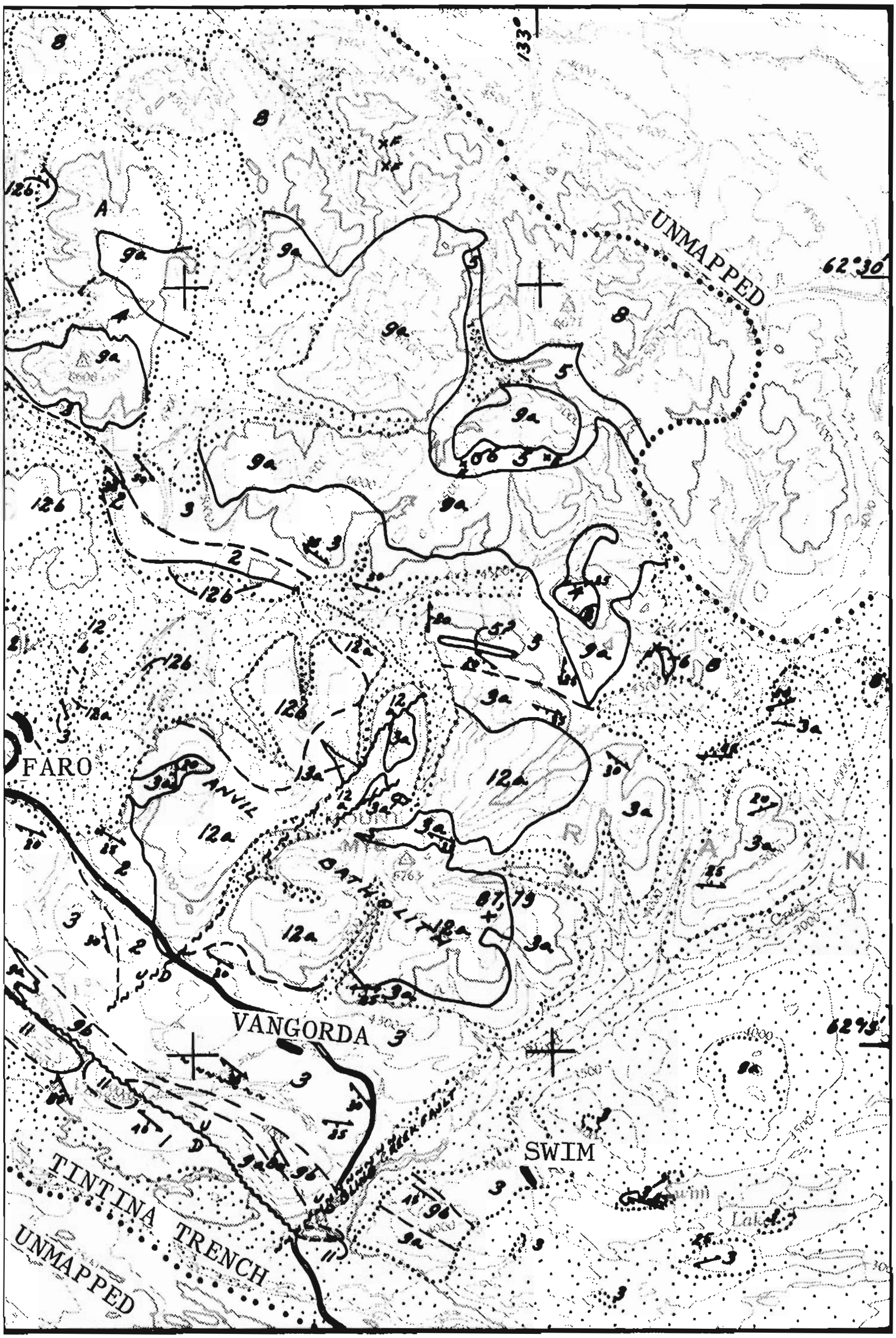
"Bleached" phyllite

Massive and banded sulphides

Disseminated and banded sulphides

Chloritic tuffaceous greenstone


UNMAPPED
UNMAPPED
TINTINA TRENCH
ANVIL
BATHOLITH
SCALE OF MILES
0
8
GENERALIZED SKETCH MAP OF
PART OF TAY RIVER MAP-AREA
(NTS 105K) SHOWING GEOLOGICAL
SETTING OF THE FARO, VANGORDA
AND SWIM BASE METAL DEPOSITS


133°
UNMAPPED
62°30'
FARO
ANVIL
BATHOLITH
VANGORDA
SWIM
TINTINA TRENCH
UNMAPPED
62°15'

Rocks of unit 9 overlie those of units 2, 3, 4, 5, 6, 7 and 8 unconformably. On and near Rose Mountain, unit 9 includes a lower member of argillaceous chert (unit 9b), about 2,000 feet thick, and an upper, conformable member, at least 1,500 feet thick, of massive andesite (unit 9a). Lateral facies changes from chert to andesite are common and thicknesses of the two members vary from place to place. North of the Anvil batholith unit 9 includes massive, amygdaloidal, pyroclastic and pillowed andesites, but the lower argillaceous chert member is generally thin or absent. A limestone bed, 2 feet thick, near the top of the chert member (unit 9b) on Rose Mountain contains fusulinids tentatively assigned a Late Pennsylvanian or Early Permian age.

Massive, well-indurated conglomerate (unit 11) up to 2,000 feet thick and with pebbles and cobbles of locally derived rocks, unconformably overlies unit 1 southwest of the Vangorda fault. This conglomerate probably formed at the base of a fault scarp resulting from displacement on the Vangorda fault and is of post-Pennsylvanian, possibly Mesozoic, age. The absence of granitic pebbles in the conglomerate seems to preclude an age younger than mid-Cretaceous.

The core of the Anvil Range is underlain by granitic rocks (unit 12) of two dominant and apparently related types. Contacts between units 12a and 12b are gradational, but contacts between these and enclosing metamorphic rocks are sharp. Along the south contact of the batholith on Mount Mye the granodiorite has a distinct cataclastic, foliated texture and the rock locally grades to muscovite augen-gneiss. Potassium-argon age determinations[3] suggest an early Upper Cretaceous age (i.e. 80-90 m.y.) for the Anvil batholith.

The structure of the Anvil Range is dominated by a doubly plunging, arch-like feature around the Anvil batholith that is probably related to intrusion of the granitic rocks and thus Mesozoic in age. Transposition or gleitbrett structures and a related strong crenulation foliation characterize the style of deformation of the Cambrian strata and obscure their internal stratigraphy. The foliation is arched around the Anvil batholith so that it dips northeast on its northeast flank and southwest on the opposite flank. Bedding attitudes in the Cambrian rocks show no consistent relationship to the foliation. Linear elements related to development of the crenulation foliation trend northwest. The Devono-Mississippian strata are less strongly deformed than the Cambrian rocks, the characteristic planar structure being an axial-plane foliation related to relatively open folds. Unit 9 is essentially undeformed, though weak development of foliation is locally evident in the argillaceous chert (unit 9b). Conglomerates (unit 11) are irregularly fractured.

The Vangorda fault is a steeply dipping structure, probably related to the Tintina fault zone. It is associated with a narrow serpentine belt (unit 10) and has brought rocks of unit 1 against those of unit 9, indicating an apparent vertical displacement in the order of 10,000 or 20,000 feet. Whether lateral displacement was associated with this apparent vertical movement is unknown. The Blind Creek fault has an apparent left lateral offset of 6,000 feet.

Following are brief descriptions of the three important base metal deposits, based in part on an examination of drill-core. The accompanying sketches show representative cross-sections of the deposits.

Cambrian phyllitic rocks of unit 3 are host rocks for the three economically important sulphide masses and are also host to several smaller, presently non-economic deposits in the area. The Faro body occurs close to the contact between units 2 and 3, but the Vangorda and Swim deposits do not. There is no apparent relation of the deposits to a particular stratigraphic horizon within unit 3 and the phyllitic host rocks near the deposits are the same as those elsewhere. The regional (?) metamorphic grade of the host rocks varies from moderate (biotite, andalusite) grade at Faro through intermediate (chlorite) grade at Vangorda to low (sericite) grade at Swim. Chloritic tuffaceous greenstone outcrops close to all three deposits, but is nowhere immediately against ore. Graphite is present in phyllites around all three deposits, but it is far more important around the Swim body than near the Vangorda or Faro deposits.

Local controls for emplacement of sulphides are as yet unknown. There is no evidence that graphite content of host rocks, proximity to granitic rocks, and relationship to the Tintina fault or northeast striking faults, cited elsewhere[1] as possible controls, are significant.

The three deposits are mineralogically similar. Primary sulphides, in order of abundance, include pyrite, pyrrhotite, sphalerite, galena and minor chalcopyrite. Tetrahedrite, bournonite and arsenopyrite have been identified as minor or trace constituents. Marcasite is the important secondary mineral; anglesite, goethite and gypsum occur sparingly. Quartz is the only important gangue mineral. In the Swim and Vangorda deposits barite (?) also occurs. Sphalerite, galena, chalcopyrite and tetrahedrite occur as inclusions in pyrite and interstitial to pyrite grains. The ores have a granular texture and probably average around 50 per cent sulphides. Proportions of the various sulphides are remarkably constant throughout individual deposits and between the deposits. Grain size of the sulphides varies within the deposits and from one deposit to another, but the average grain size in the Faro is distinctly coarser than that at Vangorda, which in turn is coarser than the Swim. Pyrite grains are generally coarser than those of other sulphides.

Structures in the ore range from a faint regular banding, apparently conformable with the foliation of host rocks, in the Faro deposit, to faithful replacements of laminae involved in transposition structures in the Swim body. The Vangorda deposit shows both types of structures. The general shape of the deposits is tabular; the plane in which they lie conforms broadly

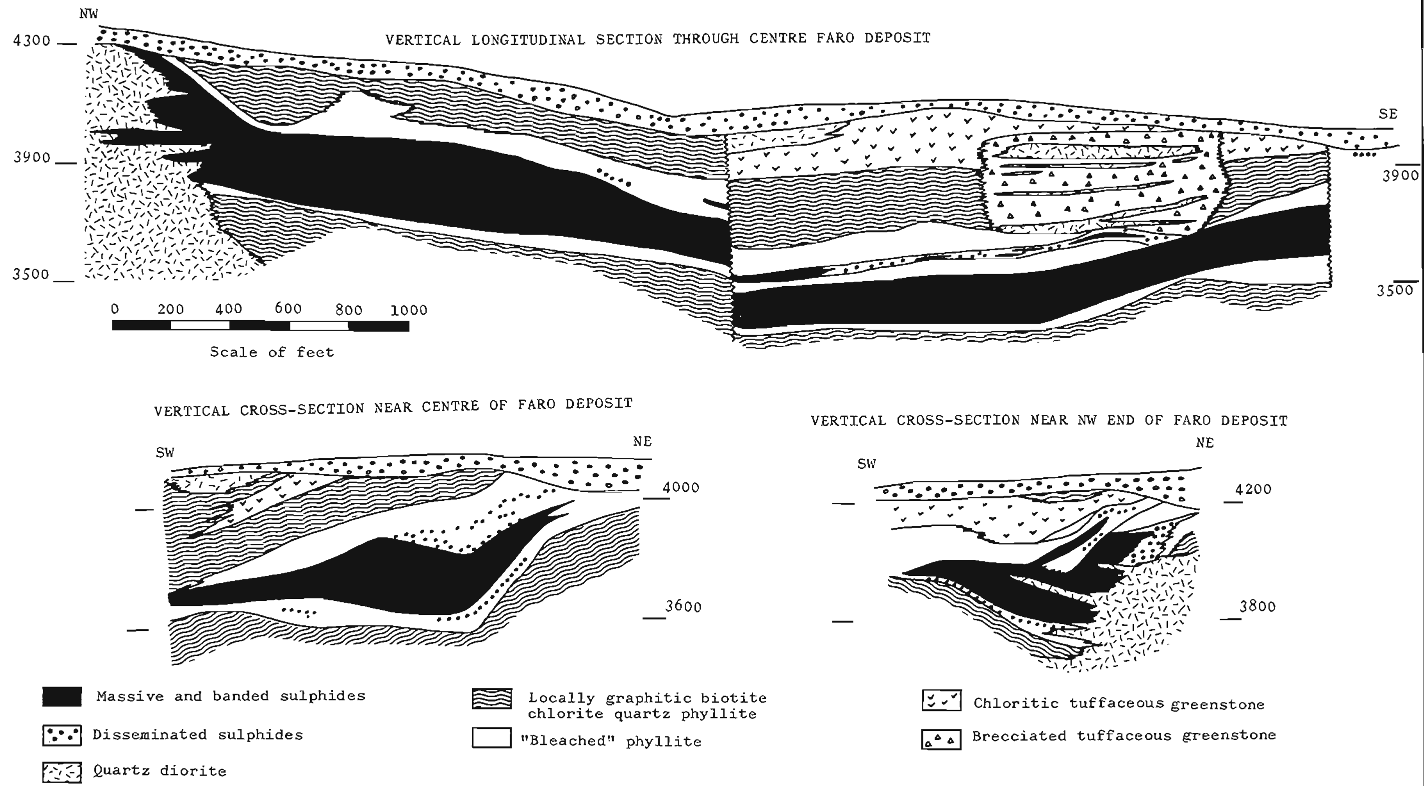
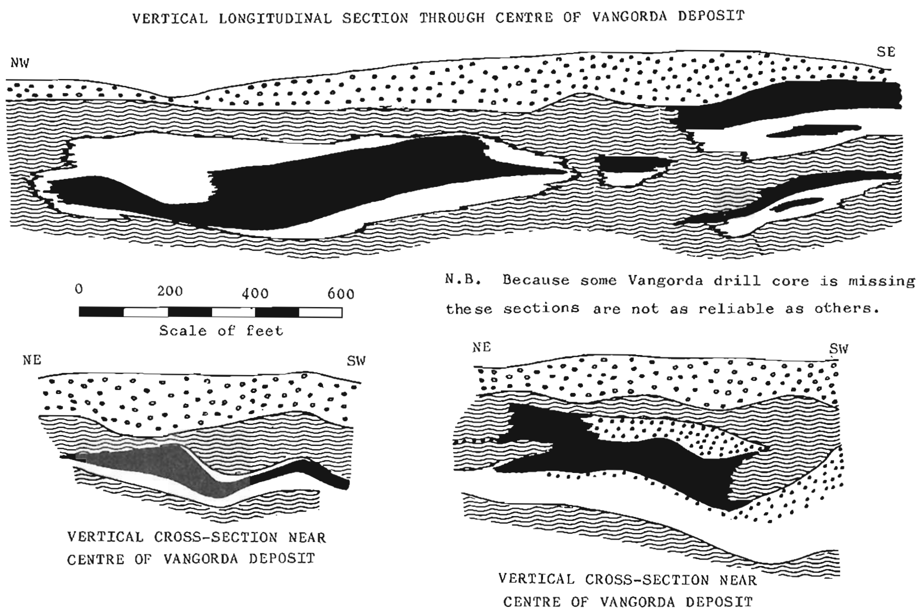


FIGURE 2 VERTICAL CROSS-SECTIONS FARO DEPOSIT

FIGURE 3 VERTICAL CROSS-SECTIONS VANGORDA DEPOSIT



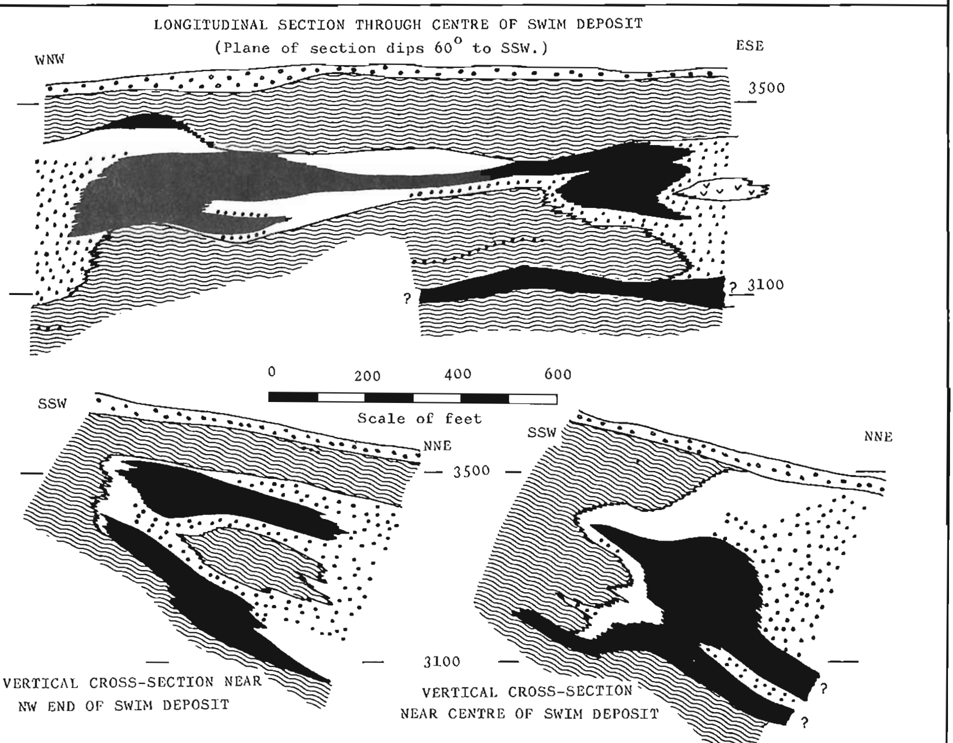


FIGURE 4 CROSS-SECTIONS SWIM DEPOSIT

to the crenulation foliation in the enclosing phyllitic strata and their long axes coincide with the intersection of this foliation and the bedding of the host rocks.

An irregular envelope of bleached rocks, locally 100 or 200 feet thick, enriched in silica, alumina and perhaps soda and potash relative to iron and magnesia, occurs around all three deposits. No other alteration effects are evident. A suite of drill-core samples from each of the three mineral deposits, collected by the writer, will be used for a bedrock geochemical study.

In the writer's opinion the deposits are early (i.e. Cambrian?) replacements of consolidated or unconsolidated quartz-rich parts of a tuffaceous Cambrian sediment. These sediments were later deformed, perhaps synchronously with regional(?) metamorphism in post-Cambrian, pre-Devonian time. Volcanism may have played an important part in the original emplacement of the sulphides. During deformation and metamorphism of the host rocks the sulphides were recrystallized and the alteration envelope formed. The Faro body was probably recrystallized for a second time during emplacement of the Anvil batholith.

In view of the foregoing, the Cambrian strata – exposed in several adjacent map-areas on both sides of Tintina Trench – are expected to prove fruitful ground for careful exploration for lead-zinc and possibly other metals such as copper.

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[2]Roddick, J.A. and Green, L.H.: Tay River map-area, Yukon Territory; Geol. Surv. Can., Map 13-1961 (1961).

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24. NORTHEASTERN PART OF MOUNT WADDINGTON MAP-AREA, BRITISH COLUMBIA (92N)

H.W. Tipper

The northeastern part of the Waddington map-area, is underlain mainly by sedimentary and volcanic rocks (Fig. 1). The metamorphic and plutonic rocks of this area are described elsewhere in this report by J.A. Roddick and W.W. Hutchison.

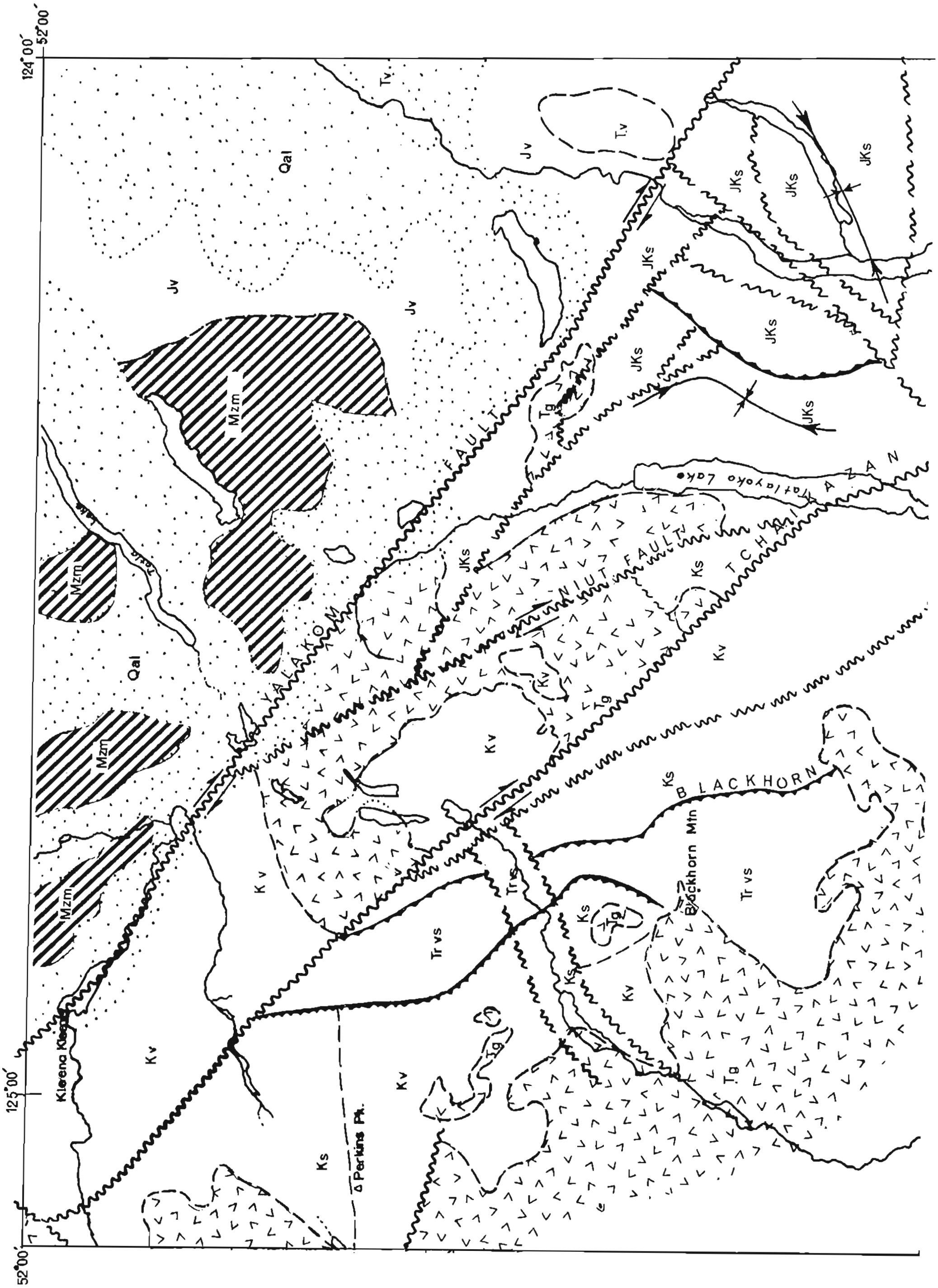
The volcanic and sedimentary rocks can be referred to three district areas, (a) northeast of Yalakom fault, (b) between Yalakom and Tchaikazan faults and east of Niut fault, and (c) the area southwest of (a) and (b). The rocks northeast of Yalakom fault (area a) are mainly Middle Jurassic volcanic (Jr) and metamorphic (Mzm) rocks; the Tertiary rocks (Tv) are flat-lying plateau basalts. The rocks of area b (JKs) are mainly greywacke, arkose, shale, and conglomerate ranging in age from early (?) Jurassic to late Early Cretaceous. The rocks of the third area are mainly Upper Triassic volcanic and sedimentary rocks (Ttvs) overlain unconformably by a group of sedimentary and volcanic rocks (Kr and Ks) of Mid-Early Cretaceous to Early Late Cretaceous age.

Granitic rocks forming part of a group of undivided plutonic rocks and metamorphic rocks (Tg) were emplaced, mainly or entirely, in late Late Cretaceous or early Tertiary time.

Faulting is the characteristic structural style of the area; the few folds recognized can be related to fault movements. The Blackhorn fault is a low angle fault in which Upper Triassic rocks have been thrust onto Cretaceous rocks. The Yalakom, Niut, and Tchaikazan faults are right-lateral transcurrent faults, younger than the Blackhorn thrust fault, that have brought three lithologically dissimilar terrains into juxtaposition.

Normal faults, later than the transcurrent movements, commonly trend northeast.

Several mineral deposits were previously known in the area and a few mineral occurrences were noted during field work. Copper minerals, mainly chalcopyrite, malachite, and bornite were noted near the volcanic-granitic contact northwest of Tatlayoko Lake, near the granitic contact south of Blackhorn Mountain, and in the Cretaceous volcanic rocks west of Chilko Lake. All of these occurrences are minor.


124°00'
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Qal
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NIUT FAULT
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BLACKHORN
Blackhorn Mtn
Tatlayoko Lake
Δ Perkins Pk.
Kleena Kleene

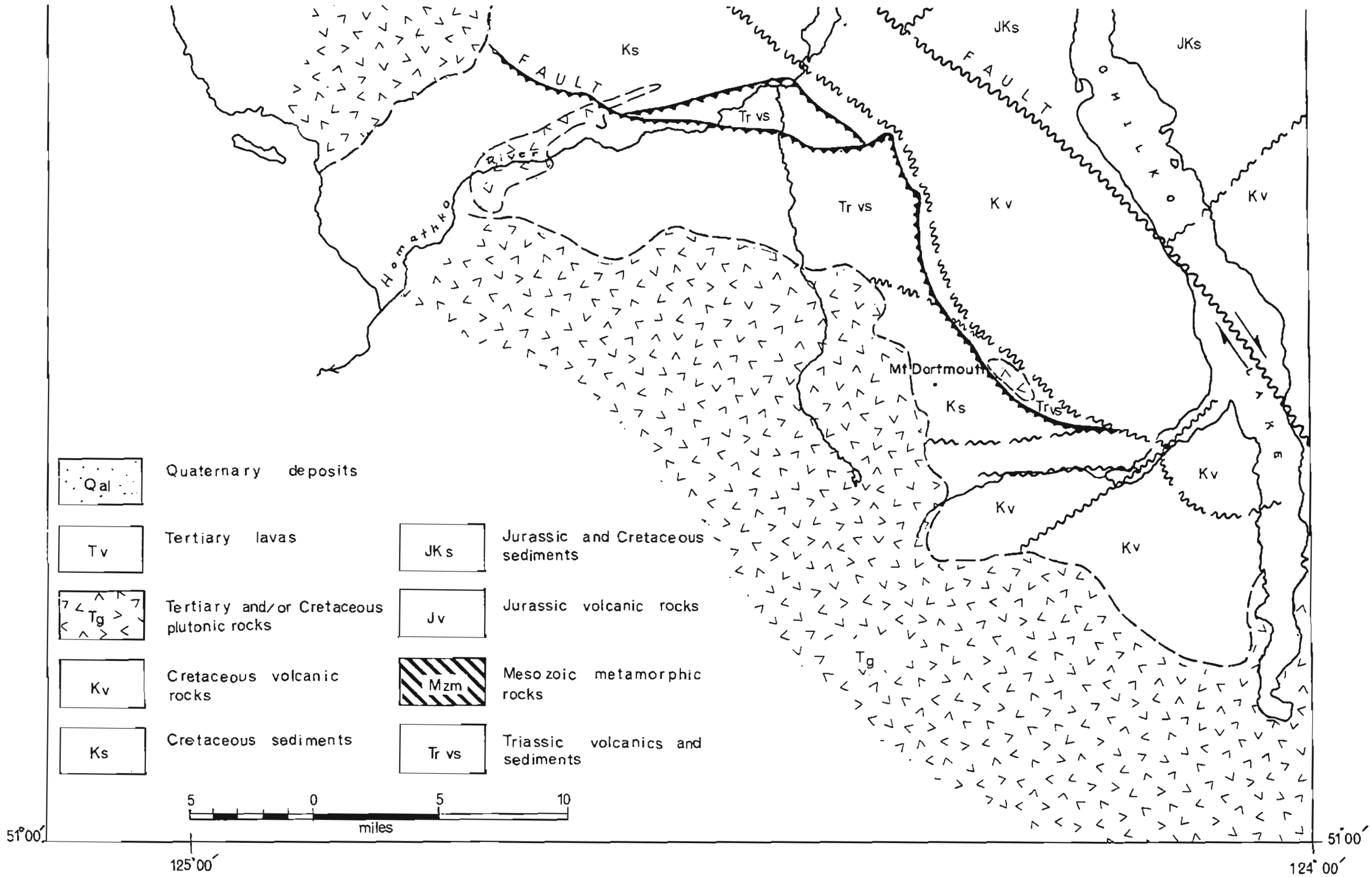

Figure 1. Sketch map showing geology of northeastern part of Mount Waddington map-area.

25. LARDEAU (WEST HALF) MAP-AREA BRITISH COLUMBIA, (82K (WEST HALF))

J.O. Wheeler

Field work was completed for publication at 1 inch to 4 miles. This involved new mapping, revision of that done nearly 40 years ago[1,2], and incorporation of several smaller areas mapped recently at scales of 2 inches to 1 mile and larger[3,4,5,6,7,8,10].

The geology of the map-area may be subdivided into three northwest-trending belts. The northeastern belt lies east of Columbia River north of Upper Arrow Lake and northeast of the valley of Trout Lake and Lardeau River. The central belt lies between Lardeau River, Upper Arrow Lake, and the road between Nakusp and Slocan Lake. The southwestern belt occupies the remaining part of the map-area exclusive of that west of Upper Arrow Lake underlain by Shuswap Metamorphic Complex and less metamorphosed sediments of the Milford and Slocan Groups.

The geology of the northeastern belt comprises the following map-units. The Battle Range granitic pluton, intrusive into Lower Cambrian and later sediments, occupies much of the northernmost part of the area west of Purcell Trench. Grits and argillites of the Proterozoic Horsethief Creek Group are restricted to the Purcell Mountains in the northeastern corner of the map-area east of Purcell Trench. Lower Cambrian formations west of Purcell Trench include, in ascending order, quartzites and phyllites of the Hamill Group; phyllites, quartzite, and limestone of the Mohican Formation; and limestone, locally yielding archaeocyathids, of the Bedshot Formation. The succeeding Lower Cambrian and later Lardeau Group is composed of the following formations. The basal formation is the Index composed of dark grey to black, buff and pale green phyllites, limestone, greenstone, and minor quartzite succeeded in order by the Triune black phyllite, Ajax quartzite, Sharon Creek black phyllite and quartzite, and Jowitt green volcanic rocks. The Broadview Formation of grits, phyllite, and greenstone was placed by Fyles and Eastwood[5] and by Read[8] at the top of Lardeau Group. Read, however, recognized the possibility that the Broadview Formation may in fact represent the Horsethief Creek Group. The present study appears to support Read's view implying that a western, volcanic-bearing facies of the Horsethief Creek Group was thrust over the remaining formations of the Lardeau Group. The principal evidence for this follows. The Broadview Formation, on a regional scale, lies on rocks ranging in age from the lower part of the Index Formation to the Jowitt Volcanics thus implying either an unconformity or a décollement beneath the Broadview. The latter alternative is favoured because of the striking similarity between the grits of the Broadview Formation and those of the Horsethief Creek Group manifested particularly by their common content of blue quartz – a constituent found in abundance only in these two units. Finally, in the central belt Read considered that the Broadview and Index Formations were separated by a slide.

If the Broadview Formation is indeed the Horsethief Creek Group then the latter was thrust onto the Lardeau Group before the Late Mississippian. This is suggested because the Upper Mississippian and later Milford Group lies unconformably upon the Broadview Formation and locally contains conglomerate having variously oriented foliated boulders of Broadview grit.

The Milford Group, composed of slate, phyllite, limestone, quartzite, chert, and some conglomerate and greenstone, is the youngest unit in the northeastern belt; it has yielded Upper Mississippian fossils.

Layered rocks of the central belt comprise the Index and Broadview Formations, the Milford Group which there contains poorly preserved Pennsylvanian or Permian fossils, the succeeding Triassic (?) Kaslo Formation composed mainly of greenstone containing northwest-trending belts of serpentine, and locally narrow zones of Upper Triassic clastic sediments of Slocan Group. The central belt is dominated by the Kuskanax granitic batholith and its satellitic stocks that are intrusive mainly with the Kaslo Formation.

The southwestern belt is underlain by argillite, phyllite, siltstone, greywacke, quartzite and limestone of the Slocan Group, volcanic rocks possibly equivalent to the Rossland Group, by metamorphic rocks of the Shuswap Complex, and by several granitic plutons emplaced along the boundary zone between the Slocan Group and the Shuswap Complex[7].

The broadly folded Purcell anticlinorium lies east of the Purcell Trench. West of this trench the structure in the northeastern and central belts is characteristic of the Kootenay Arc being complex and polyphase[9]. The oldest fold, perhaps developed at the time of the Broadview <u>décollement</u> is exposed north of Akolkolex River in the northwest corner of the map-area. It is a refolded isoclinal anticline closing to the northeast and outlined by fossiliferous Badshot limestone surrounded by an envelope of Index Formation in turn overlain by the Broadview <u>décollement</u>. Large folds considered to be phase II by Fyles in Duncan Lake area[6] have been traced northwestward where they deform the Broadview and Milford Groups and re-deform the earliest isocline. Still later phases affect all rocks in central and northeastern belts.

Deformation in the Slocan Group is complex. Early folds appear to have been directed to the northeast by subsequently have been tilted into folds with steeply dipping axial planes. The northeastern boundary of the Slocan Group is marked by a zone of extreme shearing and small shattered granitic plutons.

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[2]Cairnes, C.E.: Slocan Mining Camp, British Columbia; Geol. Surv. Can. Mem. 173 (1934).

[3]Hedley, M.S.: Geology of the Whitewater and Lucky Jim Mine areas, Slocan district, British Columbia; B.C. Dept. Mines, Bull. 22 (1947).

[4]Hedley, M.S.: Geology and ore deposits of the Sandon area, Slocan Mining Camp, British Columbia; B.C. Dept. Mines, Bull. 29 (1952).

[5]Fyles, J.T. and Eastwood, G.E.P.: Geology of the Ferguson area, Lardeau district, British Columbia; B.C. Dept. Mines, Bull. 45 (1962).

[6]Fyles, J.T.: Geology of Duncan Lake area, Lardeau district, British Columbia; B.C. Dept. Mines and Petrol. Resources, Bull. 49 (1964).

[7]Hyndman, D.W.: Petrology and structure of the Nakusp map-area, British Columbia; Ph.D. thesis Univ. Calif. (1964).

[8]Read, P.B.: Petrology and structure of the Poplar Creek map-area, British Columbia; Ph.D. thesis Univ. Calif. (1966).

[9]Fyles, J.T.: Two phases of deformation in the Kootenay Arc; Western Miner and Oil Review, vol. 35, pp. 20-27 (1962).

[10]Wheeler, J.O.: Lardeau (West Half) map-area, British Columbia; Geol. Surv. Can., Paper 66-1, pp. 102-103 (1966).

ENGINEERING GEOLOGY

26. WELLAND CANAL AREA, ONTARIO

E.B. Owen

Field work was concentrated on NTS sheets 30 M/3b and 30 L/14g (Allanburg and Welland Junction) where excavations have commenced for the new Welland Canal between Port Robinson and Port Colborne, Ontario. The materials exposed in the excavations and those obtained from numerous test borings put down by the St. Lawrence Seaway Authority were examined.

Quaternary deposits are 90 to 125 feet thick throughout the area. As the final depth of the excavations is about 65 feet, a complete vertical section of the unconsolidated materials will not be exposed. The excavated materials consist of soft, reddish brown, glacio-lacustrine, clayey silt with scattered varved clay zones overlying a soft, brown, clayey, silty till. Test borings have indicated that this till is underlain by varved clay which in turn overlies a dense, reddish brown till. The varves in the upper part of the lower varved clay are crumpled indicating overriding by the ice. Hammer refraction seismic investigations by the Geological Survey supplemented by auger borings put down along Townline, Carl and Cambridge Roads, indicates that this sequence of surficial materials probably extends across the two map-sheets. The results of the seismic work are being used in conjunction with test boring data to contour bedrock surface.

Bedrock underlying overburden in the vicinity of the excavations is the Salina Formation. Groundwater in bedrock is highly mineralized and under considerable hydrostatic pressure. Near the community of Welland the piezometric level is about 20 feet below ground surface. However, in the vicinity of Port Robinson, groundwater flowed from many of the test borings. A system of relief wells will be required along parts of the new channel during excavation to reduce the pressure of the groundwater in bedrock.

27. THUNDER BAY AND KENORA DISTRICTS, ONTARIO (53B, 52O, 52P)

E.B. Owen

Discussions were held with Inland Waters Branch, both in the office and field, regarding geological problems encountered during their feasibility studies of hydroelectric power sites and river diversion projects in northwestern Ontario. Advice was given concerning both their test boring investigations and seismic programs. Areas visited in the field include a dam site on Pipestone River (90°25'W, 52°38'N), a dam site on Albany River (88°57'W, 51°30'N), a dam site on Attwood River (88°52'W, 51°06'N) and a dam site at Keech Lake (89°56'W, 51°58'N). Precambrian bedrock exposed at these sites is usually competent and should provide satisfactory abutment and foundation material. However, in some places grouting will be necessary to seal fractures and prevent leakage. With the exception of fine-grained impervious soils construction materials are usually available close to the sites.

GEOCHEMISTRY

28. BIOGEOCHEMICAL PROSPECTING RESEARCH

Eldon H. Hornbrook

During the summer pilot project investigations of one copper and one molybdenum property in British Columbia were planned and completed, the object being to determine the scope and effectiveness of biogeochemical prospecting for copper and molybdenum.

All operational phases of the projects were carried out simultaneously. They included: (1) operation, by a three-man crew, of the analytical facilities housed in two mobile-trailer laboratories at a fixed base (Smithers, B.C.), (2) collection by a three-man crew of soil and vegetation samples and (3) shallow seismic investigations by a two-man crew. The shallow seismic investigation was carried out under the direction of G.D. Hobson to determine the depth of surficial material.

Approximately 1,500 samples of soil and vegetation were collected from 246 stations, established at both properties. The prepared samples were analyzed by colorimetric and spectrographic methods. The colorimetric analyses were made in Ottawa under the direction of J.J. Lynch. Throughout the summer the analytical results were forwarded to the computer centre in Ottawa for processing so that by early fall more than 24,000 single element determinations could be plotted for evaluation and interpretation.

Examination of the results indicates that biogeochemical prospecting methods are effective for copper and molybdenum. At the Lucky Ship property of Amax Exploration Inc., the molybdenum mineralization generally occurs in a concentric zone about the periphery of a granite plug. Contoured results for molybdenum in twigs or needles accurately define the concentric distribution of the mineralization. Similarly, on the Huckleberry property of Kennco Explorations (Western) Ltd. the results for copper in twigs or needles indicate the extent of previously known copper mineralization.

29. GEOCHEMISTRY OF LEAD-ZINC DEPOSITS IN CARBONATE ROCKS (33N, 34C, 52S (East Half))

D.F. Sangster

Lead-zinc deposits occuring in Proterozoic rocks of the Port Arthur, Ontario and Manitounuk Sound, Quebec areas were examined.

Port Arthur area

Several sphalerite-galena-barite vein deposits in dolomitic shales of the Sibley Group were examined and samples taken for geochemical purposes. The deposits are consistent in mineralogy, character (veins), and strike direction; although some extend downwards into granitic 'basement' rocks, none appear to extend upwards into an overlying carbonate zone within the Sibley. One vein contained muscovite as a gangue mineral with the sphalerite and galena; a sample of this muscovite was submitted for radiometric dating.

Manitounuk Sound area

Small pyrite-sphalerite-galena deposits are exposed in a stromatolite-bearing dolomite. Although roughly conformable in general outline with the enclosing host rock, the deposits, in detail, show cross-cutting and replacement features.

30. GEOCHEMICAL PROSPECTING METHOD DEVELOPMENT, BANCROFT, ONTARIO (31, C, D, E, F)

A.Y. Smith, W. Dyck, J.J. Lynch, D. Church and S. Withers

Geochemical prospecting methods for uranium were carried out in the Bancroft area of Ontario between June and September, 1967. Reconnaissance methods tested included stream sediment geochemistry, swamp geochemistry and hydrogeochemistry employing radon in surface waters. Detailed methods tested included soil geochemistry and the radon content of soil gas. Analyses for uranium were performed in the field mobile laboratory by employing a fluorometric method after nitric acid digestion.

Stream and swamp sediments were collected over an area of approximately 290 square miles and analyzed for uranium. Where possible two samples were collected from each site; a sample of the fine sand and silt fraction of normal active stream sediment; a sample of organic-rich sediment from the stream or of organic bottom muck from swamp sites in the drainage system. Tentative background values for uranium in these materials were: active stream sediment, less than 1 ppm U; organic sediment and swamp muck, 1 - 2 ppm U. Contrast between background and anomaly was considerably greater in the case of the organic-rich samples. However, both types of sample served to indicate anomalous areas.

Detailed soil sampling was carried out over radioactive zones on both Faraday Uranium Mines properties. Soils in both areas are of the Podzol Great Soil Group developed on thin sandy glacial overburden. Locally, in areas of impeded drainage gleysolic soils are developed. Contrary to expectation, uranium is not strongly concentrated in the humus-rich Ao horizon of most of the soils of the area. Anomalous patterns are commonly weak and poorly developed in this horizon. An exception is the case of the humus horizon of the gleysolic soils where strong concentration of uranium may occur if a nearby source of uranium exists. On the other hand, strong anomalies in uranium are developed in the iron-rich B horizon and serve to focus attention on the radioactive zones. Tentatively it may be said that uranium enters the profile in solution; there is no evidence for the transfer of uranium minerals into the soil profile from underlying bedrock sources. As a consequence the anomalies show down-slope migration and other features characteristic of solution transport. The mode of transport and fixation of uranium is presently under investigation.

Preliminary tests were carried out to determine the feasibility of using the radon content of soil-gas and of surface waters as an indication of the presence of uranium. Determination of the radon content of surface waters was carried out by degassing the water with air and collecting and counting the evolved radon in an alpha counting chamber. At the same time uranium was determined on the same water samples by a fluorometric method.

A total of 59 samples of surface waters (as distinct from groundwaters) were collected and analyzed for radon and uranium content. Radon content of these waters ranged from less than 1 pc/l. (pico curie per litre) to greater than 1000 pc/l., while uranium values ranged from less than 1 ppb (parts per billion) to 50 ppb. While detailed study of the data is still underway, several tentative conclusions may be stated. There is a general correspondence between uranium and radon levels. Streams and creeks have a higher radon content than do lakes and swamps, probably reflecting their closer proximity to groundwater sources. Considerable contrast exists between 'background' values and anomalous value in radon. The technique is simple and inexpensive and holds promise as a regional reconnaissance method for detecting uraniferous districts. However many aspects of the distribution and dispersion of radon in surface waters remain to be studied.

Radon in soil-gas was studied in the vicinity of the Bicroft Uranium mine. Soil-gas was collected from previously dug holes by means of evacuated vessels, and counted for radon content in an alpha chamber. Radon content of 30 samples of soil-gas ranged from 30 to 4600 pc/l. and showed correlation with both soil uranium content and scintillometer measurements. The method offers promise in detailed geochemical prospecting for buried uranium deposits, but future work should take advantage of recent advances in both sampling and analytical technique.

Comparative studies were made in conjunction with the Exploration Geophysics Division in several places in the Bancroft area between three detailed prospecting techniques for uranium. Coverage was obtained over the same ground employing a Gamma-ray Spectrometer, a light-weight field scintillometer and soil geochemistry. A comparison will be made between the three methods with respect to effectiveness, efficiency and costs.

31. GEOBOTANY; ONTARIO AND BRITISH COLUMBIA

Lily Usik

Circular Terrain Features in northern Ontario

From examination of aerial photographs it was suggested that certain circular terrain features noted in northern Ontario were caused by differences in the vegetation cover, and that these differences might be related to geochemical factors, in the environment[1]. A one-day ground reconnaissance of one of these 'circles' north of Timmins, Ontario confirmed the first observation. It was found that the area of the annulus of the circle was conspicuous because of the presence of more larch (Larix larcinia) than spruce (Picea sp.) in this zone as compared to the areas within and outside of it. Furthermore, the area within the circle had a dense cover of shrub-height cedar (Thuja occidentale) whereas the area outside had only individual sporadic occurrences.

It was also noted from observation of surface water conditions that the circular area associated with the dense cedar growth was much wetter than the surrounding terrain which suggested a circular depression. However, the movement of surface water was seen to be outwards from the centre of the circle into the annulus.

Samples of foliage of the tree species occurring in the different zones of the circular feature were collected for chemical analysis.

Geobotanical Investigation in British Columbia

The field investigation in British Columbia was an introductory examination of the scope, and feasibility of possible systematic methods of geobotany applied to exploration for mineral deposits. Geobotanical investigations were made for three undisturbed (or relatively undisturbed) areas where different and known mineralization occurred.

The Lornex copper deposit is situated in the Highland Valley near Ashcroft whereas the Huckleberry Mountain copper deposit and the Lucky Ship molybdenum deposit are situated southeast of Smithers in central British Columbia. Over a hundred plant species were identified in the field for the three areas, and their presence, distribution and associations were investigated and mapped in relation to mineralized and non-mineralized zones for each of the areas. During field investigation no correlation between plant species (indicator plants) or plant communities and the zone of mineralization was apparent. A study of tree ratios was made in one of the areas in order to establish relationships between mineralization and tree growth. In the same area an investigation was also made of the occurrence of conspicuous trunk deformity in one of the tree species in relation to mineralization. In another area material was collected from the dominant tree and associated herb species for chemical analysis.

More detailed analyses of field and laboratory botanical data as well as examination of aerial photographs in relation to the available geological and geochemical data, are being carried out to establish conclusive results.

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GEOCHRONOLOGY

32. ISOTOPIC INVESTIGATION

R.K. Wanless and R.D. Stevens

A field trip was carried out with the object of: (1) obtaining sample material from granitic bodies situated in the Superior Province adjacent to the Grenville Front. The K^{40}/Ar^{40} isotopic abundances for micas found in the granites will be compared with the anomalous results obtained in analogous settings near Chibougamau, Quebec, and at Churchill Falls, Labrador and (2) selecting samples suitable for zircon concentration required for U-Th-Pb age determinations.

Granites in the Superior Province

Samples were selected from three granitic bodies just north of the Grenville Front.

(a) Granite and pegmatite west of Mink Narrows, Grand Lake Victoria at the northern end of La Verendrye Parc (units 6 and 6a Geol. Surv. Can. Map 998A). Material was collected close to the front and from locations up to 5 miles north and west of the boundary zone. In addition, it was possible to obtain samples of Grenville paragneiss on the east shore of Mink Narrows. A second series of samples was collected on highway 58 about 3 miles east of Mink Narrows. In this instance it was possible to select Grenville and Superior rocks immediately south and north of the front respectively (units A and 7, Geol. Surv. Can. Map 998A).

(b) A single sample of muscovite-hornblende granite was collected just west of Shamus Lake within 1/2 mile of the Grenville Front (unit 8, Geol. Surv. Can. Map 998A).

(c) Granodiorite and granite extending from a point just east of Senneterre, Quebec, to the Grenville Front near Paradis, Quebec (units 11, 11b, Geol. Surv. Can. Map 997A). Samples were selected immediately adjacent to the front and for a distance on either side.

Zircon Sampling Sites

(a) Three large samples were collected from outcrops of unit 2 of the Preissac-Lacorne map-area (Geol. Surv. Can. Map 1179A). This unit comprises biotite schist derived from greywacke and conglomerate and is reported to contain abundant zircon (personal communication K.R. Dawson).

(b) Timiskaming conglomerate south of Rouyn, Quebec. Boulders were selected from two localities about 3 miles south of Rouyn. In one instance it was possible to remove a complete boulder weighing 151 pounds from the conglomerate.

GEOPHYSICS

33. RADIO WAVE MAPPING OF GLOUCESTER FAULT, ONTARIO

A. Becker

The current experimental survey was a continuation of work initiated during the 1966 field season. In 1967 only the EM 16 method was employed. The instrument used was a tripod-stabilized modification of commercial equipment.

The method is based on the fact that electromagnetic fields from distant VLF transmitters are propagated with an essentially horizontal magnetic field component. In the presence of conductors or conductivity discontinuities however, the magnetic field vector deviates sharply from the horizontal. The station used for the survey was NAA in Cutler, Maine.

The method was used successfully to map a two-mile length of the Gloucester Fault in the immediate vicinity of Leitrim, Ontario. It appears that this technique is capable of yielding very good spatial resolution of the fault trace. In addition to outlining the fault zone, the field results indicate a number of minor features presumably associated with it.

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[1]Becker, A.: Radio wave mapping of ground conductivity; in Report of Activities, Geol. Surv. Can., Paper 67-1A, S.E. Jenness, ed. pp. 130-131 (1967).

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34. MAGNETO-TELLURIC MEASUREMENTS, QUEBEC

A. Becker and J. Slankis

Magneto-telluric measurements at a single frequency of 8 c/s have confirmed the applicability of the method to mapping conductors and electrical conductivity discontinuities. The 1967 field work embrace measurements over three massive sulphide deposits in Quebec, a regional profile along the Senneterre-Chibougamau highway and mapping the Precambrian-Palaeozoic contact west of Breckenridge, P.Q. In all cases the conductivity anomalies were characterized not only by variations in apparent resistivity but also, unexpectedly, by the spatial anisotropy of the electric fields and the presence of a strong vertical magnetic field component in their vicinity.

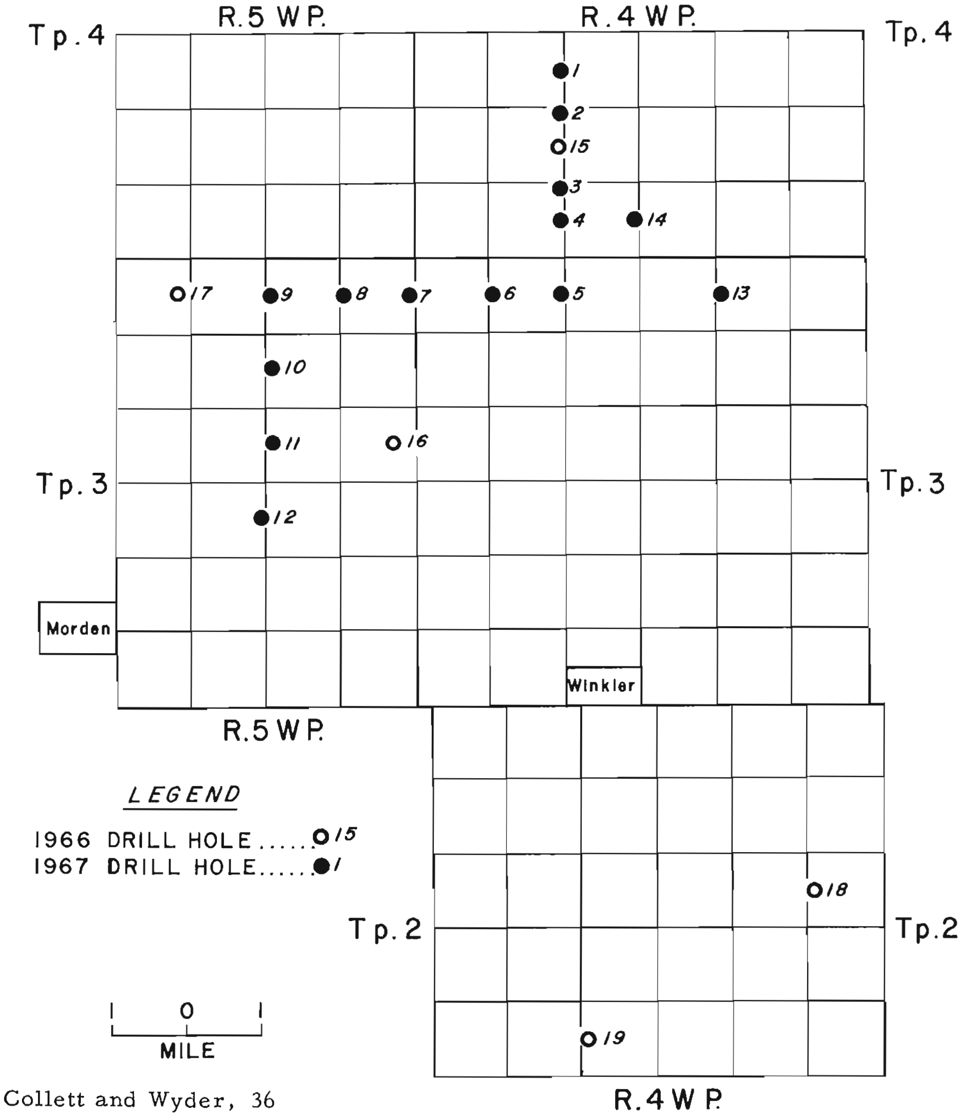


Figure 1. Location of drill-hole sites Winkler area, Manitoba.

35. AIRBORNE INPUT DEVELOPMENT CONTRACT AND SURVEY

L.S. Collett

Barringer Research Ltd., Rexdale, Ontario, the contractor, has designed and constructed a second 6- channel receiver to provide 12 channels to meet the specifications. The company has been working on the analog-to-digital and incremental tape recording system which is now almost complete. The next step is the installation of the equipment in the aircraft and flight testing.

The areas which have been selected to carry out the experimental surveys are as follows:

Oakville Basin (near Toronto)	78 line miles
Ottawa Area, Ontario	276 line miles
Project Pioneer Area, Manitoba	660 line miles
Winkler-Roland Area, Manitoba	288 line miles
Drumheller Area, Alberta	1624 line miles
Total	2926 line miles

The Drumheller area will be flown in cooperation with the Research Council of Alberta.

It is anticipated that the flying will be done in late 1967 or early 1968.

36. DRILLING, SIDE-WALL SAMPLING AND DC RESISTIVITY, WINKLER AREA, MANITOBA (62H)

L.S. Collett and J.E. Wyder

A ground follow-up program to investigate airborne input anomalies was carried out during June 1967. Fourteen holes (DH 1-14) totalling 4,310' were drilled to bedrock (see Fig. 1). Four geological sections across four INPUT anomalies have been drawn up with the aid of the side-wall sampler and electrologs. Some DC resistivity profiling was also done.

One interesting feature of the INPUT survey has been to detect a depression in the Melita and Reston Formations (Jurassic) in SE 9-8-4-4 WP. This follow-up program has also proven that sand can be detected at a depth of 180 feet in this clay-till environment.

37. EVALUATION OF AIRBORNE GAMMA-RAY SPECTROMETRY IN THE BANCROFT AND ELLIOT LAKE AREAS OF ONTARIO (Parts of 41J and 31C, D, E and F)

A.G. Darnley

In order to design an airborne gamma-ray spectrometer system suitable for mapping the distribution of potassium, uranium and thorium in regions of complex geology, detailed ground and airborne gamma-ray spectrometer measurements have been obtained over two test strips in Ontario. The test strips are approximately three miles long and half a mile wide and are located eight miles southwest of Bancroft and five miles east of Elliot Lake respectively. The strips were chosen as being typical of Shield terrain and because of their proximity to known radioactive mineral occurrences. More than 1000 ground measurements have been taken within each test strip on a 200-foot grid using field gamma-ray spectrometers. Additional control measurements will be provided by soil and rock samples which are being analyzed in the laboratory using both physical and chemical techniques.

Airborne measurements have been obtained using experimental equipment designed and operated by Atomic Energy of Canada Ltd., Commercial Products Division. This equipment measures gamma-radiation with three 5-X 5-inch NaI (Tl) detector crystals, the whole spectrum from approximately 300 kev to 3.0 mev being recorded continuously on magnetic tape. The availability of complete spectra enables the airborne data to be studied in a variety of ways for experimental purposes. In order to ensure that an adequate count rate would be obtained at different elevations, measurements were made from a helicopter whilst hovering and moving forward at slow speeds (20 to 50 mph). Ground and airborne data are compared with respect to count rates obtained in spectral windows 210 kev wide centred on 1.46 mev (^{40}K directly related to potassium content), 1.76 mev (^{214}B indicative of uranium) and 2.62 mev (^{208}Tl indicative of thorium). Flights have been made over the test strips at elevations of 250, 500 and 750 feet, with the clearance monitored by a Bendix ALA 51 radar altimeter. Aircraft position was monitored on some of the flights with a Decca Mini-Fix system.

Preliminary assessment of the results indicates that in the Bancroft test strip it is possible to distinguish areas underlain by marble, syenite and granite both on the ground and from the air by observing the corrected count-rates obtained in the K, U and Th channels in conjunction with the ratios between these count rates. Small concentrations of radioactive minerals in each of these rock types have shown up on both sets of results despite the fact that as is well known, peak to ground background radiation intensity decreases rapidly with increasing height.

At Elliot Lake the test strip traverses a subeconomic portion of the uraniferous Lower Matinenda quartzite and conglomerate, and this horizon is marked by high count-rates in the potassium, uranium and thorium channels which produce prominent radiometric anomalies both on the ground and in the air. The Nordic Argillite which occurs above the Matinenda Formation shows consistently high potassium, both on the ground and in the air. The Keeweenawan diabase shows the lowest potassium, uranium and thorium encountered in the test strip, apart from swamp and lake areas.

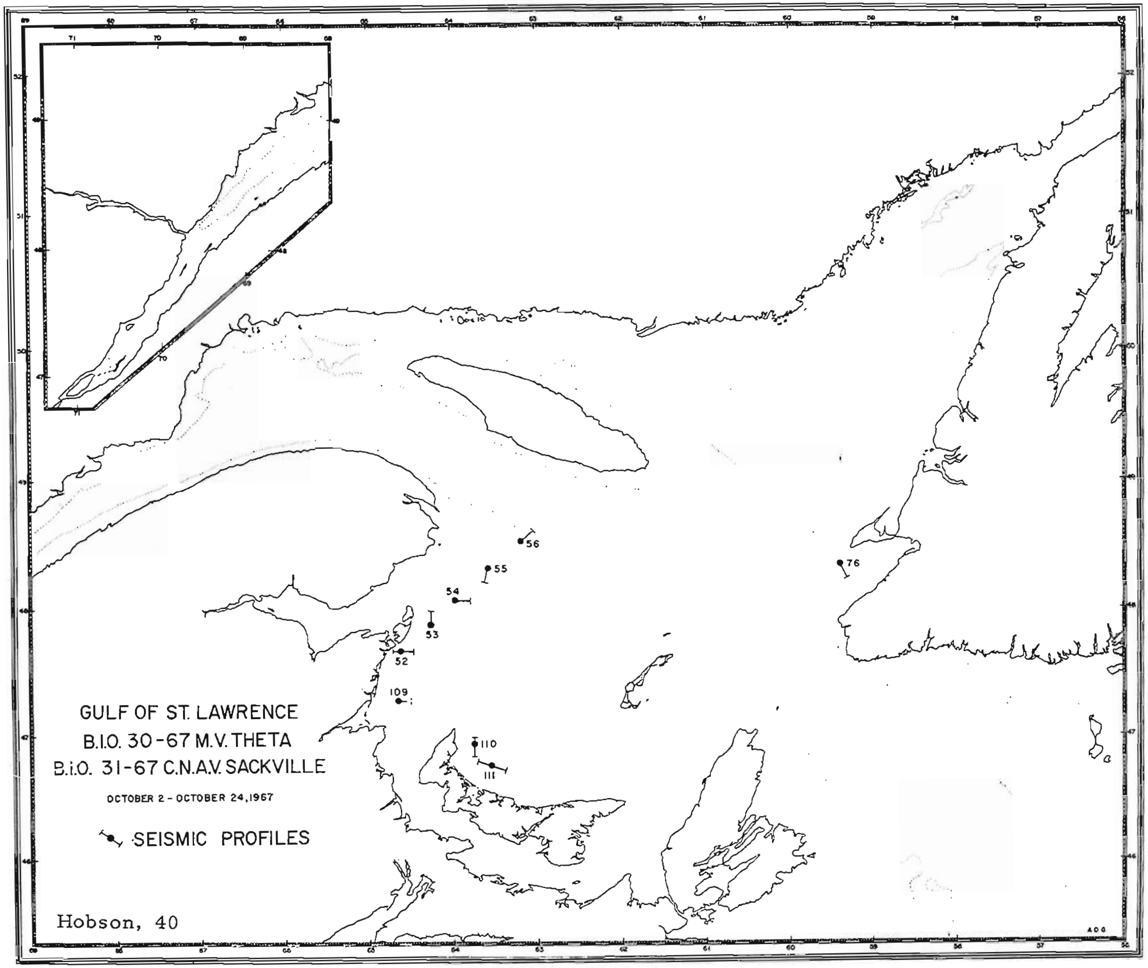
Results have been sufficiently encouraging to warrant extensive trials with a more advanced airborne gamma-ray spectrometer system in 1968.

38. GROUND GAMMA-RAY SPECTROMETER SURVEY, BANCROFT, ONTARIO (31C, D, E, and F)

Michael Fleet

A series of measurements of the γ-radiation was made in an area measuring about 3 miles by 1/2 mile near Monck Road, about 8 miles west of Bancroft, Ontario. The rock types exposed comprise mainly marbles, granites, syenites and amphibolites. The instrument used was a portable 1000-channel γ-ray spectrometer developed by Commercial Products of Canada, Limited. Measurements were made on a grid at 200-foot intervals using pace and compass, combined with a chain and compass survey of the tracks and a single cut line. Two minute counts of the 1.46 Mev (^{40}K), 1.76 Mev (^{214}Bi) and 2.62 Mev (^{208}Tl) energy levels were recorded using a window width of 210 Kev; the 3-X 3-inch detector crystal was held 3 feet above the surface. A few stations were unavoidably omitted in swampy areas. Readings were taken on nearby lakes to establish the local background. Rock specimens, drill cores and soil samples were collected both as a method of calibration of the spectrometer and also to determine the nature of the occurrence of the radioactive deposits. Twice-daily measurements were taken on a standard station in the area along with meteorological data to investigate a possible correlation between atmospheric radon and the barometric pressure. A few additional measurements were made on the Bicroft and Faraday properties.

The results, which are being prepared for publication, indicate that there are localized areas of above normal radioactivity which may occur in places underlain by any of the rock types encountered in the area. This survey provided ground control for an airborne γ-ray spectrometer survey and a portion of the same area was covered by a geochemical survey.


GULF OF ST. LAWRENCE
B.I.O. 30-67 M.V. THETA
B.I.O. 31-67 C.N.A.V. SACKVILLE
OCTOBER 2 - OCTOBER 24, 1967
SEISMIC PROFILES
Hobson, 40
52
53
54
55
56
76
109
110
111

39. TEST OF A PROTABLE RADIOISOTOPE X-RAY FLUORESCENCE ANALYSER, MOUNT PLEASANT AND BURNT HILL, NEW BRUNSWICK

Michael Fleet

Exposures, both on the surface and underground, at Mount Pleasant and Burnt Hill, New Brunswick, were visited and measurements were made of the tin contents in a variety of rock types with a portable radioisotope X-ray fluorescence analyser to test the suitability of this instrument under field conditions. Rock specimens were collected and the field measurements will be compared with laboratory analyses of the powdered samples.

40. MARINE SEISMIC INVESTIGATIONS, GULF OF ST. LAWRENCE, (11L, M; 12B, C, D)

George D. Hobson

A marine seismic program was conducted in the Gulf of St. Lawrence during October 1967 as a continuation of a program begun in 1964. Nine profiles were shot to investigate the thickness, nature and attitude of the sedimentary rocks underlying the Gulf.

Two ships, CNAV Sackville as the recording vessel, and MV Theta as the shooting vessel, were used to obtain all seismic data. Refraction seismic techniques were employed throughout. Both Nitrone Super X and Gelatine were used as explosive sources. The locations of the profiles are shown in Figure 1.

Considerably less data were procured than would normally have been obtained due to severe weather conditions during October, mechanical breakdown of certain ship equipment and the illness of a crew member. Relatively little was accomplished seismically due to an extended series of unexpected and uncontrollable events.

A cursory examination of the records indicates that generally good to excellent quality data have been obtained. No interpretation of these data has been undertaken to date of writing.

41. HAMMER SEISMIC BEDROCK INVESTIGATIONS IN NEW BRUNSWICK (21 J/16)

George D. Hobson

A model FS-3 hammer seismograph was used in the McKendrick Lake area[1], to assist the field geologist in outlining a conglomerate and to define the trace of a fault beneath overburden. The conglomerate is set against and over a greywacke.

The thickness of the conglomerate is variable attaining a maximum thickness of about 140 feet. There is a definite contrast in the seismic velocities through the conglomerate and the greywacke; velocity through the conglomerate is about 11,000 ft/sec while through the greywacke the velocity is about 15,000 ft/sec. These data were obtained over three short lines of control.

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[1]Anderson, F.D.: McKendrick Lake (21 J/16) map-area; Geol. Surv. Can., Paper 67-1, part A, pp. 168-169 (1967).

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42. HAMMER SEISMIC OVERBURDEN AND BEDROCK INVESTIGATIONS, WOODSTOCK MORAINE, NEW BRUNSWICK (21 J/4, 5)

George D. Hobson

A short seismic survey using a hammer refraction seismograph was conducted over a drumlin located about 12 miles northwest of Woodstock, New Brunswick. The purpose of the survey was to determine the relief on the bedrock surface beneath the moraine deposit in an attempt to define the direction of ice movement at the time of moraine deposition. In general, the seismologists found that the moraine has been deposited on a bedrock 'high'.

43. HAMMER SEISMIC OVERBURDEN AND BEDROCK INVESTIGATIONS, DUNDAS, ONTARIO (30 M/5)

George D. Hobson

Three lines of hammer refraction seismic control were recorded in an effort to delineate if possible the preglacial river suggested by Spencer[1]. The marine seismic survey in Lake Ontario[2], suggested the existence of such a feature in Lake Ontario. It was desirable to trace this bedrock depression westward.

One line was run across the 'high level' between Hamilton Harbour and the Dundas Marsh. Another traversed the valley on the easterly limits of the town of Dundas while the third line was run in a general north-south direction along a secondary road through the hamlet of Copetown some 6 miles west of Dundas. Vehicular traffic impeded progress to a certain extent but good data have been recorded.

The line on the easterly limit of Dundas indicates a bedrock depression approximately 180 feet deep and over one mile wide. The line through Copetown suggests a much smaller depression, perhaps 100 feet deep and half a mile wide. The line at the 'high level' suggests the presence of a very broad feature which unfortunately was not delimited on the southern end due to high noise levels within the city of Hamilton. The depression suggested by Spencer appears to be present; more detailed work will have to be done to define it.

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[1]Spencer, J.W.: Niagara Falls and Niagara District; Geol. Surv. Can., Summ. Rept., 1905-6 (1907).

[2]Hobson, G.D. and Holzl, E.: Marine seismic survey, Lake Ontario; Geol. Surv. Can., Paper 67-1, part A, pp. 143-144 (1967).

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44. HAMMER SEISMOGRAPH OVERBURDEN AND BEDROCK INVESTIGATIONS, WELLAND-PORT COLBOURNE, ONTARIO (30 M)

George D. Hobson

Refraction seismograph profiles have been obtained at 181 locations along 8 east-west roads near Welland, Ontario. These roads have been seismically surveyed eastward from the Welland Canal for about 6 miles. The refraction profiles were not reversed. Forks Road is the southerly extent of control while Carl Road marks the northern boundary.

Both model FS-2 and FS-3 hammer seismographs were used to conduct these preliminary investigations using a sledge hammer struck against a steel plate on the ground as a source of energy. Explosives were not used.

Sections have been compiled for every east-west line indicating the different layers of Pleistocene material and bedrock topography. Drift thickness varies between 50 and 210 feet. Sands and clays can be differentiated from the underlying tills but an interstratified till cannot be detected.

45. HAMMER SEISMOGRAPHY OVERBURDEN AND BEDROCK INVESTIGATIONS, SQUARE BAY, MANITOULIN ISLAND, ONTARIO (41 G/9 (WEST HALF))

George D. Hobson and H.A. MacAulay

A hammer refraction seismic survey was undertaken to provide information regarding the configuration of bedrock beneath a series of beach berms around the periphery of Square Bay on the south shore of Manitoulin Island. Continuous reversed refraction profiling was carried out along three lines radiating inland from the shores of the bay, one line from the central part of the shoreline and two from the headlands defining the easterly and westerly limits of Square Bay. In addition, individual reversed profiles were recorded at intervals of about 300 feet transverse to one selected continuous berm that roughly parallels the shoreline and is several hundred feet inland.

A Huntec model FS-2 portable seismograph was used with a sledge hammer struck against a steel plate on the ground as the energy source. The continuous reversed profiles along the radiating lines were each 160 feet long while those profiles transverse to the single berm were reversed over

100 feet. It was impossible without using explosives to record recognizable signals beyond 180 feet. Highly fractured bedrock is believed responsible for this unusual condition. The berms themselves consist of sand and/or limestone shingle.

Good interpretable data were obtained over all profiles using hammer intervals of 10 feet. Drift thickness varies up to 18 feet. Cross-sections can be drawn to depict the bedrock configuration beneath the berms and drift. Changes in bedrock elevation of one foot can be detected.

46. HAMMER SEISMOGRAPH OVERBURDEN AND BEDROCK INVESTIGATIONS, LUCKY SHIP AND HUCKLEBERRY MOUNTAIN, BRITISH COLUMBIA

George D. Hobson and F.K. Maxwell

Two shallow seismic refraction surveys were conducted in conjunction with bio-geochemical projects on the Lucky Ship molybdenum and the Huckleberry copper deposits in northern British Columbia near Houston. Refraction seismic profiles were obtained at 140 stations along two east-west lines and three north-south lines at the Lucky Ship location. Profiles were generally reversed every 100 feet. Overburden is very thin with outcrop frequently observed; overburden does not exceed 25 feet over the project area. Seismic data indicate a bedrock velocity of about 9000 ft/sec, a velocity value which is relatively low for the type of rock (rhyolite porphyry) present. This indicates that bedrock is probably highly fractured.

The second property was investigated along one east-west line and two north-south lines. All profiles were reversed giving a completely continuous line in both directions. One hundred stations were surveyed with a spacing of 100 feet between stations. Overburden varies between 10 and 35 feet in thickness.

47. HAMMER SEISMOGRAPH OVERBURDEN AND BEDROCK INVESTIGATIONS, COCHRANE, ONTARIO (42 H)

George D. Hobson and F.K. Maxwell

Two seismic refraction profiles were obtained, one line in a north-south direction the other in an east-west direction with their intersection about 20 miles east of Cochrane, Ontario. Forty-four locations, 1000 feet apart, were investigated on the east-west line while 55 locations, spaced one quarter mile apart, were surveyed on the north-south line. A study of this drainage basin within the Shield has been initiated and the seismic data were procured to provide the hydrologist with information about the type of Pleistocene materials in the overburden and the topography of the underlying Precambrian surface. Two eskers trend in a general north-south direction; lacustrine sediments form the overburden between these eskers. The north-south seismic line was surveyed along the westerly esker whereas the east-west seismic line traversed the easterly esker.

Overburden varies between 60 and 275 feet in thickness. In general, it was not possible to differentiate between sandy till and lacustrine clays. A consolidated till was detected beneath several seismic locations when a seismic velocity intermediate to clay and bedrock was detected. Bedrock velocities, when plotted on a histogram against frequency of occurrence, fall into three main groups indicating that changes in bedrock lithology exist beneath this drainage basin. Two sections have been compiled to indicate bedrock topography and overlying overburden strata.

48. AEROMAGNETIC INVESTIGATIONS OF BAFFIN BAY, THE NORTH ATLANTIC OCEAN, AND THE OTTAWA AREA

Peter J. Hood, P. Sawatzky and Margaret E. Bower

The co-operative aeromagnetic project with the National Aeronautical Establishment was continued during 1967 and investigations were carried out in northern Baffin Bay and southern Nares Strait, across the Reykjanes Ridge south of Iceland, and across the Gloucester Fault in the Ottawa area of Ontario.

The equipment used was an optical absorption magnetometer installed in the North Star aircraft of the National Aeronautical Establishment. Over the ocean navigation was by Loran A, Doppler, and Astro fixes. Over land aircraft track was located by 35 mm photography.

Acknowledgments are made to E.A. Godby, R.C. Baker, N. Davis, J. Waddell of the National Aeronautical Establishment and also the RCAF crew of the North Star aircraft, namely F/L N.F. Paul (Captain), F/L F.K. Augusta (Copilot), F/L J.G. Kilgour and F/L P.J. Middleton (Navigators), F/L D. Doncaster (Radio Officer) and Sgt. C.L. Empey (Flight Engineer) for their essential contributions to the aeromagnetic investigations herein described.

Baffin Bay

Figure 1 shows the tracks of the aircraft in northern Baffin Bay and the southern part of Nares Strait which were flown between April 14th and 22nd. This time of the year was chosen because weather conditions for airborne surveys in that area are optimum. Flight elevation was maintained at 1000 feet above the sea. The 1967 survey completes the aeromagnetic reconnaissance of the Labrador Sea and Baffin Bay in which the survey lines have been spaced an average of 1° of latitude (60 nautical miles) apart for a distance of approximately 1700 miles from the southern tip of Greenland to the northern end of Kane Basin.

A preliminary examination of the records shows some correlation in a northwesterly direction between the lines but it is not so readily apparent as in the southern part of Labrador Sea. Perhaps the most striking feature noted on the profiles was the flatness of the aeromagnetic profile for the traverses across Melville Bay. This is an indication of a substantial thickness of sediments underlying Melville Bay, which would be an interesting area for oil exploration were it not for the fact that the majority of icebergs which appear at the southern end of the Labrador Sea calve from the Greenland ice-cap into Melville Bay. The icebergs themselves undoubtedly contribute significantly to the volume of sediments being deposited in Melville Bay.

The opportunity was taken of obtaining two additional lines across the Labrador Sea at the end of the foregoing survey, and the aircraft track is shown in part on Figure 2.

North Atlantic Ocean

It was found on the profiles flown between the southern tip of Greenland and Iceland during August 1966 that there was reasonably good correlation between lines well away from the crest of the mid-Atlantic Ridge[1]. The symmetry about the crest of the Ridge is readily seen on the profiles to the southwest of Iceland (see Fig. 2) and is indicated by their being labelled, 1, 2, 3, 4, 5, B and C. This survey was a co-operative project between the U.S. Naval Oceanographic Office and Lamont Geological Observatory[2]. The other magnetic profiles plotted are from the publications of Avery[3] and Godby[4].

It was, therefore, decided to fly six low-level lines across the North Atlantic Ocean between Greenland and Ireland about 60 nautical miles apart at right angles to the Ridge in order to ascertain how far the symmetry extended. The initial aeromagnetic survey results indicated that the symmetry of the 50 or so anomalies extended from the continental shelf of Greenland to an equal distance on the other side. Using the field reversal scale of Cox et al.[5] and the geological time scale of the Geological Society of London[6], it would appear that it is possible to divide up the ocean floor into time zone bands, the oceanic crust immediately to the east of the continental shelf of Greenland being of Cretaceous age.

Gloucester Fault, southeastern Ontario

During the summer months of 1967, on an opportunity basis, a total of 14 aeromagnetic profiles were flown across the Gloucester Fault (about 16 miles southeast of Ottawa), at a flight elevation of 800 feet. Figure 3 shows one of the aeromagnetic profiles which was flown about 3500 feet north of and parallel to the Gloucester-Osgoode Township line at an angle of 55° across the Gloucester Fault. At the top of the figure is the total intensity profile and it can be seen that there is no noticeable indication of the fault except perhaps for the presence of a small anomaly. Below the total intensity profile is the same profile which has been filtered to pass anomalies having a wavelength between 0.16 and 0.48 miles long using a digital filter[7]. There is a noticeable diminution in the amplitude of the filtered total intensity trace on the downthrown side of the fault. If one compares the two profiles closely, remembering that there is a 125 to 1 difference in the vertical scales, it is possible to see the high resolution anomalies which appear on the filtered profile also on the original untouched total intensity profile. This shows that the high resolution anomalies have not been generated by the filter itself and must be due to changes in the magnetic properties of the underlying rocks.

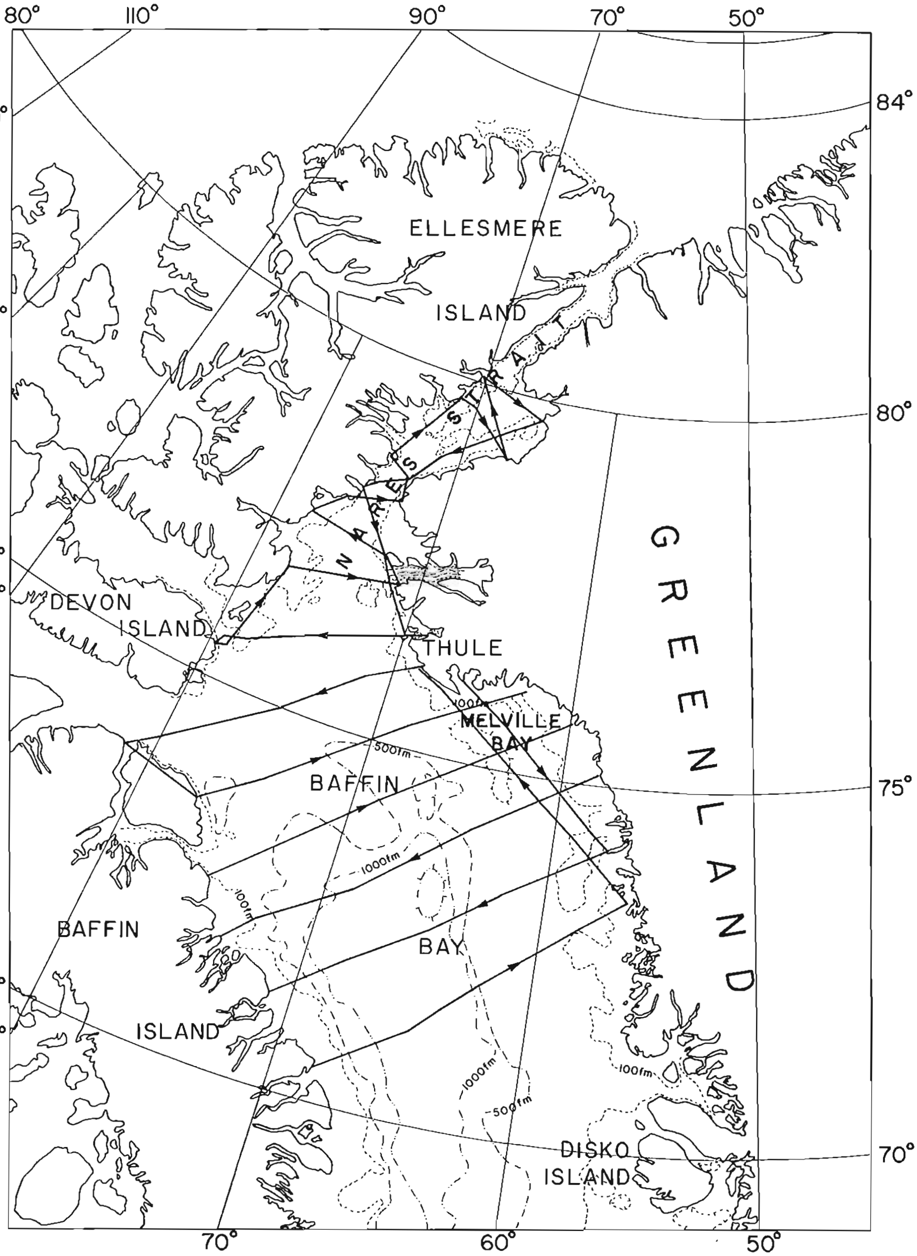

Figure 1. Track of the survey aircraft for the 1967 aeromagnetic reconnaissance of northern Baffin Bay and Nares Strait.

Figure 4 is a geological map of the Ottawa area taken from GSC Map 852A which shows the digitally-filtered total-intensity profiles across the Gloucester Fault. The numbering system for the geological legend corresponds to that on the original map; it suffices to say that the sedimentary formations are either limestone, sandstone, or shale and there seems to be negligible magnetic contrasts between these sedimentary rocks compared to that of the underlying Precambrian basement rocks which are not very deeply buried.

The anomalies seen on the profiles are therefore due to magnetization variations, which may be quite localized, in the basement rocks. In general, the Gloucester Fault is delineated quite well by the change in amplitude of the digitally-filtered profiles, and there is some indication from the profiles that the fault immediately to the north of the Gloucester Fault continues in a westerly direction.

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[1] Hood, P.J., Sawatzky, P. and Bower, M.E.: Progress report on low-level aeromagnetic profiles over the Labrador Sea, Baffin Bay, and across the North Atlantic Ocean; Geol. Surv. Can., Paper 66-58, pp. 1-11 (1967).

[2] Heirtzler, J.R., Le Pichon, X. and Baron, J.G.: Magnetic anomalies over the Reykjanes Ridge; Deep-sea Res., vol. 13, pp. 427-443 (1966).

[3] Avery, O.E.: Geomagnetic and bathymetric profiles across the north Atlantic Ocean; U.S. Naval Oceanographic Off., Tech. Rept. 161, 74 pp. (1963).

[4] Godby, E.A., Baker, R.C., Bower, M.E. and Hood, P.J.: Aeromagnetic reconnaissance of the Labrador Sea; J. Geophys. Res., vol. 71, pp. 511-517 (1966).

[5] Cox, A., Doell, R.R. and Dalrymple, G.B.: Reversals of the earth's magnetic field; Science, vol. 144, pp. 1537-1543 (1964).

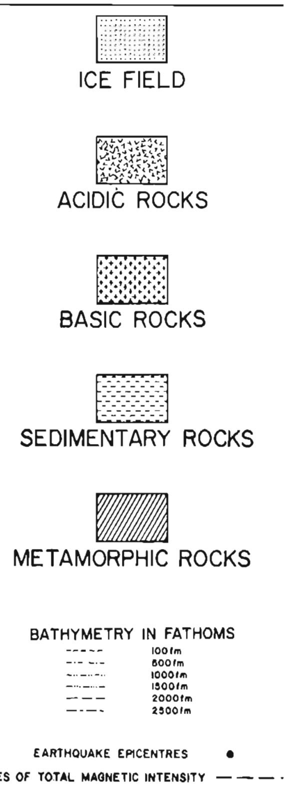
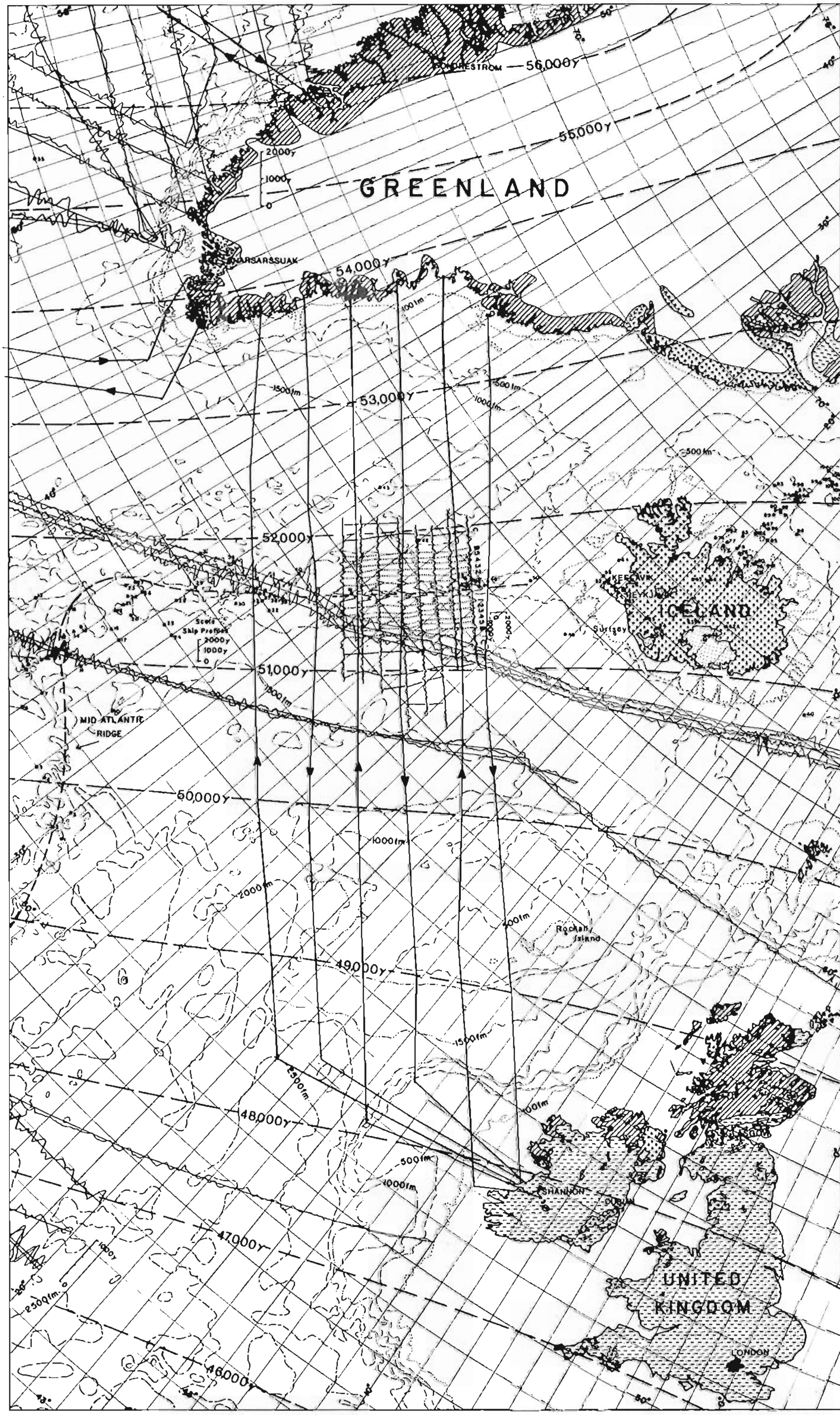


Figure 2:

Tracks of the aeromagnetic survey aircraft across the North Atlantic Ocean during June 1967. Also shown are the bathymetric contours (in fathoms), other shipborne and airborne magnetic profiles and the total intensity contours of the earth's main field.



GREENLAND
SONDRESTROM
56,000γ
55,000γ
54,000γ
53,000γ
52,000γ
51,000γ
50,000γ
49,000γ
48000γ
47000γ
46000γ
2000γ
1000γ
0
NARSARSSUAK
1500fm
1000fm
500fm
2000fm
2500fm
Scale
Ship Profiles
KEFLAVIK
REYKJAVIK
ICELAND
Surtsey
MID ATLANTIC
RIDGE
Rockall
Island
SHANNON
DUBLIN
UNITED
KINGDOM
LONDON

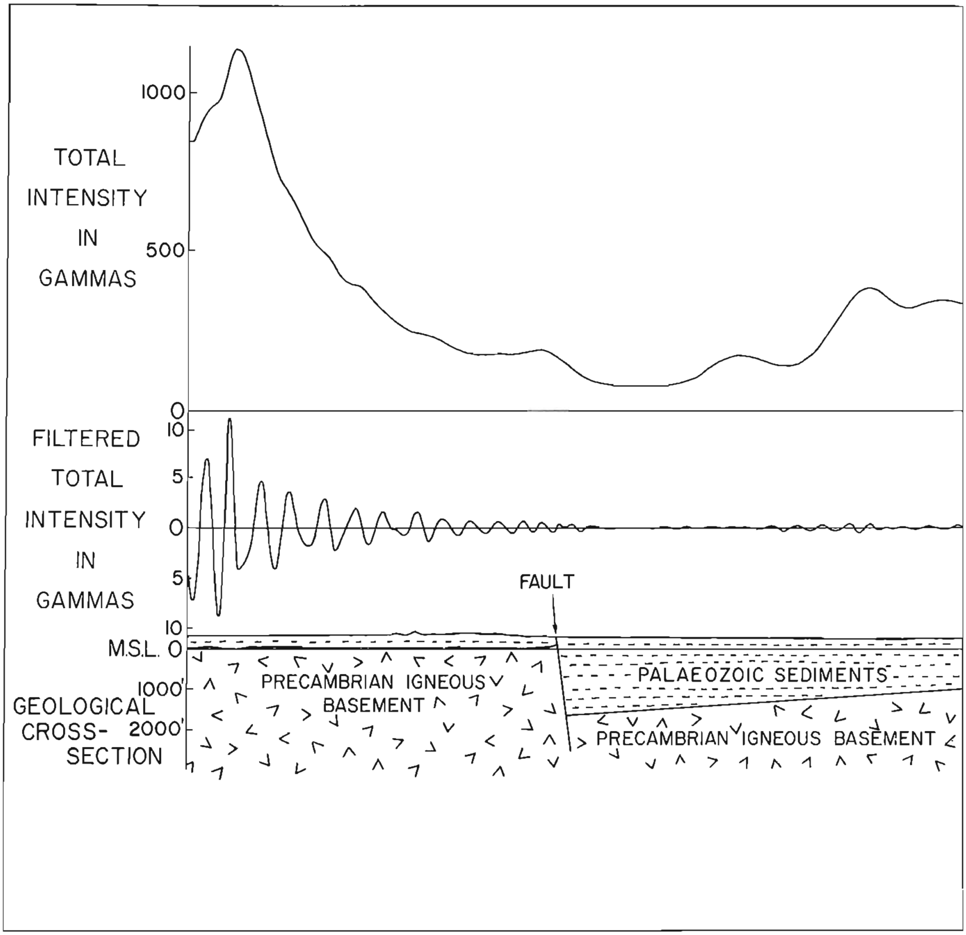
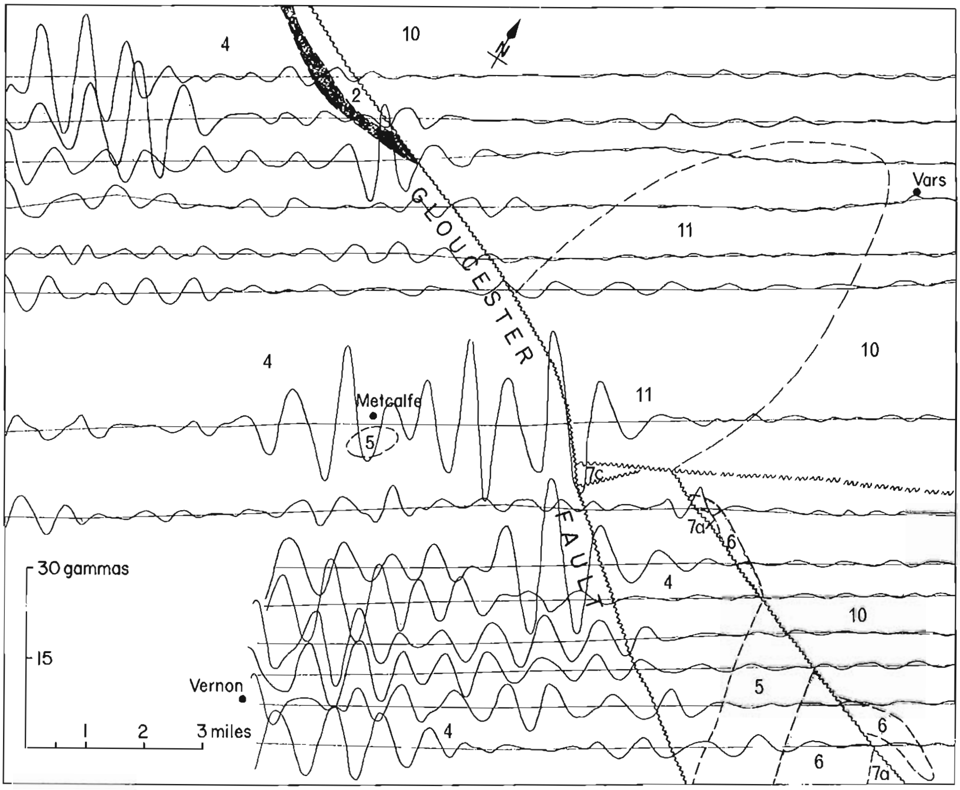


Figure 3. Total intensity aeromagnetic profile, a filtered total intensity profile, and geological cross-section across the Gloucester Fault, southeastern Ontario.



LEGEND

ORDOVICIAN

RICHMOND

11 QUEENSTON FORMATION: red shale
RUSSELL FORMATION: interbedded grey shale and dolomite

DUNDAS-LORRAINE

10 CARLSBAD FORMATION: grey shale, sandy shale, some dolomite layers.

BLACK RIVER and TRENTON

7 7a. Pamelia beds; limestone, dolomite, shale and thin-bedded sandstone.
7c. Leray beds: limestone.

CHAZY

6 ST. MARTIN FORMATION: limestone, minor shale and dolomite.

5 ROCKCLIFFE FORMATION: grey-green shale with lenses of grey sandstone.

BEEKMANTOWN

4 OXFORD FORMATION: grey limestone, magnesian limestone and dolomite.

3 MARCH FORMATION: interbedded grey calcareous sandstone and blue-grey dolomite

CAMBRIAN OR ORDOVICIAN

2 NEPEAN FORMATION: sandstone.

Figure 4. Filtered aeromagnetic profiles and geological map of part of Gloucester-Osgoode township (after GSC Map 852 A).

[6]Geological Society of London: Geological Society Phanerozoic time scale; Quart. J. Geol. Soc. London, vol. 120 S, pp. 206-262 (1964).

[7]Anders, E.B., Johnson, J.J., Lasaine, A.D., Spikes, P.W. and Taylo, J.T.: Digital filters, NASA Contractor Report, NASA-CR-136, 132 pp. (1964).

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49. GROUND GAMMA-RAY SPECTROMETER SURVEY, ELLIOT LAKE AREA, ONTARIO

P.G. Killeen

In order to provide ground control for trial of experimental air-borne gamma-ray spectrometer equipment, measurements were made over a strip extending south from Flying Goose Lake to Highway 108. This strip, approximately three miles long by half a mile wide, extends from the pre-Huronian basement, across the Matinenda and Nordic Formations, and crosses two major intrusions of Keeweenawan diabase. Readings were taken at over 1000 stations on a 200-foot grid, using a three-channel Geological Survey of Canada spectrometer. The data has been reduced to provide corrected count rates measuring potassium, uranium and thorium at each station. In this particular locality the corrected count-rate for uranium on the subeconomic outcrop of the Matinenda Formation is up to ten times greater than the average uranium count-rate for other rocks on the section.

50. PALAEOMAGNETIC MEASUREMENTS ON IGNEOUS ROCKS IN THE APPALACHIAN PROVINCE

A. Larochelle

Forty-eight oriented samples were collected from diabase dykes in the Forillon Peninsula, Gaspé and from St. Andrews, New Brunswick areas. The laboratory measurements on the first group of samples were found inconsistent among themselves and rejected as useless for further palaeomagnetic research. Laboratory work on the second group is in progress.

One hundred and thirty five oriented samples were collected from 'gabbroic' (?) intrusive bodies in the La Patrie, Quebec area from four of the Monteregian Hills. The laboratory results obtained from the first group of samples did not lend themselves to a valid palaeomagnetic interpretation and the samples were not considered further. The results obtained from the Monteregian Hills on the other hand proved to be remarkably consistent. This work confirmed the previous palaeomagnetic inferences on the Monteregian Hills and also suggested that the non-dipole component of the earth's field in Cretaceous time may have been considerably less important than it is today.

51. SEISMIC REFRACTION, ST. JOSEPH ISLAND, ONTARIO (41 J/4 (West Half))

H.A. MacAulay and George D. Hobson

Eleven miles of continuous reversed refraction seismic profiling were shot along the existing roads in the southern part of St. Joseph Island from Tenby Bay to Whiskey Bay to Old Fort St. Joe. Conventional 12-trace instruments recorded seismic data from energy generated by the detonation of small charges of explosives.

Nowhere in the area is bedrock exposed and most geologists agree that Palaeozoic rocks underlie the drift.

Based upon a correlation of observed seismic velocities with lithology, carbonates form the bedrock from Old Fort St. Joe to a location one mile south of Tenby Bay post office. From there shale bedrock for two miles to the road intersection north of the post office. These shales terminate in a significant north-facing escarpment with a drop in bedrock elevation of about 200 feet. North of this escarpment carbonates again form the bedrock.

Drift thickness varies between 70 and 190 feet south of the escarpment while north of this feature thicknesses are between 260-360 feet. The drift is thinnest in the vicinity of Whiskey Bay and Elliot Point. One seismic location is within 3/4 mile of the Henry Fremlin No. 1 hole drilled at Collins Bay so that certain correlations can be made between seismic data and the geological log of the hole. The shale and carbonates to the north appear to be Collingwood and Trenton strata respectively while the southernmost carbonates may be either Silurian or Ordovician in age. Liberty[1] does not believe that Silurian formations are present at the south end of St. Joseph Island as has been indicated by other investigators. The southernmost carbonates must therefore be Ordovician in age to concur with Liberty's interpretation that Upper Ordovician beds constitute the youngest Palaeozoic strata on the island.

Geological Conclusions (contributed by B.A. Liberty, University of Guelph).

Data presently known indicate the post-Collingwood Ordovician strata to be thicker than 200 feet. Considering the escarpment's relief to be 200 feet and with the dip being southerly at about 15 feet per mile, youngest strata close to the escarpment are considered to control the bedrock topography from the escarpment area to the southern limit of the island. Accordingly, the youngest strata on St. Joseph Island are considered to be Ordovician in age.

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[1]Liberty, B.A.: Stratigraphic studies of the Middle Ordovician and Cambrian strata in the St. Joseph Island-Sault Ste. Marie area; Geol. Surv. Can., Paper 67-1, part A, pp. 154-155 (1967).

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52. SEISMIC REFLECTION SURVEYS, ELLIOT LAKE, ONTARIO (41 J/2, 7)

A. Overton

During the period May 15 to June 15, 1967, the feasibility assessment of the seismic method was continued in the Elliot Lake area. This assessment was begun in 1966 and is described by the author[1]. The work of 1967 emphasized the continuous reflection profile method with the application of the 'common depth point' technique. The continuous reflection profile was located east of highway 108 on the Stanrock mine road.

The 'common depth point' technique involves a number of reflection recordings for each subsurface reflection point with different shotpoint to geophone spacings. Analysis of these data require that recording be on magnetic tape. After corrections for elevations of shotpoint and geophone, thickness of low velocity overburden and ray path geometry have been applied to each recorded trace representing a subsurface reflection point, these traces are combined or 'stacked' to accentuate primary reflected energy and discriminate against multiple reflected energy, randomly reflected surface waves and random noise. This method has been used successfully in certain difficult areas of exploration for oil. Processing of the magnetic tapes into seismic reflection sections is now in progress.

A refraction profile was also conducted to estimate seismic velocities in the various formations outcropping and subcropping along highway 108 north of the Denison mine access road onto the granitic rocks north of the Algom Quirke mine. Results of this bedrock velocity survey and the bedrock velocity determinations from the reflection profile, suggest that measured velocities are more subject to errors of determination than bedrock type. But even if the measured velocities are taken as correct, the indicated range of 17,000 ft/sec to 21,000 ft/sec suggests small velocity contrasts. This does not present a favourable condition to the seismic reflection method, but reefs have been found with similar small velocity contrasts and the final appraisal must await the processed reflection sections.

[1]Overton, A.: Seismic studies, Elliot Lake area; Geol. Surv. Can., Paper 67-1, part A, pp. 155-157 (1967).

53. PALAEOMAGNETIC MEASUREMENTS ON SILURIAN AND DEVONIAN ROCKS IN NORTHERN NEW BRUNSWICK (21 O/10, 15)

G.W. Pearce

One hundred and fifty-one oriented samples, mainly of basalt, were collected from Devonian formations in the Upsalquitch Forks and Campbelton areas of northern New Brunswick. Laboratory studies on these samples are at present in progress and it is hoped that the results of these studies will provide an estimation of the Devonian magnetic pole position for eastern North America. Twenty-nine oriented samples of Silurian acidic igneous rocks from the same areas were collected for a preliminary study to establish whether they are useful for palaeomagnetic methods.

54. EM ANOMALIES, MOOSE RIVER AND KINMOUNT AREAS, ONTARIO

W.J. Scott

A square-wave generator with frequencies from .63 to 3 Hz, operating at a power level of 300 watts, was constructed for use in the projected resistivity work. Field tests of this unit and of an SIE Model RS-4 12-channel seismic unit were carried out in the Gatineau Park north of

Ottawa. In a preliminary survey on one of the broad airborne EM anomalies in the Moose River area, results indicate the existence of a bedrock depression filled with conductive overburden, whose position may coincide with the anomaly. Further tests were carried out in the Ottawa and Kinmount areas to determine the requirements for pre-amplifiers and amplifiers to be built this winter to enable the RS-4 to be used as a multi-channel resistivity unit.

55. GROUND STUDIES BASED ON AIRBORNE INFRA-RED IMAGERY

V.R. Slaney

The study was designed to test the efficiency of a number of portable ground instruments and techniques for the relocation and examination of infra-red anomalies. Further studies were directed to obtain basin information on the radiation temperatures of natural objects and to study changes in radiation in time and under varying weather conditions.

A number of effluent sources along the Detroit River were located and examined from a small boat using a Stoll-Hardy radiometer and thermistor probes. Increases in river temperature at the effluent outlets ranged from less than 2°C for municipal effluents, through 4°-5°C for outflows from thermal power stations, to more than 10°C for heavy industrial plants and distilleries. Thermistor probes with a thermal sensitivity better than ± 0.1°C were found to be the most useful measuring device.

Investigations were also carried out to locate several areas of cold water along the edge of the Ottawa River near Vaudreuil. The pockets of cold water which were first recognized as the result of an airborne infrared survey are believed to originate by seepage into the river from a series of buried river valleys. A Barnes PRT5 radiometer with a 2° angular field, leased for the project, was mounted in a canoe and linked to a paper strip recorder. At Belle Plage and Oka Ferry the near shore water radiation temperatures were 0.3° and 0.5°C respectively lower than in mid-stream. Around the mouth of the Rigaud River (a supposedly negative anomaly) near-shore radiation temperatures rose 0.5° to 1.0° above mid-river temperatures, a pattern similar to that found at Pointe Cavagnole and other areas where no airborne anomalies had been located. Instrument accuracy was no better than ± 0.2°C, largely because of continual changes in the attitude of the water surface relative to the radiometer head.

The Barnes radiometer was also mounted at the open rear end of a truck to obtain a continuous record of radiation along the verges of two unpaved roads crossing Rigaud Mountain. The traverses were repeated several times in daylight and at night. The traverse records obtained on consecutive evenings or at different times of night can be correlated in detail. Each natural subject, such as an outcrop, bare soil or a road, and particularly each type of vegetation cover, marsh, short grass, dense bushes or tall tree cover, has a characteristic radiation pattern. The pattern is modified but rarely masked by influences of elevation, aspect, wind and surface moisture. During the day, solar heating modifies radiation temperatures to a continuously varying degree, depending on the sun angle, the pattern of sunlight on the subject and the presence of passing clouds. For this reason, all quantitative radiation studies should be carried out in the evening or at night.

56. SAMPLE COLLECTING FOR PALAEOMAGNETIC STUDY

D.T.A. Symons

(a) Dean Channel: Two hundred and ninety-two (292) oriented samples from 75 sites were collected from basic intrusives along the Seaforth and Dean Channels. The samples come mostly from dykes which occur in swarms and which were intruded at various times during the Cretaceous and Cenozoic. The purpose of this study is to classify the dykes by their palaeomagnetic properties and thereby assist the present mapping of the Coast Ranges. Three weeks were spent collecting these samples. Dr. A.J. Baer assisted in the site selection.

(b) Mount Edziza: Four hundred and twenty-one (421) oriented samples from 95 sites were collected from basic to intermediate extrusives on Mount Edziza. The samples come from three stratigraphic sections of Tertiary and Recent rocks around the volcanic centre. The purpose of this study is to date the flows in this flat-lying sequence by their remanence directions, and thereby assist in the correlation between sections and in the establishment of a type section for the Cenozoic volcanics of British Columbia and the Yukon. Three weeks were spent collecting these samples with the co-operation and assistance of Dr. J.G. Souther.

(c) Cobalt: Sixty-four (64) samples from 16 sites were collected from the Nipissing diabase 'sill' and the Cobalt series sediments to determine the suitability of these units for palaeomagnetic study.

57. MULTIBAND AERIAL PHOTOGRAPHY

V.R. Slaney

A system for the production of multiband aerial photography has been established and tested on the ground.

Four motorized Hasselblad cameras have been arranged to fit into a standard aircraft mount. An intervalometer capable of firing any one or more of the cameras has been built by Mr. H. Gross. Film development tests were carried out on panchromatic, infra-red, colour and colour infra-red film by the photographic laboratories of the Geological Survey. Sensitometric step wedges were provided through the courtesy of Capital Air Surveys Ltd. At the present time, panchromatic film can be exposed through 13 filter combinations and developed to a required gamma ± 0.07 gamma. Infra-red film can be similarly exposed and developed to a required gamma ± 0.09 gamma.

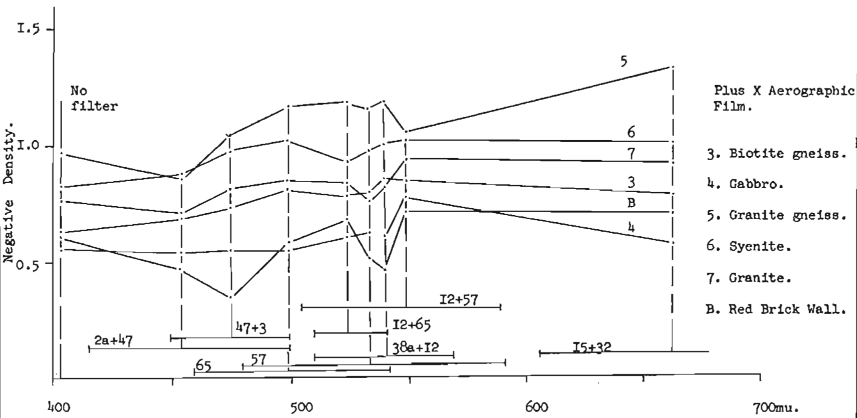

Figure 1. Density changes in filtered photographs of Bancroft rocks.

Samples of typical weathered and unweathered rocks were collected from the Bancroft district and from the area north of Otter Lake, Quebec. The samples were photographed, using panchromatic film, through 12 different sets of Wratten gelatine filters. Figure 1 illustrates how the tone contrast between rock types can be emphasized or reduced according to the filter combination employed.

The cameras are to be flight tested in the Bancroft district.

A further report, Paper 145, on geophysical investigations, will be found on page 226.

MINERAL DEPOSITS

58. MINERALOGY OF ASBESTOS DEPOSITS, JEFFREY MINE; ASBESTOS, QUEBEC

F. Aumento

The Jeffrey Mine, Asbestos, Quebec was the main area investigated. Representative samples were collected for use in a comparative study of the serpentine mineralogy in various ultramafic complexes. Samples of asbestos fibre were also collected to determine variations in fibre both within the orebody, and in comparison to fibres from other mines in the area.

Most of the sampling was carried out in the open pit of the Jeffrey Mine. Three traverses were made across the pit; two along the west wall and one along the east wall. These traverses are transverse to the main structural trends of the orebody and the enclosing serpentinized peridotite intrusion. Samples of the serpentinized peridotite (both ore-bearing and waste) cross-fibre and slip-fibre asbestos, picrolite, talc, brucite, granitic vein material and associated rocks, were collected. In addition, a core from a diamond drill-hole located in a waste zone along the south wall of the pit, but intersecting ore at depth, was examined and sampled down to a depth of 1,320 feet. The associated barren granular serpentinite, pyroxenite, and gabbro outcropping to the south of the orebody were also sampled.

A two-fold program of laboratory studies is being carried out: (1) the serpentinized peridotite and other serpentinized rocks will be studied in thin section; the serpentine minerals will be separated from the crushed rocks and studied by X-ray diffractometry. Results will be compared with those from similar studies (partially completed at this time) carried out on serpentine minerals from the Mount Albert intrusion, Quebec, and the Muskox intrusion, Northwest Territories. It is hoped to relate the different serpentine polymorphs that may have developed to the type of intrusion and to the chemical environment. (2) the chrysotile fibres will be studied by X-ray diffraction and electron microscopy in an effort to explain the variations in the physical properties of the fibres. Samples from the Jeffrey Mine, and samples previously collected from other mines in the area will be investigated.

Geochemical and X-ray microbeam studies will also be carried out on these samples at the Department of Geology and Mineralogy, Oxford University, by graduate students under the supervision of Dr. E. J. W. Whittaker, Reader in Mineralogy.

59. WALL ROCK ALTERATION OF SILVER DEPOSITS; COBALT AND GOWGANDA, ONTARIO (31 M, 41 P)

A.S. Dass

Deposits of silver ore in the areas around Cobalt and Gowganda were examined. The work consisted of mapping alteration zones in underground mines, studying the alteration of rock types, and collecting samples of altered and fresh rocks and ore from drill-cores, surface outcrops and dumps.

The area studied comprises early Precambrian Keewatin plutonic, volcanic and sedimentary rocks overlain unconformably by Proterozoic Cobalt sediments, which were intruded by Nipissing diabase. Palaeozoic rocks overlie Proterozoic rocks with great unconformity and are overlain by Pleistocene glacial and post-glacial deposits.

The silver deposits occur as thin veins and lenses in Cobalt sediments, Keewatin rocks, pre-Algoman lamprophyre dykes and Nipissing diabase. There is a close association of silver-nickel-cobalt ores with Keewatin interflow bands and certain volcanic flows. A large proportion of the silver ores tend to be near the Keewatin-Cobalt contact. The veins are steeply dipping and extend a few hundred feet horizontally and vertically. The vein minerals consist of typical complex arsenides and sulph-arsenides of cobalt-nickel-iron, native silver, sulphides of base metals and carbonate gangue minerals. The relationship of arsenides and sulphides is not fully understood, but geochemical work indicates that the sulphides, with subordinate arsenides, are mainly confined to Keewatin rocks. Deposits in Cobalt sediments are rich in arsenides with a lesser amount of sulphides; the Nipissing diabase carries arsenides with very little sulphides.

All rocks have been altered, especially in areas adjacent to the veins. The wall-rock alteration is well-marked in Nipissing diabase and Keewatin greenstone, but is less well-marked in Cobalt sediments. The alteration is characterized by a narrow dark chloritic band adjacent to the vein, passing transitionally into a light coloured (bleached) band and then into an unaltered zone. The bands show bilateral symmetry about the veins, and the alteration zones rarely exceed six inches in width.

Chloritization, sericitization, carbonatization and, to some extent silicification took place in the altered zones. The unaltered Nipissing diabase, containing labradorite, augite and titaniferous magnetite, is completely destroyed and replaced adjacent to the veins by fine grained carbonate, chlorite, sericite and leucoxene. In the light (bleached) band, plagioclase is highly sericitized and augite is completely changed to carbonate, saussurite and magnetite. The dark band consists of pennine chlorite, calcite and saussurite. The minerals present in the altered zones of Keewatin greenstones adjacent to the veins include quartz, sericite, carbonate and leucoxene. Chlorite spots occur in all the rock types adjacent to the veins. The composition of the chlorite spots changes near the veins; the chlorite is probably an iron penninite.

Major elements show some variation within altered zones of Keewatin greenstones and Nipissing diabase, but not in Cobalt sediments. The dispersion patterns of trace elements show bilateral symmetry about the veins in all rock types.

In Keewatin greenstone wall-rock, Na_2O, MgO, TiO_2 and H_2O are generally depleted in the altered zones. S, CO_2 and MnO show an increase as the vein is approached. Fe_2O_3, Al_2O_3, CO_2, SiO_2 and K_2O are extracted from the alteration zone by some veins and added by others. The dispersion of Ag, As, Sb, Ni, Co, Mn and Hg outward from the veins is broad and veins may be indicated as far as 50 feet away by these elements.

In Nipissing diabase wall-rock, H_2O, S, and Fe_2O_3 show an increase in all the altered zones, while CO_2 and SO_2 show a general depletion. K_2O, Na_2O, Mno, CaO and MgO are abstracted from some of the altered zones and added in others. Al_2O_3 and TiO_2 do not show marked variation. The dispersion of trace elements is narrow and veins are indicated only 10 to 15 feet away by a rift in Ag, As, Ni and Co.

In Cobalt sediments H_2O, S, CO_2, Fe_2O_3, MnO, MgO and CaO show an increase towards the vein, while SiO_2, Na_2O, Al_2O_3 and TiO_2 show a general depletion. K_2O is extracted from some zones and added in others. The dispersion of Ag, As, Sb, Ni, Co, Mn and Hg is widespread outward from the veins, and veins may be indicated as far as 100 feet away by these elements.

It seems that the principal agents responsible for the alteration are carbon dioxide and sulphur. These volatiles reacted differently with various constituents of Keewatin rocks, diabase and Cobalt sediments.

60. METALLOGENIC STUDY OF THE THUNDER BAY REGION, ONTARIO (42, 52)

J. M. Franklin

All types of mineral deposits in the Proterozoic rocks of the Thunder Bay district, as well as uranium, copper, and nickel deposits in Archaean rocks were examined during the summer of 1967.

Silver-bearing veins in the Proterozoic rocks are of two types. The largest group of veins form a belt with a strike of N60°E, and is confined to Animikie rocks. This belt is five miles wide and extends from Pass Lake to Whitefish Lake, a distance of over seventy miles. Silver occurs principally as argentite, and is accompanied by galena, sphalerite, barite, green and purple fluorite, calcite, and quartz. The richest deposits are in the Rove Shale with a few occurrences in the argillite members of the Gunflint Iron Formation. All are near the contact of the Animikie rocks with diabase sheets.

Less common are deposits characterized by the native silver and sulph-arsenide-bearing veins of the Silver Islet mine. These deposits form a belt extending from Silver Islet to Jarvis Island, and parallel in trend to that previously discussed.

Lead-zinc deposits are confined to the lower units of the Sibley Group, and to the contact between the Sibley and the Archaean basement rocks. The veins are controlled by fracture and fault zones, and by unconformities, and are associated with local bleaching of the red Sibley mudstones. Preliminary chemical data indicate that the Sibley rocks contain an anomalous amount of lead and zinc, and may be the source of the vein material.

Two types of copper mineralization have recently been discovered near Disraeli Lake. One contains chalcocite, covellite and native copper in a porous dolomitic stromatolite horizon, located near the base of the Sibley Group. This mineralized zone forms an aureole around the second type of copper deposit. In the latter, chalcopyrite is disseminated throughout a syenitic zone developed as a contact phase of a large gabbro plug.

Small copper deposits are located near the unconformable contact of the Sibley Group with a large Archaean granite mass (Bowker Mountain) near Dorion. Chalcocite and chalcopyrite occupy fractures in the basal sandstones and mudstones of the Sibley Group in these deposits.

Two types of copper deposits were examined in the Osler Group. Native copper and chalcocite fill fractures and amygdules in the basaltic rocks. In addition, native copper has been found in interflow arkosic lenses.

Copper-nickel deposits of the region may be divided into three types: (1) those associated with massive serpentinites as at Shebandowan, (2) those occurring as sporadic sulphide concentrations near the edges of gabbro dykes, and (3) those associated with layered, differentiated mafic bodies, as in the Great Lakes Nickel Company deposit near Pigeon River. The latter deposit contains a disseminated sulphide zone near its base, above which is a distinctive chromite horizon.

Uranium occurrences are confined to Archaean granitic and metamorphic rocks of the Nipigon area. At Jackfish Lake, near Terrace Bay, a radioactive zone at the contact between granite and greenstone was examined. Copper-zinc deposits in Archaean rocks near Shebandowan were also visited.

61. STUDY OF IRON DEPOSITS IN CANADA

G.A. Gross

Carbonate-sulphide facies of Algoma type iron-formation were examined in the Michipicoten area of Ontario and comparative studies are continuing on different sedimentary facies of cherty iron-formation.

Two magnetite deposits were examined in the Grenville belt at Marmora and Newboro Lake, Ontario as part of a continuing survey of iron ore deposits in Canada.

62. URANIUM IN CANADA

H. W. Little

Brief examinations of activity and exploration for uranium were made at Bancroft, Elliot Lake, Beaverlodge, Johan Beetz, Makkovik, Papachouesati River, and Favourable Lake areas.

Bancroft[1] lies within the Grenville Province which comprises high grade metamorphic rocks and intrusions of Neohelikian age. There the former producing mines worked irregular ore shoots in bodies of mainly unzoned leucogranite pegmatite that occur within amphibolite and metagabbro, for the most part on the periphery of gneiss domes that have granite cores. The principal ore mineral is uranothorite. Hematitization in and near the ore is widespread. The only current major exploration activity is reported at Faraday mine which is being dewatered preparatory to examination and appraisal.

At Elliot Lake[2] ore occurs entirely within pyritiferous oligomictic conglomerate at or near the base of the Matinenda Formation, the lowermost unit of the Aphebian (Huronian) System. The principal ore mineral is brannerite. Major quantities of uranium are currently being mined at Denison and Rio Algom Nordic mines, and a lesser amount by underground leaching at the Stanrock mine. The Rio Algom Quirke mine has been dewatered and, it is said, preparation is being made for production. Exploratory drilling in the area has not yet been investigated by the writer.

Farther east, the Agnew Lake[3] deposit, owned by Kerr-Addison mines, occurs in basal conglomerate in a succession of white quartzite beds that rest upon granite and dip steeply southward. At depth in the west end of the deposit, the contact has apparently been folded and for some distance dips gently northward. It is planned to commence a shaft in January 1968.

At Beaverlodge[4] the ore deposits occur in veins within gneisses and amphibolites of the Tazin Group, or within mylonitized equivalents of these rocks. The ore-bearing veins occur within or near certain major easterly trending faults, in particular the St. Louis, Black Bay, Crackingstone, and Boom Lake faults. The veins are characterized by abundant silicification, carbonatization, and hematitization ('red alteration'). The ore mineral is pitchblende. The only producing mine is the Fay-Verna of Eldorado Mining and Refining Company, which is now actively developing its new Hab property some 5 miles north of the Verna. Companies that are currently engaged in exploratory drilling on veins or favourable structures are Eldorado, Mokta, Norbaska, Gunnex, and Newmont.

The writer and A. J. Baer of the Geological Survey examined the basal part of the Athabasca Group where the unconformity is exposed near the south shore of Lake Athabasca. No anomalous radioactivity was detected in any of these exposures.

In the Johan Beetz[5] area, which is on the north shore of St. Lawrence River and within the Grenville Province, there is a circular structure comprising a complex of granite and unzoned pegmatite with some metasomatized quartzite and minor metagabbro. In the central part, coarse-grained to very coarse grained red granite predominates, and contains pegmatite bodies ranging in size from pods a foot or two across to zones many hundreds of feet in length and, possibly, breadth. Near the periphery of the circular structure, granite is much less abundant and quartzite even more so. There rock exposures are less abundant and only small parts of the area have been mapped in detail, but pegmatite also seems to be extensive. The pegmatite in the northern part of the body is white to grey rather than red. No examination was made of the metamorphic rocks surrounding the circular body.

Parts of the coarse-grained red granite and of both red and white pegmatites are radioactive. The most radioactive parts of the white pegmatites are generally small, ovoid grey patches that are exposed in the walls of trenches. The radioactive minerals appear to be tiny unidentified black crystals and a secondary yellow mineral that occurs along fractures in the rocks. Grandroy[6] has reported assays of samples from trenches in excess of 0.2 per cent U_3O_8 across 52 feet.

Only Gulf Uranium and St. Pierre Uranium, operating under joint management, have so far diamond drilled their showings. Other development in the area consists only of stripping and trenching.

In the Makkovik area[7] of Labrador, a succession of sedimentary and volcanic rocks of the Aillik 'series' has been mapped by British Newfoundland Exploration Limited. These rocks are warped into a canoe-shaped fold trending 10°N to 20°E, the apex of which is a few miles south of Makkovik. A few small bodies of granite intrude these rocks. Locally the sediments and volcanics are metasomatized to porphyroblastic rocks and amphibolite, but elsewhere bedding, some crossbeds, and pillows have been discerned. To the west of this fold is the Kitts deposit, comprising pyrite, pyrrhotite, and pitchblende in veins and replacements in black phyllite that is interbedded with greenstone. In nearby quartzite a radioactive vein has been traced intermittently for several thousand feet. Elsewhere similar radioactive veins occur almost exclusively in two quartzite members of the succession exposed on the flanks of the fold. One of these veins also contains molybdenite.

The Papaskwasati basin[8], north of Lake Mistassini, was completely staked in 1967, but although radiometric examination of most if not all outcrops, and some stripping, has been done, only Phelps-Dodge have done any diamond drilling. Papaskwasati sediments consist almost entirely of white feldspathic quartzite, with the exception of a thin, dark grey argillaceous bed at or near the base and a basal oligomictic conglomerate that has a maximum known thickness of perhaps 40 feet. The lateral extent of these units is as yet not known. The conglomerate is radioactive, but other than a few crystals of pyrite no primary metallic minerals were seen in hand specimens. However some outcrops show yellow secondary minerals.

In Favourable Lake area[9] Cam Mines are exploring ground formerly held in 1955 and 1956 by Sigoasco Explorations Limited. The claims extend from the southern part of Favourable Lake S 60° E past Bearhead Lake. In general they straddle the contact between medium- to coarse-grained red granite to the south and amphibolite and migmatite, possibly a septum, to the north. Foliation in these metamorphic rocks is apparently parallel to the contact and dips steeply southwest. Near the contact the amphibolite is invaded by tabular and lenticular bodies of pink to red pegmatite from a few inches to perhaps a few tens of feet in width, which are in places strongly radioactive. Parts of this zone have been trenched and one showing, near Bearhead Lake, has been diamond drilled. Radioactive sections of the core have all been shipped for assay, and some results have been published[10]. From the first diamond drill core an assay of 0.149 per cent U_3O_8 over 10.7 feet was recorded, but subsequent values were generally less promising.

Four and one-half miles northwest of the drilled site, and near the granite-migmatite contact, there is another showing that was not seen by the writer due to snow. Samples from trenches were assayed and as published were 0.072 per cent U_3O_8 across 48 feet, 0.181 per cent across 15 feet, and 0.150 per cent across 20 feet.

In addition to these showings others examined by the writer occur in the granite south of Bearhead Lake. Certain points within the granite, which is somewhat radioactive, record radioactivity two or three times background.

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[1] Satterly, J.: Radioactive mineral occurrences in the Bancroft area; Ont. Dept. Mines, vol. LXV, part 6 (1957).

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

[3] Card, K.D.: Hyman and Drury townships; Ont. Dept. Mines, Geol. Rept. No. 34 (1965).

[4] Robinson, S.C.: Mineralogy of uranium deposits, Goldfields, Saskatchewan; Geol. Surv. Can., Bull. 31 (1955).

[5] Cooper, G.E.: Johan Beetz area; Quebec Dept. Nat. Resources, Geol. Rept. No. 74 (1961)

[6] Northern Miner, Aug. 10, 24, and 31, 1967.

[7] Kranck, E.H.: Bedrock geology of the seaboard of Labrador between Domino Run and Hopedale, Nfld.; Geol. Surv. Can., Bull. 26 (1953).

[8] Chown, E.H.: Preliminary report on the Papachouesati River area; Mistassini territory; Quebec Dept. Nat. Resources, P.R. No. 415 (1960).

[9] Donaldson, J.A.: Geology, North Spirit Lake, Ontario; Geol. Surv. Can., Map 50-1960 (1960).

[10] Northern Miner, Aug. 17 and 31, Sept. 7, 1967.

63. GEOLOGY OF CANADIAN TIN DEPOSITS

R. Mulligan

In the northwestern Cordillera, investigation of potential tin occurrences continued in connection with the metallogenic study of the Cassiar batholith. Tin is concentrated in many of the lead-zinc sulphide deposits as well as quartz-greisen veins with tungsten and/or molybdenum, and skarn deposits. Mineral deposits of various types, granitic bodies, and stream sediments were sampled to provide additional information on tin distribution.

The unique tin-beryllium deposits in limestone in the Lost River area, Seward Peninsula, Alaska, were briefly examined, through the courtesy of C. L. Sainsbury of the U. S. Geological Survey.

A field test of the Portable Radioisotope X-ray Fluorescence Analyzer was carried out at the Mount Pleasant, New Brunswick tin deposit, in collaboration with A. G. Darnley of the Exploration Geophysics Division.

64. METALLOGENIC STUDY OF THE BERYLLIUM-TIN PROVINCE OF THE CASSIAR BATHOLITH, YUKON AND BRITISH COLUMBIA

R. Mulligan

About three weeks of field work was done in late June and July in the southeastern part of the project area in conjunction with a regional mapping project by H. Gabrielse. Mineral occurrences were examined and sampled, and some granite bodies and stream-sediments were sampled to provide further information on trace-element distribution.

In the southeastern part of the McDame area[1] (104P), mineral deposits of various types occur in successive belts along and subparallel with the northeast flank of the Cassiar batholith.

Molybdenite-bearing quartz-greisen veins occur in five localities, mostly confined to the endocontact zone of the batholith. One of these east of Limestone Peak, 59°15'N has been drilled extensively and a group about three miles south was being explored in 1967. Some beryl occurs in at least one, and the beryllium mineral danalite occurs in a contact skarn southwest of Needlepoint Mountain[2].

Argentiferous lead-zinc sulphide deposits occur in the Proterozoic-Lower Cambrian limestone bands of the exocontact zone, where they carry abundant magnetite. Lead-zinc sulphide deposits in equivalent rocks form another belt from Mount Haskin to McDame Post, on the northeast flank of the McDame synclinorium.

Gold-bearing quartz-pyrite-tetrahedrite veins are numerous in a zone extending from Quartzrock Creek to the head of Pooley Creek, mainly in greenstone of the Sylvestre Group. Placer gold deposits are still being mined along McDame Creek. A few chalcopyrite-pyrrhotite deposits occur farther southwest, near the lower contact of the Sylvester Group.

Some nickel and copper showings, and asbestos occurrences in addition to the Cassiar Mine deposit, are associated with ultramafic bodies within the Sylvestre greenstones of the McDame synclinorium.

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[1] Gabrielse, H.: McDame map-area, Cassiar district, British Columbia; Geol. Surv. Can., Mem. 319 (1963).

[2] Mulligan, R.: Beryllium occurrences in Canada; Geol. Surv. Can., Paper 60-21, pp. 6, 7 (1960).

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65. GEOLOGY AND DETECTION OF THE RARE EARTH ELEMENTS CERIUM AND YTTRIUM

E.R. Rose

As a first step in a study of the geology of rare earth deposits of Canada, about which little is known, an attempt was made by the writer, during the summer of 1967, to develop a method of detecting rare earth elements which could be used to advantage in the field by geologists and prospectors. Such a test is prerequisite to the acquisition of data on the manner of occurrence and distribution of these elements and to a study of deposits of rare earth elements in Canada. Satisfactory results were achieved in developing a series of chemical tests for detecting the presence of cerium and yttrium, the two most abundant rare earth elements, as well as that of a number of other commonly associated rare elements. The methods of these tests will be described in detail in a subsequent paper.

Based on results obtained using these tests, a number of complex granite pegmatites in the Gatineau hills of Quebec, and in the Perth area of Ontario, were found to be enriched mainly in yttrium. Apatite occurrences in both of these areas, as well as in the Eganville area of Ontario, were found to be enriched mainly in cerium.

PALAEONTOLOGY

66. MACKENZIE MOUNTAINS, DISTRICT OF MACKENZIE

David L. Dineley

Collections of fossil vertebrates were made from the Delorme Formation (Siluro-Devonian) at four localities within the area of Operation Selwyn. The sections in which these localities occur were measured by field parties in 1966.

At locality No. 69014 (62°33'N, 127°45'W) high on the mountain side southeast of Grizzly Bear Lake, a large number of poraspid-like cyathaspidids with squamation largely intact is of major interest. With these also occur large and small cephalaspids, large and small pteraspids, other heterostracans and several forms which appear to have possessed an unusual carapace of small scale-like units. These fossils occur in a dark, somewhat shaly and pyritiferous dolomitic lithology with conspicuous lamination. Rare marine invertebrates were found in these beds. A possible lagoonal environment with quiet sedimentation is thought to be suitable for the production of this rock-type and its fauna.

At locality No. 69017 (63°25'N, 128°W) near the summit of an unnamed peak west of the Natla River, a two-foot bed of yellow-weathering grey mudstone contains a large number of ostracoderm remains. Collected material includes several new forms which may be akin to *Corvaspis*, while others are new cyathaspidids, all of a relatively large size. From two slightly lower beds of limestone similar cyathaspidids were collected, and lower in the sequence again are horizons with *Pteraspis* and *Traquairaspis* respectively.

An exactly comparable situation occurs on the next ridge to the southeast where horizons with *Pteraspis* and cyathaspidids were also found. From both ridges large collections of material were made.

In the Sekwi Range near June Lake a collection of cyathaspidids was made in the col at the base of the Delorme Formation. There large numbers of *Vernonaspis* were collected.

The resulting collection will make an important addition to knowledge of ostracoderm distribution in the northwest. Preliminary examination suggests that the vertebrate faunal sequence in the Delorme is closely comparable to that in Siluro-Devonian formations elsewhere in North America and Northwest Europe.

67. UPPER SINEMURIAN BEDS IN THE FERNIE GROUP OF SOUTHEASTERN BRITISH COLUMBIA

Hans Frebold

The Lower Jurassic Phosphate beds in southeastern British Columbia belong to the Sinemurian stage. Hitherto fossils indicating the lower part of this stage were known. During the field work in 1967 a younger fauna was found in the Phosphate beds of the Lodgepole area south of Fernie, British Columbia. It contains ammonites of the families Eoderoceratidae and Oxynoticeratidae which indicate the presence of one of the upper zones in the upper Sinemurian (=Lotharingian). Beds of this age were hitherto unknown in the Jurassic Fernie Group of Alberta and British Columbia. Other components of this fauna are Rhynchonellidae, Pleuromyidae, Aviculidae, Pectinidae and Ostreidae. At no other locality were beds of this age found and it is supposed that they were removed before the deposition of younger Lower Jurassic beds. In other areas they were probably not deposited.

68. MIDDLE CAMBRIAN TRILOBITE STUDIES NEAR FIELD, BRITISH COLUMBIA

W.H. Fritz

Approximately six weeks were spent near Field, British Columbia collecting trilobites in conjunction with the Burgess Project. The trilobites will be used to date various stratigraphic horizons in order to understand an abrupt westward increase in thickness of the Stephen Formation (<u>see</u> Aitken and Fritz in this publication). In particular, they will aid in locating the Burgess shale within the thick Stephen to the west, and in correlating it with part of the thin Stephen only a short distance to the east.

A total of 187 collections were made from three sections on the north face of Mount Stephen, four sections on the south face of Mount Field, one section through the Burgess Quarry, and one section on the Trans-Canada Highway immediately west of Sherbrooke Creek.

Preliminary studies indicate that upper and lower formational contacts of the Stephen do not change appreciably in age as the formation thickens westward. The most rapid deposition to the west seems to have taken place in the lower portion of the formation. The abrupt change in thickness is accompanied by a striking faunal change that is interpreted as a response to environment.

69. STRATIGRAPHY AND PALAEONTOLOGY OF LOWER CRETACEOUS AND UPPER JURASSIC ROCKS OF NORTHEASTERN CORNER OF MOUNT WADDINGTON MAP-AREA, BRITISH COLUMBIA (92N)

J.A. Jeletzky

About five weeks of 1967 field season were spent in a detailed stratigraphical-palaeontological study of Lower Cretaceous and Upper Jurassic key sections of several late Mesozoic outliers in northeastern corner of Mount Waddington map-area (92N). This work was undertaken to support the mapping of this part of Mount Waddington map-area by H.W. Tipper (see his report and map in this publication).

Potato Range syncline

The north-trending Potato Range syncline, confined between Tatlayoko Lake and the northern part of Chilko Lake, is filled out by an about 5,000-foot thick succession of neritic to non-marine, commonly richly fossiliferous Upper Jurassic (Oxfordian to Upper Tithonian) and Lower Cretaceous (Berriasian to Barremian) greywacke and (?) arkose sandstones with minor interbeds of siltstone and pebble conglomerate. The ratio of siltstone increases rapidly southward and southeastward. This fact and the southern to southeastern dips of foreset beds indicate a closely situated northerly to northwesterly source area for the Upper Jurassic and Lower Cretaceous rocks of the Potato Range syncline.

The at least 700-foot thick Upper Oxfordian (Buchia concenctrica zone) to Upper Portlandian s. str. (Buchia piochii zone) greywacke and siltstone overlie the older Jurassic rocks with an erosional disconformity. The upper Callovian and lower Oxfordian rocks appear to be absent in all sections studied.

The about 1,200-foot thick Upper Tithonian (Buchia fischeriana and Buchia terebratuloides zones) and Berriasian rocks (Buchia okensis and Buchia uncitoides zones) are represented by non-marine, often coaly and plant-bearing rocks, except for a few thin (6 inches to 5 feet) wedges of Buchia uncitoides coquina near its middle.

The largely marine, about 1,350-foot thick Valanginian greywackes (Buchia tolmatschowi, Buchia pacifica and Buchia crassicollis zones) appear to be overlain erosionally disconformably by the only 150- to 200-foot thick, possibly incomplete marine Hauterivian greywacke and siltstone. Except for its topmost 10-15 feet, which contain diagnostic uppermost Hauterivian ammonites (Simbirskites broadi and Shasticrioceras), only Inoceramus ex gr. colonicus and Acroteuthis (Boreïoteuthis) ex gr. impressa were found in this unit.

Some 1,800 feet of unfossiliferous, possibly non-marine greywacke overlie gradationally the Hauterivian marine rocks in the northern part of Potato Range, where their top is not reached in the syncline's axis. These rocks are of a general Barremian age, however, as they are overlain by (and possibly interfinger with?) some 1,000 feet of the Upper Barremian and (?) Aptian marine greywackes in the southern part of Potato Range. The latter contain Aconeceras ex gr. nisus (d'Orbigny), Hemihoplites ex aff. soulieri (Matheron), and Phyllopachyceras infundibulum (d'Orbigny); their top is not reached in the syncline's axis.

Tsuniah Lake syncline

East of the northern part of Chilko Lake the northeast-trending and severely faulted Tsuniah Lake syncline exposes almost exclusively an extremely thick succession of flysch-like Albian and (?) Aptian clastics faulted against middle Jurassic rocks on both its flanks; it consists of (in ascending order):

1. Dark to bluish grey, commonly tuffaceous and sandy siltstone and shale with considerable interbeds and members (up to 500 feet) of dark grey, mostly fine grained greywacke. The exposed thickness of this invariably badly faulted siltstone-shale unit definitely exceeds 3,000 feet and probably exceeds 5,000 feet; it grades upwards into unit 2 but its base was not observed.

The basal 900 feet of the shale-siltstone unit did not yield any diagnostic fossils. They could possibly be Upper Aptian in age because of the occurrence of the early Albian Brewericeras (Leconteites) lecontei and Aucellina ex gr. gryphaeoides fauna in the immediately overlying, some 1,500-foot thick middle part of the unit. The discovery of Upper Aptian Acanthoplites ex gr. reesidei fauna in the lithologically similar shale-siltstone succession about 10 miles to the east of our sections (at the northeast end of Konni Lake at the western margin of Taseko Lakes map-area) agrees well with this hypothesis.

The presence of Anahoplites sp. indet. some 600 feet below the top of siltstone-shale unit indicates a middle Albian age for its upper part.

2. Grey to brown-grey, mostly fine-grained greywacke with mostly minor interbeds and members of sandy siltstone and shale as in unit 1. Some grit and pebble conglomerate interbeds occur near the visible top. Unfossiliferous, except for locally common, poor plant remains and one indeterminate ammonite found in the uppermost siltstone member. The longest measured, apparently unfaulted section is about 5,500 feet thick with

another 1,000 feet or more exposed in its inaccessible uppermost part. The unit is assumed to be of middle to upper Albian age and (?) possibly younger.

Fault wedges of siltstone and greywacke of Buchia concentrica and Buchia mosquensis zones are preserved on the southeastern flank of Tsuniah Lake syncline just east of Chilko Lake. These rocks appear to be continuous with the contemporary rocks of the Potato Range syncline. However, they contain less greywacke and more sandy siltstone than the latter. This suggests their deposition in more offshore parts of the basin.

Hauterivian Rocks in Headwaters of Stikelan Creek and in Sapeye Creek Canyon

The at least 1,400-foot thick succession of lower to middle Hauterivian, commonly tuffaceous greywackes and arkoses with lesser interbeds and members of dark grey, sandy siltstone and shale was found in headwaters of Stikelan Creek immediately north of Tredcroft Glacier. This thick succession appears to represent only Homolsomites oregonensis and Speetoniceras cf. agnessense-Simbirskites (Hollisites) lucasi zones of British Columbia standard[1] which are not represented by fossils and possibly are absent in the much thinner Hauterivian succession of the Potato Range syncline.

According to H. W. Tipper, who visited these sections later in season, the Hauterivian clastics unconformably overlap the Upper Triassic rocks. They appear to grade upward into a thick succession of late Hauterivian and (?) younger pyroclastic rocks. The mostly maroon- to purple-coloured, commonly well-bedded (waterlain?), volcanic breccias and tuffs were not studied in any detail.

The Hauterivian section of Sapeye Creek Canyon on the northwestern side of Sapeye Lake is badly faulted and invaded by numerous intrusive dykes. The inferred upward succession obtained by combination of several partly overturned and faulted partial sections appears to be as follows:

1. Lower Hauterivian non-marine unit consisting of variously coloured, commonly carbonaceous to coaly greywacke and arkose with numerous interbeds of black to dark grey or dark brown, carbonaceous to coaly siltstone and shale. Siltstone and shale contain some 3- to 12-inch thick pods and lenticular interbeds of impure coal. Presumably equivalent to Homolsomites oregonensis zone of the Stikelan Creek section. Base cut off by faults. Grades upward into unit 2. Visible thickness is about 250 feet.

2. Early middle Hauterivian marine greywacke unit consisting of dull to dark grey, mostly fine-grained hard greywacke interbedded with some similarly coloured sandy siltstone. This unit is about 125 feet thick and is rich in Speetoniceras cf. agnessense and Simbirskites (Hollisites) lucasi; it grades upward into unit 3.

3. Black, apparently unfossiliferous shale with clay ironstone concretions. Some interbeds of greywacke as in unit 2. Top covered or faulted. Visible thickness is about 150 feet.

4. Siltstone, black to dark grey, with thin interbeds of greywacke and Inoceramus fragments. Locally rich in large Inoceramus n. sp. identical with that found in the late middle and (?) upper Hauterivian rocks of Yohetta Lake-Tchaikazan River area[2]. This unit appears to grade upward into a several thousand feet thick succession of late Hauterivian and (?) younger pyroclastic rocks lithologically similar to that observed in Stikelan Creek section (see there). Its base is invariably faulted. Visible thickness up to 250 feet.

Older Lower Cretaceous rocks were not seen in Sapeye Creek Canyon and probably were not deposited there. The writer was unable to find the early middle Albian shales [Brewericeras (Brewericeras) hulenense zone] previously recorded from the canyon.

The thicknesses and facies of the Hauterivian rocks of the Stikelan and Sapeye Creeks sections are extremely similar to those of the Yohetta Lake-Tchaikazan River area of the southwestern corner of Taseko Lakes map-area[2] but not to those of the Potato Range syncline. They appear therefore to represent the northwesterly continuation of the same southwestern marginal zone of Tyaughton Trough as the latter area.

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[1] Jeletzky, J.A., and Tipper, H.W.: Upper Jurassic and Cretaceous rocks of Taseko Lakes map-area and their bearing on the geological history of southwestern British Columbia; Geol. Surv. Can., Paper 67-54 (in preparation).

[2] Jeletzky, J.A.: Stratigraphy and palaeontology of Lower Cretaceous and Upper Jurassic rocks of Taseko Lakes (92-0) and Pemberton (92-J) map-areas; in Summary of Activities: Field, 1966; Geol. Surv. Can., Paper 67-1, Part A, pp. 65-68 (1967).

70. FORAMINIFERA FROM THE MARINE LOWER CARBONIFEROUS IN THE MARITIME PROVINCES

Bernard Mamet

Twenty sections and fifty scattered outcrops were investigated for foraminifera in New Brunswick, Nova Scotia and Newfoundland. The facies seems unfavourable to the microfauna in most of New Brunswick; moreover, in Newfoundland, widespread dolomitization obliterates the original structures of the carbonates. In contrast, the Windsor in its type-section as well as along a northeast trend in Nova Scotia yields excellent assemblages of Endothyridae and Archaediscidae. Systematic thin-sectioning of the material is now in progress.

Preliminary results indicate that in the type-region of the Windsor, the A zone is usually barren with the exception of scattered Earlandia. Zones B to D are rich in foraminifera which indicate a high Visean age; Zones 14?, 15, 16_i and 16_s have been encountered. Zone E, in the Kenetcook River is lowermost Namurian (zone 17). These zones have also been recognized in the Antigonish area, at Cape Dauphin and in Port Hood Island.

The microfauna has obvious affinities with the fauna observed in the Upper Meramec and Lower and Middle Chester of the Central Appalachians and Midcontinent. Moreover, many 'cosmopolitan' genera are present (Neoarchaediscus, Planospirodiscus, Asteroarchaediscus) and allow comparison with the English and Belgian biostratigraphic schemes.

The brachiopod assemblages recognized by Bell are fairly consistent with the microfaunal zonation; only minor discrepancies have been observed between the macro- and microfaunal approach.

An abnormal marine Horton (?) has been discovered in the Lake Ainslie area. The marine Endothyridae observed as nuclei in oolites, indicate a Visean age. Since the age of the Windsor is clearly restricted to the higher part of the Visean, the Horton which underlies it in continuity, may well range into Visean time.

PETROLOGY

71. POST-ULTRAMAFIC DYKES AND ASSOCIATED ROCKS IN THE ASBESTOS MINING AREAS IN THE EASTERN TOWNSHIPS, QUEBEC

Aniruddha De

Field work was carried out in continuation of last year's field program to study and collect specimens from the 'acid dykes' and associated rocks of the asbestos mines of Thetford Mines, Black Lake and Asbestos. In the British Canadian Mine the ultramafic rocks are comparatively fresh harzburgites with isolated areas of dunite (olivine up to 94.9% Fo.). A dioritic biotite-plagioclase rock has been encountered in the subsurface in the mine at Black Lake, where a riebeckite granite has also been found.

Contacts between the serpentinized ultramafic rock and Caldwell quartzite have been studied in the Normandie Mine, Black Lake.

Contact metamorphism of slates, phyllites and quartzites by the serpentinized ultramafic rock has been studied in detail in the Jeffrey Mine. The slates and phyllites are sulphide-bearing carbonaceous rocks with some carbonate, and the quartzites show well-rounded quartz grains in a carbonate cement. A zone with calc-silicate minerals has been formed at the contact with the serpentinite by metamorphic differentiation during contact metamorphism. The concentration of lime- and alumina-rich assemblages consisting of diopside, zoisite, grossularite and prehnite formed in the metasedimentary rocks by reaction and precipitation from solution near the serpentinite contact as a more pure hydrous fluid passed into the ultramafic body to cause serpentinization.

Specimens collected from the exposures of the so-called 'breccia' and 'acid volcanics' (Coleraine Group, Ordovician or Cambrian) occurring in the cemetery of Coleraine town and in the unpaved road cutting about one mile to the east of Coleraine, have been identified as rocks of a greywacke suite. Further examination of the last named locality showed by the orientation of graded bedding and load casts that the eastern limb of the anticlinal structure here has a direction of 'younging' to the east. The greywackes occur in between the two belts of ultramafic rocks in the area.

72. INVESTIGATIONS OF METEORITES

J. A. V. Douglas

A reported meteorite fall at Eastman, Quebec was investigated in April 1967. The fireball of June 7 was also investigated but field study showed that it had landed south of the International Boundary.

73. STUDY OF ULTRAMAFIC ROCKS, YUKON TERRITORY

D. C. Findlay

Reconnaissance studies of Yukon ultramafic intrusions, begun in 1966, were continued during the 1967 season. Intrusions in the following areas were examined briefly, and reference sample suites collected: Kluane Range (115 A-Dezadeash and 115 F and G-Kluane), Dawson (116 B and C), Teslin (105 C), Tay River (105 K) and Watson Lake (105 A). Field studies to date (1966 and 1967) indicate that at least two types of ultramafic intrusions occur in Yukon. The southwestern belt (Kluane Range) is characterized by narrow dyke- or sill-like bodies that typically contain feldspar-bearing olivine-rich rocks (dunite, peridotite) with subordinate pyroxene-rich rocks (picrite, olivine pyroxenite) and minor associated gabbroic rocks (olivine gabbro, gabbro). Copper-nickel sulphides occur in and near the intrusions at several places along the belt, notably Canalask (White River), Quill Creek, and Dickson Creek. Preliminary olivine composition determinations from the Canalask peridotitic rocks are in the range 83-85 per cent forsterite, and these are probably typical of the belt. Various features of these intrusions, including their sill-like shape, the composition of their olivine, their lithological variations, and the presence of interstitial feldspar (now altered to secondary minerals) suggest that they formed through differentiation of basaltic magmas. Toward the southeast end of the Kluane belt, in Dezadeash area (115 A) the character of the ultramafic intrusions changes; the bodies are larger, individual rock types are coarse-grained, and they contain prominent clinopyroxene-rich zones. Feldspar-bearing ultramafic rocks are absent or inconspicuous. Olivine from one of these intrusions, a small dunite body near Haines Junction, has a composition of 89 per cent forsterite.

Most other intrusions examined in Yukon show characteristics common to alpine-type peridotites. They are variable in size and shape, ranging from small elongate lenses to larger, oval-shaped plutons and their dominant rock type is green to brown-weathering, serpentinized peridotite, typically containing 15-20 per cent pyroxene. One representative of this type, a small intrusion lying northeast of Teslin Lake near Lone Tree Creek, shows alternating zones of dunite, peridotite and olivine pyroxenite, suggesting that some form of mechanical (flowage) differentiation was operative during emplacement. A large example of this type, the Dunite Mountain body (105 F) contains only buff-weathering dunite with olivine compositions in the range 90-94 per cent forsterite, significantly different from those of the Canalask body in Kluane belt. It was originally thought that this intrusion might have characteristics of southeast Alaskan-type zoned ultramafic intrusions, a point of potential economic interest since intrusions of this family (e.g. Good News Bay, Alaska, Tulameen, British Columbia and various intrusions of the Ural Mountains, U.S.S.R.) were notable as the source of important placer platinum deposits, the precious metals being associated with chromite in the ultramafic rocks. A chromite concentrate from the Dunite Mountain body was therefore assayed for platinum and palladium by the Mines Branch, Department of Energy, Mines and Resources, but neither element was detected.

74. PETROLOGIC STUDIES OF ULTRAMAFIC ROCKS IN THE AIKEN LAKE AREA, BRITISH COLUMBIA (94 C (WEST HALF))

T.N. Irvine

Mapping and detailed sampling of the Polaris ultramafic complex located 6 miles northeast of Aiken Lake[1] was completed and a reconnaissance inspection was made of some of the other mafic and ultramafic rocks in the vicinity with a view to relating the Polaris body more closely to its regional environment. This work was begun in 1965. The Polaris complex is about 9 miles long and 1 mile to 3 miles wide. It consists mainly of dunite and olivine-rich peridotite (wehrlite) but has well-developed minor units of olivine clinopyroxenite, magnetite-rich hornblende clinopyroxenite, and hornblendite. These lithologies establish it definitely as a 'critically-undersaturated' ultramafic body similar to those found in southeastern Alaska, near Tulameen in southern British Columbia, and in the north-central part of the Ural Mountains, U.S.S.R. K-Ar dates of 164 and 152 m.y. recently obtained for biotite and hornblende from the complex, indicate that its age is Middle Jurassic.

In addition to the geologic work, a gravity survey of the Polaris complex was conducted through the cooperation of the Observatories Branch. Data were collected from lines along and across the body, and preliminary analysis indicates a considerable anomaly which may provide information on the extent of the ultramafic rocks at depth.

In regard to economic potential, the similarity of the Polaris complex to the Tulameen and Uralian ultramafic bodies suggests that it may contain significant quantities of platinum-group metals. However these would be expected in association with chromite, but analysis of a sample of this mineral showed less than .005 ounces a ton Pt; Pd could not be detected. The chromite itself is rarely concentrated and only in small bodies[1]. Sulphides are also rare, the principal observed occurrence being two small zones of disseminated pyrrhotite in hornblendite along the southwest side of the complex. Spectrographic analyses of six samples from these zones showed 700-1,500 ppm Cu, and 70-150 ppm of each of Ni and Co. The hornblende clinopyroxenite has a concentration of 10-25 per cent magnetite, but is of very minor extent.

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[1] Roots, E.F.: Geology and mineral deposits of Aiken Lake map-area, British Columbia; Geol. Surv. Can., Mem. 274 (1954).

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75. PETROLOGY AND STRUCTURE, PINNACLE PEAKS MAP-AREA, BRITISH COLUMBIA (82 L/1, 82 L/8 and parts of K/4 and 5)

J.E. Reesor and E. Froese

Pinnacle Peaks map-area is characterized by a structural and thermal culmination within the Shuswap Metamorphic complex. Metamorphic rocks within the central part of the map-area consist of schist, quartzite, calc-silicate gneiss, and marble - a well-differentiated, thin-bedded, succession of heterogeneous metasediments. Within the sillimanite zone these rocks are laced with pegmatite and granitic veins and dykes. Rocks mapped by Jones[1] as Cache Creek Group, lie along the western periphery of the Pinnacles structural culmination.

Pelitic rocks in the central part of Pinnacles structure contain sillimanite-muscovite (± almandine) and similar rocks peripheral to the sillimanite-bearing rocks carry staurolite, and in some cases, kyanite and/or andalusite. There is a rapid transition from sillimanite-bearing schist to staurolite and finally to greenschist facies rocks in a few thousand feet of stratigraphic thickness. Rocks of the Cache Creek Group are affected by this metamorphism. Similarly along the western periphery, single pelitic layers may be traced from fine-grained staurolite schist to a coarse sillimanite (± almandine) zone.

The principal east-west structure of the Pinnacles culmination consists of a very large northward verging fold outlined by carbonate and/or diopside-bearing quartzite. At the western limit of exposure of the carbonate quartzite, the fold is open with a gently west plunging axis. Within the central part of the Pinnacles area this fold is isoclinal, overturned, verging northward, and the lower limb is thin and discontinuous. The eastern extension of the fold has not yet been mapped. On the basis of incomplete mapping along the western periphery of the metamorphic rocks the upper metamorphics and overlying greenschist rocks are folded in a large north-south fold, that is apparently synchronous with the east-west fold of the deeper zone.

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[1] Jones, A.G.: Vernon map-area, British Columbia; Geol. Surv. Can., Mem. 296 (1959).

76. GEIKIE RIVER MAP-AREA, SASKATCHEWAN (74 H)

A.J. Baer

Mapping of this area for publication at a scale of 1 inch to 4 miles was started and completed. The map-area is heavily drift-covered, and except for regions situated east of Highrock Lake and southeast of Geikie River, outcrops occupy less than 5 per cent of the area.

White sandstone of the Athabasca Formation probably underlies the northwestern half of the map-area, but is readily weathered and rarely outcrops. Its contact with older rocks is nowhere exposed.

The major structural element of the area is a mylonitic zone extending from Pendleton Lake at least 30 miles northeastward. It marks the boundary between a complex of east-trending hornblende-rich augen-gneiss to the east and one of biotite-rich gneisses and meta-arkoses to the west. These two complexes have been recognized and described in areas to the south[1].

Rocks to the west of the mylonitic zone are mostly fine grained, ilmenite- and magnetite-bearing biotite gneisses which may contain small pale crystals of cordierite. The biotite gneisses are accompanied by, and occasionally interlayered with a light beige meta-arkose containing isolated grains of hornblende.

Highly sheared and chloritized pink granitic rocks, which commonly exhibit flaser texture, occupy most of the ridges immediately west of the mylonitic zone. Their contacts with biotite gneisses and meta-arkoses are obscured by shearing.

To the east of the major mylonitic zone, dark, medium-grained hornblende-biotite augen-gneisses are abundant. They appear to grade into a coarse grained massive quartz monzonite body in the extreme southeast corner of the map-area.

No mineral occurrences of economic interest were noted in the course of field work.

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[1] Money, L.P.: The geology of the Barnett Lake area (W 1/2) Saskatchewan; Sask. Dept. Mineral Resources, Report 60 (1961).

77. FOND-DU-LAC MAP-AREA, SASKATCHEWAN (74 O)

A.J. Baer

Mapping of this area for publication at a scale of 1 inch to 4 miles was started and completed.

Drift-covered Athabasca Formation occupies low ground south of Lake Athabasca, but north of the lake relief is greater and except for an area east of Fontaine Lake, drift is negligible.

According to their degree of metamorphism and to their structure, rocks situated north of Lake Athabasca may be subdivided into two major groups. To the southwest, south and southeast, they belong in the granulite facies or show evidence of retrometamorphism from this facies to the amphibolite facies. They commonly include leucocratic quartz-rich garnet and/or pyroxene-bearing gneisses which may contain up to 80 per cent quartz, and dark, medium- to fine-grained pyroxene gneisses of noritic composition. A prominent belt of garnet-sillimanite gneisses (with or without pyroxene) probably also belongs in this facies. Thin intercalations of iron-formation have been encountered locally. Where rocks of the granulite facies have been retrometamorphosed, garnet and pyroxene are commonly wrapped by biotite flakes, and quartz crystals have assumed a characteristic milky-blue colour. The northern parts of the map-area are underlain by a complex of biotite gneiss, hornblende gneiss and amphibolite.

Granitic rocks, which are conspicuously absent from rocks of the granulite facies, are commonly associated with biotite and hornblende gneisses and they form intrusive plutons or large domes around which the gneisses are conformably draped. Granitization features are common in the gneisses.

The transition between gneisses of this complex and those of the granulite facies is gradational and field investigations indicate that biotite and hornblende gneisses are chiefly granitized equivalents of the granulite facies rocks. Mylonite has formed in some places at the contact between rocks of the two facies.

The structural trend of biotite gneisses and hornblende gneisses is consistently northeast and dips are steep to the southwest, except on domes of granitic rocks.

The dominant trend of garnet- and pyroxene-gneisses of the granulite facies is southeast or east, and is particularly well-preserved in the southwestern part of the map-area. In most places the foliation has been deformed along northeast-trending lines and displays variable degrees of crenulation; in size these structures vary from a few millimetres to a few miles.

There appears to be good correlation between east- or southeast-trending deformation and granulite facies metamorphism on the one hand, and northeast-trending deformation, granitization and amphibolite facies metamorphism on the other; the northeast trend being more recent than the east and southeast trend.

Geiger counters and scintillometers were used regularly on traverse but except for previously known occurrences, no radioactive showings have been found. The basal unconformity of the Athabasca Formation is well-exposed 5 miles east of Poplar Point, south of Lake Athabasca, but it does not show any significant concentration in radioactive minerals.

Some deep purple fluorite has been found on the south shore of Oldman Lake, 1 mile east of the west end of the lake, along the extension of the St. Louis fault. The fluorite occurs in quartzo-feldspathic veinlets that cut a sheared hornblende-biotite gneiss.

78. VOLCANIC STUDIES, GRENVILLE PROVINCE; ONTARIO

W.R.A. Baragar

A chemical study of volcanic rocks of the "Grenville Series" was undertaken this summer in collaboration with J.M. Moore of Carleton University. Two sections of the Grenville volcanic succession near Bishops Corner, about 10 miles north of Kaladar, were sampled at stratigraphic intervals of about 400-500 feet. Each sample will be analyzed for the major elements by X-ray fluorescence spectrometer and for a number of minor elements by spectrograph. The region in which the sections are located is being studied in detail by Prof. J.M. Moore.

Section 1, extending southwestward from the southwest tip of Kashwakamak Lake, crosses a northwesterly-trending volcanic formation that is about 10,000 feet thick. The upper 6,000 feet of the section is composed predominantly of salic fragmental rocks and the lower 4,000 feet of chiefly mafic fragmental and massive rocks. The formation dips nearly vertically and is believed to face northeast. It is both overlain and underlain by carbonate rocks.

Section 2 is along the power line between the village of Cloyne and Skootamatta River to the west. It crosses a succession of mafic volcanic rocks, some 12,000 feet thick. The succession dips steeply eastward and faces eastward, according to top determinations by pillows. The bottom of the section is formed by the intrusive contact of the Elziver granite, hence the full thickness of the volcanic formation at this locality is unknown. Presumably, because the volcanic formations at sections 1 and 2 are considered equivalent, its full thickness must be very little greater than that measured.

Twenty-seven samples were taken along section 1 and 31 samples along section 2.

79. STUDY OF THE HURWITZ GROUP, DISTRICT OF KEEWATIN (55 J, K, L, 65 I, G, H)

R.T. Bell

Rocks of the Hurwitz Group were first mapped on a broad regional scale by Lord[1]. Later the name Hurwitz Group was applied by Wright[2] to these white and pink orthoquartzites and associated sandstones, greywackes, conglomerates, slates, and dolomites, in the District of Keewatin. Eade[3, 4] refined the stratigraphy of the group in the Kognak River area. The present work is the first year of a comprehensive study of the Hurwitz Group north and northeast of the Kognak River area. Field work was largely confined to the Tavani (55 K) and Kaminak Lake (55 L) areas (see A. Davidson and W.W. Heywood, this publication).

Figure 1 and the accompanying legend illustrate the main features of the Hurwitz Group. A four-fold division of the group was effected: a conglomeratic sequence (4), an orthoquartzite sequence (5), a slaty-cleaved mudstone and siltstone sequence (6), and a volcanic sequence (8). Discontinuous pods of gabbroic rocks (7) cut the mudstone sequence in southeastern Tavani area, and a thick gabbro sill with a feeder dyke cuts the Hurwitz near Quartzite Lake in the Kaminak Lake area. The gabbroic intrusives are genetically related to a volcanic suite (8).

Sediment transport in the orthoquartzite sequence, based largely on ripple-mark data, indicate palaeocurrents from the southeast.

A younger unit of quartzitic, micaceous, and feldspathic sandstone (9) directly overlies the mudstone sequence (6) and possibly overlies the orthoquartzite sequence (5) near Hudson Bay. No contact relations were observed but mapping of these sediments in the Tavani area suggests that unit 9 overlies the Hurwitz with a slight unconformity. This unit may be equivalent to unit 12 of the Kognak River area[3].

Crossbedding data in unit 9 suggest sediment transport from the southwest. Unit 9 is interpreted to be non-marine in contrast to units 5, 6, and 8, which are of marine origin.

Basal contact relations

Faults commonly separate the lower rocks of the Hurwitz from older rocks. In addition, study of the basal contact relations of the Hurwitz is frustrated by a 50- to 200-foot interval almost totally devoid of outcrops. Scattered outcrops of intensely sheared, gritty, pink and grey, impure quartzite, and pink and grey phyllonites, here and there associated with red and orange soils and a few pebbly sandstone and argillite fragments in frost boils, justify designation of this interval as a separate unit-3.

In several locations, for example near Last Lake, the orthoquartzite succession lies unconformably on Archaean volcanic and granitoid rocks, and near the northwest arm of Kaminak Lake the conglomerates lie unconformably on Archaean volcanic and dioritic rocks.

The conglomeratic beds of unit 2 are always associated with Archaean greywacke and volcanic rocks, and one such conglomerate in the southwest corner of the Tavani area is cut by a sheared diabasic dyke, resembling some of the dykes that cut Archaean (unit 1) but not Hurwitz rocks. For these reasons unit 2 is tentatively assigned to the Archaean. However, it is possible that unit 2 may be roughly correlative with unit 4.

Hurwitz-like rocks, MacKenzie Lake metasediments

In the vicinity of MacKenzie Lake, a belt of metamorphosed and highly deformed Hurwitz-like rocks is exposed. These have been subdivided and tentatively assigned to the conglomeratic and orthoquartzite sequences (see Section L, Fig. 1). These rocks apparently overlie granitic gneisses. The contact between units 4b and 5a was not observed. Illustrated thicknesses for these units are only very cautious estimates. (For distribution of the Mackenzie Lake metasediments see A. Davidson this report.)

Precambrian fossils

Large, tectonically deformed, domical stromatolites occur in unit 6b at Quartzite Lake in the Kaminak Lake area.

At two localities, small, curved and tapering, arenaceous spindles with longitudinal median sculpture were found in ripple-mark troughs on the surface of large blocks of orthoquartzite, near the top of the unit 5c.

LEGEND

PROTEROZOIC

UNNAMED GROUP

9	Grey, pink, and brown, quartzitic, micaceous, and feldspathic, sandstone; minor siltstone and mudstone; minor pebbly beds.

HURWITZ GROUP

8	Light to medium green-grey volcanics; massive to pillowed; intercalated with argillite, siltstone and tuff.
7	Gabbro
6a 6b	(a) Grey, green, black and pink mudstone and siltstone; (b) Pink dolomite and mudstone.
5e	Grey to brown-grey metamorphosed quartzose, impure siltstone and sandstone; metamorphosed to schist.
5d	White and grey, fine-grained orthoquartzite; thin bedded.
5c	White and pink, fine-grained orthoquartzite; thin bedded, ripple-marked.
5b	Pink, white, and grey, coarse-to medium-grained orthoquartzite; massive; minor fine quartz-pebble conglomerate; minor hematitic sandstone.
5a	White quartz- and quartzite-pebble conglomerate; massive; minor white orthoquartzite.
4c	Grey and green-grey, polymictic, pebble to boulder conglomerate and conglomeritic siltstone; minor coarse-grained quartzose sandstone; characterized by granitoid, quartz and quartzite pebbles.
4b	Grey, sericitic quartzose sandstone; granitoid pebble zones; metamorphosed to schist.
4a	Grey, polymictic, pebble to boulder conglomerate and conglomeritic siltstone; characterized by abundant granitoid boulders and rare quartz pebbles; metamorphosed.
3	50 to 200' interval almost totally lacking outcrop; red and grey sheared mudstone and sandstone, minor pebbly pink and grey sandstone found locally on frost-boils in this zone.

ARCHAEAN (?)

2	Grey and green-grey, polymictic cobble and boulder conglomerate and conglomeratic siltstone; characterized by granitic boulders and rare quartz pebbles; associated with Archaean greywacke and volcanics (1) and may be integral part of same.

ARCHAEAN

1	Greywacke, acid to basic extrusive rocks, dioritic and granitic intrusive rocks, iron formation.

~~	unconformity
~~ ? ~~~	possible unconformity
— — — —	limit of exposure

Bell, 1967

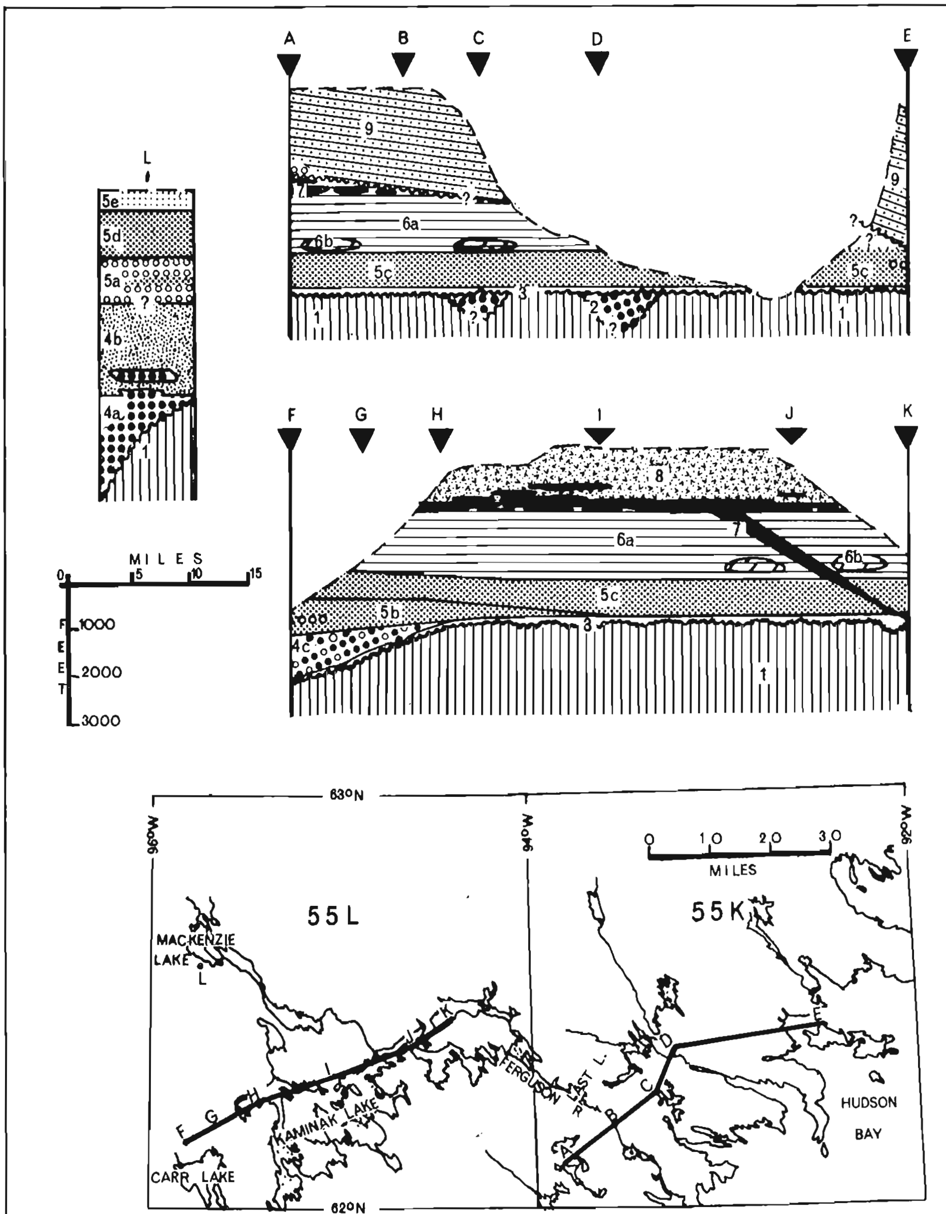

Figure 1. Schematic diagrams illustrating division of the Hurwitz Group with approximate thicknesses, and lithologies in the Tavani and Kaminak Lake area, N.W.T.

Bell, 1967

These structures may have been formed by organic or inorganic processes (H. Hofmann, personal communication).

Padlei area

The next phase of this study will be near Padlei (East halves of 65 I and 65 H) where it may be possible to relate the Hurwitz in the Carr-Kaminak basin with that studied by Eade[3] at Henik Lakes.

In anticipation of this study a one-day trip was made by Cessna 180 to the Padlei area in August. It appears that the orthoquartzite succession thickens and becomes more conglomeratic, and the conglomeratic succession likewise thickens. No volcanic rocks similar to unit 8 were observed, but outcrops of the gabbro sill were noted. Aerial observation suggests that the MacKenzie Lake metasediments continue southwestward into the adjacent map-area.

A model NE970 Scintillometer (manufactured by Nuclear Enterprises, Limited) was used from time to time during this summer. No significant results were obtained in the Kaminak Lake and Tavani areas. However at an outcrop of quartz-pebble conglomerate near the locality described by Heywood and Roscoe[5] in the Padlei area, a reading of 600 CPS (counts per second) was observed. This contrasts with readings of 25 to 30 CPS on the orthoquartzites of unit 5c, 70 to 120 CPS on sandstones of unit 9, and 120 to 250 CPS on granitic rocks.

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

[2] Wright, G.M.: Geological notes on central District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 55-17 (1955).

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

[4] Eade, K.E.: Kognak River area (west half), District of Keewatin; 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; Geol. Surv. Can., Paper 67-1A, p. 21 (1967).

80. RECONNAISSANCE OF PRECAMBRIAN ROCKS OF THE JAMES BAY AND SOUTHWESTERN HUDSON BAY LOWLANDS (37 J, O)

H.H. Bostock

A reconnaissance of Precambrian rocks along the borders of, and within the James Bay and southwestern Hudson Bay Lowlands was undertaken as part of Operation Winisk. A region extending from 10 to 20 miles beyond the Palaeozoic contact, and from 84°W (west of Hearst, Ontario) to 59°N (north of Churchill, Manitoba) was examined. Mapping was extended westward to 96°W to complete reconnaissance of the Churchill and Herchmer map-sheets. Particularly interesting results of this work include: the location and mapping of little known areas of folded mafic volcanic rocks, the discovery of gneissic and massive granitic rocks southeast of Sutton Lake, and the delineation of the extent of Proterozoic rocks in the Sutton Lake and Churchill map-areas.

Folded mafic volcanic rocks occur as inliers within the Palaeozoic rocks 18 miles north of Missisa Lake and 8 miles northeast of Ogoki. Similar rocks outcrop on upper Ekwan River at 53°18'N and to the northwest, on Tabasokwia Channel River and Ashweig River, and on Seal River at 95°10'W. Gossan zones that follow beds of laminated, pyrrhotite-bearing, mafic siltstone between amphibolite layers, were noted on Seal River.

Massive to gneissic granitic rocks form a low ridge up to 10 miles wide that extends southeast for 50 miles from a point 24 miles southeast of Sutton Narrows. Gently dipping Proterozoic sedimentary rocks and diabase sills [1] are exposed intermittently at the flanks of this ridge and are presumed to lie (covered by younger deposits) along its northeastern perimeter. The southeastern extremity of exposed Proterozoic rocks is on a promontory 22 miles north of Swan River and 13 miles west of James Bay, a position more than 60 miles south of that anticipated by projecting westward the trend of Proterozoic rocks on the east shore of James Bay. Gently dipping Proterozoic rocks are also exposed beneath diabase 15 miles west northwest of the north end of Hawley Lake, and diabase knobs project through the muskeg in near linear array from the latter exposure toward the mouth of Winisk River.

In the Churchill area the Churchill quartzite is exposed through the overlying Palaeozoic rocks and glacial drift from 13 miles east to 16 miles southwest of Churchill. Cobble-bearing quartzite forms a small inlier on Herriot Creek, 18 miles southwest of the westernmost exposure of Churchill quartzite; quartzite and siltstone form a near-circular, basin-like remnant 6 miles in diameter that is exposed just west of the Palaeozoic contact between the North and South Knife Rivers near their junction. Farther to the northwest near Seal River, quartzite dips gently north and northeast and is probably continuous to the north with rocks comparable to the Great Island Group[2]. Slate, siltstone, quartzite, and some sandstone strike east-west along North Knife River from the Palaeozoic contact west to 96°W. These latter rocks are closely folded.

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[1] Hawley, J.E.: Geology and economic possibilities of Sutton Lake area, district of Patricia; Ont. Dept. Mines Ann. Rept., vol. XXXIV, Pt. VII, pp. 1-56 (1925).

[2] Davison, W.L.: Caribou River map-area, Manitoba; Geol. Surv. Can., Paper 65-25 (1966).

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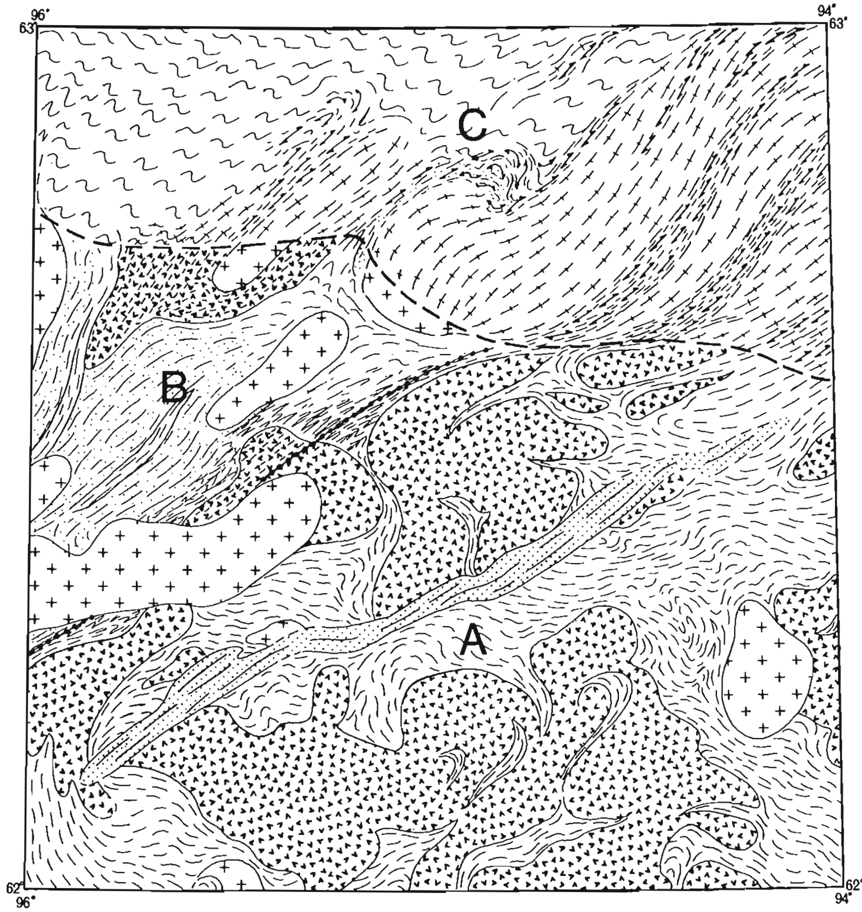
81. KAMINAK LAKE (55 L) MAP-AREA, DISTRICT OF KEEWATIN

A. Davidson

Kaminak Lake map-area, bounded by 94° and 96°W and 62° and 63°N, encompasses a little over 4,500 square miles. Its centre is 95 miles west-southwest of Rankin Inlet and about 260 miles north of Churchill, Manitoba. It lies entirely within the barren-lands of the southern District of Keewatin, Northwest Territories.

Apart from a small amount of reconnaissance work carried out in 1966, reconnaissance mapping for publication at a scale of four miles to the inch was accomplished by a combination of helicopter and ground traverses, with light float-plane support, during July and August 1967. Ground traverses were restricted to the southern half of the area, where outcrop is abundant. Thirteen days of helicopter traversing served to cover two-thirds of the area, including the more remote and sparsely exposed parts. Over 300 landings were made from flight lines between two and four miles apart.

The map-area has been tentatively divided into three regions (A, B, and C in Fig. 1) on the bases of gross lithological, structural, and metamorphic differences as summarized in Table I. Region A is underlain by a deformed assemblage of predominantly volcanic rocks of low metamorphic grade that has been intruded by a variety of plutonic rocks ranging in composition from gabbro to granite. Both volcanic and plutonic rocks are intruded by numerous northerly trending diabase dykes. All these rocks are older than the sedimentary and volcanic rocks of the Hurwitz Group (see R.T. Bell, this report), which occupy a fault-bounded trough near the centre of the map-area.



LEGEND

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

Migmatite composed mainly of layered or homogeneous gneiss with pink granite or aplite sheets and dykes, commonly with domal structures or folds with shallow southwesterly plunge.

Relatively homogeneous granitic, granodioritic, or dioritic gneiss, derived mainly from older plutonic rocks.

Layered gneiss, derived mainly from volcanic and sedimentary rocks.

Hurwitz Group (see Bell, this report)

Massive, homogeneous pink adamellite or granite, commonly with megacrysts of K-feldspar.

Older plutonic rocks; gabbro, diorite, tonalite, adamellite (undifferentiated), in places considerably sheared and altered.

Metasedimentary rocks; mainly metagreywacke and biotite schist with cordierite porphyroblasts; some quartzite, arkose, conglomerate, iron formation.

Metavolcanic rocks; mainly greenstone or amphibole schist; minor intercalated felsic volcanic rocks, greywacke, and iron formation in places.

20 miles

N

Figure 1. Sketch map of the geology of the Kaminak Lake map-area.

Table I

Outline of differences between regions A, B, and C of Figure 1

	Region A	Region B	Region C
Lithology	Mainly metavolcanic rocks cut by variety of igneous plutons, overlain by Hurwitz Group.	Mainly metasediments cut by granitic plutons.	Gneisses and migmatites. New granite restricted to dykes and sheets.
Structure	Steeply dipping and plunging structures, strike chiefly west or northwest except around plutons. Northeast trending folds with shallow undulating axes in Hurwitz Group trough.	Dominant northeast strike. Northwest trend of region A folded about northeast axial planes with steep axes; northeast trending folds with shallow axes in sediments.	Northeasterly striking folds in gneisses, with gentle southwest plunge; flow folds and domal structures in migmatites.
Metamorphism	Low grade (greenschist) with local amphibolite grade near and between plutons; grade increases near boundaries of regions B and C.	Medium grade (amphibolite); cordierite knotted schists are developed from the greywackes. Increases towards region C.	Medium to high grade; pelitic gneisses carry kyanite and/or sillimanite. Old plutonic rocks recrystallized to fine- and medium-grained orthogneisses.
Pre-Hurwitz diabase dykes	Trend northerly, variable; not metamorphosed in south, grade increases to north and northwest.	Trend northeasterly; metamorphosed to lower amphibolite grade.	Few remnants recognized, commonly boudinaged, now garnet amphibolites.

Region B is underlain predominantly by metasediments that are intruded by plutons of granite or adamellite. Sediments are mainly greywacke-type, but arkosic and quartzose sandstones and conglomerates are present to the northwest, and there is no evidence as yet for a structural break between the two types. The quartzose sediments are similar in some respects to the quartzites of the Hurwitz Group to the southeast. The dominant structural trend of folds is northeast. Diabase dykes cut the granitic rocks and greywackes in the southeast part of this region. Most of the pelitic sediments are metamorphosed to biotite-rich schists containing large porphyroblasts of cordierite.

Region C is underlain by a complex mixture of gneisses and migmatites, apparently derived almost entirely from the rocks of regions A and B. Volcanic and sedimentary rocks have become layered gneisses and plutonic rocks are now elongated bodies of orthogneisses that are thoroughly recrystallized and of much finer grain size than their parent rocks. These transitions can be traced across the boundary between regions A and C, and take place within about four miles. As the diabase dykes of regions A and B are followed northwards, they become increasingly metamorphosed; only scattered remnants of them are found within region C. New granitic material is restricted to sheets and dykes throughout the region, although mainly concentrated in the part mapped as migmatite in Figure 1; there are apparently no 'new' granite batholiths. The dominant structural trend is northeasterly, and many of the gneissic rocks have a pronounced internal lineation that plunges gently to the southwest in most places. Domal structures and flow folds are abundant in the migmatites. Southeasterly striking lamprophyre (minette) dykes up to eight feet wide occur throughout regions A and B but were not observed in region C. They cut Hurwitz Group rocks and are therefore younger than it. One large diabase dyke which is in fact a system of dykes en echelon, traverses the map-area from near the centre of the northern boundary to near the southeast corner. It may be a continuation of the long dyke mapped by Wright[1], and, if so, is at least 230 miles long.

Trenching and drilling has been carried out in several places within the metavolcanic rocks in region A where gossans suggest sulphide deposits. Many more small gossans were noted in the greenstones; most of those examined show finely disseminated pyrite and/or pyrrhotite where fresh rock can be obtained. Small amounts of chalcopyrite were noted in narrow quartz veins that cut the volcanic rocks of the Hurwitz Group at Quartzite Lake. In places magnetite-hematite iron-formation is associated with sediments intercalated with the volcanic rocks. On the boundary of the map-area southeast of Kaminak Lake, one bed of iron-formation composed almost entirely of iron oxides is as much as forty feet thick, but elsewhere, e.g. southeast of Victory Lake, the oxide-rich beds are much thinner. An unusual pluton of alkalic syenite is described elsewhere in this report.

[1] Wright, G.M.: Geological notes on central District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 55-17 (1955).

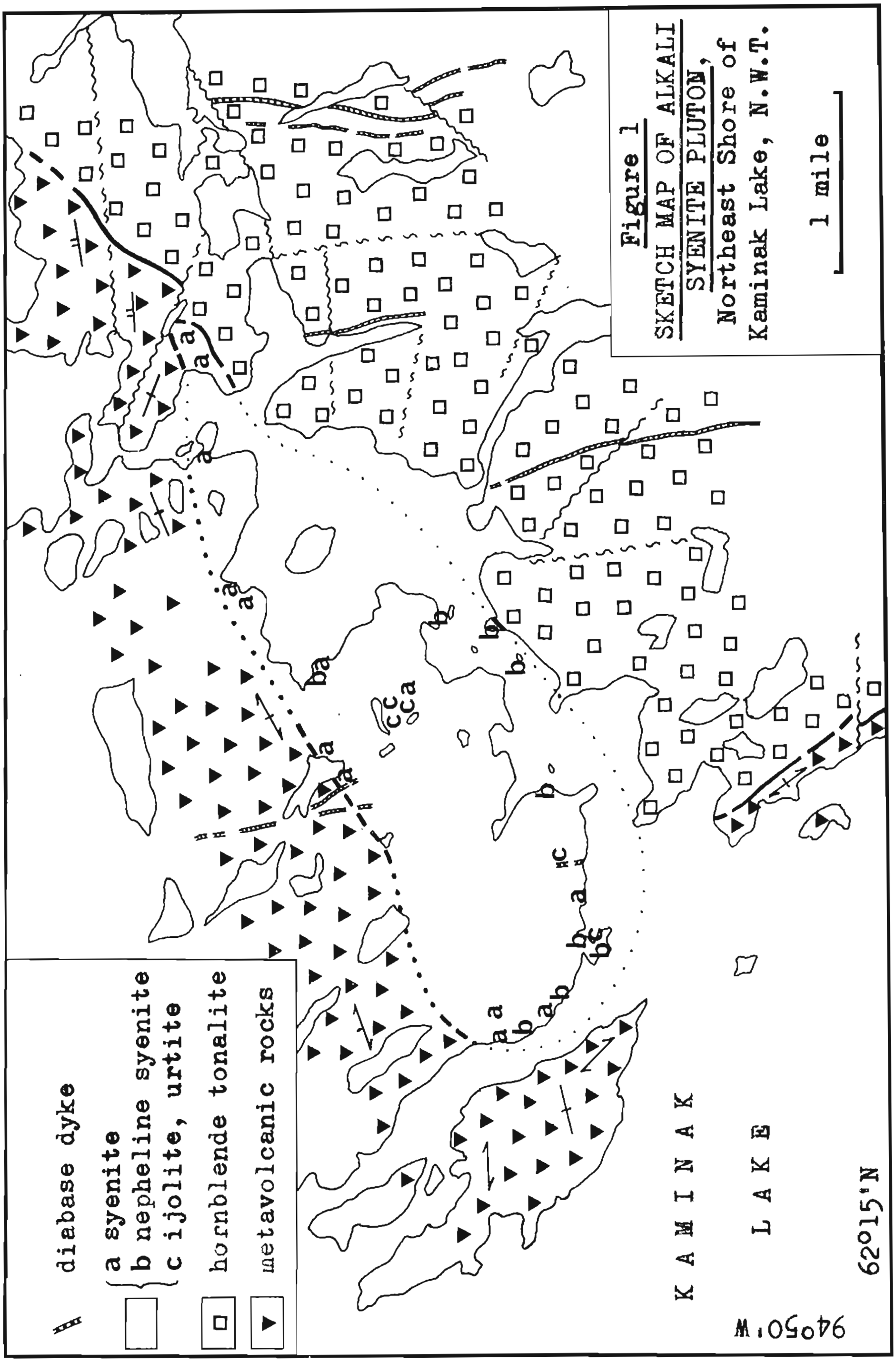


Figure 1
SKETCH MAP OF ALKALI SYENITE PLUTON, Northeast Shore of Kaminak Lake, N.W.T.

82.

AN OCCURRENCE OF ALKALI SYENITE, KAMINAK LAKE MAP-AREA (55 L) DISTRICT OF KEEWATIN

A. Davidson

An outcrop of nepheline syenite was noted by Kidd[1] during geological reconnaissance in the Kaminak Lake map-area in 1930. This locality was revisited briefly last summer; several more outcrops of alkalic rocks were found, and a pluton approximately 4 1/2 miles long by 1 1/4 miles wide was outlined. The alkalic pluton lies between a hornblende tonalite batholith and its metavolcanic country rocks (Fig. 1).

The alkalic pluton is poorly exposed and underlies a topographic low, including an arm of Kaminak Lake, surrounded by higher, rocky ground. Outcrops within this depression are low and deeply weathered for the most part; a characteristic gravel or sand of grey feldspar and black biotite grains is developed along the lake shores. The alkalic rocks are medium to very coarse grained. Composition is highly variable over short distances. The rocks can be grouped into three main categories: (a) pink to grey leucosyenite composed almost entirely of alkali feldspar (microcline perthite); apatite, pyrite, and biotite are minor accessories, and albite and calcite are interstitial; (b) grey nepheline syenite, composed predominantly of nepheline, alkali feldspar, and/or vermicular intergrowth of these two minerals, with variable amounts of biotite, aegirine-augite, magnetite, andradite, and calcite, minor accessory apatite, rutile, and pyrrhotite, and secondary cancrinite; (c) black to dark green ijolite and all gradations to light grey urtite, composed mainly of nepheline and aegirine; some rocks of this category contain very coarse flakes of biotite, and others contain up to 20 per cent andradite and 10 per cent apatite; feldspars are usually absent.

The andradite garnet in these rocks is black in hand specimen and deep orange-brown in thin section. Its refractive index of $1 \cdot 90 \pm 0 \cdot 01$ and its cell edge of $12 \cdot 090 \pm 0 \cdot 005$Å suggest that it is the titaniferous variety known as melanite.

The letters in Figure 1 are observed outcrops of rocks assigned to the corresponding categories described above. Rocks of all three categories are closely associated in some outcrops where they form steeply dipping layers that strike approximately parallel with the nearby contact or, in the central part of the pluton, parallel with the long axis of the pluton.

In general, syenites of category (a) predominate along the northwest edge and at the northeast end of the pluton. Syenite dykes cut the metavolcanic rocks and the tonalite in the two places where the contact is

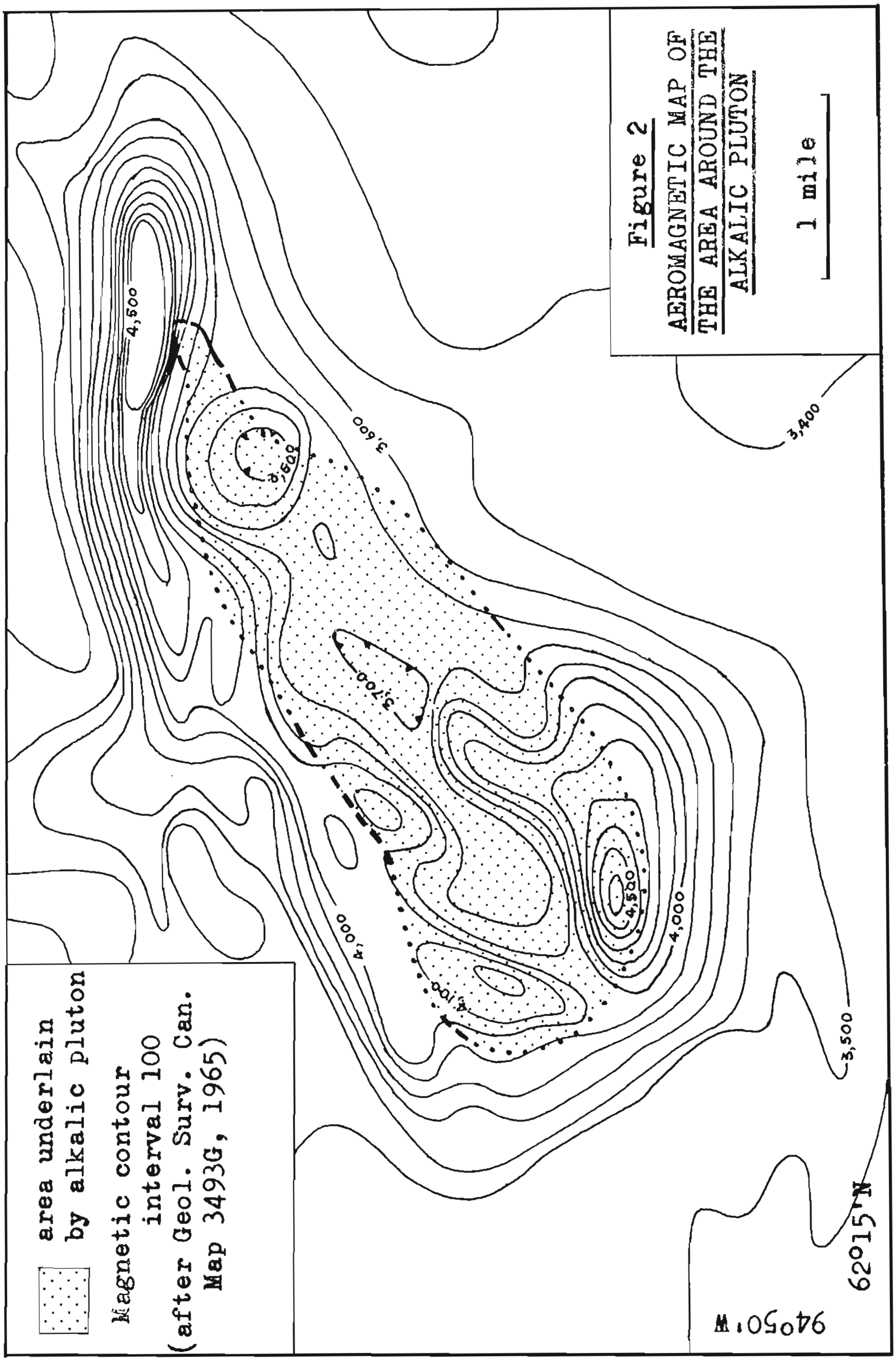


Figure 2
AEROMAGNETIC MAP OF THE AREA AROUND THE ALKALIC PLUTON

exposed; they also cut aegirine-bearing rocks within the pluton. At the southwest end, coarse-grained nepheline syenites of category (b) predominate, but grade into biotite ijolite in a few places. There appears to be very little metasomatic alteration of the country rocks near the margins of the pluton. Diabase dykes, characterized by scattered, large plagioclase phenocrysts, cut the alkalic pluton. Dykes of this swarm are known to be older than the sediments of the Hurwitz Group exposed elsewhere on Kaminak Lake (see R.T. Bell, Davidson, this report). The alkalic pluton is therefore pre-Aphebian[2] in age, and may be late Archaean. It is planned to submit specimens for radiometric age determination.

Figure 2 is adapted from the aeromagnetic map of map-area 55 L/7 (Geol. Surv. Can. Map 3493G) and shows the magnetic variation about the syenite body. The high anomaly to the north of the pluton lies within the metavolcanic rocks. Note that the core of the pluton is magnetically low.

This pluton, the only one of its kind found during last summer's reconnaissance of the Kaminak Lake map-area, is reported here because certain elements of economic significance (e.g. columbium, rare earth metals) are commonly found in such bodies. Although no unusual minerals that might contain major quantities of such elements have as yet been identified, field examination and collection of specimens were necessarily cursory, and it is probable that the occurrence is worthy of more detailed investigation. Specimens will be submitted for chemical and spectroscopic analyses and the results will be published later.

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[1] Kidd, D.F.: Kaminak-Kaminuriak Lakes map-area, Northwest Territories; Geol. Surv. Can., Interim Manuscript Report (1930).

[2] Stockwell, C.H.: Fourth report on structural provinces, orogenies, and time-classification of rocks of the Canadian Precambrian Shield; in Age determinations and geological studies; Geol. Surv. Can., Paper 64-17 (part II), pp. 1-21 (1964).

83. CHURCHILL REGION, MANITOBA (54 L, M, 64 I)

W.L. Davison

During a brief visit to Churchill map-area (54 L) geological features were examined in company with W.W. Heywood and H.S. Bostock (see report by H.H. Bostock in this paper). A helicopter was used to visit adjacent parts of Caribou River (54 M) and Shethanei Lake (64 I), and more information was gained from these previously mapped areas[1, 2]. A belt of mainly acid to intermediate volcanic rocks, 10-20 miles across, lies south of Seal River and extends across the east boundary of Shethanei Lake area. Although partly, and perhaps entirely, surrounding a body of granite north of North Knife River, the volcanic rocks show no obvious signs of intrusion or metamorphism by granite. Shear zones are locally prominent. The relationship of these rocks to the Great Island sedimentary sequence appears similar to that observed farther north, where volcanic rocks were interpreted to directly underlie the Great Island Group[3]. A traverse along the southern boundary of Caribou River area resulted in minor adjustments to map-unit boundaries[1]. Sparse disseminations of sulphides occur in sheared and metamorphosed volcanic rocks near the mouth of Seal River, and in mafic rocks elsewhere.

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[1] Davison, W.L.: Caribou River map-area, Manitoba; Geol. Surv. Can., Paper 65-25 (1966).

[2] Taylor, F.C.: Shethanei Lake, Manitoba; Geol. Surv. Can., Paper 58-7 (1958).

[3] Davison, W.L.: Nejanilini Lake (64 P) and Caribou River (54 M) map-areas; in Report of Activities: Field, 1964; Geol. Surv. Can., Paper 65-1 (1965).

84. PROTEROZOIC SEDIMENTARY ROCKS OF NORTHERN SASKATCHEWAN (74 N)

J.A. Donaldson

A six-day visit to the Beaverlodge area, northern Saskatchewan, provided an opportunity to view type sections and characteristic features of the Martin Formation, with the aim of assessing the possibility that the Martin red beds correlate with the South Channel-Kazan red bed sequence of the Baker Lake area, Northwest Territories. Field observations confirmed earlier impressions, based on discussions, published descriptions, and specimen comparisons, that red beds in both areas represent similar sedimentary facies deposited in comparable tectonic settings[1].

Visits to several widely-spaced outcrops of the Athabasca Formation provided the opportunity to note many features similar to those found in the Thelon Formation of the Dubawnt Group, including development of a basal regolith, compositional and textural maturity, abundance of orthoconglomerates, characteristic trough-festoon crossbedding, and widespread presence of interstitial clay minerals.

A major unconformity is exposed on Slate Island in Lake Athabasca[2]. Although slaty siltstones below the unconformity may belong to the Tazin Group rather than the Martin Formation[3], conglomerates above the unconformity contain abundant fresh clasts of red arkose, and the conglomerate probably represents basal Athabasca strata rich in Martin-derived clasts, regardless of whether the unit upon which it unconformably rests at this locality is Martin or Tazin. This suggests, in accord with Fahrig's earlier analysis[3], that the Athabasca is younger than the Martin, and that a period of uplift and erosion of the Martin preceded deposition of the Athabasca Formation. Thus the Martin-Athabasca relationship appears to be analogous to the Kazan-Thelon relationship, lending further support to regional correlation of the paired sequences.

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[1] Donaldson, J.A.: Two Proterozoic clastic sequences: a sedimentological comparison; Geol. Assoc. Can., vol. 18, p. 52 (1967).

[2] Hale, W.E.: Forcie Lake map-area, Saskatchewan; Geol. Surv. Can., Paper 55-4 (1955).

[3] Fahrig, W.F.: The geology of the Athabasca Formation; Geol. Surv. Can., Bull. 68, pp. 31-32 (1961).

85. ANORTHOSITE INVESTIGATIONS, QUEBEC, NEWFOUNDLAND AND LABRADOR (22 O, 13 NW, 14 SW)

R.F. Emslie and P.L. Roeder

During July and August five weeks were spent in examination and sampling of three areas of anorthositic and related rocks in Labrador.

In the Michikamau Lake area[1, 2] additional samples of the layered series, the anorthosite zone, and the iron-enriched rock suite, were obtained. Certain field relations were re-examined to supplement earlier observations.

In the Harp Lake area a 30-mile long section of one of the largest anorthositic intrusions in the Canadian Shield was examined on a reconnaissance scale. Several rock units similar to those of the Michikamau intrusion were observed and rhythmically layered structures were seen in many places. Dips of layers average 20-30 degrees to the north and east and persist along much of the length of Harp Lake.

Two weeks were spent in the Kiglapait-Manvers area north of Nain. Most of this time was used to examine the Kiglapait layered basic intrusion[3] which is similar in several respects to the Michikamau intrusion; both contain thick tractolitic layered series and late ferrous-rich differentiates. The grain sizes of fractolitic rocks of the Kiglapait intrusion are notably finer, on the average, than those of the Michikamau intrusion. The olivine-plagioclase ratio is also greater in the Kiglapait rocks than in the bulk of equivalent Michikamau rocks. Nevertheless the similarities between the intrusions are sufficiently impressive to leave little reason to doubt a genetic relationship.

Some exposures of the Nain anorthositic intrusion[4, 5] were also examined and sampled.

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[1] Emslie, R.F.: Michikamau Lake, east half, Quebec, Newfoundland; Geol. Surv. Can., Paper 63-20 (1963).

[2] Emslie, R.F.: The Michikamau anorthositic intrusion, Labrador; Can. J. Earth Sci., vol. 2, pp. 385-399 (1965).

[3] Morse, S.A.: Mineral variation in the layered series of the Kiglapait intrusion, Coast of Labrador, Canada (abstract); Geol. Soc. Am., Sp. Paper 73, p. 208 (1963).

[4] Wheeler, E.P., 2nd: Anorthosite and associated rocks about Nain, Labrador; J. Geol., vol. 50, pp. 611-642 (1942).

[5] Wheeler, E.P., 2nd: Anorthosite - adamellite complex of Nain, Labrador; Bull. Geol. Soc. Am., vol. 71, pp. 1755-1762 (1960).

86. LAKE PANACHE-COLLINS INLET MAP-AREAS, ONTARIO (41 I/3, H/14)

M.J. Frarey

Mapping of these areas completed in 1967, consisted chiefly of studies south, east, and north of Tyson Lake. To the south and southeast, the rocks are mostly gneissic igneous or quasi-igneous types; north and east of the lake there are important amounts of layered paragneiss. The gneisses of igneous affinity display numerous variations in composition and texture, but for the most part are coarse-grained, pink, biotitic, and low in quartz. They appear to range from granite to diorite. The paragneisses are fine- to medium-grained, well-layered, commonly garnetiferous, and range from leucocratic quartz-feldspar gneiss with small amounts of mica, commonly sericite, to dark biotitic and/or hornblendic gneiss. Meta-quartzite is common, especially north of Tyson Lake. Meta-conglomerate was seen locally at Tyson Lake, Strata Creek, and on Broker Lake, at the eastern limit of the map-area. The paragneisses are commonly migmatitic from the addition of granitic pods, streaks, veins, and layers. A few of the small granite pegmatite bodies contain allanite.

A few westerly or northwesterly trending basic dykes cut the gneisses.

The dominant foliation in the gneisses strikes northeast and dips moderately to steeply southeast. Exceptions occur at the margins of large intrusions. Common almost everywhere is a strong southeasterly-plunging lineation expressed by wrinkling, rodding, mullion structure, or mineral elongation and streaking. Later deformation has produced numerous northwest-trending schistose zones, augen-gneisses and mylonites, and ultramylonites.

87. GEOLOGY ACROSS THELON FRONT, DISTRICT OF MACKENZIE (76 I, J)

J.A. Fraser

The area east of Bathurst Inlet, District of Mackenzie, is known from reconnaissance mapping by helicopter[1], to be underlain mainly by plutonic rocks of the Slave and Churchill structural provinces. The boundary between the provinces (Thelon Front) in this area is defined by differences in radiogenic age, lithology, and structure. A study of these features was begun in 1967 in the frontal region (76 J, 76 I) at 66°35'N by mapping on a scale of 1 inch to 4 miles. In addition, samples were collected for modal, chemical, and potassium-argon isotope analyses.

Muscovite-biotite granite, migmatite, and andalusite-cordierite schist, the so-called 'knotted schists' derived from sediments of the Yellowknife Group of Archaean age, occur west of the Front. In this sector also is a northeasterly trending belt of closely folded, unmetamorphosed dolomite and quartzite. The belt is 12 miles long, one mile wide, and is bounded by faults. The sediments are more than 300 feet thick and are probably correlative with those of the Western River Formation[2] of Aphebian age.

East of the Front is a zone 15 miles or more wide composed of garnet-bearing migmatite and amphibolite, and minor sillimanite and kyanite schist. The garnet zone is bordered on the east by a belt of cataclastic rocks more than 6 miles wide which comprises non-garnetiferous, strongly foliated, finely laminated, pink and grey quartz-feldspar gneiss and mylonite, and biotitic and amphibolitic gneisses cut by pegmatite. Schists and gneisses east of the Front are probably derived in part from Archaean sedimentary and volcanic rocks and possibly in part from Proterozoic sediments.

Dykes of fresh diabasic gabbro intrude migmatite and older rocks west of the Front and are abundant in the mylonite belt east of the Front. Elongated bodies of amphibolite which outcrop east of the Front in both the garnet and cataclastic belts may represent pre-Hudsonian dykes.

A northerly trending foliation defined by compositional layering is common to the schists and to some of the amphibolitic gneisses. A younger, northeasterly foliation, defined by compositional layering and by orientation of platy minerals is characteristic of the cataclastic rocks and is developed locally in granitic migmatite. It is approximately parallel to the trend of the unmetamorphosed sediments. In the knotted schist exposed west of the Front both foliations are evident.

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[1] Fraser, J.A.: Geological notes on northeastern District of Mackenzie, Northwest Territories; Geol. Surv. Can., Paper 63-40 (1964).

[2] Tremblay, L.P.: Preliminary account of the Goulburn Group, Northwest Territories; Geol. Surv. Can., Paper 67-8 (in press).

88. VOLCANIC STUDIES IN THE TIMMINS-KIRKLAND LAKE-NORANDA REGION OF ONTARIO AND QUEBEC (42 A, 32 D)

A.M. Goodwin

The two-year program of volcanic studies in the Timmins-Kirkland Lake-Noranda region was completed during the 1967 field season. This region, 140 miles by 30 miles, is underlain by variably deformed and metamorphosed Precambrian volcanic rocks, sediments and intrusions. The Archaean volcanic rocks received main attention.

Field work

During the 1967 field season eight additional stratigraphic sections were completed as summarized below. Three are in the Timmins area, two in the north Kirkland Lake area, and three in the Rouyn-Noranda area. An additional three partial sections were completed in the Rouyn-Noranda area.

Area	Section	(miles) Length	No. Samples	Average Sample Spacing (feet)
Timmins	Kamiskotia	3	10	1500
	Nighthawk	8	22	1800
	Bowman	4.5	13	1800
Kirkland Lake	Bernhardt-Garrison	10	37	1400
	Misema-Harker	10.5	68	800
Rouyn-Noranda	Kanasuta	14	63	1200
	Duprat	7	40	900
	Arntfield	6	24	1200
	Others	8	45	1000
	Total/Average	71	322	1164

Together with the 1966 field results a total of sixteen stratigraphic sections 176 miles long have been completed in the region. A total of 782 volcanic units distributed along the sixteen section lines have been systematically sampled for chemical analysis of major and minor elements.

Complementary studies have been completed in the immediate vicinity of Kirkland Lake by R.H. Ridler and in the Pontiac sediments by J. Holubec (see this report).

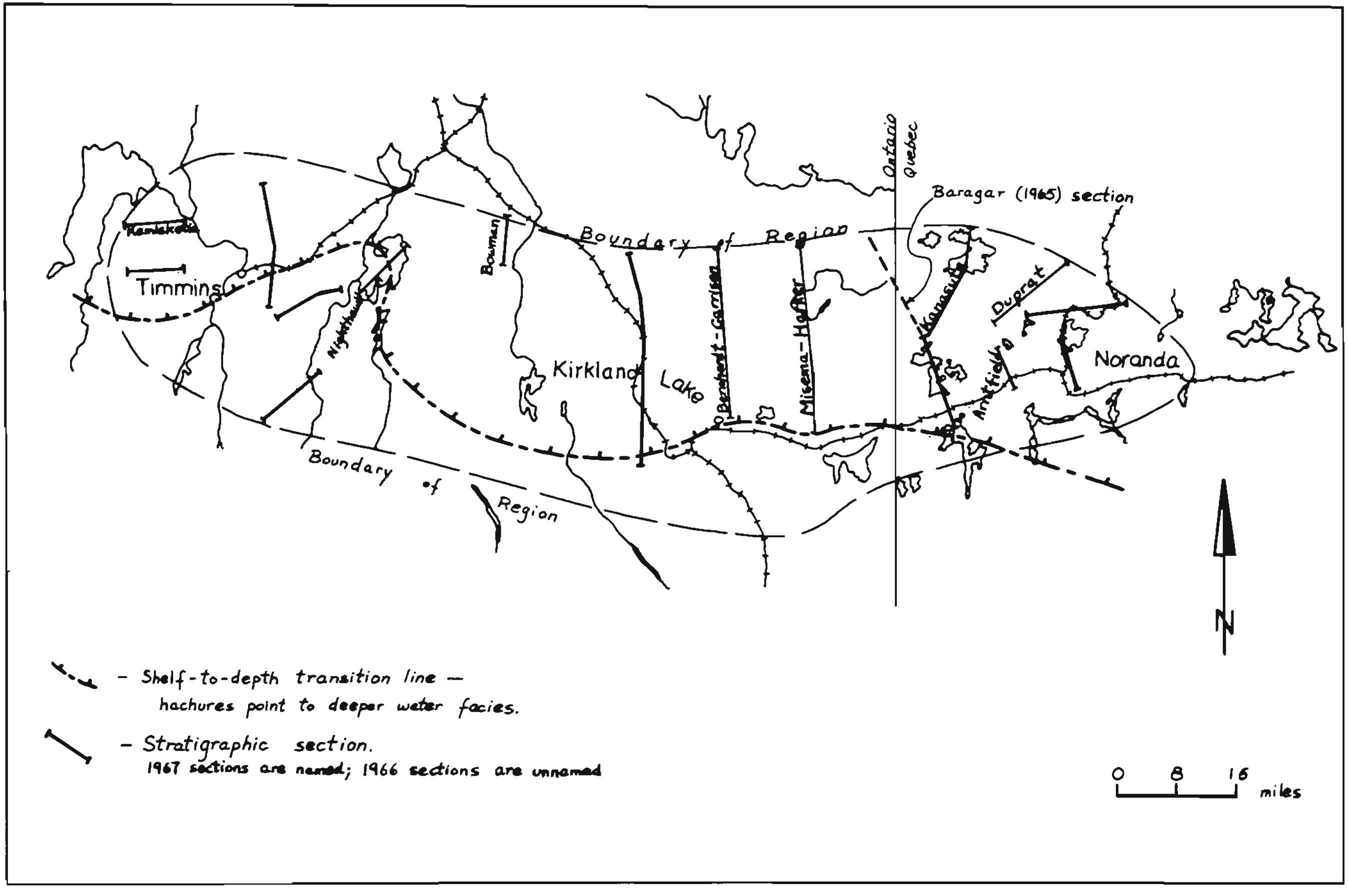

Figure 1: Location of stratigraphic sections and principal facies transition in the Timmins-Kirkland Lake-Noranda region of Ontario and Quebec.

Results

Archaean rocks of the region form part of a basinal assemblage which is characterized by complex facies changes in both vertical and lateral directions (see Geol. Surv. Can. Paper 67-1, Part A, pp. 138-142). This basin was developed in stages, younger parts in general lying to the north. In the eastern part of the region (Rouyn-Noranda area) older sediments (Pontiac) south of Rouyn are in sheared contact to the north with presumed younger volcanic rocks (Blake River Group). In the central part (Kirkland Lake-Harker township area) older volcanic rocks (as in Skead and Catharine townships) pass northward to mainly younger volcanic rocks (the western extension of the Blake River Volcanics). In the western part of the region (Timmins area) older, mainly volcanic rocks in the south (Delora Group) are in sheared contact to the north with younger volcanic and sedimentary rocks (Tisdale Group, etc.).

In contrast to this rôle of younger rocks lying to the north, a number of narrow, east trending zones of sedimentary and volcanic rocks (Timiskaming) at Timmins, Kirkland Lake and south of Rouyn, clearly overlie and are younger than the immediately subjacent volcanic and sedimentary rocks. Whether or not the Timiskaming rocks are also younger than all the volcanic rocks in the north part of the region is not known.

The position of these comparatively narrow, east-trending Timiskaming zones in each of the three areas, coincides in general with the east-trending contact in each area between older rocks to the south and younger rocks to the north. This coincidence of east-trending elements suggests that these zones were intermittently active during basinal development and deformation. Thus not only were the vertical movements inherent to basinal development largely hinged about these zones, but at a later stage during accumulation of Timiskaming rocks the same zones became the focus of renewed activities involving volcanism, intrusion, sedimentation, and deformation.

Considering the region at large, the overall pattern is that of an episodic progression in basinal development from south to north. This overall pattern emerges despite the presence of many local facies changes within and between the volcanic and sedimentary components. Forthcoming chemical information will shed light on the general chemical history of volcanism in the region and assist with problems of stratigraphic correlation.

89. SEDIMENTOLOGY OF THE YELLOWKNIFE GROUP, YELLOWKNIFE, DISTRICT OF MACKENZIE (85 J/8, 9, 16)

J.B. Henderson

A detailed study was initiated on the sedimentary rocks of Archaean age in the Yellowknife area. This was concentrated on Division C of the Yellowknife Group[1, 2]. These rocks are primarily interbedded greywackes and slates of that type common throughout the Archaean of the Canadian Shield. Although the structure is complex, the area is well-suited to such a study due to the low grade of metamorphism, the excellent preservation of primary structures, and the clean exposure of the outcrop.

The past field season was spent in measuring a series of sections along the east shore of Yellowknife Bay. Each section was studied on a bed-by-bed scale and parameters such as thickness, composition, texture and sedimentary structures were noted. Sedimentary facies will be defined on the basis of these parameters. From a study of the distribution, frequency of occurrence and variation among the various facies it is hoped that the probable mechanism of deposition of these sediments can be determined and, hence, a palaeoenvironmental interpretation of the deposit and its role in the history of the Archaean basin.

On the basis of the past summer's work it seems likely that these sediments are turbidites. They consist generally of sand-shale units that range from thin laminations to massive beds up to 25 feet thick. Average thickness is less than one foot. Each bedding unit has a sharp, although commonly irregular base that grades from sand-sized material into shale. The Bouma cycle, consisting of a basal graded interval followed by a lower parallel laminated interval, a ripple laminated interval, an upper parallel laminated interval and finally a massive shale interval – a cycle, that has been recognized in many of the flysch or turbidite deposits of Europe – was recognized in whole or in part in many of the bedding units of the Yellowknife sediments. Throughout most of the section and particularly the lower part along the east shore of Yellowknife Bay, the overall amount of sand in the bedding units greatly exceeds the amount of shale with, in many places, beds several feet thick having less than two inches of shale at the top. With only a few exceptions, the maximum grain size in the bedding units is that of a medium sand. North of Yellowknife Bay, along Yellowknife River, and higher in the section, the sediments tend on the whole to be much more thinly bedded and to have a much greater shale content.

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

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

90. TAVANI MAP-AREA, DISTRICT OF KEEWATIN (55 K)

W.W. Heywood

During the 1967 field season reconnaissance geological mapping of the Tavani map-area was undertaken and completed with the exception of the region around Rankin Inlet.

The southern half of the area is underlain by an assemblage of metamorphosed basic to acidic volcanic rocks, and sedimentary rocks. Thick-bedded greywacke is abundant from the Copperneedle River to Corbett Inlet. Locally it is thin bedded with intercalated 1/4- to 1/2-inch magnetite layers. Southwest of Wilson Bay iron-formation as much as 150 feet thick overlies conglomerate. In the northern part of the area, northeasterly trending schistose, gneissic and granitic rocks prevail. In the area around Rankin Inlet volcanic and sedimentary rocks form a southeasterly plunging syncline. Hurwitz quartzite, present throughout the area in northeasterly belts is discussed in detail by R.T. Bell elsewhere in this report.

A moderately well-defined line can be drawn to separate the granitic to gneissic rocks in the northern part of the area from the predominantly volcanic and sedimentary rocks in the south. This line, extending westerly from Pangertot Peninsula, is in part a fault and in part a metamorphic boundary; however, details are at present insufficient to define its character.

Several small plutons that include diorite, syenite (?), quartz diorite, quartz monzonite and granodiorite intrude all rocks except those of the Hurwitz group.

No mineral occurrences of economic importance were noted but numerous rusty zones are present in the volcanic rocks. Disseminated chalcopyrite occurs in some of the flow breccia units. Quartz-magnetite iron-formation occurs in the Archaean greywacke and tuff units in several areas. It is thinly layered and fine grained except locally where recrystallization has occurred as a result of metamorphism.

91. PRECAMBRIAN STRATIGRAPHY, SEDIMENTOLOGY, PALAEOCURRENTS AND PALAEOECOLOGY IN THE EAST ARM OF GREAT SLAVE LAKE, DISTRICT OF MACKENZIE (75 L)

P.F. Hoffman

A two-year study of Precambrian sedimentary and volcanic rocks was completed. Much new information was obtained concerning the origin and environmental and stratigraphic significance of algal stromatolites. Sedimentological interpretation permits the reconstruction of the following depositional history of the area.

Four divisions of strata, separated by unconformities, were named by Stockwell[1] (in ascending order) the Wilson Island, Union Island, Great Slave and Et-then Groups. The Wilson Island Group is intruded by Kenoran granitic rocks and is therefore Archaean. The Great Slave and Union Island Groups overlie the Archean rocks unconformably. The Great Slave Group is intruded by quartz diorite laccoliths and dykes, one of which has been dated at 1845 million years (K-Ar biotite). The Great Slave and Union Island Groups are therefore Aphebian. The Et-then Group overlies the quartz diorite bodies but is cut by diabase dykes and sills of the Mackenzie swarm (about 1300 million years) and is thus late Aphebian or Helikian in age.

The dominant lithology of the Wilson Island Group is crossbedded, white orthoquartzite interbedded with lesser amounts of well-sorted subarkose and conglomerate, all of fluvial origin. The orthoquartzites, which are nearly 10,000 feet thick, overlie acidic volcanic rocks and grade upwards through interbedded quartzite, dolomite and argillite to dark grey argillites with thin siltstone beds and laminae. Crossbedding indicates that the orthoquartzites were transported from southeast to northwest. The Wilson Island Group is an example of the rarely preserved Archaean 'shelf-type' of deposition, and may be the lateral equivalent of the eugeosynclinal Yellowknife Group, not found in the East Arm.

The Union Island Group is extremely restricted in distribution and good exposures of the contact with the overlying Great Slave Group are lacking. Rapid pinching out of the upper Union Island Group beds beneath the contact without facies changes in the lower beds, suggests a regional unconformity. The Union Island Group includes black shales and basic pillow lavas, both probably of submarine origin, which are facies not found in the Great Slave Group.

The Great Slave Group is the most varied and extensively exposed, and was divided into six formations by Stockwell[1]. Each of the formations discussed below contains several distinct mappable units. The group has a cumulative maximum thickness in excess of 20,000 feet.

The Sosan Formation consists primarily of crossbedded, mechanically mature, pebble subarkose. These rocks were deposited under fluvial conditions and sediment transport was from northeast to southwest. The sandstones become finer-grained stratigraphically upward, and the coarse-grained lower units pinch out to the northeast indicating a diachronous depositional onlap from southwest to northeast. Interbedded stromatolitic dolomite, siltstone, and crossbedded orthoquartzite and calcarenite record a temporary marine transgression into the area north of Lac Duhamel. The youngest beds in the formation consist of red shale and siltstones which contain sedimentary structures and highly inconsistent palaeocurrent patterns suggestive of marine processes. The formation is more than 5,000 feet thick at the southwest end of the area and thins to the northeast.

Reworked basic vitric tuffs, tuffaceous sandstones, andesite flows, and diatreme breccias assigned by Stockwell[1] to the lower Kahochella Formation were probably deposited contemporaneously with the uppermost Sosan beds at the northeast end of the area where no volcanic rocks occur. The volcanogenic strata, found only in the southwestern half of the East Arm, are overlain by red shales containing thin beds of granular hematitic sandstones with flat pebble conglomerate, gypsum crystal casts, and calcareous stromatolites in the lower part, and abundant calcareous concretions and reworked concretion conglomerates in the upper part. The red shale sequence, which is 1,100 feet thick and gradational with the underlying Sosan Formation in the area lacking volcanic strata, is of shallow marine origin. Dark green argillites, probably of deeper water origin, overlie the red shales and thicken from 30 feet in the northeast to more than 500 feet in the southwest where they contain turbidites. A laterally persistent unit, less than 100 feet thick, of laminated red calcareous argillite is present at the top of the formation.

Along the northern margin of the East Arm, the Pethei Formation consists of 1,100 to 1,500 feet of limestone and dolomite deposited on a shallow marine platform. Biohermal stromatolites surrounded by coarse-grained clastic carbonate beds occur at many horizons at the margin of the platform. Elsewhere on the platform, thick bedded crinkly laminated limestones, oolitic limestones and continuous beds of stromatolitic limestone and dolomite occur. The margins of the platform are commonly dolomitized but breccia beds have been recognized. South of the platform, thin, evenly bedded aphanitic limestone, interbedded limestone and argillite, and nodular calcareous argillite, variously mapped as Kahochella or Stark Formation by Stockwell[1] are the lateral deeper water equivalents of the platform strata. In the southwestern part of the area, sections containing graded greywacke turbidite beds and carbonate beds probably also of turbidite origin, occur at several stratigraphic horizons. Palaeocurrents in the platform beds reflect bimodal tidal currents perpendicular to the margin of the platform. Palaeocurrents in the 'basinal' facies to the southwest are poorly defined but are mostly sub-parallel to the platform margin.

The Stark Formation overlies the Pethei Formation disconformably but with no angular discordance. Red mudstone with halite crystal casts indicating highly saline water and arid climatic conditions, is the dominant lithology. Two units of brightly coloured interlaminated limestone and dolomite, each about 100 feet thick, are laterally persistent throughout the area. These carbonate beds contain stromatolites, ripple laminations, edgewise conglomerates, and convolute laminations. The carbonate units, as well as the red mudstones, are commonly brecciated and chaotically folded. The breccias are genetically related to thin beds of clastic carbonate conglomerate which occur in the upper parts of the Stark and the basal Tochatwi Formations. The breccias are at least in part syndepositional and are interpreted as resulting from subaerial solution collapse, erosion, transport and redeposition of the carbonate beds by mass gravity movement.

The Tochatwi Formation overlies the Stark Formation with transitional contact and consists of about 2,500 feet of red non-marine lithic sandstones. The sandstones are crossbedded, some single units being as much as 17 feet thick. Overlying the sandstones are 700 feet of extensively mudcracked red shales bearing gypsum and halite crystal casts. Sediment transport was from southwest to northeast, opposite to that in the sandstones of the Sosan Formation.

The Pearson Formation consists of at least 500 feet of columnar basalt flows and overlies the Tochatwi Formation conformably.

The Et-then Group overlies the Great Slave Group with angular erosional unconformity. The Murky Formation, consisting of 0 to 3,500 feet of thick, massively bedded boulder conglomerate with lenses of lithic sandstone, was deposited at the base as a series of anastomosing alluvial fans. some derived from topographic highs within the present East Arm, and others from the faulted southeastern margin of the basin. The boulders include virtually every lithology of the underlying strata except those limited to the northern margin of the area such as the Pethei platform facies. Crossbedded pebbly arkosic sandstones of the Preble Formation are at least 12,000 feet thick and overlie the Murky Formation. Sediment transport in the Preble Formation was from northeast to southwest, parallel to the border faults of the graben, in which flowed the river systems that deposited this formation.

This study will form the starting point for interbasinal stratigraphic correlation of Aphebian sedimentary strata in northwestern Canada.

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[1] Stockwell, C.H.: Great Slave Lake, east and west; Geol. Surv. Can., Maps 377A, 378A (1936).

92. STRUCTURE AND BASEMENT RELATIONSHIPS OF ARCHAEAN METASEDIMENTS IN THE NORANDA-MALARTIC AREA OF QUEBEC

J. Holubec

The area under study, 50 miles by 25 miles, consists of a belt of volcanic rocks to the north, a belt of Pontiac metasediments to the south, separated by Timiskaming conglomerates.

The purpose of this detailed structural and lithological study is to:

1. investigate the relationship between these belts and to determine their structure,
2. determine the tectonic history of deeper parts of the earth's crust, as represented in this area.

Detailed field investigations were conducted especially along the lakes. Three sections were studied - along Opasatica Lake, along Beauchastel, Montbillard and Provancher Lakes, and along Bruèrre and Kinojevis and Caron Lakes. On the basis of the thickness of the sedimentary beds and quantity of coarse-grained and argillitic materials, an attempt will be made to divide the lithologically monotonous Pontiac succession into several stratigraphic zones. Samples were collected for chemical, petrographic and age determination analyses.

M.E. Wilson[1] proposed an unconformity between the older Pontiac metasediments and younger Timiskaming conglomerates. New information shows that the Timiskaming overlies the Pontiac metasediments with erosional unconformity. The development of this disconformity was due only to uplift and rapid erosion of unconsolidated Pontiac sediments and not to orogenesis. The Kawagama metasediments and older volcanic rocks as in La Pause, Preissac, La Motte and Malartic townships are very likely of the same age as the Pontiac metasediments, amphibolites and diorites. All these rocks represent an older group in the area studied.

The younger rocks of the area comprise two distinct assemblages: (a) acid and basic volcanic rocks of the Blake River Group which form a volcanic cycle, and (b) the Timiskaming conglomerates. The relationship between these groups is transitional - only local erosion and redepositional features were observed, phenomena which are very widespread in volcanic and flyshoid terrains. There is no evidence of any regional unconformity between these two assemblages.

The whole area was deformed and metamorphosed during one main Kenoran tectogenesis. As stated above the relationships along the southern boundary of the Timiskaming belt do not imply pre-Timiskaming folding and metamorphism.

Minor beds of conglomerate containing syenite and schist pebbles are known within the Pontiac sediments[2]. Recent study shows that the problem of identifying the basement of the Archaean sediments will depend on studies of the genesis of various granitoids.

In the deepest parts of the Pontiac assemblage, there are complicated tectonic, lithologic and magmatic relations. Three types of granitoids have been distinguished: (a) intrusive granitoids; (b) syntectonic or pretectonic granitoids which form sills and dykes in sediments and which were broken into angular forms during subsequent deformation; (c) fragments and blocks of granitoids which are of angular shape and occasionally slightly rounded. Pebbles of granitoids and metasediments are very rarely present. Toward the base of the sequence the granitoid blocks are larger. In one locality, 3 1/2 miles east-northeast of Bellecombe village and on the west shore of Kinojevis Lake, granitoid blocks appear to rest directly on a granitoid basement. However, the relationships between basement and overlying in Pontiac sediments is somewhat obscured by remobilization of the basement.

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[1] Wilson, M.E.: Royan-Beauchastel map-areas, Quebec, Geol. Surv. Can., Mem. 315 (1962).

[2] MacLaren, A.S.: Preliminary map Kinojevis, Temiscamingue country, Quebec, Geol. Surv. Can., Paper 52-6 (1952).

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93. OPERATION BYLOT, NORTH-CENTRAL BAFFIN ISLAND, (27, 37, 38, 48)

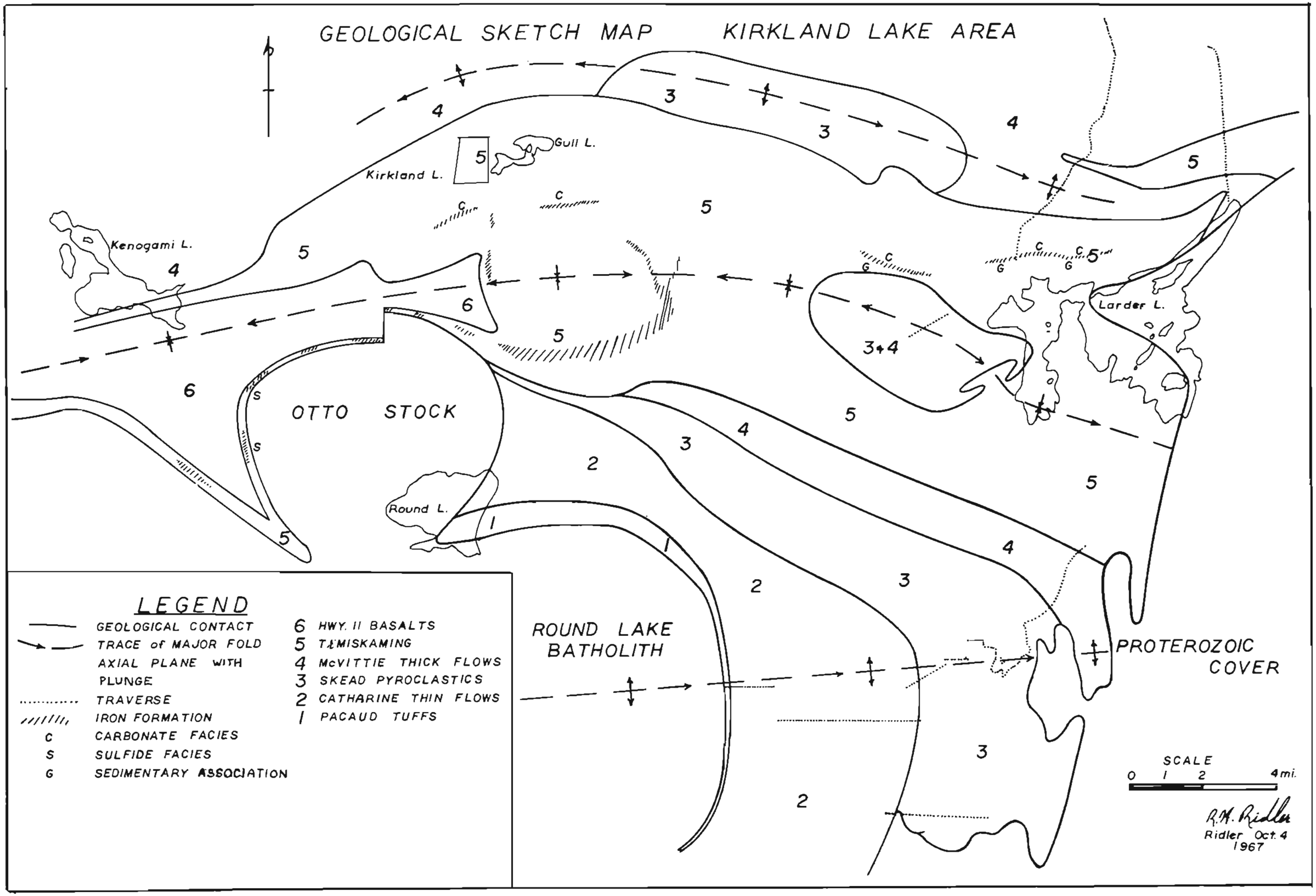
G.D. Jackson

A reconnaissance helicopter survey – 'Operation Bylot' – will be carried out during 1968 in that part of Baffin Island north of 69° and east of 80°. During August, 1967, a preparatory visit was made to this map-area and information was obtained concerning the geology, topography, weather, available facilities and suitable camp sites. Arrangements were made for the caching of gas supplies. Transportation was provided by a Cessna 180 with oversized wheels. Landings were made at about 20 localities on different types of terrain, and many more localities were checked by low passes and 'near landings'. This preliminary examination indicated that most of the region is underlain by varied migmatitic gneisses that were last intensely deformed and metamorphosed during the Hudsonian Orogeny. These gneisses, and to a much lesser extent the overlying metasediments, have been intruded by granitic rocks, pegmatites, and by some basic intrusions. Several belts and pockets of infolded metasediments appear to overly the gneisses comformably in some places and transitionally in others. The largest belt extends across Baffin Island in the southern part of the map-area from Longstaff Bluff on the west to Home Bay on the east, and has a maximum width of at least 80 miles. A discontinuous belt of metasediments extends southeast for about 120 miles from the Mary River area to east of the north end of the Barnes Ice-Cap. Meta-apelites and meta-greywackes are abundant in most metasedimentary areas. In addition meta-arkose and marble are common in the southern part of the map-area and meta-basalt and iron-formation in the northern. The lithology, stratigraphy, metamorphic and structural history of these rocks bear a striking resemblance to certain rocks on Melville Peninsula.

The metasediments are highly deformed and are interfolded with adjacent gneisses so that generally the metasediments occupy synclinal areas and the gneisses anticlinal areas. Doubly plunging overturned folds, refolded folds, recumbent folds, and small nappe-like structures have been noted. Major trends seem to range from east-west in the south to southeasterly in the north.

Gently folded Middle Late Proterozoic strata outcrop on Bylot Island, and south of Eclipse Sound. At the later locality they occupy a synclinal belt that extends from the west edge of the map-area southeast for about 80 miles. Middle Late Proterozoic diabase dykes trend mainly northwest and intrude the other Precambrian rocks. Ordovician-Silurian strata outcrops mainly along the west edge of the map-area, and are only slightly deformed. Horizontal to slightly inclined Mesozoic (Triassic ?) coal-bearing strata outcrop southwest of Pond Inlet and on southwestern Bylot Island.

Spectacular, rusty-weathering zones abound in the metasediments in the southern part of the map-area. Some of these are traceable for miles. A few small zones in the southwestern part of the area were found to contain small amounts of pyrite, pyrrhotite and locally, chalcopyrite. Blue-weathering oxide iron-formation a few miles north of the Barnes Ice-Cap may have a small amount of iron ore associated with it. However, it was not possible to land at this particular locality.


GEOLOGICAL SKETCH MAP KIRKLAND LAKE AREA
Kirkland L.
Gull L.
Kenogami L.
Larder L.
Round L.
OTTO STOCK
ROUND LAKE BATHOLITH
PROTEROZOIC COVER
LEGEND
GEOLOGICAL CONTACT
TRACE of MAJOR FOLD AXIAL PLANE WITH PLUNGE
TRAVERSE
IRON FORMATION
C CARBONATE FACIES
S SULFIDE FACIES
G SEDIMENTARY ASSOCIATION
6 HWY. 11 BASALTS
5 T&MISKAMING
4 McVITTIE THICK FLOWS
3 SKEAD PYROCLASTICS
2 CATHARINE THIN FLOWS
1 PACAUD TUFFS
SCALE
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R.H. Ridler
Ridler Oct. 4 1967

94. ARCHAEAN STRATIGRAPHY AND MINERALIZATION IN THE KIRKLAND LAKE AREA OF NORTHEASTERN ONTARIO (32 D, 42 A)

R.H. Ridler

The following field work was completed during the 1967 season:

1. stratigraphic cross-sections totalling 27 miles in length in two parts of the area, namely McVittie and McGarry townships in the northeastern part and Catharine and Skead townships in the southern part;
2. investigation of the 'Timiskaming' volcanic-sedimentary complex which extends across the northern part of the area;
3. 186 samples were taken for bulk chemical analysis; and
4. numerous mineral occurrences were examined and sampled.

This research, combined with that of the 1966 field season (see Geol. Surv. Can., Paper 67-1, pp. 159-162) completes the field study of Archaean stratigraphy and mineralization in the Kirkland Lake area.

Stratigraphy

McVittie township: The volcanic sequence in the northeastern part of the Kirkland Lake area contains about 7,500 feet of basalt lava flows. Individual flows are from 400-800 feet thick. Each flow generally displays a thin, slightly chilled base (about 5 per cent of total thickness), a thick, medium- to coarse-grained, massive central phase (30-60 per cent of total thickness), an upper pillowed phase (30-60 per cent of total thickness), and a thin flow-top scoria. Just to the north of the township a quartz-eye dacite breccia zone about 1,000 feet thick is intercalated with the basalt lava flows. 'Timiskaming' sedimentary and volcanic rocks unconformably overlie the basalt flows in the southern part of the township.

McGarry township: The stratigraphy and structure in the adjoining township to the east are similar with two exceptions: (1) variolitic pillow lavas comprising 5-10 per cent of the volcanic succession are present near the unconformity with the overlying 'Timiskaming' rocks and (2) quartz-eye dacite breccia is more abundant forming an estimated 20-30 per cent of the volcanic succession. Also the associated pillow lava is probably more andesitic in composition.

Catharine-Skead townships: A succession of steeply dipping, northeast- to east-facing volcanic rocks up to 12 miles wide was examined and sampled. The lowermost volcanic unit of the succession abuts on the

Round Lake batholith to the west; the uppermost volcanic unit is overlain by 'Timiskaming' sediments to the east. The volcanic succession in ascending order is as follows: (a) 500 feet of andesitic tuff and lapilli, (b) 30,000 feet of basalt lava flows, (c) 25,000 feet of andesite-dacite pyroclastic rocks, and (d) 3,000 feet of interlayered basalt lava flows (95 per cent) and cherty rhyolite tuff (5 per cent). Several differentiated peridotite-gabbro sills are present, and make up 2-3 per cent of the succession.

Iron-Formation

Substantial layers of sulphide and carbonate facies iron-formation are present in the area. Both iron facies are interpreted as penecontemporaneous with the main mass of oxide facies iron-formation in Boston township which contains the Adams iron mine. In general the layers of sulphide facies iron-formation, which may be up to 200 feet thick, lie to the east and west of the Adams mine whereas the main bands of carbonate facies iron-formation, which are up to 50 feet thick, lie to the north. A fourth type of iron-formation comprises thin layers of magnetite in fine grained greywacke.

Stratigraphically the main zone of iron-formation lies near the base of the 'Timiskaming' succession as provisionally interpreted for the area (unit 5, Fig. 1) where it is associated with trachytic tuff and breccia.

Regional Stratigraphic Framework

The pre-'Timiskaming' volcanic sequence exposed in both the southern and northern parts of the area comprises in ascending order (where fully developed): andesitic tuffs (unit 1), a succession of thin basalt lava flows (unit 2), andesite-dacite pyroclastics (unit 3), and an overlying succession of comparatively thick basalt flows (unit 4). On the basis of limited chemical data and subject to later verification, this sequence of volcanic rocks displays an abnormal upward increase in potash content.

As provisionally interpreted, the 'Timiskaming' sequence includes both the main Kirkland Lake belt of trachytic volcanics, sediments, and syenitic plutons and certain volcanic and sedimentary rocks lying south of the main belt, as shown on Figure 1 (unit 5). The 'Timiskaming' assemblage includes domical piles of pyroclastics and associated greywacke. These pyroclastics have a distinctively high potash content. Iron-formation of the area is associated with these pyroclastics and greywacke. The lithologic character of many of the 'Timiskaming' clastic sediments also indicates widespread erosion of the underlying volcanic rocks. Gold mineralization is associated in particular with syenite intrusions present in the main belt of trachytic rocks. In addition some disseminated gold occurs in the carbonate facies iron-formation.

A succession of post-'Timiskaming' basalt lava flows, about 5,000 feet thick, lies south of Kenogami Lake in the western part of the area.

Deformation

The main period of deformation accompanied the intrusion of granitic and syenitic plutons.

A set of major, east-trending folds was developed in conjunction with emplacement of the Round Lake batholith. Superimposed on these major folds are domical structures each with syenitic cores developed within the main belt of 'Timiskaming' rocks. Within the 'Timiskaming' belt the earlier folds are mainly isoclinal whereas the later domical folds are rather open. Dips and plunges are generally steep.

95. OPERATION TORNGAT; QUEBEC, NEWFOUNDLAND-LABRADOR (13 M, 23 P, 24 A, B, G, H, I, J, P)

F.C. Taylor

During the 1967 season helicopter reconnaissance mapping of northeastern Quebec and northern Labrador was started. The author was assisted by R. Skinner, C.K. Bell and E.W. Reinhardt of the Survey Staff. This project, known as Operation Torngat, will take at least two field seasons to complete and is scheduled for completion in 1969. The past summer saw the following areas completed: 23 P (W1/2); 24 B, 24 G, 24 J, 24 I, 24 P, 25 A, and 14 M. The bedrock is entirely Precambrian. The oldest rocks are Archaean[1] and these form a coastal strip, probably less than twenty miles wide, extending from Nachvak Fiord north to Ryan Bay. These Archaean rocks consist of granulites, amphibolite, thin tabular anorthosite bodies, commonly with amphibolite layers, and diverse quartzo-feldspathic rocks. The remainder of the mapped area is probably Proterozoic. Low grade metamorphic rocks of the Labroador Trough occur in areas 23 P (W1/2) and 24 B. Rocks to the east of these and areas 24 G, J, are also Labrador Trough strata but are probably much more highly metamorphosed to the amphibolite and granulite facies. These rocks extend well to the east and north without any apparent major geological discontinuity. Many rocks in areas 24 P and 25 A are probably continuations of strata exposed on southern Baffin Island consisting of graphite-quartz-feldspar gneisses, crystalline limestone and granitic gneisses.

Rocks of the Ramah Group occur on the south side of Nachvak Fiord where they unconformably overlie the Archaean rocks. Diabase dykes of several ages and orientation cut all but the Ramah Group rocks.

A few large boulders of Palaeozoic limestone occur on the coast in the vicinity of Kellinek Island suggesting that the offshore area may consist of Palaeozoic sedimentary strata.

No major economic mineral occurrences are known in the area.

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[1] Stockwell, C.H.: Tectonic map of the Canadian Shield, Geol. Surv. Can., Map 4-1965 (1965).

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96. GRENVILLE PROJECT; MONT LAURIER AND KEMPT LAKE MAP-AREAS, QUEBEC (31 J, O)

H.R. Wynne-Edwards

The Mont Laurier and Kempt Lake areas were revisited for a short period in June to collect further materials and information required for the preparation of the final report on the Grenville project. Sampling included type specimens of each of the major map units, material for correlation with aeromagnetic maps, and samples for chemical analysis in the initial stages of a geochemical project designed to test the correlation of the gneiss complex in the northern half of the map area with rocks believed to be equivalent in the Superior Province to the northwest. It is hoped that further age determinations will also be available before the final report is complete. The results of the Grenville Project have appeared in preliminary form[1] and some of the conclusions arising from this work were presented in a symposium on "Age relations in high-grade metamorphic terrains" during the Geological Association of Canada meeting in August 1967.

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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).

QUATERNARY GEOLOGY

97. SURFICIAL GEOLOGY, PRINCE GEORGE MAP-AREA, BRITISH COLUMBIA (93 G)

J. E. Armstrong and S. F. Leaming

In cooperation with ARDA the Geological Survey has undertaken a study of the Quaternary geology of the Prince George map-area (93 G). The objectives are twofold: (1) to gather areal information on surficial deposits and geomorphic features, concentrating on collection and presentation of data for ARDA land classification purposes; and (2) to contribute to knowledge of the Quaternary stratigraphy and chronology of the area.

Leaming undertook most of the 'inventory' mapping phase (objective 1) and for practical purposes completed this work in 1967. The area investigated is approximately 5,600 square miles, and the study was largely on a reconnaissance scale of mapping of 4 miles to 1 inch. His geological summary of the first stage of this work in 1966[1] is applicable to the final stage of the study completed in 1967.

The second objective, a study of the Quaternary stratigraphy and chronology of the area, was undertaken jointly by Armstrong and Leaming. They examined in detail most of the thick sections of surficial deposits, up to 500 feet, outcropping along the Fraser and Nechako Rivers and their tributaries and were able to come to the following conclusions:

(1) All the major river valleys predate the last major glaciation and probably predate all the glaciations. During the last deglaciation these valleys contained large meltwater streams.

(2) The area has been subjected to at least 3 major advances of the Cordilleran glacier. At the Big Slide on the Fraser River 10 miles north of Quesnel four till sheets were observed, suggesting possibly more than three major glaciations, however, four till sheets were not found elsewhere in the map-area. In places the glacial deposits are separated by intertill deposits, although the latter do not appear to be widespread.

(3) At least 95 per cent of the glacial deposits exposed at the surface were laid down by the last major Cordilleran glacier during Fraser Glaciation[2]. These are the deposits with which ARDA soil scientists and foresters are concerned.

(4) During the Fraser Glaciation, and during earlier glaciations, the drainage of the area underwent considerable disruption; good evidence has been found by the writers and earlier workers, indicating that the late Tertiary drainage in the valley of the Fraser River was northward whereas the present drainage is southward.

(5) Large glacial lakes existed during the deglaciation of the last ice sheet and although these lakes all reached about the same maximum altitudes of 2,300 to 2,500 feet they were probably separated by ice blocks most of their history.

Tipper[3] and Lay[4] mapped Miocene (?) sediments in the Fraser and Nechako River valleys and along some of their tributaries. Tipper wrote: "The Miocene (?) sediments represent the Miocene drainage system of a northward flowing ancestral Fraser River. These sediments are poorly consolidated, generally undeformed, and in places generally indistinguishable from Pleistocene or Recent river gravels". A more detailed examination of the deposits mapped as Miocene (?) by Tipper confirms the statement quoted. Some of the most characteristic deposits are quartzite-rich gravels, in most places weathering yellow to orange. The writers found that these gravels and associated sediments that are shown on Map 49-1960 as Miocene (?) are in reality all three ages suggested by Tipper. They are in part late Tertiary; in part intertill, probably belonging to more than one stade; and in part late glacial (deglaciation) or post-glacial. The surface exposure of sediments that may be positively identified as Miocene (?) is probably a minor part of the area shown on Map 49-1960. Undoubtedly the quartzite-rich gravels of post-Tertiary age are reworked and redeposited Miocene (?) gravels as they are found in areas where the ice movement was north and east towards outcrop areas of lithologically similar quartzites. No such quartzites are found in the areas from which the ice moved. Placer gold is found in places in all the quartzite-rich gravels regardless of age.

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[1] Leaming, S. F.: Surficial geology, Prince George (93 G) map-area; Geol. Surv. Can., Paper 67-1, part A, p. 71 (1967).

[2] Armstrong, J. E., Crandall, D. R., Easterbrook, D. J., and Noble, J. B.: Late Pleistocene stratigraphy and chronology in southwestern British Columbia and northwestern Washington; Bull. Geol. Soc. Am., vol. 76, pp. 321-330 (1965).

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

[4] Lay, D.: Fraser River Tertiary drainage-history in relation to placer-gold deposits (part II); B. C. Dept. Mines, Bull. 11 (1941).

98. SEDIMENTOLOGICAL STUDIES OF THE GLACIAL VARVES IN ONTARIO

Indranil Banerjee

Three areas have been chosen for detailed study, (1) the clay belt in northern Ontario, (2) the Belleville-Gananoque area and (3) the Toronto region in southern Ontario.

In northern Ontario, two new varve sequences were measured, one (316 varves) at a river bluff in the Blanche River east of Englehardt and the other (276 varves) at the Pike River section east of Matheson. At the Twin Falls and North Driftwood River sections graphic logs of the sedimentary structures found in the basal sandy varves were prepared. Similar logs were prepared for the esker deposits around Matheson and Kirkland Lake at five gravel pits and five trenches. Mean palaeocurrent directions measured from cross-stratification in the varves and the esker deposits are S80°W and S20°E respectively.

Detailed varve measurements and preparation of graphic logs were also carried out in two clay pits near Belleville, southern Ontario. The larger clay pit shows three cycles of varves overlain by a mudflow deposit which is overlain in turn by thin sandy varve with crosslamination. Palaeocurrent measurements have an isotropic distribution with no preferred direction.

In a gravel pit at Cheeseborough north of Gananoque, where the section shows varves lying on top of gravels and sands of an esker, gravelly, massive or crossbedded sands at the base pass towards the top into sandy turbidites (with loaded and graded base and laminated top) and then to varves.

In the Toronto region varves were studied in the Scarborough Bluffs (Scarborough Cresent locality) and the Don Valley brickyard. In the former locality 300 varves from the base were measured in a 90-foot section. Current-ripple lamination, load casts and flute casts have been observed. The mean palaeocurrent is S10°W. In the Don Valley brickyard numerous sedimentary structures in the varves including current ripple lamination, convolute lamination, slump structure, scour-and-fill, parting lineation, slide marks and animal tracks (?) have been studied. Palaeocurrent measured here is S40°E.

The current-generated structures and the features of sub-aqueous erosion found in the varves indicate the presence of some type of current, probably a turbidity current, operating in the lake bottom.

Laboratory study of the texture, microstructure and composition of the varves is in progress.

99. GLACIAL GEOLOGY AND GEOMORPHOLOGY, SOUTHWESTERN ELLESMERE AND NORTHWESTERN DEVON ISLANDS, DISTRICT OF FRANKLIN (Parts of 49 B, C, 59 A, D)

W. Blake, Jr.

Studies of glacial geology and geomorphology in southwestern Ellesmere Island and northwestern Devon Island were carried out from a base at Cape Storm, Ellesmere Island. Support was provided largely by a Piper Super Cub equipped with low-pressure tires, but on occasion a helicopter was used. W. Blake, Jr. concentrated on studying glacial landforms and post-glacial marine deposits, on recording the marginal positions of glaciers, and on collecting samples for radiocarbon dating. R. A. Souchez, University of Brussels, studied rates of frost shattering and slope development at several sites below the limit of postglacial marine submergence and investigated shear moraines around the margins of the main ice-cap in southwestern Ellesmere Island.

The altitude of the limit of postglacial marine submergence exceeds 400 feet at the mouths of several fiords along the south coast of Ellesmere Island and on Devon Island at the west end of Jones Sound. In general the marine limit decreases in altitude northward along the Ellesmere Island fiords, and it is also below 400 feet to the northwest near Norwegian Bay.

At several localities adjacent to Jones Sound dark brown pumice was found on the raised beaches. In the manner of its occurrence on the beaches and in hand specimen appearance it is similar to pumice occurring on raised beaches in Spitsbergen[1]. Precise levelling showed that the level at which the pumice is concentrated rises toward the west, indicating that the ice cover during the last glacial maximum was thicker over the west end of Jones Sound (on Devon Island) than it was at the mouths of fiords along the south coast of Ellesmere Island.

Shear moraines are best developed along the northwest margin of the main ice-cap in southwestern Ellesmere Island. There, at an altitude of over 2, 000 feet, well-rounded pebbles and cobbles occur in moraine ridges. The presence of this material, derived from outwash now buried beneath several lobes of the ice-cap, indicates an expansion of these lobes since the time of deposition of the outwash. Closer to sea-level on both Ellesmere and Devon Islands, marine shells have been incorporated into the 'dirty' basal zone of certain glaciers, and a number of glaciers are now impinging on undisturbed marine deposits. These occurrences show that when the early postglacial marine deposits were being laid down, _ca._ 9, 000 to 8, 000 years ago, these glaciers were considerably reduced in size. In fact, at the present time most of the outlet glaciers appear to be close to their maximum extent since general deglaciation.

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[1] Blake, W., Jr.: Radiocarbon dating of raised beaches in Nordaustlandet, Spitsbergen; in Geology of the Arctic, Toronto: Univ. Toronto Press, pp. 133-145 (1961).

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100. GEOMORPHOLOGY, STRATIGRAPHY, CHRONOLOGY, AND MIGRATION OF SAND DUNES IN MANITOBA AND SASKATCHEWAN (62 G, 72 K)

P. P. David

A detailed study of sand dunes and dune areas in Canada is being carried out by the author. In 1967 the field work was sponsored by the Geological Survey. Most of the summer was spent in the northern half of the Great Sand Hills of Saskatchewan (Prelate map-area, 72K), and a few days were spent in each of the following dune areas: Dundurn, Sask., Brandon, Man., Camp Petawawa, Ont., and Allumette Island, Que.

Great Sand Hills of Saskatchewan (northern half):

(1) The rate of advance of active dunes was measured using a series of reference points established in front of the dunes in previous years. The dunes showed a decrease in the rate of advance, probably due to an increase in precipitation in the area during the past few years. Photo-interpretation studies, supported by field observations, indicate that vegetation invades the upwind portions of sand dunes at the same rate as the front of the dune advances.

(2) The rate of mass-transfer of sand was measured under variable wind regimes at the surface of a large active dune using surveying laths laid out in a series of traverses across the dune. These measurements were complemented by wind profile studies across the same dune.

(3) Primary sedimentary structures are not apparent in the dunes because of the unsuitable textural and mineralogical composition of the sands. Some sparse-looking layers of light grey sand, which may have formed by

leaching at the surface of the dune, were the only indicators of bedding found in exposures. Secondary structures, e.g. concentric and polygonal joints were recognized at the surface of moist dunes following deflation of the loose cover sand by strong winds.

(4) Truncated and/or poorly developed soil profiles were recognized in a few dunes. Their usefulness in deciphering the chronology of sand dunes awaits further detailed studies. Some of the dunes overlie thick deposits of silts of glacio-lacustrine origin, others occur on fluvioglacial sands[1]. Locally, the base (?) of dunes have large accumulations of fossil snail shells that may be wind transported. Radiocarbon age of these shells should give a maximum age for the beginning of eolian activity in the area. Sand tongues extending down-windward from the main body of dune occurrence, overlie loess that has locally an organic-rich horizon in its upper portion.

(5) The following morphological elements were recognized on most of the stabilized dunes: head, slip-face, axial low, back slope, wind-furrows, back scarps, wings, back ridge, and deflation depression. In order to explain morphological differences among dune types, contour maps with 5-foot interval were constructed for two of the type-dunes recognized in the area.

(6) The vegetational cover in the Great Sand Hills varies according to the morphology of the terrain[2]. Plants in the area were identified for the author by Mr. J. Hudson from the Saskatchewan Research Council, during a two-day field trip in the area. A survey of the vegetational cover indicated that Psoralea lanceolata and Rumex venosus are two shrubs that can invade rapidly bare sand surfaces on active dunes. Among the shrubs of tall and medium tall growth the following species affect the development of dunes, either by functioning as sand traps or by protecting the front of advancing dunes from erosion by crosswinds: Elaeagnus commutata, Rosa woodsii, Betula occidentalis, Prunus virginiana var. melanocarpa, Salix interior, S. bebbiana, S. lutea, Shepherdia argentea, in order of their relative frequency[2]. There is a gradual change in plant association in the upwind direction away from an active dune starting characteristically with Psoralea lanceolata occurring alone, and passing into an association that has herbs characteristic of a climax association. Elsewhere, in areas of rugged topography formed by closely spaced true blow-out dunes, Artemisia cana is a characteristic shrub. On the inside of blow-out depressions thick growths of Juniperus horizontalis and Arctostaphylos uvaursi keep slopes at angles as high as 50 degrees. Most of the above species of plants accompanied by Artemisia frigida, A. campestris, Symphoricarpos occidentalis, and Ribes oxyacanthoides, where they occur in front of active dunes, prevent the development of lee-ward dunes and cause a permanent loss of sand from the dunes by trapping sand that is carried off the dune in suspension.

(7) Samples of sands were collected along traverses across different parts of the Sand Hills, and from the different type-dunes, for laboratory studies of granulometric composition and surface texture. Earlier

studies[3] indicated a definite pattern in the distribution of eolian sands of differing surface characteristics in the area.

Brandon area, Manitoba

Dark horizons representing the solum of buried paleosols occur extensively in the dunes of the Brandon area. Samples collected in previous years from these horizons were dated at 1,290 ± 130 B.P. (GSC-774) and at 2,320 ± 160 B.P. (GSC-817). Both dates should represent the beginning of large scale dune activity in the area. The latter date is similar to the GSC-579 date, at 2,330 ± 130 B.P. that gives the age of a piece of wood found overlying a paleosol in an early Assiniboine Valley, under 45 feet of dune sand, at the edge of the Brandon dune area (R.W. Klassen, personal communication). Field evidence suggest that there may be as many as four distinct periods of dune building in the area. In one of the dunes four vertebrae of a deer-sized animal were found directly above one of the buried paleosols under younger dune sand.

Dundurn area, Saskatchewan

A small group of sand dunes of the filled elongate parabolic type[1] have northeasterly oriented axes, whereas the majority of the dunes that are of the true blow-out type, have southeasterly oriented axes. The present wind pattern at Saskatoon was found to have an equivalent effective wind direction pointing due west[3]. The solution of this problem awaits further studies.

Other areas

Measurements of active dunes in the Camp Petawawa and Allumette Island areas indicate very little change in the position of the front of the dunes. In the former area the height of small true blow-out dunes was reduced as a direct effect of the shallow source of sand available for dune building.

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[2] David, P.P.: A study of roundness of wind-blown sands from Hungary and the Canadian Great Plains; McGill Univ., unpubl Master's thesis, 120 pp. (1961).

[3] Hulett, G.K.: Species distributional patterns in dune sand areas in the grasslands of Saskatchewan; Saskatoon, Univ. Saskatchewan, unpubl. Ph.D thesis, 139 pp. (1962).

101. QUATERNARY GEOLOGY, COLUMBIA RIVER VALLEY, BRITISH COLUMBIA

R. J. Fulton

Quaternary studies at the southern end of the Arrow Dam Reservoir were completed this summer. The Arrow Dam Reservoir lies within the Columbia Valley and the new lake will extend 145 miles from Castlegar in the south to Revelstoke in the north. Most of the reservoir area studied lies within the valley occupied by Lower Arrow Lake; only 6 miles of the valley immediately above the dam site is occupied by river.

One exposure of Quaternary sediments deposited prior to Fraser Glaciation was found. This consists of a paleosol developed in loess and overlain by gravel, sand, and till. Charcoal collected from the paleosol will be dated by radiocarbon to test whether it correlated with a paleosol of a similar nature exposed near Duncan Lake 75 miles to the northeast[1, 2].

At the site of the dam and to the south, terraces occur on the sides of Columbia Valley up to 1,000 feet above the valley floor. Terraces above an altitude of 1,700 feet were deposited while ice remained in the valley, whereas lower terraces are post-glacial and of normal fluvial origin. The high glacial terraces consist largely of fine-grained sand and silt. Collapsed structure, included gravel lenses, and their perched position on the valley wall is evidence that the lake in which these fine grained materials were deposited was marginal to ice. Most of the fluvial terraces are cut in ice contact lacustrine materials and exposures typically consist of several feet of well-sorted stratified gravel overlying fine-grained sand and silt with 'collapsed' structure.

Ice contact terraces may be traced upstream to Syringa Creek 6 miles west of the dam site. Beyond that point, fans and deltas built into Lower Arrow Lake constitute the main late-glacial Quaternary deposits. As some of these features are raised as much as 600 feet above present lake-level (high water 1,400 feet) the valley must have been occupied by higher stages of Arrow Lake during and after ice retreat. A post-glacial delta comprises a higher, clearly separated series of forms suggesting a rapidly dropping lake level and a lower closely spaced series suggesting a gradual change from one lake level to the next during later lake history. Southward decrease of about 5 feet per mile in the elevation of the highest of the lower series of deltas is attributed to differential isostatic rebound.

[1] Fulton, R.J.: Quaternary geology Duncan Dam area, Purcell Trench; *in* Report of Activities, May to October 1966; Geol. Surv. Can., Paper 67-1, part A, p. 59 (1967).

[2] Fulton, R.J.: Olympis Interglaciation, Purcell Trench, British Columbia; Bull. Geol. Soc. Am. (in press).

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102. MORAINES OF TIEDEMANN GLACIER, COAST MOUNTAINS, BRITISH COLUMBIA

R.J. Fulton

One week was spent studying the 15-mile long Tiedemann Glacier on the west side of Mount Waddington in the Coast Mountains of British Columbia. This study, carried out in conjunction with the bedrock geology project of H.W. Tipper, was designed to provide information on the age of moraines that are younger than the Fraser Glaciation, but are old enough to support mature forest.

Two prominent moraines (moraine A and moraine B) occur along the valley walls in the lower five miles of the alpine glacier valley. Moraine A consists of a series of sharp boulder ridges with a prominent outermost ridge up to 800 feet above the present valley floor, while the highest part of the main outermost ridge of moraine B is 700 feet. Moraine B crosscuts moraine A showing that moraine B is younger than A and was probably deposited during a readvance. Both moraines support mature vegetation.

A series of small end moraines lie on the valley floor between moraine B and the snout of the glacier. The moraine closest to the glacier is unvegetated, but vegetation is present and becomes progressively more mature on ridges down-valley from the glacier terminus.

Radiocarbon dating and dendrochronological work will be used to establish limiting dates for each moraine. Samples for pollen analysis and radiocarbon dating were collected from bogs outside and between moraines A and B.

103. QUATERNARY GEOLOGY, SHUSWAP RIVER-MABEL LAKE VALLEYS, BRITISH COLUMBIA

G. W. Smith

Mapping of surficial deposits and study of deglaciation and drainage development in the Mabel Lake and Shuswap River valleys and in Eagle Valley between Revelstoke and Sicamous was completed during the 1967 field season. These investigations were undertaken under the direction of R. J. Fulton in conjunction with the Quaternary geology salvage project in the Columbia River valley (see report by Fulton elsewhere in this publication).

Pre-classical Wisconsin sediments were described in the valleys of Harris and Bessette Creeks and along the east edge of Mabel Lake. Volcanic ash found within successions of lacustrine silts at two localities may be correlative with ash found in soil horizons at Cherryville and Okanagan Centre (Fulton, personal communication). Ash from these localities is lithologically similar to a volcanic ash found in the Kootenay Lake valley which is about 33,700 years old (GSC-542). In addition, a thin, peaty horizon near the middle of the sub-till lacustrine unit at Bessette Creek has been sampled for radiocarbon dating.

Glacial deposits within the area appear to relate exclusively to the last period of regional glaciation. Study of large- and small-scale directional features and the analysis of till fabrics and pebble counts indicate that final ice movement during the last glacial episode was from the north-northeast, and that it was locally strongly altered by major valleys and upland summits.

Deglaciation was characterized by stagnation of isolated bodies of ice within the major valleys and by extensive ponding and diversion of glacial meltwater. The distribution of major ice-marginal lakes is recorded by kettled gravel terraces up to 700 feet above the present valley floors. Ice-marginal drainage has been delineated in a general way by mapping widespread ice-contact deposits and meltwater channels.

A plexus of non-kettled terraces and deltaic features record the positions of late-glacial and postglacial base levels higher than present. Pebble lithologies of these deposits and precise elevations of terrace levels provide detail on the nature of major drainage during and following deglaciation of the area. Within Mabel Lake valley, a southward slope of approximately 4 feet per mile on the highest non-kettled terraces is related to postglacial isostatic uplift.

Bottom samples for radiocarbon dating have been collected from several small bogs in an effort to outline the rate and direction of ice retreat from the area.

104. ST. GEORGE MAP-AREA, NEW BRUNSWICK (21 B, 21 G)

N.R. Gadd

The initial investigation and mapping of Pleistocene deposits in the St. George map-area and adjacent parts of southwest New Brunswick indicate that in the coastal zone (up to about 200 feet elevation) glacial and marine deposits are of limited extent and clean, glaciated wave-washed bedrock outcrops make up most of the land surface. Areas at greater elevation and farther inland show a complex of glacial, glacio-marine, and glacio-lacustrine sediments deposited as the last continental ice-sheet retreated northward. A new radiocarbon date, obtained on marine shells from Sandy Point on the east bank of St. Croix River about five miles north of St. Andrews, shows that the area was ice-free at least 12,300 years ago (GSC-795, 12,300 ± 160). A moraine that trends northeasterly across the area studied, and a related glacio-marine delta at Pennfield, are possibly of similar or greater age. The age relationships with the similar Cherryfield-Eastport moraine systems of Maine and with gravelly moraines of similar trend in the vicinity of St. John, New Brunswick, have yet to be established.

Groundwater is already obtained from extensive gravel deposits in the St. George, Lake Utopia, and Pennfield plain areas for use in the local fisheries. Aquifers in these deposits have the largest potential for further groundwater development.

105. QUATERNARY GEOLOGY, OPERATION WINISK, HUDSON BAY LOWLAND (32, 42, 43, 44, 53, 54)

B.G. Craig and B.C. McDonald

Field work concentrated primarily on two aspects of the Quaternary geology; (1) the stratigraphic succession of interglacial, glacial, and post-glacial deposits, and (2) the late-glacial and post-glacial history as regards the pattern of deglaciation, the extent, chronology and pattern of the post-glacial marine invasion and its influence on the pattern of deglaciation, and the amount and chronology of late Quaternary isostatic uplift.

River-bank sections expose a fairly consistent Quaternary stratigraphy throughout the Lowland. Interglacial (?) sediments are widespread and include clay, peat, river gravels and marine shell-bearing sand. Rarely, till was noted underlying these sediments. At least two till sheets (Wisconsin?), locally separated by stratified sand and silt, overlie the interglacial(?) sequence. West of 86°W, marine shell fragments were observed in the upper tills. In the southeastern and northwestern parts of the Lowland, silt and sand, apparently of fresh-water origin, overlie the upper till but underlie sediments of the Tyrrell Sea. In the central part of the Lowland, evidence of the lacustrine phase is absent and locally it appears that the sea was in contact with glacier ice. Silt and sand of the Tyrrell Sea, in many places containing pelecypod shells, blanket most of the Lowland below the marine limit. Peat has accumulated on the marine sediments.

Broad areas of well-developed glacial landforms indicating flow direction as the ice-front retreated are found mostly above the area inundated by the Tyrrell Sea. Throughout most of the area such features generally indicate an overall retreat towards the sea, although the ice-margin appears to have been highly lobate. It also appears that the retreat was not synchronous across the region but that the southeast part of the present land area was under the sea while the country to the northwest was still covered with glacial ice. In the extreme northwest part of the area flow features indicate a northward retreat of the ice-margin, presumably towards the Keewatin ice divide.

The elevation of the highest recorded marine features shows a two-fold variation, a decrease from the southeast and northwest parts of the area towards the central part and a northward increase from the outer limits of the marine invasion towards the sea. Lesser local variations appear to be related to the pattern of ice retreat.

106. RECENT SUBMERGENCE IN NOVA SCOTIA AND PRINCE EDWARD ISLAND (11, 20, 21)

D.R. Grant

A project to determine the absolute rates of coastal submergence is nearing completion. The 1967 phase dealt mainly with the stratigraphy of recent deposits, and the sampling of drowned fresh-water peat and stumps, commonly overlain by salt marsh mud. Submerged Indian shell-heaps, early Colonial artifacts and structures, and recently submerged roads were also studied.

The study will produce submergence curves which are essentially plots of the time-stratigraphic history of a single datum that is a unique and ubiquitous surface, clearly defined on the present shore, and discernible and dateable in the sedimentary record. These conditions are fulfilled by the plane of mean high water springs (the average level of the highest monthly tides). This limit is identified at present as the highest beach berm or the limit of salt-dependent plants, and in the past as the transition from fresh- to salt-water sediments. Thus, the age and position of the fossil datum at any site records the earliest permanent arrival of the highest marine plane. This is valid only where there is no hiatus at the contact, and where the distances between datum and mean sea level, and between contact and substrate do not change with time. Commonly however, a disconformity occurs at the fossil datum and the sediments show an abrupt change from bog peat to salt peat. Under these circumstances, a date on the lowest salt peat will give a minimum age for the fossil datum and only some will yield the minimum rate of submergence.

The sources of error most commonly encountered, however, have just the opposite effect. It has become clear that the amount of submergence has been exaggerated, either by faster rise of datum relative to mean sea level, or by depression of fossil datum relative to the substrate. Several mechanisms are responsible.

(1) Local changes in tidal range with time are inferred, notably in the Fundy embayment. At present, the tidal range (from 9 to 53 feet) is due to optimum conditions of basin geometry and present sea level position, and to the coincidence of natural and tidal periods of oscillation. The range was much less over the last 12,000 years when land-sea relations were different, and before formation of Chignecto Isthmus. Analogous long-term changes in tide range may also have occurred in the southern Gulf of St. Lawrence. The open Atlantic coast, on the other hand, with its 6-foot range, or the nearly tideless Bras d'Or Lakes, may well provide standards for comparison. Short term increases also, are possible where extensive upper-estuary marshland dyking has disturbed the hydraulic equilibrium.

(2) Changes in sedimentation rates, either naturally, or artificially induced, are an expected source of uncertainty about former positions of datum interpolated within a section with few dates.

(3) Stratigraphic error due to compaction is inevitable where compressible material underlies the datum; for example, where a barrier-beach overrides bog or lagoon deposits; where a dense, sediment-laden salt marsh encroaches upon bog peat; and where man-made structures traverse compactible substrates. Differential compaction has been observed in section to exceed 100 per cent, and in many places fully accounts for the observed 'submergence'.

Applying these criteria to the discrimination of spurious and bona fide submergence sites, only 25 of the more than 50 known, qualify as 'control points' on which a regional submergence history may be based.

Control sites collectively bracket a period from at least 4,000, and possibly 8,000 years B.P. to perhaps as recent as 100 years B.P. Preliminary datings indicate a regional rate of one to two feet per century, as exemplified at a variety of sites:

(i) Fort Beausejour, Cumberland Basin – 38 feet of high tide salt mud over stumps about 3,000 years old, and 3.3 feet of mud over a corduroy road less than 300 years old;
(ii) Avon River estuary, Minas Basin – salt marsh over stumps, minus 42 feet to 28 feet, dating 4,400 and 3,500 years B.P., respectively, as well as 1.5 feet of marsh over timbers less than 100 years old;
(iii) Cape Sable Island – the base of a 6-foot thick peat bog lies 20 feet below datum and dates 1,470 years B.P. (GSC-731);
(iv) Port Joli, N.S. – Indian shell-heaps about 900 years B.P. are drowned three feet;
(v) McNab's Island, Halifax Harbour – pioneer relics 100-200 years old are 3.5 feet below datum;
(vi) at Fortress Louisbourg, Cape Breton Island there is abundant proof from such high tide-related features as mooring rings, sewage drains, sluices, and quay portals, of a submergence exceeding 2.5 to 3.0 feet since 1730.

Additional data were also collected on the disposition and activity of late glacial ice, in view of its influence on subsequent changes of level. On Cape Breton, newly observed striae support the concept of a radially-spreading, land-locked Bras d'Or lowlands ice mass.

North of Yarmouth, the South Mountain ice-cap, first confirmed by drift dispersion, left striae, grooves and facets on North Mountain and built a moraine parallel to the coast, with attendant striae, small drumlins and meltwater channels, while high sea levels reworked the distal slope. Tape measurement of marine limit in cliff sections reveals a change in rate and direction of uplift at a point near the transition between hummocky topography disoriented by the late ice-cap, and esker- and drumlin-lineated terrain of earlier Laurentide flow. Extensive pre-Classical Wisconsin shell-bearing tills and sand units underlie the younger tills in this area. One shell sample has been dated as 38,000 years B.P. (GSC-695).

107. MASS-WASTING STUDIES IN THE OGILVIE AND WERNECKE MOUNTAINS, YUKON TERRITORY

J. T. Gray

The aim of the project is the assessment of rates of mass movement terms of rockfall and avalanche activity and of creep processes on steep slope environments in the Ogilvie and Wernecke Mountains. Study areas were selected in the Tombstone area 35 miles northeast of Dawson City and in the Bear River area 160 miles east of Dawson.

Tombstone area. Investigations were undertaken to compare talus slopes, gullies and rates of erosion on the syenites with those on quartzite and slate. During the spring melt, avalanche and rockfall occurrences were recorded and several estimates of quantities of debris brought down by avalanches onto snow covered talus cones were made, although the technique had clear limitations. Five talus cones, a rock glacier and a form transitional between a landslide and rock glacier were instrumented for surface movement. It was possible to insert wooden rods to measure movement in a profile 1.3 metres deeper in an area of relatively fine-grained debris in one of the cones. All the long profiles of the cones were obtained and characteristics of the surface debris sampled. Other periglacial and glacial phenomena in the region were mapped but not examined in detail.

Bear River area - is underlain by dolomitic limestones and by slate interbedded with quartzite. Talus cones on both bedrock units were surveyed in the same manner as in the Tombstone region. Many of the cones in Bear River area grade into pro-talus masses of debris which appear to be one form of rock glacier. In some cases these 'pro-talus rock glaciers' have protruded far enough to divert drainage in the valley bottoms. In addition to studies of rates of movement on the talus cones, several sample nets were laid out to catch annual rockfall debris. Other work in the area included the installation of pegs and plastic tubing to measure rates of movement on solifluction lobes, stripes, and on stone streams. The latter are a particularly interesting form, with a probable multiple origin. Finally, mapping of all periglacial and glacial phenomena in the area was carried out from ground reconnaissance and from air photos.

A few days were spent eight miles east of the Dempster Highway at Mile 43 investigating large, overlapping solifluction lobes on shales and phyllites. Their advanced degree of development probably reflects both the lithology and also of the considerable length of time that has elapsed since the last glaciation in the valley. The antiquity of the glaciation also is suggested by the poor state of cirqui preservation at the valley head.

Lichenometrical techniques are being used to analyze large rockfalls and debris flows which have occurred within the last hundred years or so. A lichen factor for several of the common crustose and foliose species was obtained for the last sixty years from the piles of tailings left by the gold dredges in the vicinity of Dawson.

Mineral occurrences observed. Chalcopyrite, azurite and malachite were noted in surficial debris below outcrops of dolomite and slate at the following localities on the Nash Creek map-sheet – (a) 64°45'N, 134°15'W, and (b) 64°48'N, 134°15'W. Galena was noted on the surfaces of rock fragments in the syenites at localities in the Tombstone area on the Dawson map-sheet, 64°25'N, 138°34'W.

108. MALLORYTOWN-BROCKVILLE AREA, ONTARIO (31 B/5, B/12, C/9)

E.P. Henderson

Striae, fluting, and drumlinoid ridges record two movements of ice across the Mallorytown-Brockville area. The oldest movement flowed 10 to 20 degrees west of south over most of the area, with greater westward deflection of ice to as much as S35°W near the St. Lawrence River in the southwest corner of the area, as has been recorded previously southwesterly towards Kingston[1]. A later ice movement towards the south and east of south followed cessation of the earlier movement but did not extend much past Brockville. Lobation of the ice following extensive calving into deep proglacial lake waters to the south and east combined with some readvance of the ice-margin, may best explain the pronounced change in direction of flow of the last ice north and east of Brockville. Though areas farther west from Brockville seem unaffected, there is evidence south of the International Boundary[2] of a readvance that flowed east of south out of this area.

Glacial deposits are thin, generally less than 3 feet thick, but locally the sandy till may be much deeper on the flanks of hills or in the lee of escarpments. Rock exposures are prevalent above the marine limit, particularly in uneven, rough country underlain by Precambrian rocks, but are less common in areas below the marine limit where in addition to any glacial deposits, large areas have a cover of marine sand and clay, and in areas underlain by Palaeozoic rocks.

Glacio-fluvial sediments are present principally as kames, with remnants of a large esker forming most of 5-mile-long Grenadier Island in the St. Lawrence River and two small islands farther downstream. Most of the more extensive deposits have formed on slopes more or less facing the direction towards which the ice flowed. Below the marine limit, ice-contact deposits are much modified and have been mostly eroded, and the material redeposited by wave and current action. The biggest reserves of valuable granular material are on Grenadier Island and in kame deposits in the vicinity of Prescott. The former are largely unexploited, probably because of difficulty of access.

As the ice-margin withdrew to the north and east, a proglacial lake in the Ontario basin, held up by an ice-dam in the St. Lawrence Valley, spread over the entire area, depositing clay and sand in depressional areas of the lake floor. After disintegration of the ice-dam to the east and draining of the proglacial lake, much of the area was invaded by the Champlain Sea. All the land east of Brockville was submerged whereas only shallow embayments and an arm of the sea along the St. Lawrence Valley existed to the west, even at the time of maximum extent of the Champlain Sea.

Beaches and bars attributed to the marine phase are found as far west as Atkins Lake, 12 miles northwest of Brockville, at elevations up to 435 feet above sea-level. Though marine shells have not been found associated with shore features considered to mark the marine limit, the features occur abruptly over several miles at the same general altitude and always where a long fetch existed towards open Champlain Sea waters. Marine shells occur in shore deposits a few miles to the east at levels 50 to 60 feet below the assumed marine limit, suggesting some withdrawal of marine water from its maximum transgression before invasion of the basin by a marine fauna.

As continuing isostatic recovery raised the land surface after recession of marine water eastward, much marine sand was blown into tracts of parobolic and irregular dunes. Dunes reach heights of 40 to 50 feet and are best developed near Algonquin, where they cover several square miles. West of Algonquin there is evidence for considerable migration of individual dunes under the influence of easterly winds, some dunes having moved west from where they originated on marine sand deposits to a position on flat areas of thin till and rock west of the marine limit.

Altitudes of the marine limit near Atkins Lake and in the Ottawa area[3] show the highest Champlain Sea water-plane to be tilted by post-Champlain differential uplift at approximately 5 1/2 feet per mile. Several long narrow swamps in the Brockville area draining to the northeast and aligned closely to the direction of maximum uplift appear to contain unusually deep organic deposits. Accumulation probably continued over a long time as differential isostatic recovery slowly raised the lower ends of the marshes at a slightly greater rate than the upper ends, spreading and perpetuating waterlogging throughout the marsh area. The upper end of the largest marsh lies 8 miles west of Brockville at Forthton Station and runs northeast from there for more than 10 miles.

[1] Henderson, E. P.: Surficial geology, Gananoque-Wolfe Island, Ontario; Geol. Surv. Can., Map 13-1965 (1965).

[2] MacClintock, Paul and Stewart, D. P.: Pleistocene geology of the St. Lawrence Lowland; N.Y. State Mus. Sci. Surv., Bull. 394 (1965).

[3] Gadd, N. R.: Surficial geology of Ottawa map-area, Ontario and Quebec; Geol. Surv. Can., Paper 62-16 (1963).

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109. SURFICIAL GEOLOGY, AISHIHIK LAKE, YUKON TERRITORY (115 H)

O. L. Hughes

Mapping of surficial geology of Aishihik map-area at reconnaissance scale was completed. Field work consisted mainly of (1) ground-checking with helicopter support of photo-interpretation in areas difficult of access from roads or by boat, and (2) drilling by portable diamond drill of surface organic deposits. The radiocarbon samples obtained will provide minimum ages for successive glacial advances.

The digitate limit of the late Wisconsinan McConnell advance[1] of the Cordilleran ice-sheet has been traced across the map-area; locally moraines within the McConnell limit indicate significant readvance. In west-central Aishihik map-area, moraines mark the McConnell limit of valley glaciers that originated in Ruby Range.

Ice-marginal features, much-modified, mark the limits of the earlier, more extensive Reid advance[1] of the Cordilleran ice-sheet. In the north part of the map-area, the Reid limit appears to be also the limit of glaciation, and evidence for older, more extensive glaciations recognized by Bostock in Carmacks and McQuesten map-areas to the north is lacking.

Locally, rather well-preserved moraines lie between the McConnell and Reid limits indicating an advance of intermediate age that is not represented by moraines in Carmacks and McQuesten map-areas.

A boring in permanently frozen glacio-lacustrine sediments in an area of presumed themokarst topography showed that ground ice in lenses from a few millimetres to nearly a metre thick constitute 30 per cent or more of the total section. The ratio of ice to sediment is sufficient to account for the thermokarst topography by local melting of the ground ice.

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[1] Bostock, H. S.: Notes on glaciation in central Yukon Territory; Geol. Surv. Can., Paper 65-36 (1966).

110. SURFICIAL GEOLOGY, STRATFORD-CONESTOGO AREA (40 P/7, P/10)

P. F. Karrow

Mapping of the Stratford and Conestogo sheets, an area of 870 square miles, began in 1965 and was continued in the summer of 1967. The main geological problems of the area are the delineation of the several till sheets which occur at the surface, the correlation and delimiting of the numerous subsurface till sheets exposed along the valleys, and the characterization and determination of source of each of these till sheets. Field work and laboratory analyses thus far suggest some tentative conclusions. Some techniques, such as till fabrics and carbonate analysis, have proven troublesome and only partly successful in helping to solve some of the problems of the area.

Figure 1 shows significant relationships in the area, as tentatively interpreted at this time.

The probable line of division between the Huron-Georgian Bay ice lobe and the Erie-Ontario ice lobe is indicated by a dashed line following the Elmira and Waterloo moraines. Most moraines, including both till and kame moraines, appear to have been overridden at least once after their construction by earlier ice movements. Thus large tracts of the Waterloo kame moraine have been overridden and are capped by clay till, (area 'P', Fig. 1), perhaps the correlative of the Cary-aged Port Stanley Till of the Erie lobe. The next younger advance from the east deposited the sandy Wentworth Till (W) of probable Port Huron age, but constructed no moraine at its terminus.

The Elmira kame moraine was overridden from the north by the Georgian Bay ice lobe. Till of this advance (C) extends north of the Elmira moraine, is silty to clayey in texture, and has abundant dolomite in the matrix. The Milverton moraine, a clay till moraine in its southern extent in the area, was overridden from the north and is mostly capped by a gritty silt till (N) with abundant dolomite; this till extends westward and northward beyond the map-area. An even younger advance of the Georgian Bay lobe may have reached Listowel, in the northwest corner of the area, depositing a sandy till; this till may be merely a coarser facies of till 'N' but flat terrain has not revealed stratigraphic relationships adequately.

East of the Milverton moraine, the surface till is a clay till (D) which either mantles, or constitutes, the Macton moraine, a previously undescribed moraine which trends southeast. Clay till like 'D' occurs at the surface north and south of the moraine and is the surface till at the Conestogo Dam road cut.

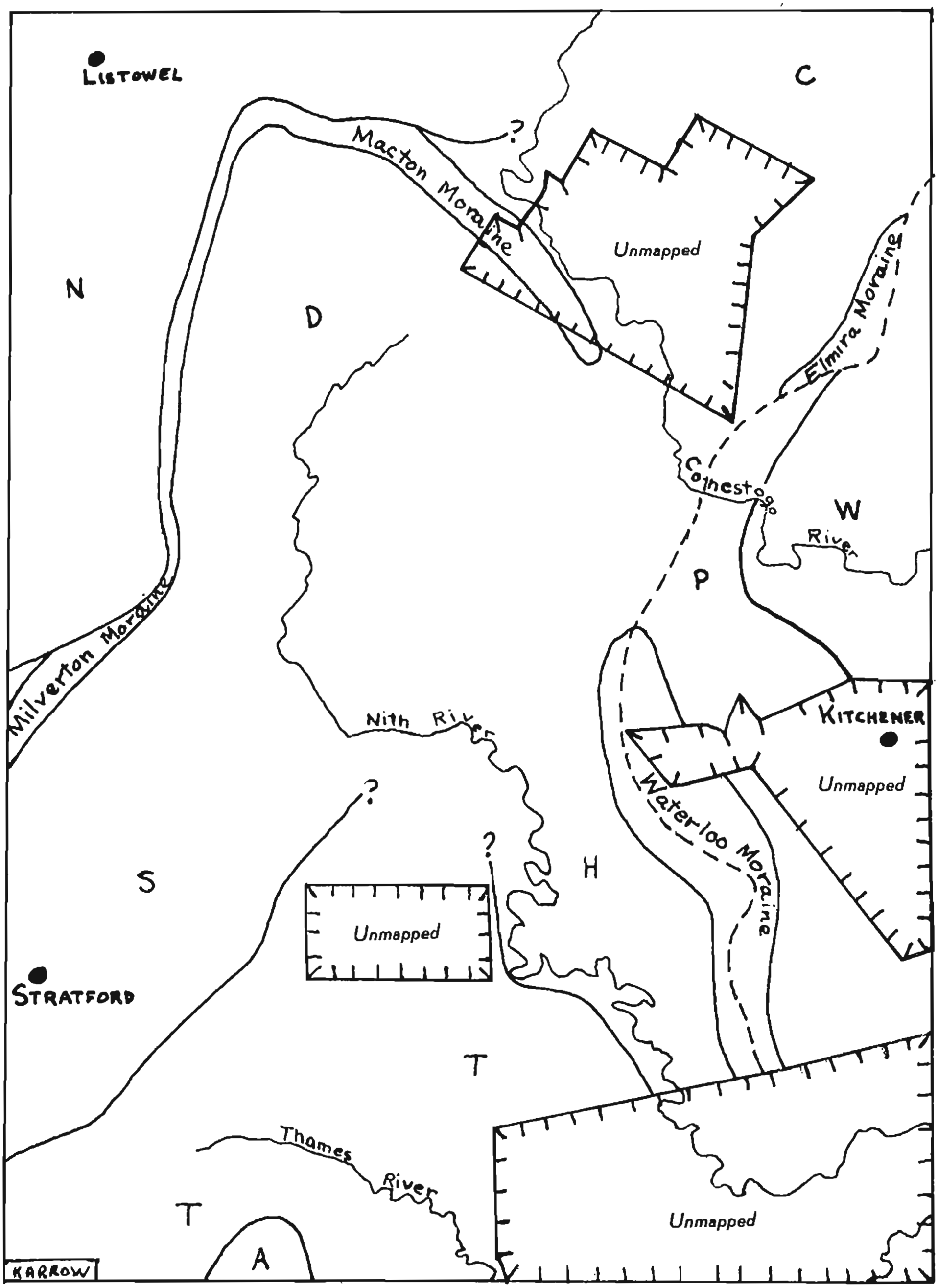

Figure 1. Sketch map of Stratford-Conestogo area, showing glacial features. Letters refer to till sheets discussed in text.

Till (S) is a sandy silt till, commonly occurring in small northeasterly-trending ridges between which are extensive sheets and lenses of lacustrine silt. Again, the ridges may only be mantled by till 'S', as similar ridges occur to the southeast beyond the area of till 'S' in the area of the next older, and underlying, till (T). Till 'T' is a gritty clayey silt till which extends south beyond the area and east to the Nith River where it overlies clay till (H).

Tills 'T', 'H', and 'P' overlie directly the sandy, stony Catfish Creek Till (A) of Tazewell age, deposited by ice moving from the north and northeast. An area of till 'A' occurs at the surface at the southern boundary of the area, apparently an inlier unmantled by the later ice advance which deposited till 'T'.

Several distinct till sheets of various, but usually fine, textures occur between tills 'D' and 'A'. Most tills above till 'A' (Catfish Creek Till) are believed to be of Cary age.

Older tills have now been discovered below the Catfish Creek Till in a belt extending from New Hamburg to Drayton in the northeast part of the area. The origin of the several lithologic till types is as yet unknown.

111. DRIFT STRATIGRAPHY AND BEDROCK TOPOGRAPHY VIRDEN AREA, MANITOBA (62 F)

R.W. Klassen and J.E. Wyder

Test-hole drilling through 16,600 feet of drift and bedrock at 59 sites within the Manitoba part of the Virden area (62 F) was completed during the last two months of the field season. The test-holes were electrically logged and most of the fine sediments penetrated were sampled at 5- or 10-foot intervals by means of a side-wall sampling device.

Bedrock topography maps, compiled from available subsurface information, provided control in selecting drilling sites. The sites were located where data on depth to bedrock was not available or was unreliable, and/or where maximum stratigraphic information could be obtained. Most drilling sites were northwest of the Souris River which approximately marks the boundary between thick drift (greater than 200 feet) to the northwest and thin drift (50 feet or less) along the flanks of the Turtle Mountain upland to the southeast.

A preliminary bedrock map based on drilling results is in preparation and will be available at an early date. Detailed studies of bedrock channels in this area using geophysical methods and drilling are planned as a follow-up to the 1967 field program.

112. QUATERNARY GEOLOGY AND GEOMORPHOLOGY OF ASSINIBOINE VALLEY AND ITS TRIBUTARIES, MANITOBA AND SASKATCHEWAN

R. W. Klassen

Surficial mapping and test-hole drilling along Assiniboine, Shell and Qu'Appelle Valleys began in 1966 and was continued during the first two months of the 1967 field season.

Assiniboine and Shell Valleys in the Duck Mountain area (62 N/3 W 1/2) were mapped on a scale of 1 inch to 1 mile and Assiniboine Valley in the Brandon area (62 G/10 W 1/2) was mapped on a scale of 4 inches to 1 mile.

Three tills outcrop along Assiniboine and Shell Valleys in the Duck Mountain area. The tills commonly comprise a total thickness of 25 feet or less and can be recognized on the basis of colour, the presence or absence of jointing, and by the preferred orientation of elongated pebbles. The oldest till exhibits the highest degree of oxidation and the youngest the lowest degree which suggests that they were deposited during three intervals of glaciation and not by merely minor fluctuations of one glacier. The pebble orientations indicate that an interval of glaciation in a westerly direction was followed by glaciation in a southwesterly direction, which in turn was followed by a final interval of glaciation in a southeasterly direction. The uppermost till is generally less than 4 feet thick and is commonly separated from the underlying till by a boulder pavement marked by grooves and striae that correspond to the preferred orientation of pebbles in the overlying till.

Deeply pitted terraces within Shell Valley are evidence that it was filled largely with ice rather than drift during the last interval of glaciation.

Test-holes were drilled through 2,500 feet of surficial sediments and bedrock at 12 sites within Assiniboine Valley near Virden and Miniota, Manitoba and adjacent Qu'Appelle Valley near Esterhazy, Saskatchewan. The test holes were logged electrically and the fine sediments penetrated were sampled at 5- or 10-foot intervals by means of a side-wall coring device. A 745-foot test-hole in the Esterhazy area (SW 1/4 sec. 29, tp. 17, rge. 2 W 2) penetrated 716 feet of drift above shale bedrock.

113. GLACIOFOCUS AND THE MUNRO ESKER OF NORTHERN ONTARIO

Hulbert A. Lee

Development of the glaciofocus method of mineral exploration begun in 1963[1] was continued in the Munro esker of northern Ontario. The study is aimed at relating the direction and distance of transport from a bedrock source-region of a mineral indicator of economic importance.

During 1964, 1966, and 1967 a massive, gravelly sand layer within the Munro esker was investigated. Two localities from which significant indicators could be derived were selected, one at the south end of Lake Abitibi and the other near Kirkland Lake at the Upper Canada gold mine. Fragments of strongly magnetic nickeliferous dunite were derived from the former locality and free gold from the latter. Further work indicated, however, that the source of the free gold is auriferous pyrite; only in the upper four feet of the esker is gold in the free state – in subsequent lower layers it is contained within pyrite grains. Variations in the distribution of indicators were determined both laterally and vertically. Element analysis for Pb, Zn, Cu, Ni, Co and Ag was carried out from 4-foot vertical channel samples and for comparative purposes from the A and B horizons of the soil profile.

The following tentative conclusions are of interest to mineral exploration. (1) The choice of size ranges is not important. Variance analysis for all size ranges gave similar graphs. (2) The upper four feet is adequate for channel samplings. (3) Air photograph study can aid in the selection of the sample grid. The surface expression of the massive, gravelly sand facies is a hump on the esker ridge covered by jack pine, alder, hazel, willow, and birch. Recognition of such sites is also applicable to highway engineering as they contain material best suited in size for crushing.

In 1967 the field group comprised 4 geologists, 3 geology students, 2 operators for heavy equipment, and a diamond drilling crew. The following equipment was used and tested under northern Ontario bush conditions: A Bucyrus-Erie B 15 – 1/2-yard shovel mounted on pads, a Bucyrus-Erie B 22 – 3/4-yard shovel mounted on pads, an International diesel 3414 tractor with 3120 backhoe attachment mounted on wheels, and a double track MS Bombardier. A Denver automatic gold panner was used for part of the project but its use was discontinued until further test work could be done.

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[1] Lee, H.A.: Glacial fans in till from the Kirkland Lake fault: A method of exploration; Can. Mining J., vol. 85, No. 4, pp. 94-95 (1964).

114. BURIED VALLEYS NEAR KIRKLAND LAKE, ONTARIO

Hulbert A. Lee

The Munro esker follows and fills a linear *en echelon* series of bedrock troughs. Diamond drilling was done in one of the troughs in hopes of reaching bedrock, first to determine the nature of the trough, second to further the study of buried valleys, and third to establish the relationship between kimberlite indicators and the trough. A kimberlite indicator, pyrope was reported by Lee[1] and kimberlite fragments were found in the sands in Gauthier township in the 1967 field season. The drill-hole is vertical, and is situated in Gauthier township, central part of mining claim 303 47. Drilling was stopped in October, 1967 at a depth of 738 feet while still in esker sands.

[1] Lee, H.A.: Investigation of eskers for mineral exploration and buried valleys near Kirkland Lake, Ontario; Geol. Surv. Can., Paper 65-14, 20 pp. (1965).

115. POST-GLACIAL UPLIFT STUDIES NORTH OF LAKE HURON

C.F.M. Lewis

Field studies were continued to determine recent rates of uplift north of Lake Huron and Georgian Bay and comprised the following activities: (1) instrumental (stadia) survey of the Nipissing Great Lakes shoreline at selected localities to provide elevation data and hence regional deformation of the ground surface since Nipissing time; (2) collection of organic material intimately associated with shoreline deposits to provide a radiocarbon age for the raised Nipissing shore; and (3) collection of basal organic sediments in small lakes with surface elevations ranging from that of Lake Huron up to that of the Nipissing strand.

The Nipissing shoreline is expressed in most places as an erosional terrace and shore bluff. Shoreline development was strong in thick drift over Palaeozoic sedimentary bedrock from Sault Ste. Marie to St. Joseph Island and on Manitoulin Island. Low shore bluffs were encountered in clay till and glacio-lacustrine silty clay sediments between Precambrian bedrock outcrops north and west of the present Lake Nipissing. Many disconnected shoreline fragments in this area did not consistently define a single water-plane of uniform gradient. Lack of overburden, forest vegetation, and poor access thwarted discovery of Nipissing shore features along the east coast of Georgian Bay between French River and Nobel and between Mactier and Honey Harbour. Except in the vicinity of Sault Ste. Marie, distinct correlatable shorelines below the Nipissing beach (e.g. Algoma stage) were not observed. A total of 36 localities distributed between Sault Ste. Marie, North Bay, and MacTier were surveyed. On Manitoulin Island J. E. Smith began an associated study (reported elsewhere in this publication) of well-developed Nipissing and modern beach features on Manitoulin Island with special reference to the development of criteria for fitting water-planes to raised beach features.

New excavations between Britannia and Dominion Bay on Manitoulin Island revealed organic lagoon or marsh deposits, 1 metre thick, beneath a Nipissing bay-mouth bar. Stumps and roots buried beneath sandy bar materials were discovered in growth position on top of the organic detritus. It is hoped that this deposit will provide an environmental and chronological record of the Stanley-Nipissing interval, especially a maximal age for the latter lake stage. Further contributions to Nipissing and post-glacial Great Lakes chronology are expected from cores of complete sediment sequences collected from two lakes impounded behind Nipissing bars on Manitoulin and St. Joseph Islands. Preliminary radiocarbon dates of basal organic sediments from small lakes in the vicinity of North Bay (collected in 1966) suggest that Upper Great Lakes drainage via the Mattawa River system had stabilized at the Stanley-Nipissing level (about 700 feet at present) prior to 8,300 B.P. and had essentially ceased prior to 5,000 B.P.

Small lakes (diameter less than 0.5 miles) in the study area that are isolated from large river or runoff flows commonly deposit only fine-grained plant and algal detritus (gyttja). The organic sediments are generally 1 metre to 10 metres thick and overlie inorganic sand, silt, or clay with a visible discontinuity. Based on the premise that the underlying inorganic sediments relate to a time when Lake Huron with its strong wave and current action flooded the small lake basins, and that organic sedimentation began when the small basins were uplifted from Lake Huron, it should be possible to date the time of emergence by radiocarbon analysis of the basal gyttja from the ponds or lakes in question. Further, if several lakes at various altitudes in an uplifted area are analyzed it should be possible to construct an emergence curve for that area. To date, basal organic sediments in 17 lakes have been cored for this purpose using a standard Livingstone piston corer. Eight of these lakes are between Lake Nipissing and Georgian Bay with altitudes ranging from 588 feet to 677 feet a.s.l., and the remaining nine lakes are eastern Manitoulin Island area with elevations between 580 feet and 650 feet a.s.l.

At the invitation of Dr. W.M. Tovell, Royal Ontario Museum, the author spent one week sampling and examining bottom deposits in the entrance to Georgian Bay between Tobermory and Fitzwilliam Island using facilities of the Great Lakes Institute, University of Toronto. Results of this study were reported[2] to the Kingston meeting of the Geological Association of Canada.

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[1] Lewis, C.F.M.: Post-glacial uplift studies in northern Lake Huron basin; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1, Part A, pp. 150-151 (1967).

[2] Tovell, W.M. and Lewis, C.F.M.: Topography and bottom deposits between Tobermory and Fitzwilliam Island, Georgian Bay, Ontario; Program, Geol. Assoc. Can.; Queen's University, Kingston, Aug. 30 – Sept. 1 (1967).

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116. SEDIMENT STUDIES IN LAKE ONTARIO AND LAKE ERIE

C.F.M. Lewis

Studies of the nature, sequence, and areal distribution of sediments in Lake Ontario were continued[1] in 1967 during a five- and seven-day period in July and October respectively. With M.V. Theron, chartered for Great Lakes studies by the Inland Waters Branch, serving as a sampling station, surficial sediments at 109 stations were sampled and investigated using grab and gravity coring devices. This work was directed towards (1) increasing areal sample coverage to six-mile spacing on a triangular grid and (2) investigating the relation of water depth to sediment texture and composition in the vicinity of glacio-lacustrine sediments exposed on the lake bed along the northern margin of the basin.

In addition, piston cores up to 40 feet in length were recovered at 15 locations in the small northeastern basin near the lake outlet, in the deepest portions of the main basin and along the trend of a mud-covered till ridge (moraine?) crossing central Lake Ontario.

Most cores penetrated the post-glacial sediment column into late-glacial clay. At several stations the contact between the two materials could be correlated with prominent sub-bottom reflections recorded in echograms of a 15 kc. echo sounder. Laboratory sedimentological analysis of the sampled material is currently in progress.

The author shared a six-day cruise aboard M.V. Brondal on Lake Erie with A.L.W. Kemp, Inland Waters Branch. Echograms and sediment cores (piston and gravity) were obtained at 14 locations in the area of channels crossing the Long Point-Erie and Pelee-Loraine moraines, in western Lake Erie between Pelee and Bass Islands, and in Long Point Bay. The collected material including shells and plant detritus for C^{14} dating, will augment the data of previous studies[2] on lake-bed morphology and chronology of Early Lake Erie.

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[1] Lewis, C.F.M. and McNeely, R.N.: Survey of Lake Ontario bottom deposits; in Proc. Tenth Conf. on Great Lakes Research, Great Lakes Res. Div., Univ. Michigan, Ann Arbor (in press).

[2] Lewis, C.F.M., Anderson, T.W. and Berti, A.A.: Geological and palynological studies of Early Lake Erie deposits; in Proc. Ninth Conf. on Great Lakes Research, Great Lakes Res. Div., Univ. Michigan, Ann Arbor, Publ. No. 15, pp. 176-191 (1966).

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117. CORNER BROOK AREA, NEWFOUNDLAND

V.K. Prest

More than two weeks were spent in the Corner Brook-Pasadena area of western Newfoundland at request of Department of Forestry and Rural Development on a Land Classification Pilot Project. The party included foresters, biologists and pedologists, as well as game and wildlife observers and recreation officers with a wide range of interests. It was hoped that a surficial geology reconnaissance of the parent soil materials would provide a rough framework for the detailed sub-divisions of the peddogists and foresters.

The area was not well-suited to this purpose as regards character and variety of parent materials present. It has, in large part, a ubiquitous sand till mantle; within these areas the forest cover varied considerably due to pedalogical and other parameters. The forest cover in places showed little change when one passed from the sand till onto stratified sediments, nor did it vary appreciably with thickness of till. The influence of bedrock is noticeable in some places and surprisingly lacking in others. For instance the toxic effect of serpentinite-peridotite bodies is obvious and in one case a serpentinite gravel body also reflects this magnesium-calcium imbalance. On the other hand a very thin sand till mantle, even though containing many limestone boulders, was sufficient to mark the expected influence of the underlying limestone; the till matrix gave a pH of only 5.5 close to the bedrock surface.

Surficial geological studies which automatically consider the influence of the local and regional bedrock geology, do not in themselves provide the key to forest-cover changes. They will prove more directly applicable in some areas than in others. Geology may be no more or less important than pedological, topographical, and biological studies, but it does serve to provide a crude framework within which the other factors or parameters may be more intelligently considered.

118. POST-GLACIAL CRUSTAL DEFORMATION ON MANITOULIN ISLAND, ONTARIO

J. Edward Smith

As part of an investigation of recent uplift around Lake Huron (see report by C.F.M. Lewis in this publication) the writer undertook detailed investigations on that part of Manitoulin Island between 81°50' and 82°40'W to determine the Recent deformation of the ancestral Lake Nipissing water plane. The Nipissing stage – that slightly transgressive post-glacial lake level existing from the initiation of a triple outlet phase in the Upper Great Lakes until the termination of discharge via the North Bay outlet[1] – is represented by the highest of a continuous series of littoral deposits formed at and following the maximum of the transgression from the low Stanley stage and extending to the modern shore. As such, the Nipissing is a pronounced and well-preserved strandline that can be traced nearly continuously about Manitoulin Island.

For the most part, the Nipissing shoreline is erosional in origin, consisting of a till bluff, 5 to 40 feet high, behind a near-shore flat of bedrock, boulder pavement, or modified till. In coarse-grained tills a berm intervenes between the bluff and the near-shore flat. Locally, the berm and bluff have been undercut by immediately post-Nipissing water levels. In select locations erosional bluffs may be traced directly into synchronous depositional bars. On the south shore of the island, the Nipissing frequently takes the form of a massive constructional sand berm, in places masked by dunes.

The elevation of the Nipissing water plane was determined from beach morphology at 26 sites. At each site five detailed profiles, spread over a distance not exceeding a quarter mile, were made by accurate levelling or theodolite profiling. Elevations were closed by levelling to the nearest topographic, hydrographic, or highways bench mark; however, frequent use was made of the horizontality of the present Lake Huron level to reduce the labour involved. The writer considers the Nipissing elevations, determined from the mean of the applicable profiles at each site, to be accurate to 6 inches. These elevations will be analyzed by trend-surface analysis.

Beach ridges of shingle, cobbles, pebbles, and sand commonly occur below the Nipissing level. These ridges were profiled and sampled in Square Bay, on the south shore of Manitoulin Island, to determine (a) the continuity of berms about the bay, (b) the identity of individual or berm groups which may represent still-stands of lake level, (c) systematic changes of beach ridge morphology and materials with exposure and off-shore gradients, (d) the role of minor bedrock escarpments in the positioning of berms, (e) the internal structure of sand and shingle ridges, and (f) the relative importance of wind-blown sand. Seismic investigations of the bedrock configuration beneath the post-Nipissing berms were conducted by G.D. Hobson. The writer completed a series of echo-sounding profiles in Square Bay and adjacent Dominion, Loughed, Lonely, and Dean Bays. Laboratory analysis of many sediment samples will be required before the above objectives can be assessed. It is hoped that they will further the understanding of both Nipissing and post-Nipissing coastal morphology.

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[1] Hough, J.L.: Geology of the Great Lakes; Univ. Illinois Press, Urbana, Ill., pp. 259-262 (1958).

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119. PLEISTOCENE GEOLOGY, SNAG-KLUANE LAKE, SOUTHWESTERN YUKON (115 F (EAST HALF), G, J, K (EAST HALF))

V.N. Rampton

Field work was completed in the area west of Donjek River between St. Elias Mountains and the all-time limit of glaciation. Techniques for quantitative description of moraines and for relating slope to age were used in determining the chronology of glacial advances. Neoglacial moraines adjacent to the snouts of Klutlan and Natazhat Glaciers were dated by lichenometry and dendrochronology.

Photographs were taken of the lower part of the Klutlan Glacier, the Natazhat Glacier, and small glaciers along the northern flank of the St. Elias Mountains between the Alaskan boundary and the Donjek River and will be compared with the earlier vertical air photographs in order to document recent changes in the glacier margins.

Stratigraphic sections southwest of the Shakwak Valley and along the White River include tills showing different depths of oxidation as well as volcanic ash and peat of apparent interglacial age.

The extent of two late Pleistocene glacial advances was traced by moraines, meltwater channels, and erratics. Erratics and glacial materials related to earlier Pleistocene glaciations and found at high elevations to the southwest of the Shakwak Valley, were briefly investigated.

Surface samples from different vegetational zones were collected to determine the modern pollen rain of these zones. A lake on a drift plain older than 48,000 years B.P. was cored for pollen studies. Although a loess, which is tentatively correlated with the last Pleistocene advance in the area, was penetrated, the base of the lake sediments was not reached because of mechanical difficulties.

120. MORAINAL STUDIES OF THE BIGHORN AND GRIZZLY GLACIERS, YUKON TERRITORY (115 G)

N. W. Rutter

The purpose of this study was to contrast deposits formed by known 'surged' and 'normal' alpine glaciers in order to provide criteria for recognition of these deposits in the glacial record. This is necessary in order to prevent the erroneous interpretation that evidence for a glacial advance automatically implies a regional climatic change.

A recent 'surged' moraine of the Bighorn and recent 'normal' moraines of the Grizzly were selected for study because of their similarity in size, climate and geologic terrain, and their proximity to each other and the 'surging' Steele Glacier. A group from the University of Alberta studied flow characteristics and till deposition of the snout area of the Steele. The writer had the benefit of discussions with members of the Alberta group as well as accommodation and board at certain times during the study period.

About a week was devoted to field studies and data collecting on the moraines of each glacier. The surficial deposits and erosional features were mapped in detail. Five sites in each area were selected in undisturbed till close to the till-bedrock interface for fabric analyses. Samples were also collected from each site for lithologic and texture analyses in the laboratory.

Results of the field mapping indicate that the Bighorn or 'surged' moraine is characterized by a thin, discontinuous, irregular mantle of drift, commonly composed of ice-contact stratified material; lateral moraines with subdued or no ridges marking the upper limit of glaciation; and extensive mixing of lithologic types in the till. The surge has eroded the bedrock surface moderately, with about 7 to 10 feet of material removed from the preexisting valley floor.

Ground moraine of the Grizzly or 'normal' glacier is characterized by an irregular, continuous, relatively thick mantle of drift composed mostly of till. A series of lateral moraines are present, some ice-cored, representing repeated halts during retreat. The upper limits of ice are well-marked by prominent ridges. Similar lithologic types within the till are often strung out in bands parallel to glacier flow.

Fabric analyses reveal profound differences in pebble orientation of tills of the moraines of the two glaciers. Pebbles from undisturbed till a few feet above bedrock in the valley floor of the Bighorn moraine show little preferred orientation when compared to those in similar positions in the Grizzly moraines. Furthermore, any preferred orientation in the till pebbles of the Bighorn moraine are not in the direction of glacier flow, whereas in the Grizzly moraines the pebbles are either parallel or nearly parallel to the flow direction.

Texture analyses of till from moraines of both glaciers indicate that the matrix of Bighorn till is coarser-grained than the matrix of Grizzly till.

121. SURFICIAL GEOLOGY ALONG THE BOW RIVER VALLEY IN THE VICINITY OF CALGARY, ALBERTA (82 O)

N. W. Rutter

Two weeks of the 1967 field season were spent in the study of the glacial geology along the Bow River valley in the vicinity of Calgary. This is an outgrowth of earlier work carried out west of Calgary[1, 2].

The most significant discoveries this year include shield rocks found farther west than previously reported in the upper most Cordilleran till[3]. This may indicate that the Laurentide ice front moved farther west, prior to the last Cordilleran advance, than previously thought.

Volcanic ash interbedded with silt or directly overlying a paleosol has been discovered in several localities in the area. One of the better exposures is located along the banks of the Bow River valley near the Trans-Canada Highway bridge within the Calgary city limits.

[1] Rutter, N. W.: Surficial geology of the Banff area; unpubl. Ph. D. thesis, Univ. Alberta (1966).

[2] 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).

[3] Tharin, J. C.: The glacial geology of the Calgary area, Alberta; unpubl. Ph. D. thesis, Univ. Illinois (1960).

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122. SURFICIAL GEOLOGY OF THE PEACE RIVER DAM AND RESERVOIR AREA, BRITISH COLUMBIA

N. W. Rutter

The geological study and mapping (1/50,000) of glacial deposits and morphology of the Peace River dam (W. A. C. Bennett Dam) and reservoir area were continued. Most of the field season was devoted to study of the Finlay River valley between Finlay Forks and Ft. Ware and the Parsnip River valley between the Nation River and Finlay Forks. Previously, the areas along the valleys of the Peace River from Finlay Forks to Portage Mountain and the Parsnip River from Windy Point to the Nation River had been investigated[1].

Thick, surficial deposits outcrop in many localities along the widely meandering Finlay River. These consist for the most part of lacustrine silt and clay (some units over 150 feet thick) from Finlay Forks north to about Davis Creek. Here and there the lacustrine deposits are overlain and underlain by till and glacio-fluvial deposits.

North of the Davis Creek area to Deserters Canyon thick glacio-fluvial gravel is the dominant deposit with some till and lacustrine sediments present.

North of Deserters Canyon (out of the reservoir area) to Ft. Ware the best stratigraphic sections of the entire area occur. One section, about 1 1/2 miles southeast of Del Creek displays the following sequence:

Top	9.0 feet	Till 1
	45.5	Till 2
	18.0	Lacustrine silt
	1.5	Fluvial gravel
	3.5	Till 3

	67.0	Fluvial sand and gravel
	±50.0	Till 4
	±35.0	Fluvial gravel
Bottom	±50.0	Oxidized fluvial sand and gravel

Radiocarbon dating material has been collected from nearby oxidized sands and gravels believed to be correlative with the lowest most unit in the above section.

Along the Parsnip River valley from the Nation River to Finlay Forks, lacustrine and glacio-fluvial deposits dominate, although till is present in some places. An important section across from the mouth of the Manson River on the Parsnip River includes:

Top	23.5 feet	Lacustrine silt and sand
	9.0	Fluvial sand
	10.0	Lacustrine clay
	46.0	Till and gravels
	15.0	Fluvial sand and gravel
Bottom	49.0+	Fluvial gravel

Until further office and laboratory studies are made, only a general glacial history can be presented. Evidence is present for four glacial advances that flowed down the Finlay River valley. The two thick till units represented by tills 2 and 4 in the first section cited may represent the same two advances that took place in the Parsnip River valley as reported earlier[1]. These advances are believed to have been widespread. Till 3 may represent a minor re-advance of the glacier that deposited till 4. Till 1, which is relatively thin, appears to mantle pre-existing surficial topography down-valley to about the area of Deserters Canyon, where it is no longer observed.

Post-glacial deposits consist mainly of wind blown sand commonly underlain by a paleosol.

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[1] Rutter, N.W.: Surficial geology of the Peace River dam and Reservoir area, B.C.; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1A, p. 87 (1967).

123. PLEISTOCENE GEOLOGY, LAKE MEGANTIC AREA, SOUTHEASTERN QUEBEC (21 E (EAST HALF))

W. W. Shilts

At least two till sheets are exposed in section. The lower till was deposited by a glacier flowing from the northeast, and the upper till by a glacier flowing from the northwest. The upper till may be a compound unit consisting of a lower compact sandy till member that is separated from an upper clayey till member by lake sediments. The clayey till appears to have been deposited during a glacial readvance over proglacial lake clays. Small landslides in the Chaudière River valley are due in part to these sub-till lake sediments which extend an undetermined distance back under the valley sides.

Orientations of striations, till fabrics, moraines, and meltwater channels indicate that the ice-front of the last glacier to cover the region was aligned parallel to the Chaudière River valley. Contrary to earlier reports, no evidence for significant lobation in the Lake Mégantic or Chaudière River valleys has been noted.

The possible occurrence of gold in till will be examined by a detailed mineralogical study.

124. QUATERNARY STUDIES IN THE SOUTHWESTERN PRAIRIES

A. MacS. Stalker

Field work in 1967 consisted chiefly of investigation of Quaternary stratigraphy along South Saskatchewan River system. This work was done in association with Dr. C. S. Churcher of University of Toronto and Royal Ontario Museum, Toronto, who collected and studied vertebrate fossils. Altogether some 350 vertebrate specimens were collected, 90 of which came from a coulée on the farm of H. W. Wellsch at Stewart Valley, Saskatchewan. Known sites here are largely exhausted, and exploration of other nearby gullies failed to reveal new ones. However, many more gullies remain to be examined than have been investigated to date.

At Medicine Hat vertebrate fossils have been retrieved in substantial number from five separate beds, with apparent time spans ranging from Sangamon or earlier to a postglacial age of 11,200 ± 200 years (unpublished radiocarbon date: GSC-805). Unexpectedly, during the past summer, a prolific fossil bed was found between the upper two till units here, and this bed evidently represents a substantial ice-retreat and considerable lapse of time. The author previously considered the top three till units at Medicine Hat to be of Classical Wisconsin age, but this new discovery indicates that only the top till may be so. Cause of the remarkable succession of prolific vertebrate beds is not fully understood. However, the region throughout much of Quaternary time afforded animals easy access to South Saskatchewan River and good fords across it combined with nearby good grazing land and brush along the river. In addition, as high land bounds the region on east, south, and northwest, the area was readily flooded whenever the river was obstructed farther downstream or its grade raised, burying animal remains and thus protecting them. At times such flooding may have occurred when glaciers farther north and east both blocked drainage and caused local concentration of animals that had been driven from their former habitats. Man undoubtedly played a major role in concentrating the fossils of the upper beds.

The fauna of greater than Classical Wisconsin age found at Medicine Hat to the end of 1966 includes: *Canchites ?canadensis*; *Lepus* sp.; *Cynomys* cf.; *ludovicianus*; *Citellus ?richardsonii*; *Canis* sp.; *Vulpes* sp.; *Mammuthus jeffersoni*, *Equus conversidens*; *Antilocarpa americana*; *Ovis* cf. *canadensis*; *Bison* sp. The postglacial fauna includes: *Canis lupus*; *Equus conversidens*, *Bison* sp.

Stalker[1] described 'Kipp Section' on Oldman River near Lethbridge. Here 280 feet of drift overlies up to 20 feet of 'preglacial' gravel, all on top of bedrock. During 1967 Cordilleran till was found at the north end of the exposure, in NW 1/4 sec. 18, tp. 9, rge. 22, W 4th mer., underlying the gravel. This till probably was deposited near the terminus of a glacier flowing northeastward down Belly River valley from the United States. This is 7 miles east of any previously known occurrence of mountain till. More importantly, it underlies gravel formerly considered 'preglacial' whereas other Plains occurrences of mountain till have overlain such gravel, commonly with gradational contact. This newly-found exposure apparently represents a different assemblage of 'preglacial' gravels which display puzzling features, including lack of or only poor bedding, apparent extremely rapid deposition, contortion during or following deposition with vertical alignment of many stones, and a marked paucity of fossils. Such features can be largely explained in terms of an early mountain glaciation such as is indicated at Kipp Section, with its attendant outwash, cold climate, and periods of permafrost.

The following addition should be made between units A and B of Kipp Section[1].

GLACIAL

Till, dark brown; stony with clayey matrix; stones mostly round, a few striated .... 6 feet

Sand, coarse, stony; massive, not cemented .... 2 feet

The geology of sites being developed by archaeologists of University of Calgary and Glenbow Foundation of Calgary was studied, in a continuation of the cooperative work of past years. Most of the sites investigated this summer were in Waterton National Park, and were being excavated by a party under direction of Mr. B. Reeves and Dr. R. Forbis.

[1] Stalker, A. MacS.: Quaternary stratigraphy in southern Alberta; Geol. Surv. Can., Paper 62-34 (1963).

125. QUATERNARY GEOLOGY AND GEOMORPHOLOGY, WHITECOURT (83 J) MAP-AREA, ALBERTA

D. A. St-Onge

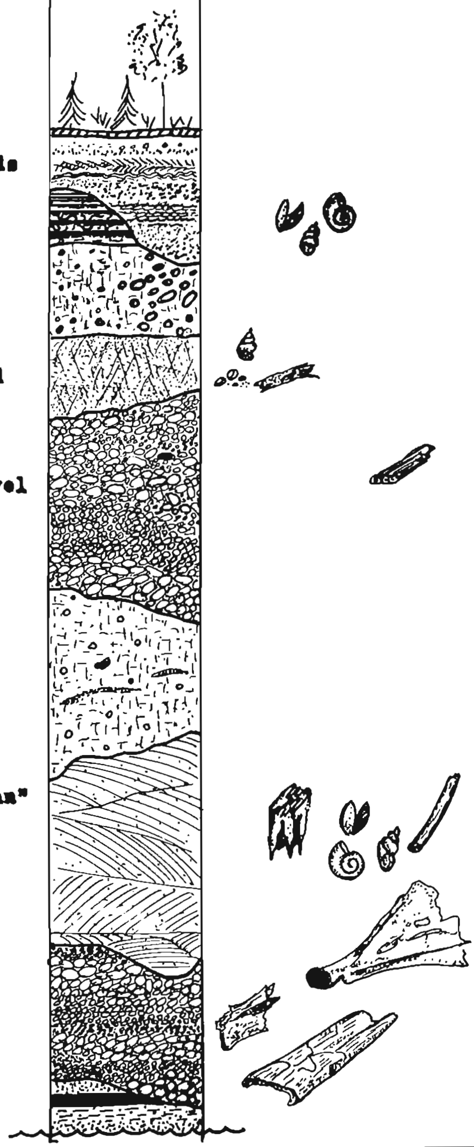
Surficial geology mapping of the Whitecourt map-area, started in 1966, was completed in 1967. All sections along the Freeman and Berland Rivers were examined during boat and helicopter traverses. The stratigraphy, summarized in Figure 1, is exposed in numerous sections along the Athabasca, Freeman, Berland, Sakwatamau and East Prairie Rivers, all of which occupy 'preglacial valleys'.

The 'Saskatchewan gravels' are found on bedrock, as valley fill 10-40 feet thick, and as terrace deposits 5-10 feet thick on the sides of preglacial valleys. The material ranges in size from coarse sand to quartzite boulders; in thick sections a coarse rythmic bedding is apparent. The upper 5-10 feet is usually strongly oxidized to a striking reddish orange. The gravels are unconformably overlain by coarse, crossbedded sands and by silt bands. No 'Shield' stones have been found in either the gravels or the sands, but abundant coal fragments are present in both. Numerous bones, teeth and shells have been found in these two units.

A black sandy clay till with few stones (Lower Till) overlies the sands. Upon drying it typically forms small prisms 3 to 10 inches long and 0.5 inch to 2 inches across. The joint faces are weathered a deep brown. Thin, commonly undulating, sand lenses are present in this deposit. A striking characteristic of this till is its remarkable homogeneity throughout Iosegun and Whitecourt map-areas.

In several exposures the lower till is overlain by lenticular deposits of coarse outwash gravels and sands and, in one instance, by silts. The latter were deposited in a pond or shallow lake and contain abundant organic remains (wood, seeds and shells), a specimen, collected at L.S.D. 11, sec. 16, tp. 63, rge. 7, W 5th, yielded a C 14 date of 10,900 ± 160 (GSC-859).

GENERALIZED SECTION

MATERIAL	SECTION	ORGANIC MATERIAL	RANGE of THICKNESS
			
Deltaic sands			3'-50'
Lake varves			5'-10'
Upper till			10'-12'
Outwash sand			0'-20'
Outwash gravel			0'-30'
Lower till			5'-20'
"Saskatchewan"			
sands			20'-40'
and			
gravels			10'-40'
Bedrock			

The overlying 'Upper Till' varies widely in texture and composition. In the lowlands it is a massive, stony grey to dark brown, sandy silt forming vertical faces along deep valleys. In places it displays a columnar structure. Towards the Swan Hills it forms a thin, excessively stony veneer, on glacially deformed bedrock. In some cases where the Lower and Upper Tills are in contact, a boulder pavement marks the boundary.

Varved or massive glacial lake silts blanket the moraine deposits in the lowlands bordering the Athabasca Valley. The massive silts, commonly over 50 feet thick commonly display a well-developed hummocky topography. Some lenses in the silt mounds contain numerous shells. A sample from L.S.D. 13, sec. 12, tp. 58, rge. 8, W 5th, yielded a C 14 date of 10,200 ± 170 (GSC-861).

Finally, in early post-glacial time the Athabasca River constructed large deltas. There are at least four of them and they range in altitude from about 2,450 feet a.s.l. near Whitecourt to about 2,000 feet a.s.l. near Chisholm. The material in these deltas is medium to coarse sand which has since been blown into large dunes.

126. PALYNOLOGICAL INVESTIGATIONS, ONTARIO AND NOVA SCOTIA

J. Terasmae

Postglacial peat and lake sediment samples were collected in the central Hudson Bay Lowland, in support of Pleistocene geological studies related to Operation Winisk. A radiocarbon date of 7,140 ± 170 years B.P. (GSC-831) was obtained for basal post-marine deposits in the 'Forks of Albany' area.

Palynological and geological samples were collected on Sable Island from modern soils, buried soils in dune sand and submerged peat, in support of a study of palaeoecology and postglacial history of this island. In addition, studies were made of modern vegetation on the island and of pond sediments with the aid of coring and SCUBA diving. A fossil mastodon site was sampled in southern Ontario, near Ingersoll. Palynological, malacological and sedimentological studies are in progress to establish the stratigraphic position of the mastodon fossils, estimated to be about 10,000-11,000 years old, and the palaeoecological conditions existing at that time. Depositional conditions of marl were studied in five lakes in the Kingston-Belleville area, Ontario, with the aid of coring and SCUBA diving. There appears to be a relationship between the depth of water, depth of thermocline and the deposition of either marl or dark, rubbery, algal or fine-detritus gyttja. It can be anticipated that useful palaeolimnological and palaeoclimatic data can be obtained from these studies, when coupled with palynological and chemical investigations.

Sediments in three lakes were cored in the Owen Sound area, Ontario, to gain information on the age of the Singhampton and Gibraltar moraines and of Lake Algonquin at Wiarton.

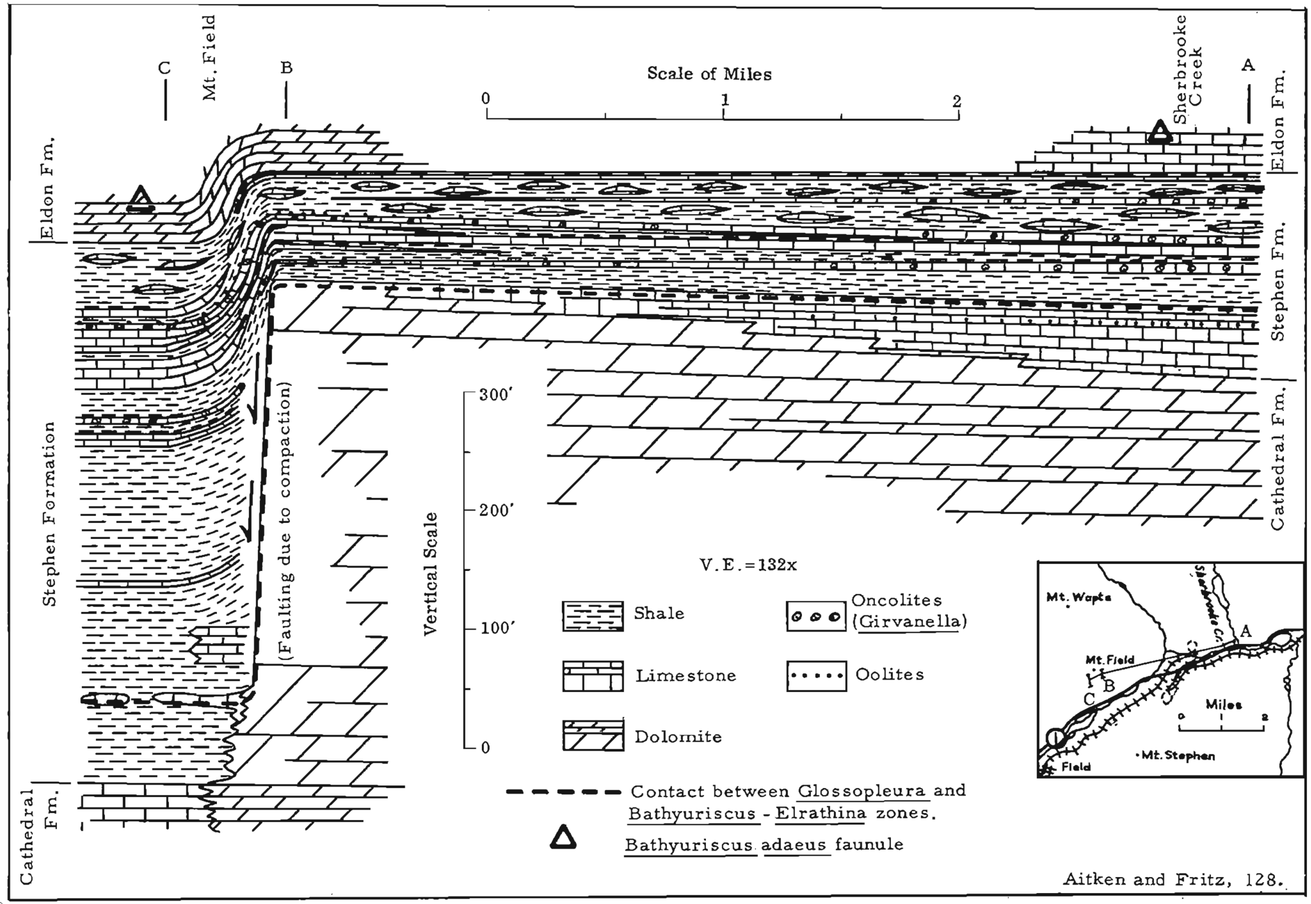


Figure 1. Stratigraphic cross-section of the Stephen Formation, Sherbrooke Creek to Mount Field, B.C.

STRATIGRAPHY AND STRUCTURAL STUDIES

127. RECONNAISSANCE FOR OPERATION NORMAN, DISTRICT OF MACKENZIE (86, 96, 97, 106, 107)

J.D. Aitken, D.G. Cook and C.J. Yorath

The writers conducted a reconnaissance by fixed-wing aircraft of the area to be investigated under Operation Norman. The purpose was to evaluate the amount and quality of outcrop, to obtain terrain data to assist in air photo studies and to inquire into support logistics from Inuvik and Norman Wells.

The operation area includes that part of the Western Canada Sedimentary Basin lying between the Precambrian Shield and 132°W and between the Arctic coast and 64°N.

Cretaceous and Tertiary (?) shales are well-exposed along the broad river valleys north of the junction of the Carnwath and Anderson Rivers and along the lower Kugaluk River. Few outcrops were seen between the major river systems. Within the Mackenzie Mountains, well-exposed sections of Cambrian, Ordovician-Silurian, Devonian and Cretaceous rocks occur but, south of the Arctic Coastal Plain to Great Bear Lake, outcrops are small and widely scattered.

During the winter months the writers will be conducting detailed airphoto interpretation and logistics planning for the first phase of Operation Norman.

128. BURGESS SHALE PROJECT, BRITISH COLUMBIA (82 H/8 (WEST HALF))

J.D. Aitken and W.H. Fritz

The Burgess Shale quarry was worked by a crew of four geologists (Dr. H.B. Whittington, Dr. D.L. Bruton, and the authors), two assistants, a blaster, and two labourers for a period of six weeks. The area quarried in 1967 exceeded 200 square feet. From this area, six feet of shale barren of fossils of particular interest was stripped away to expose the underlying seven feet of productive beds, including the 'phyllopod bed'. With the exception of certain large, highly fossiliferous slabs preserved intact for display purposes, and several layers, each a few inches thick, of non-fissile, barren silty shale, all rock from the productive zone was split thin in the search for fossils. Despite a distinct diminution in the numbers of fossils at the north end of the quarry, a large collection was obtained.

The quarry in its present state, representing the combined efforts of Walcott, Raymond, and ourselves, now lies in sparsely fossiliferous strata at its north end, and at the south end, a minor fault has brought about distortion and alteration of the strata. Any further quarrying will have to be directed into the hillside, at a rapidly increasing 'strip ratio', and will be much more expensive than our work to date. For this reason, there is some doubt whether our permit to quarry for a third and final year will be exercised.

Through stratigraphic studies and fossil collecting in the quarry section, the section on the south face of Mount Field, and the section on Mount Stephen, the position of the Burgess Shale (phyllopod bed) relative to the Mount Stephen section can now be demonstrated. These studies have revealed also that the Stephen Formation on Mount Stephen and Mount Field thickens abruptly from 180 feet to 1,030 feet, chiefly by passage across a nearly vertical bank margin (Fig. 1) which marks the western limit of the uppermost 700 feet of dolomite and limestone of the Cathedral Formation. This relationship explains the appearance in the lower part of the thickened Stephen Formation of deepwater and slope facies which are not represented in the thinner sections to the east. The existence of a submarine bank margin of high relief is proved by the position of the contact between the Glossopleura and Bathyuriscus-Elrathina zones which occur at the top of the carbonate bank at its basinward edge, and 700 feet lower in the adjacent shaly section (Fig. 1). Minor faulting at the nearly vertical contact between shales and dolomites does not affect older strata, and is attributed to differential compaction.

In the light of the above observations, the unique Burgess Shale fauna and its preservation may be attributed to ecologic and diagenetic conditions controlled by proximity to the foot of the bank margin (basinward edge of the regional carbonate bank represented by the upper Cathedral Formation).

129. STRUCTURAL ANALYSIS OF THE WESTERN RANGES, ROCKY MOUNTAINS, GOLDEN, BRITISH COLUMBIA (Parts of 82 N)

H.R. Balkwill

Investigation of the geologic structure and other aspects of the regional geology began in 1966 as part of Operation Bow-Athabasca[1]; field work on the project was completed in 1967. The boundaries of the area of study and an outline sketch of the geologic structure are shown on Figure 1.

An abrupt southwesterly change from a carbonate facies to a slate and shale facies occurs in the Middle and Upper Cambrian succession several miles east of the project area. The carbonate strata are characterized by broad, open folds with little evidence of penetrative deformation on a mesoscopic scale. Southwest of the zone of facies transition, the rocks are strongly cleaved, penetrative deformation is pronounced, and folds are tight and near-isoclinal. Mesoscopic fabric data were collected for analysis of the kinematics and dynamics of deformation of the slate facies.

A complex synclinorium, which follows Split Creek and Otterhead River, contains Ordovician rocks of the McKay or Goodsir Group. The structure extends north of Blaeberry River where it has been named the Mount Laussedat Syncline[2]. Alkalic dykes with sodalite are intruded along the axial planes of folds in rocks contiguous to the Mount Laussedat Syncline at Mount Mather. Alkalic rocks from the Ice River Complex, 30 miles to the southeast, are mid-Palaeozoic in age (330-340 m.y.)[3]. If the alkalic rocks of Ice River and Mount Mather are contemporaneous, some deformation of this part of the Rocky Mountains, prior to mid-Palaeozoic time, is indicated.

An anticlinorium with an asymmetric, fan-shaped profile lies along Redburn and Porcupine Creeks and plunges southeastward to the Ottertail Range. Resistant carbonate strata of the Ottertail Formation outline the limbs of the anticlinorium. Minor faults and the axial planes of folds on the east and west limbs of the structure are overturned and dip westerly and easterly respectively. The core of the anticlinorium, in the Van Horne Range, is comprised of Middle and Upper Cambrian slates of the Chancellor Group. Strongly developed slaty cleavage in these rocks assumes a fan-shaped distribution about the profile of the structure. In the headward part of Porcupine Creek slates are metamorphosed to hornfels, possibly because of thermal activity related to the nearby alkalic intrusions.

A succession of westerly overturned structures comprise the western part of the Van Horne Range and northern Beaverfoot Range and represent the westerly flank of the Porcupine Creek anticlinorium.

LEGEND

QUATERNARY

8	Surficial deposits

DEVONIAN (?)

7	Mount Mather alkalic dikes
6	Ice River alkalic complex

MIDDLE DEVONIAN

5	Cedared Formation

ORDOVICIAN AND SILURIAN

4	Mount Wilson Formation, Beaverfoot Formation

UPPER CAMBRIAN, LOWER AND MIDDLE ORDOVICIAN

3	McKay (Goodsir) Group, Glenogle Formation

UPPER CAMBRIAN

2	Ottertail Formation

MIDDLE AND UPPER CAMBRIAN

1	Chancellor Group, Canyon Creek Formation

Geological contact . . . .

Cleavage, inclined . . . .

Thrust fault, upright, barbs on upthrust block . . . .

Thrust fault, overturned, barbs on upthrust block . . . .

Normal fault, solid circles on downthrown block . . . .

Anticline, upright . . . .

Anticline, overturned . . . .

Syncline, upright. . . . .

Syncline, overturned . . . .

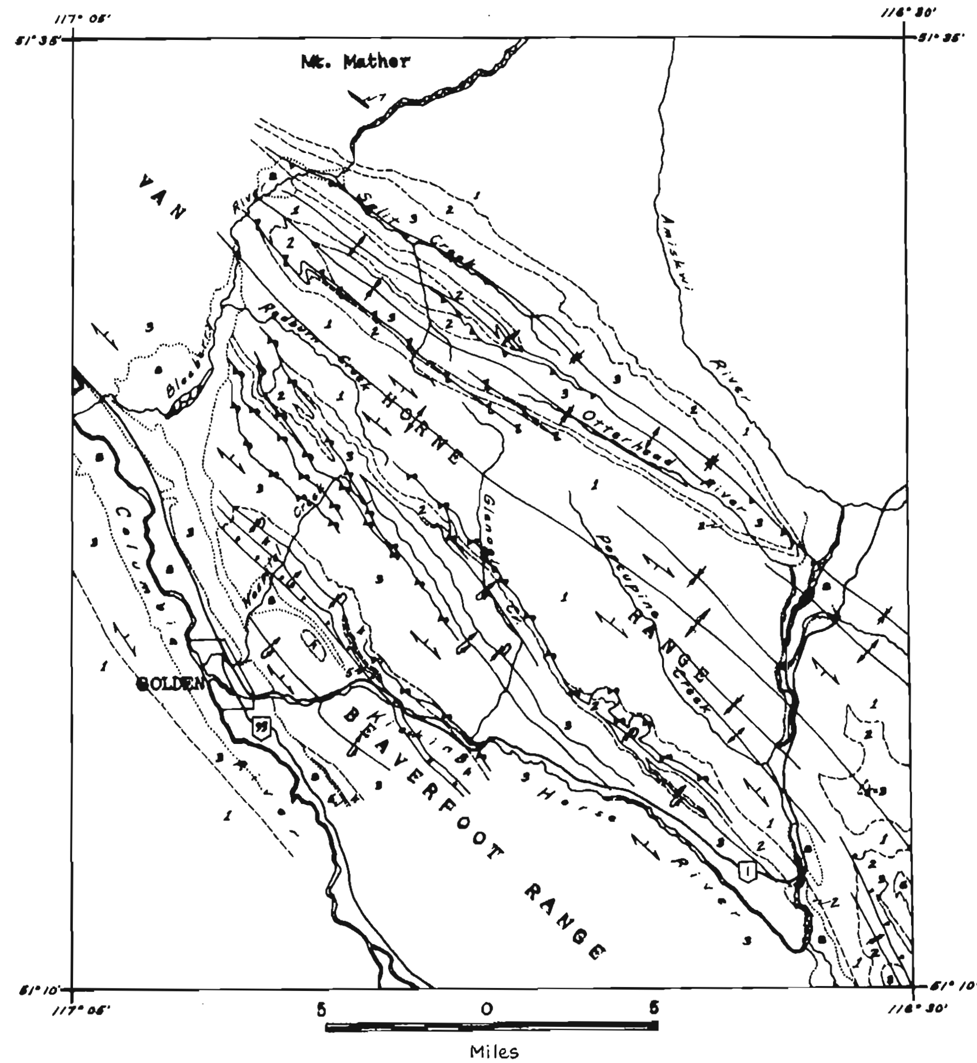


Figure 1. Sketch map of the geology of the Western Ranges, Rocky Mountains, near Golden, British Columbia.

Northwest trending normal faults, with the east side down, occur in the northern part of the Beaverfoot Range.

The floor of the Rocky Mountain Trench is occupied by strongly cleaved slates of the McKay Group and Canyon Creek Formation in the axial zone of a complex synclinorium adjacent to the Porcupine Creek anticlinorium.

Structural and stratigraphic continuity is maintained across this part of the Western Ranges; no major faults were observed which correspond to the Chancellor Fault and White River Break of North and Henderson[4].

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[1] Price, R.A.: Operation Bow-Athabasca, Alberta and British Columiba; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1, Part A, pp. 106-112 (1967).

[2] Wheeler, J.O.: Rogers Pass map-area, British Columbia and Alberta; Geol. Surv. Can., Paper 62-32 (1963).

[3] Lowden, J.A.: Age determinations by the Geological Survey of Canada; Part 1, Geological age determinations; Geol. Surv. Can., Paper 60-17, pp. 6-7 (1960).

[4] North, F.K. and Henderson, G.G.L.: Summary of the geology of the southern Rocky Mountains of Canada; Alta. Soc. Petrol. Geol. Guidebook, Fourth Ann. Field Conf., 1954, pp. 15-81 (1954).

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130. M'CLINTOCK INLET REGION, NORTHERN ELLESMERE ISLAND (120 C-G, 340 C-H)

T. Frisch and H.P. Trettin

The geology of the upper part of M'Clintock Inlet was investigated briefly by the writers, Frisch studying igneous and metamorphic rocks and Trettin, Palaeozoic strata.

At the head of the inlet, Ordovician limestones rest with low-angle fault contact on marbles and quartz-rich biotite-muscovite schists of the Cape Columbia Complex. The limestones are of Richmondian age (Unit 5 of Trettin, 1966, Fig. 2)[1] and at least 9,000 feet of Middle and Upper Ordovician sedimentary and volcanic rocks, which normally underlie them, are not seen there. Both basement rocks and Ordovician strata are unconformably overlain by Pennsylvanian red beds, which indicates that the low-angle faulting occurred prior to Pennsylvanian deposition. Low-angle faults of this type have been observed elsewhere in the M'Clintock Inlet region and at least some seem to be the result of gravity sliding.

A major serpentinite body was discovered east of the inlet. Its areal extent is unknown but is comparable to that of the ultramafic mass on the other side of the inlet, 16 miles to the northwest[1]. The southern end of the newly-discovered body is in fault contact with Permo-Carboniferous strata. Granitic boulders in the serpentinite talus suggest that salic intrusions are associated with the ultramafic body, as they are with the western mass.

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[1] Trettin, H.P.: Precambrian to Carboniferous rocks of M'Clintock Inlet region, northeastern Ellesmere Island, Geol. Surv. Can., Paper 66-1, pp. 7-11 (1966).

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131. TRIASSIC STRATIGRAPHY BETWEEN BOW RIVER AND CROWSNEST PASS, ALBERTA AND BRITISH COLUMBIA (82 G, J, O; 83 C, E, F)

D.W. Gibson

Field work in 1967 consisted of measuring several stratigraphic sections for a detailed study of the stratigraphy and petrology of Triassic rocks in the Rocky Mountains and Foothills between Bow River and Crowsnest Pass. This investigation is an extension of, and concludes earlier work begun in 1962, between Smoky and Brazeau Rivers[1].

South of Bow River, Triassic strata are divided into two main and contrasting formations, similar to those previously recognized from the area between Smoky and Brazeau Rivers. A comparison of the Sulphur Mountain and Whitehorse Formations south of Bow River with the same formations between Smoky and Brazeau Rivers, shows several stratigraphic variations.

Whitehorse Formation

The Whitehorse Formation consists mainly of light grey to buff-weathering limestone, dolostone, and calcareous and dolomitic sandstone. The formation is thin, with thicknesses ranging between 20 and 40 feet. The

Whitehorse Formation is restricted mainly to the Elk River and Lodgepole Creek-Wigwam River regions of British Columbia. Unlike the Whitehorse Formation north of Bow River, the formation south of Bow River is not amenable to subdivision into distinct lithofacies.

Sulphur Mountain Formation

The Sulphur Mountain Formation consists of dark grey- to brown-weathering siltstone, silty shale, silty and sandy limestone, and minor amounts of dolostone, and is divisible into three distinct lithofacies: a lower, recessive-weathering, shaly siltstone unit; a blocky, brown-weathering, siltstone unit; and an upper, dolomitic siltstone unit. These units are similar in part to those recognized between Smoky and Brazeau Rivers. However, one notable contrast between the rocks of the two regions may be found in the blocky siltstone unit. South of Bow River, the unit is much thinner bedded, particularly in some western sections, and displays a progressive increase in calcite concentration from east to west, such that, some strata in the Elk River region may be classed as silty limestone. All units in the Sulphur Mountain Formation where exposed, can be readily correlated throughout the area investigated.

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[1] Gibson, D.W.: Triassic stratigraphy between the Athabasca and Brazeau Rivers; in Report of Activities, May to October, 1966; Geol. Surv. Can., Paper 67-1, Part A (1967).

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132. STRATIGRAPHIC AND STRUCTURAL STUDIES OF THE UPPER CRETACEOUS OF THE SOUTHERN ALBERTA PLAINS (72 E, L; 82 H, I)

E.J.W. Irish

Surface geological mapping in the southern Alberta Plains, comprising the map-areas Gleichen (82 I), Medicine Hat (72 L), Lethbridge (82 H), and Foremost (72 E), was completed.

Most of southern Alberta is covered with thick deposits of glacial silt, sand, gravel, and till; bedrock exposures are scarce except along parts of major stream valleys. The exposed strata belong to the Cretaceous Alberta Group; the Cretaceous Milk River, Pakowki, Foremost, Oldman, Bearpaw, Blood Reserve, St. Mary River, Edmonton, Eastend, Whitemud, Battle and Frenchman Formations; the Cretaceous and Tertiary Willow Creek Formation; and the Tertiary Ravenscrag, Cypress Hills, Porcupine Hills and Paskapoo Formations.

Lithologic units equivalent to the Whitemud and Battle Formations of the Cypress Hills region were mapped along the west flank of the Sweetgrass Arch as far south as Oldman River. These distinctive units with the included Kneehills tuff bed form the only reliable lithologic marker in the Edmonton Formation and are used, farther south, to mark the boundary between the St. Mary River and Willow Creek Formations.

133. SOUTHWEST ELLESMERE ISLAND AND WESTERN DEVON ISLAND (49 B, C; 59 A, D) (OPERATION GRINNELL)

J.Wm. Kerr

Those parts of southwest Ellesmere Island west 84°W and south 77°33'N were completed during the first year of field work.

In a small area on the south coast of Ellesmere Island east of 86°W rocks of the Canadian Shield outcrop. They are predominantly composed of gneiss striking northwest, and intruded by pre-Ordovician basic dykes.

The shield is overlain and flanked on the north and west by northwest-dipping Devonian and older formations of the Central Stable Region that were disrupted by normal faults of probable Tertiary age. This region merges on the northwest into the broad Schei syncline, which contains Silurian and Devonian rocks that were folded in pre-Pennsylvanian time.

Map units on the south flank and south of the Schei syncline, with representative thicknesses and lithologies, are as follows. Unit 1: crystalline basement. Unit 2: unnamed, unconformable upon basement, recessive, thin-bedded argillaceous limestone and dolomite; minor gypsum and stromatolitic limestone interbeds; about 670 feet thick. Unit 3: unnamed, medium grey to brownish grey dolomite; bluff-forming; 430 feet thick. Unit 4: limestone, limestone flat-pebble conglomerate, interbedded gypsum-anhydrite and quartz sandstone; recessive; about 800 feet thick. Unit 5: (Eleanor River Formation ?) limestone, dark grey, ledge-forming; cf. Maclurites and cf. Hormotoma et al., about 1,300 feet thick. Unit 6: (Bay Fiord Formation) lower part gypsum anhydrite; upper part interbedded dolomite and shale; recessive; thickness 1,000 feet. Unit 7: (Thumb Mountain

Formation) limestone, dark grey, bluff-forming; 800 feet thick. Unit 8: (Irene Bay Formation) limestone, resistant, with greenish weathering recessive shale and shaly limestone interlayers; thickness 300 feet. Unit 9: (Allen Bay Formation) dolomite, dark brown, petroliferous and vuggy; mottled limestone and dolomite at base; at top grades to very light grey limestone and dolomite bluff; 1,100 to 1,350 feet thick. Unit 10: unnamed, mainly light grey to cream dolomite; limestone and siltstone interbeds; basal light coloured bluff, recessive higher up; forms coastal cliffs of Cape Storm; east of head of Muskox Fiord a section is 700 feet thick.

South of Borgen in Goose Fiord Greiner[1] reports that the northernmost section of the Douro Formation contains 175 feet of dolomite at the base, and this is probably the uppermost part of unit 10. Succeeding formations mapped in this area are those of Greiner[1] and McLaren[2].

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[1] Greiner, H.R.: Southern Goose Fiord; in Fortier, et al., Operation Franklin, Geol. Surv. Can., Mem. 320, pp. 292-303 (1963).

[2] McLaren, D.J.: Southwest Ellesmere Island between Goose Fiord and Bjorne Peninsula; in Fortier, et al., Operation Franklin, Geol. Surv. Can., Mem. 320, pp. 310-338 (1963).

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134. PALAEOZOIC STRATA OF THE CENTRAL AND LOWER MACKENZIE RIVER REGION, DISTRICT OF MACKENZIE

W.S. MacKenzie

Two months field work, preparatory to a proposed air-supported operation (Operation Norman, 1968) involved a preliminary reconnaissance survey of outcrop sections in the vicinity of Norman Wells, the Mackenzie, Wernecke and Ogilvie Mountains to the west, and at Campbell Lake near Inuvik.

Precambrian and Cambrian strata were observed infrequently throughout the region. Precambrian dolomites cut by sills of gabbro occur in the area between the Snake and Bonnet Plume Rivers, at Noisey Creek and in the Knorr Range to the south. Cambrian beds, in graptolite facies, also occur at Noisey Creek, but appear to be absent in the Knorr Range where Ordovician beds rest directly on the Precambrian. Gypsiferous strata (Saline River Formation) were observed in the MacKay Range southeast of

Norman Wells. At Imperial River to the west a thick sequence, about 3,200 feet, of Cambrian quartzite and dolomite is overlain by about 200 feet of the gypsiferous beds.

Pre-Middle Devonian strata comprising Ordovician, Silurian and Lower Devonian beds occur (a) in facies entirely of carbonate rock, (b) in facies with basal carbonates and overlying graptolite-bearing beds, and (c) in facies entirely of argillaceous graptolite rocks.

The carbonate facies, consisting essentially of dolomites of the Ronning Formation, extends west from Norman Wells along the Mackenzie Mountains to Knorr Range.

Basal carbonates and overlying graptolite-bearing beds occur in the area south of Peel River between Knorr Range and Blackstone River to the west. At Knorr Range the basal carbonates are relatively thin, less than 500 feet, whereas at Blackstone River the dolomites, frequently porous, are almost 4,000 feet thick.

A graptolite facies occurs in the Richardson Mountains west of Peel River.

The overlying sequence of Middle Devonian Rocks is truncated from east to west by a disconformity which affects the uppermost Kee Scarp Limestones at Norman Wells and cuts progressively downward through the underlying Hare Indian and Hume Formations until at Knorr Range to the west, only a few feet of the Hume Formation remain. Still farther to the west, in the Nahoni Range, strata below the disconformity are probably equivalent to the Bear Rock-Gossage carbonates of the Norman Wells-Mackenzie Mountain region.

Dolomites of the Bear Rock Formation occur only in the vicinity of Norman Wells while laterally equivalent limestones of the Gossage extend north to Anderson Plain and west to near Snake River.

The overlying Hume Formation, at Norman Wells and along the Mackenzie Mountains to the west, consists of lower argillaceous limestones and upper relatively pure limestones. A different Hume Formation facies containing porous crinoidal limestones and reef-like beds occurs near Inuvik and adds economic interest to this area.

Kee Scarp Formation limestone, productive at Norman Wells, occurs locally, at Norman Wells, Fort Good Hope, and Powell Creek. At Powell Creek its maximum thickness is 850 feet.

The Upper Devonian Canol Formation overlies the disconformity throughout the region. In the vicinity of Norman Wells the Canol thins where the underlying Kee Scarp is thick. At Powell Creek, for example, where the Kee Scarp reaches its maximum development the Canol Formation is absent and shales of the overlying Imperial Formation occur above the disconformity.

135. CARBONATE-EVAPORITE CYCLES, SOURIS RIVER FORMATION, SASKATCHEWAN

R.W. Macqueen and L.L. Price

The Upper Devonian Souris River Formation of the Saskatchewan subsurface consists of complexly interbedded limestones, dolomites, mudstones or shales, and evaporites. Data on the nature and distribution of these rocks [1, 2] suggest that they may have originated as coastal lagoon, tidal flat, and supratidal sabkha[3] sediments comparable with those of certain modern carbonate environments in the Middle East[4]. To test this hypothesis, a single complete core of the Souris River Formation was examined in detail, through the cooperation of Southwest Potash Corporation of Canada, owners of the core.

Some of the similarities between rocks of the Devonian Souris River Formation and modern coastal lagoon-sabkha sediments are as follows:

1. Comparable lithologic (sediment) assemblages are present in both settings. These assemblages consist of micritic and bioclastic limestones (Devonian) or lime sediments (modern), microcrystalline dolomite, and evaporites (anhydrite in the Devonian setting; gypsum and anhydrite in the modern setting).

2. Textural similarity between certain of the ancient rocks and modern sediments is striking – e.g. Souris River Formation microcrystalline dolomites with anhydrite nodules may be closely matched in the modern coastal sabkha setting.

3. Probable blue-green algal mat laminated sediments, typical of the modern sabkha margin environment, occur in the Souris River Formation core examined.

4. The vertical order of rock types encountered in the Souris River Formation is cyclic, and resembles that encountered in modern coastal lagoon-sabkha cores described elsewhere[4, 5].

As well as the obvious differences in mineralogy and constituent carbonate-secreting organisms between modern coastal lagoon-sabkha sediments and any comparable Palaeozoic sedimentary rocks, the following Souris River Formation – modern coastal lagoon-sabkha differences also exist:

1. Anhydrite is much more abundant in the Souris River Formation (beds or lenses up to 6 feet thick occur in the core examined) than in the modern coastal sabkha setting.

2. Mudstones or shales, conspicuous in Souris River Formation cycles, are unknown in the modern setting.

3. Souris River cycles seem to average about 20 feet thick as compared with about 2 to 5 feet thick for modern cycles[4, 5].

4. Laminated rocks interpreted as algal mat sediments are rare in the Souris River Formation core examined.

5. Beds of halite, unknown in the modern setting, are reported from the Souris River Formation in other localities[2].

6. Apparent 'dedolomites' (rocks composed of calcite but exhibiting the texture of micro- to fine-crystalline dolomite) occur at several levels in the Souris River Formation core examined, but are unknown in the modern setting.

Thin-section studies are in progress. X-ray diffraction studies of clays, carbonates, and evaporites may be undertaken. However, it seems already apparent that a Persian Gulf type coastal lagoon-sabkha model[4] is inadequate to fully explain the origin of Souris River Formation sediments.

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[2] Lane, D.M.: Souris River Formation in southern Saskatchewan; Sask. Dept. Min. Resources, Rept. No. 92 (1964).

[3] Illing, L.V. and Taylor, J.C.M.: Discussion of paper "Origin of marine evaporites by diagensis" by D.J. Shearman. Trans. Inst. Mining Met., vol. 76, pp. B82-86 (1967).

[4] Shearman, D.J.: Origin of marine evaporites by diagenesis; Trans. Inst. Mining Met., vol. 75, pp. B208-215 (1966).

[5] Illing, L.V., Wells, A.J. and Taylor, J.C.M.: Penecontemporary dolomite in the Persian Gulf; in Dolomitization and limestone diagenesis, Soc. Econ. Paleontol. Mineral., Spec. Pub. No. 13, pp. 89-111 (1965).

136. UPPER PALAEOZOIC STUDIES IN THE SVERDRUP BASIN, DISTRICT OF FRANKLIN (49 C, F; 59 B; 79 B)

W.W. Nassichuk

Stratigraphic and biostratigraphic investigations were carried out on Pennsylvanian and Permian rocks in selected areas of southern Ellesmere, northwestern Devon and northeastern Melville Islands during the 1967 field season. On the former two islands Permian formations near the southeastern and southern margins of the Sverdrup Basin were studied. Particular attention was devoted to units that post-date the Belcher Channel Formation, a limestone and sandstone unit that is widespread along the eastern and southern margin of the basin. Both the Belcher Channel Formation and the underlying Canyon Fiord Formation contain time-sensitive fusulinids in contrast with younger, commonly discontinuous formations that are devoid of fusulinids but contain rare ammonoids and an abundance of well-preserved but little-studied brachiopods. Faunas were systematically collected from post-Belcher Channel formations in the study areas of southern Ellesmere Island in an attempt to show relationships with better known sequences farther to the southwest along the basin margin, on Devon Island (Grinnell Peninsula) and Melville Island (southern Sabine Peninsula).

On northern Sabine Peninsula, Melville Island, structurally complex strata were examined on Barrow Dome, a major evaporite (anhydrite, gypsum) piercement structure that is situated near the axis of the Sverdrup Basin. Limestones and shales interbedded with evaporites have yielded an abundance (several thousand specimens) of early Pennsylvanian (Bashkirian) ammonoids and are considered to represent the oldest known marine rocks in the Sverdrup Basin. Ammonoids of comparable age are also known to occur in the South Fiord diapir, on the west side of Axel Heiberg Islands.

Ellesmere Island

Some two miles west of the head of Trold Fiord less than 100 feet of glauconitic sandstone with some interbedded limestone rest with probable faulted contact upon the Canyon Fiord Formation and are unconformably overlain by sandstone of the Lower Triassic Bjorne Formation. Little stratigraphic information concerning the glauconitic unit can be added to that provided by Tozer[1]. However, elsewhere on Ellesmere Island comparable rocks are known to overlie the Assistance Formation.

In two areas on southern Bjorne Peninsula, Permian rocks overlying bioclastic limestones of the Belcher Channel Formation were examined; within three miles of Great Bear Cape and some 25 miles to the northeast of

Great Bear Cape (77°37'N). In the latter area nearly 1,400 feet of strata are present and in this sequence two subdivisions are recognized. The lower subdivision is about 1,000 feet thick and consists of uniformly thin- to medium-bedded calcareous siltstone and sandstone, bioclastic limestone and, near the top, minor amounts of cherty limestone. The upper unit, 'Great Bear Cape limestone', about 400 feet thick, includes the youngest rocks in the immediate area and consists of light grey, medium-bedded bioclastic limestone. Brachiopods are the most numerous part of the contained fauna. In the vicinity of Great Bear Cape the formations are approximately 700 feet and 200 feet thick respectively. Ammonoids are abundant near the middle of the lower formation. Included are Neoshumardites Ruzhencev, Uraloceras Ruzhencev, ? Neopronorites Ruzhencev and Talassoceras Gemmellaro. A Lower Permian (late Sakamarian or early Artinskian) age is indicated by these fossils. For additional information concerning ammonoids from Bjorne Peninsula see Nassichuk, Furnish and Glenister[2]. The fauna of this unit, particularly the ammonoids, are remarkably different and somewhat older than that occurring high in the typical Assistance Formation. A tentative correlation might be made with the Sabine Bay Formation and perhaps the lower part of the Assistance Formation but definitive equivalence cannot yet be documented.

The upper bioclastic limestone formation is similar to 'Unit A' of Nassichuk[3] which on eastern Sabine Peninsula, Melville Island, overlies the late Lower Permian Assistance Formation. Brachiopod faunas from this unit on Bjorne Peninsula are similar in gross aspect to those from 'Unit A' but collections from both areas have not been studied critically by specialists.

Devon Island

Large fossil collections were made from the type Assistance Formation on northern Grinnell Peninsula, however little stratigraphic information can be added to that provided by Harker and Thorsteinsson[4] and by Nassichuk[3]. About two miles west of Lyall River, near the top of the Assistance Formation, a new ammonoid locality was discovered. One of the more cosmopolitan of Permian ammonoids, Medlicottia Waagen has been for the first time recorded from the Canadian Arctic Archipelago. Evolutionary development of the Arctic species is consistent with the assignment of a late Lower Permian age.

Melville Island

Barrow Dome, a circular diapiric piercement structure some 4 miles in diameter, is centrally situated on northern Sabine Peninsula. On the northern and eastern parts of the dome, an abundance of ammonoids and other fossils, particularly solitary corals, were recovered from shales and limestones that are interbedded with anhydrite at several localities on both sides of a thick, arcuate, diorite dyke (?) which occurs near the northern and eastern margins of the dome. Towards the centre of the dome, deformation is more intense than at the periphery, where relatively concordant beds of shale, limestone and anhydrite are locally about 200 feet thick. Although fossils are present in isolated uplifted blocks near the centre of the dome, the relative stratigraphic position of faunas there is obscure because of structural complications. However, in a section 250 feet thick on the north-central margin of the dome, ammonoids of different aspect were recovered at two stratigraphic levels. In the lower level occur species of Reticuloceras Bisat and Bisatoceras Miller and Owen whereas slightly higher in the section representatives of Gastrioceras Hyatt and Branneroceras Plummer and Scott are known. The ammonoids indicate a Lower Pennsylvanian (Bashkirian) age and, in North America, suggest correlation with the Hale Formation (early Morrowan) a few thousand miles to the south, in the midcontinent.

A massive, vuggy, dark grey limestone that contains an abundance of brachiopods occurs at several localities on the northern margin of the dome. This rock apparently occurs stratigraphically above the ammonoid zones and resembles the biohermal limestone that occurs above a thick-bedded sequence of anhydrite at Hare Fiord, north-central Ellesmere Island. In the latter area early Middle Pennsylvanian (Moscovian) ammonoids occur in the biohermal limestone. However, a direct correlation with rocks at Barrow Dome is tentative and must await additional faunal studies, especially of the brachiopods. It is conceivable that at least part of the bedded anhydrites of north-central Ellesmere Island are of Lower Pennsylvanian age, equivalent to interbedded anhydrites, shales and limestones of Barrow Dome.

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[1] Tozer, E.T.: Trold Fiord in Geology of the north-central part of the Arctic Archipelago, Northwest Territories (Operation Franklin); Geol. Surv. Can., Mem. 320, pp. 370-380 (1963).

[2] Nassichuk, W.W., Furnish, W.M. and Glenister, B.F.: The Permian Ammonoids of Arctic Canada; Geol. Surv. Can., Bull. 131, pp. 1-56 (1965).

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137. OPERATION WINISK, HUDSON BAY LOWLANDS, ONTARIO, MANITOBA, QUEBEC, DISTRICT OF KEEWATIN

A.W. Norris and B.V. Sanford

During the field season the Hudson Bay Lowlands and some of the peripheral Precambrian terrain were mapped on a reconnaissance scale by members of Operation Winisk. The Lowlands, a relatively flat, poorly drained area largely covered by muskeg and bog, borders the southwest side of Hudson Bay. It is about 845 miles long and varies from 100 to 260 miles wide embracing an area in excess of 130,000 square miles.

Members of the Geological Survey participating on this operation and their responsibilities are as follows: H.H. Bostock - Precambrian along the edge and within the Lowlands; L.M. Cumming - Ordovician; B.S. Norford - Silurian; B.V. Sanford and A.W. Norris (operation leader) - Devonian; L.L. Price - Mesozoic; and B.G. Craig and B.C. McDonald - Pleistocene. In addition, J. Terasmae and R.J. Mott of the Survey visited the operation during the early part of the season for pollen studies in the southern part of the Lowlands; and two officers of the Bedord Institute of Oceanography were attached to the operation for part of the summer studying deltaic deposits of some of the larger rivers.

The operation was supported by two Bell 47G-4 helicopters and one de Havilland Otter. Inflatable rubber boats, easily portable by helicopters, and powered by outboard motors, were used to traverse a large number of the rivers along which most of the bedrock and Pleistocene exposures occur.

The Palaeozoic-Precambrian contact, especially along the southwest edge of the Lowlands, was delineated for the first time. Of unusual interest was the discovery of a fairly large area of Proterozoic and older Precambrian rocks immediately southwest of Cape Henrietta Maria. These rocks have been brought to the surface by a broad northeast trending arch which in part subdivides the Lowlands into two main sedimentary basins. Most of the southern basin is present on the mainland, whereas only the southwestern edge of the northern basin is present on land with the greater part of it lying beneath Hudson Bay.

Unlike previous work, which was restricted to parts of the Lowlands, members of the operation had the unique opportunity of examining the exposed rocks throughout the entire Lowlands. As a result, the Palaeozoic succession in the south can be related to that in the north, and it seems likely that a more uniform and consistent terminology can be established for the various formations.

Rocks of Middle (?) and Upper Ordovician ages are much more widely distributed in the Lowlands than was formerly supposed, and are present in both the southern and northern basins. The sequence in the north appears to be the more complete. Some of the carbonate rocks along Churchill River formerly mapped as Ordovician are actually part of the basal Silurian succession.

Rocks of Lower, Middle, and Upper Silurian ages are widely distributed in both basins, and also underlie Akimiski Island, which is part of the southern basin, where they have been mapped for the first time. They are in part closely analogous to the succession of southwestern Ontario.

Rocks of Lower, Middle, and Upper Devonian ages are more fully represented in the southern basin than in the north where they are known to be present but not exposed. The Devonian succession has been reinterpreted and revised on the basis of outcrops and diamond drill-cores, and appears to be closely related to the Devonian sequences of southwestern Ontario, New York, and Michigan. Fossiliferous Devonian talus from the northern basin, which was presumably derived from off-shore, also suggests some faunal and lithological similarities to the Devonian of Manitoba.

Rocks of Upper Jurassic or Lower Cretaceous age outcrop only in the southern basin. They are once again receiving attention because of renewed interest in lignite coal present in these rocks. The presence of coal in the northern basin was not confirmed and is unlikely to be present on the mainland in that area.

138. WILDCAT HILLS WEST, ALBERTA (82 0/7 (WEST HALF))

N.C. Ollerenshaw

The geological investigation (mapping, structural geology and stratigraphy) of the Wildcat Hills West area has been completed. This study extends the work of G.S. Hume[1] and integrates surface geology with recent well data.

The basic structure of the area is a sequence of closely spaced, northwest-southeast trending thrusts, that repeat the Upper Cretaceous Wapiabi and Brazeau Formations. The Cardium and Blackstone Formations are involved locally and the Lower Cretaceous Blairmore Group is exposed in the western part of the area. Several complicated folded and faulted structures occur within the area and are related to the termination of the Burnt Timber[2] and Waiparous thrusts[2]. In contrast to the areas immediately to the north, the basal part of the Brazeau Formation contains several minor marine shale units, the result of intertonguing with the Wapiabi Formation. There is no evidence of a consistent 'basal Edmonton conglomerate' as suggested by Hume[1].

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[1] Hume, G.S.: The west half of Wildcat Hills map-area, Alberta; Geol. Surv. Can., Mem. 188 (1936).

[2] Ollerenshaw, N.C.: Burnt Timber Creek, Alberta; Geol. Surv. Can., Map 65-11 (1965).

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139. GEOLOGICAL OBSERVATIONS, POTASH MINE SHAFTS, SASKATCHEWAN

L.L. Price

Current exploitation of the Middle Devonian potash deposits in Saskatchewan offers an opportunity, that may not occur again, to gain geological detail of the overlying subsurface strata. A program to preserve geological data encountered during shaft-sinking operations has been undertaken with the cooperation of the Saskatchewan Government and various potash companies, in an extensive area having no bedrock exposure. Although palaeontological material is of prime interest, the project also permits the collection of lithologic samples and the observation of some contact relationships, structures and results of sedimentary processes that are not seen in surface exposures. A number of studies are in progress using data from this project.

Suites of Mesozoic samples from potash mine shafts are the basis for current palynological work by R.L. Cox of the Geological Survey, for micropalaeontological work at the University of Saskatchewan and a conodont study by T.T. Uyeno is in progress on Palaeozoic material. Preliminary palaeontology by A.W. Norris, E.W. Bamber, H. Frebold and J.A. Jeletzky has been completed on material so far available. Ammonites from the KI shaft at Esterhazy identified by Frebold[1], indicated, for the first time, the Jurassic age of the troublesome non-marine sand aquifer of that area (miscorrelated in early reports with the Cretaceous Blairmore). An assemblage of fossils from the base of the Upper Cretaceous white speckled shale at Vanscoy (Cominco #1 shaft) identified by Jeletzky[2], supported by stratigraphic evidence, suggests that the second (Favel) zone of white specks is absent in that area.

Information obtained from this program will be incorporated in a general study of the white speckled shales and in separate reports on the Esterhazy, Lanigan and Saskatoon areas.

The project has had the voluntary support of the companies involved, and they have been generous in making available their own facilities and have extended many courtesies to personnel of the Geological Survey. We are indebted in particular to International Minerals and Chemical (Canada) Ltd., Alwinsal Potash of Canada Ltd., Allan Potash Mines, Cominco Potash, Duval Corporation, Potash Company of America, Southwest Potash Corporation of Canada, Noranda Mines Ltd., Potash Division and Cementation Company (Canada) Ltd.

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[2] Jeletzky, J.A.: Personal communication.

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140. ELLEF RINGNES ISLAND, DISTRICT OF FRANKLIN (Parts of 69 C, D, E, F, G; 79 E, H)

D.F. Stott

Geological mapping at one inch to 4 miles, employing helicopter and foot traverses, was initiated in 1967. Only a few stratigraphic sections were examined in detail because inclement weather seriously hampered field operations.

Two successions, virtually unknown previously, occur on Reindeer Peninsula. Quartzose sandstones with some interbedded yellowish mudstone, of unknown thickness, are tentatively assigned to the Triassic. Overlying those rocks, grey mudstone and overlying highly glauconitic sandstone[1], about 350 feet thick, apparently represent the Jurassic Savik and Wilkie Point Formations respectively. Younger sedimentary beds, ranging in age from Jurassic to Tertiary, are well-exposed along prominent cuestas around several piercement structures in the central and southern part of the island. The marine and non-marine shales and sandstones of that sequence[2, 3, 4] are assigned to the Deer Bay, Isachsen, Christopher, Hassel, Kanguk, and Eureka Sound Formations. The Beaufort Formation, a late Tertiary or Pleistocene unconsolidated sand deposit of the Arctic Coastal Plain, covers Isachsen Peninsula.

Diabase, basalt, and gabbro dykes and sills intrude the Deer Bay Formation between Deer Bay and Louise Fiord. Similar rocks also occur within the Isachsen Formation on the northern part of Christopher Peninsula. A system of northeasterly trending normal faults is found in the same region.

Several large diapirs with cores of gypsum and anhydrite are present in the central and southern part of the island. Those include the previously studied Isachsen, Dumbbells, Hoodoo (Meteorological Peninsula) and Malloch domes[3, 4, 5] and the less well-known Haakon and Helicopter domes on the eastern side of the island. Palaeozoic brachiopods were collected from exotic blocks of limestone within the domes. Limited stratigraphic evidence suggests that the domes developed over a prolonged period of time, probably as a result of halokinesis and geostatic loading followed by compressional stress related to the Tertiary orogeny.

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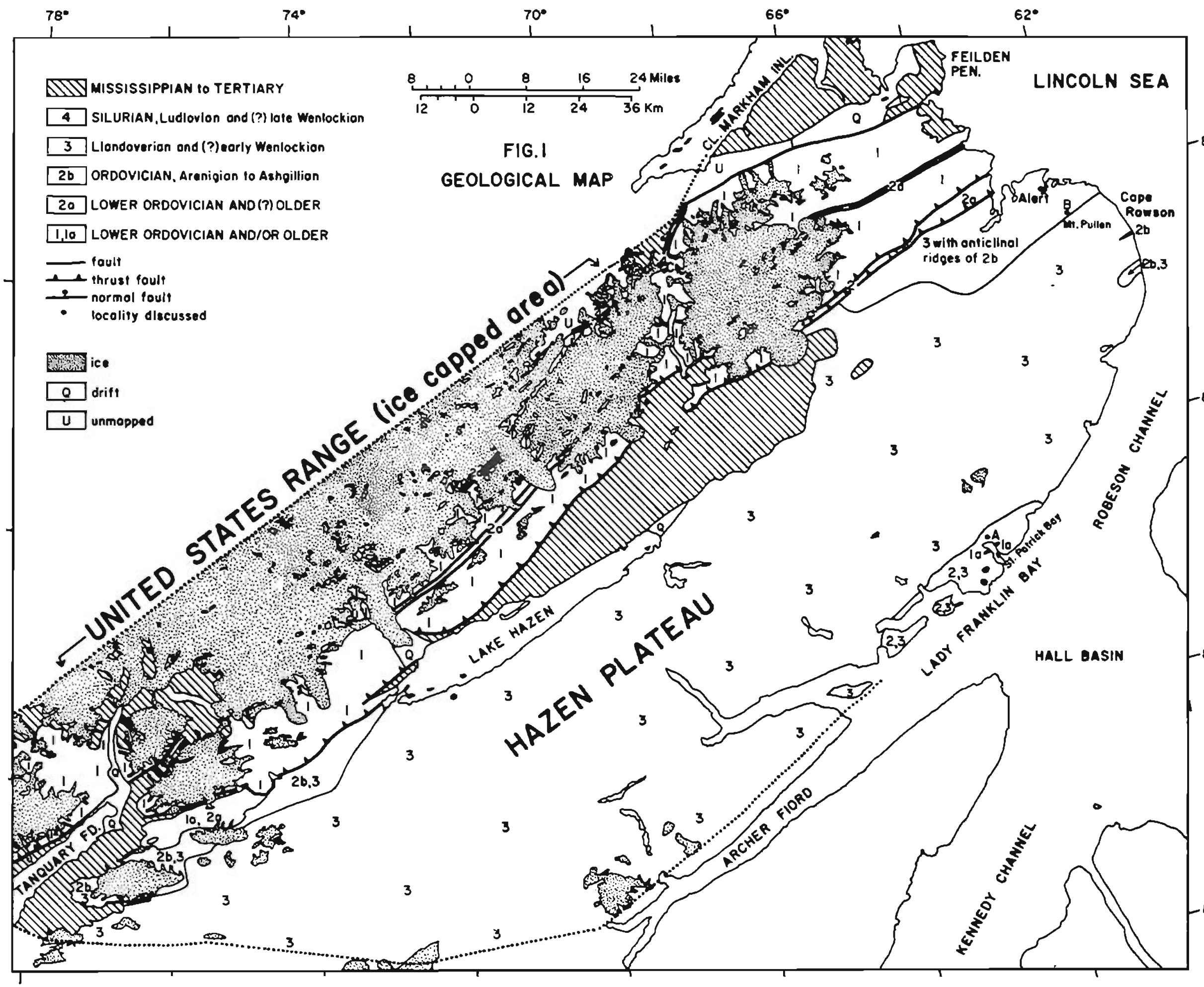
FIG. I
GEOLOGICAL MAP
MISSISSIPPIAN to TERTIARY
4 SILURIAN, Ludlovian and (?) late Wenlockian
3 Llandoverian and (?) early Wenlockian
2b ORDOVICIAN, Arenigian to Ashgillian
2a LOWER ORDOVICIAN AND (?) OLDER
1, 1a LOWER ORDOVICIAN AND/OR OLDER
fault
thrust fault
normal fault
locality discussed
ice
Q drift
U unmapped
8 0 8 16 24 Miles
12 0 12 24 36 Km
UNITED STATES RANGE (ice capped area)
HAZEN PLATEAU
LAKE HAZEN
TANQUARY FD.
CL. MARKHAM INL.
FEILDEN PEN.
LINCOLN SEA
Alert
Mt. Pullen
Cape Rowson
3 with anticlinal ridges of 2b
St. Patrick Bay
LADY FRANKLIN BAY
ROBESON CHANNEL
HALL BASIN
ARCHER FIORD
KENNEDY CHANNEL
78°
74°
70°
66°
62°
82° 30'
82° 00'
81° 30'
81° 00'

141. PRE-MISSISSIPPIAN GEOLOGY OF UNITED STATES RANGE AND HAZEN PLATEAU, NORTHEASTERN ELLESMERE ISLAND

H.P. Trettin

About one month of field work was spent on this project, making foot traverses from nine fly camps. The present summary includes data obtained in 1966, and during one week in 1962.

Stratigraphy

The sediments studied were previously mapped as Cape Rawson Group, a reconnaissance unit[1, 2, 3, 4]. In the present area, the Cape Rawson is divisible into four major map-units that range in age probably from Cambrian to Lake Silurian. Because of tight folding and much faulting, representative sections are difficult to obtain.

Lower Ordovician and/or older

Map unit 1 comprises the oldest known strata in the map-area and its base is not exposed. An incomplete section at Hare Fiord (see ref.[5] Fig. 1, loc. 4) is about 3,300 feet thick.

The unit consists mainly of sandstone with lesser amounts of siltstone, slate, phyllite, pebble conglomerate and limestone. Individual beds are extensive. Small-scale crosslamination is fairly common, but large-scale cross-stratification is rare. The sandstones are composed mainly of quartz, feldspar (mostly microcline), chlorite, muscovite, metamorphic rock fragments, and carbonate and vary considerably in compositional maturity.

The lower and middle parts of the unit are relatively coarse grained, resistant to weathering, and lacking in red beds, whereas the upper part is shaly and silty, partly red in colour, and recessive weathering. The uppermost green and red slates and phyllites have been mapped locally as unit 1a.

Two facies are distinguished. (1) In the western parts of the area, between Tanquary Fiord and Hare Fiord (mainly west of the area shown in Fig. 1), map-unit 1 is relatively coarse grained and rich in red beds. (2) In the central and eastern parts, finer grained sediments are more abundant, red beds less common, and at least one bed of limestone is present.

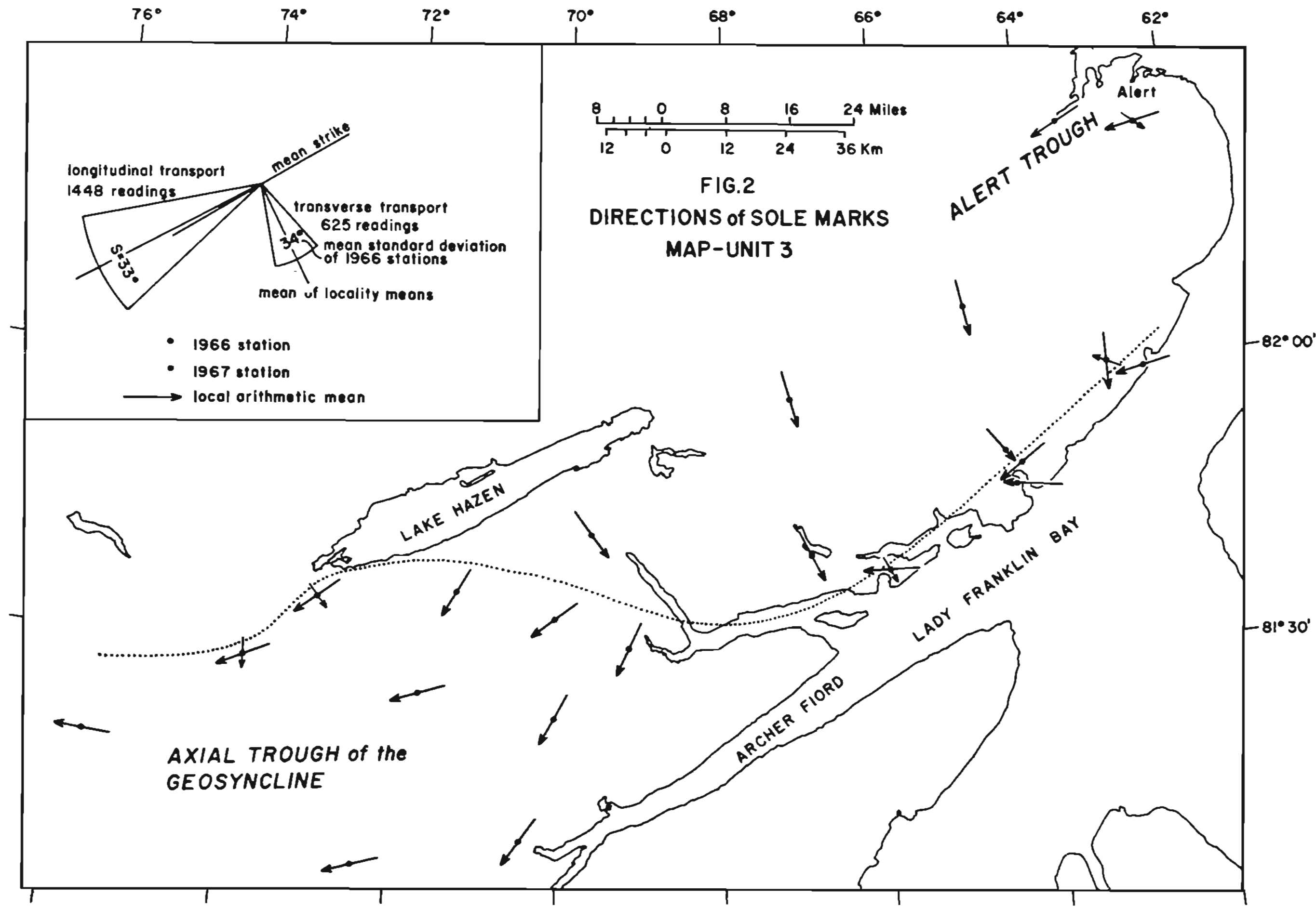

FIG. 2
DIRECTIONS of SOLE MARKS
MAP-UNIT 3

Diagnostic fossils have not been found in the unit. It underlies map-unit 2, so that its age is Lower Ordovician or older, and may be mainly Cambrian. It is similar both macroscopically and microscopically to unit 1b of the Rens Fiord Complex of northern Axel Heiberg Island[6]. A K-Ar determination on a sheared sandstone from that unit yielded an apparent age of 535 ± 35 m.y.

Ordovician and (?) older

Map-unit 2 overlies 1 with apparently conformable contact. It consists of thinly interstratified chert, shale, and limestone with a small proportion of calcareous chert breccia. A nearly complete section at St. Patrick Bay (Fig. 1, loc. A) is about 800 feet thick.

The chert is light to dark grey, very thin-bedded to laminated, and weathers dark grey, or yellowish brown owing to included authigenic pyrite. The shale, partly calcareous or cherty, is dark grey, generally thinly laminated, and pyritic. The limestone is pure, or argillaceous, mostly laminated or crosslaminated, and weathers dark grey or yellow. It may be up to 3 feet thick, but commonly is only a few inches thick.

The unit is divisible in two members that can be traced on air photographs.

Map-unit 2a, the recessive lower member, is relatively rich in limestone. The proportion of chert, however, increases stratigraphically upwards, and also laterally from the United States Range towards Hazen Plateau. An incomplete section at locality A is about 200 feet thick. Fossils have not been found in the unit but, because it directly underlies beds containing Arenigian graptolites, it is considered to be Lower Ordovician and (?) older.

Map-unit 2b, the resistant upper member, consists mainly of chert, some shale, and small amounts of limestone and calcareous chert breccia. Complete sections at Mount Pullen (loc. B, Fig. 1) and St. Patrick Bay (loc. A) are both about 600 feet thick. The unit has yielded *Tetragraptus*, *Isograptus*, ? *Paraglossograptus*, *Climcagraptus* aff. *bicornis* (Hall), and probably ranges in age from Arenigian to Ashgillian.

Silurian

Map-unit 3 overlies 2b with an abrupt, but probably conformable contact. A complete section has not yet been found, although from the wide distribution of these sediments it may be concluded that they are more than a few thousand feet thick.

Map-unit 3 consists of numerous alternations of calcareous sandstone, calcareous siltstone, and shaly limestone with a small proportion of pebble conglomerate. The sandstones are graded, massive, laminated or show small-scale crosslaminations. The siltstones commonly show current ripple marks and convolute lamination. Most argillaceous limestones are thinly laminated.

The sandstones are composed of about equal proportions of quartz and carbonate grains with small amounts of muscovite, chlorite, feldspar, chert, and metamorphic rock fragments.

The unit is correlative with the Llandoverian and (?) early Wenlockian Imina Formation of northwestern Ellesmere Island[6, 7] and on M'Clintock Inlet[8]. Monograptus cf. priodon has now been found in all three areas.

Unit 4 is present within the area mapped only in a fault slice on the northwest side of the United States Range. It consists of limestone, argillaceous limestone, and shale. The beds have yielded Atrypella phoca (ref.[4], p. 28), and are correlative with a limestone on M'Clintock Inlet (ref.[7], Fig. 2, unit 7: ref.[5], p. 16). Their age is Ludlovian and late Wenlockian.

Depositional History

Cambrian (?)

Map-unit 1 appears to be marine. Facies relationships, and directional structures indicate that the sediments were derived from the northwest. From the petrography of the sandstones it is concluded that they were derived from a metamorphic-plutonic terrane. The time interval represented by this unit ended with wide-spread shallow-water conditions, that are indicated by green and red slates in the United States Range as well as on Hazen Plateau, and the north coast of Lady Franklin Bay (Fig. 1, loc. A).

Ordovician

During the Ordovician, Hazen Plateau was the site of a relatively deep 'starved' basin. This is inferred from the lithology of the sediments (graptolitic shales, radiolarian (?) cherts, allochthonous limestones), and from the thinness of the unit. In the Lower and Middle Ordovician the trough was confined to the present map-area. In the Late Ordovician it expanded to include parts of the adjacent miogeosyncline and magmatic belt (see Fig. 3).

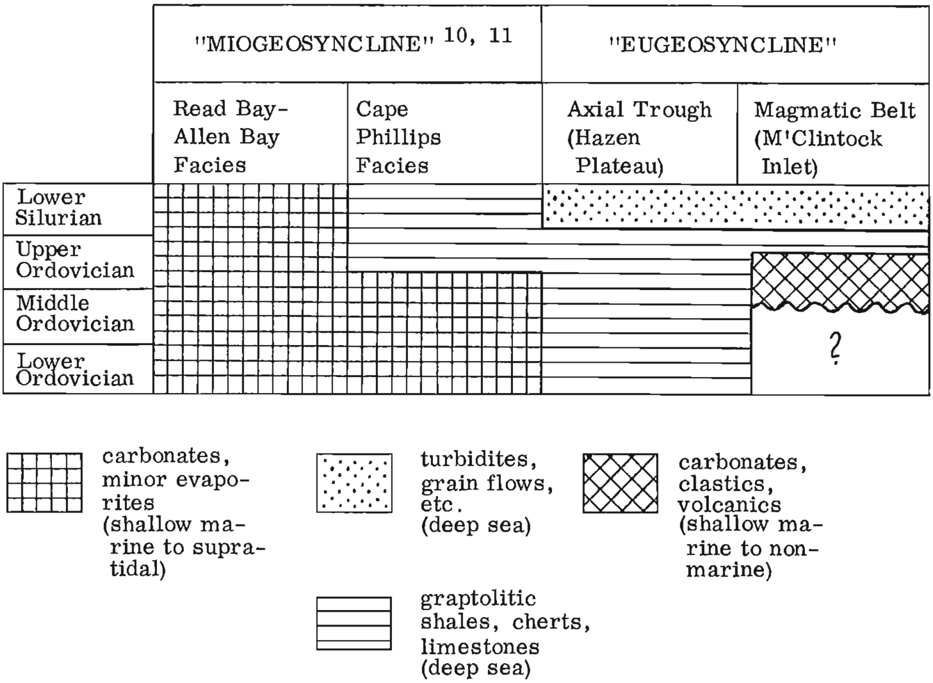

Figure 3: Major Facies, Lower Ordovician to Lower Silurian, central and northeastern Ellesmere Island.

Early and (?) early Middle Silurian

In Early Silurian time the basin became filled with relatively coarse clastic sediments carried by turbidity currents, grain flows or related phenomena. A statistical study of directional sole markings (mainly flute casts, grooves, and ridges; to lesser extent chevron marks) indicates that the currents descended from the northwest and were deflected in the basin to the southwest. A total of 2,073 readings were taken at 22 stations (Fig. 2). The average local standard deviation is 33 degrees, and the confidence limits of the means are about $\pm 6°$. Average structural strike is 240° (reference meridian 69°W), average longitudinal transport 243°, and average transverse transport 153° azimuth. Within the basin, two troughs are now recognized; a minor one near Alert, which, based on the fact that longitudinal markings here are confined to the lower part of the section, was filled relatively early; and the main axial trough of the geosyncline. The latter prevented coarse clastic sediments from reaching the miogeosyncline.

Structure

United States Range

The pre-Carboniferous basement of the United States Range consists mainly of tightly folded strata of map-unit 1, which form an outcrop belt about 230 miles long, and up to 20 miles wide. On the southeast, this belt is bounded by thrust faults. The northwestern boundary has only been seen at locality C (Fig. 1), where it is a normal fault. However, the predominant southeasterly dips at this locality and southwest of Feilden Peninsula suggest an earlier period of thrusting to the northwest. In the centre of the range, there are several straight and narrow valleys floored by map-unit 2a, which probably represent minor grabens.

Map-unit 1 thus forms an elongate uplift partly bounded by thrust faults, and partly by normal faults. This uplift culminates southeast of locality C, and from there plunges northeast, reaching sea level at the coast of Lincoln Sea. As a result of this plunge, the United States Range dies out northwest of Alert. Beneath the culmination, map-unit 1 shows incipient regional metamorphism.

Because the faults bounding the United States Range uplift involve Miocene strata, the present structure must have formed in Middle Tertiary or later time.

The following data indicate that map-unit 1 was elevated also in the Late Devonian-Mississippian orogeny, and that it remained high, or was elevated intermittently again, during a prolonged interval following that orogeny. (1) Throughout the area discussed, the basal deposits of the Sverdrup Basin rest mainly on map-unit 1, the Ordovician and younger rocks having been removed by intervening erosion. (2) The Sverdrup Basin succession overlying map-unit 1 is locally incomplete. At Feilden Peninsula, for example, the Pennsylvanian (?) Sail Harbour Group is absent, and at the head of Tanquary Fiord, the entire upper Palaeozoic to Middle Triassic section is missing[9, 12].

Hazen Plateau

Hazen Plateau is underlain mainly by tightly folded strata of map-unit 3 with anticlinal ridges of map-unit 2b in some areas. Extensive outcrop areas of units 2a and 1b are confined to tracts immediately adjacent to the United States Range. The folds, formed by flexural slip, are either upright or slightly overturned to the southeast. In some areas, back-limb thrusting to the southeast is common.

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[12] Nassichuk, W.W. and Christie, R.L.: Upper Palaeozoic and Mesozoic stratigraphy between Tanquary Fiord and Yelverton Pass, Ellesmere Island; Geol. Surv. Can., Paper (in prep.).

142. STRATIGRAPHY AND STRUCTURE OF THE MARBLE CANYON FORMATION IN THE MARBLE RANGE, CLINTON AREA, BRITISH COLUMBIA (92 P/4 E, W)

H.P. Trettin

H.P. Trettin spent one week of field work in order to conclude this project. He measured a few sections, collected fossils, and clarified structural detail. The conclusions reached in 1965 were confirmed[1]. In particular, new evidence has been obtained that the limestones wedge out on the southwest side of the range.

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GENERAL

143. MARINE GEOLOGICAL INVESTIGATIONS, NORTH ATLANTIC OCEAN

F. Aumento and D. E. Lawrence

The Bedford Institute of Oceanography provided ship time on the C.S.S. Hudson for two G.S.C. scientists during the B.I.O. 1967 Meteorological Cruise. Two separate bottom features in the North Atlantic Ocean were surveyed and sampled: the Flemish Cap (lat. 46°30'N, long. 44°25'W), a shallow bank about 350 miles east of St. John's Newfoundland, and San Pablo Seamount (lat. 39°00'N, long. 61°00'W) one of the Kelvin Seamounts about 400 miles SSE of Halifax, Nova Scotia.

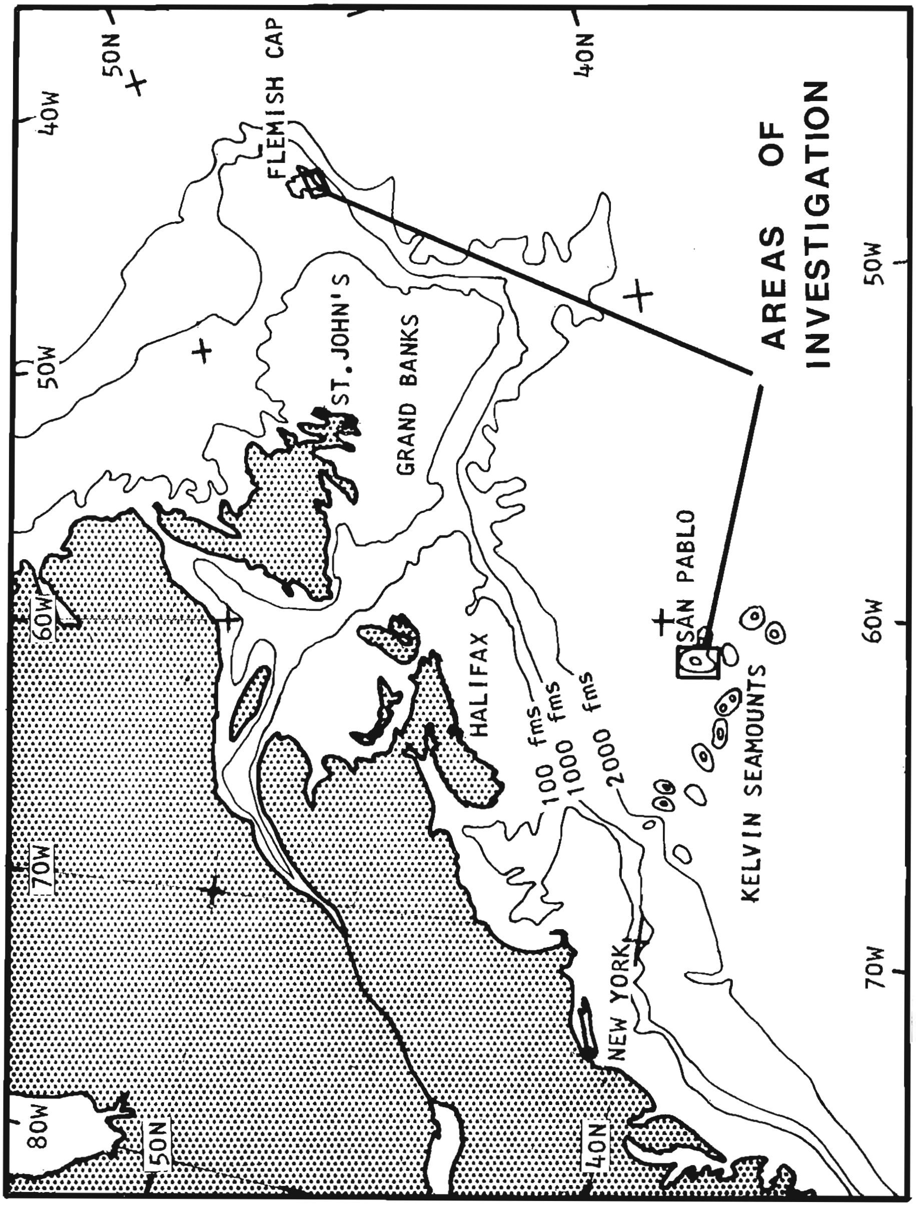
On Flemish Cap work was confined to a small area of the south-eastern slopes where steepness and ruggedness were thought to provide more chance of dredging bedrock. Dredgings were attempted at various depths, from 200-1600 fathoms; a large number of boulders of diverse acidic rock types were recovered, presumably transported and dropped on the Cap by icebergs. Bedrock may not have been sampled at anytime.

A bathymetric survey of the area of investigation was also undertaken to position the dredge samples relative to the topography. Soundings were plotted on a 1:125,000 Mercator projection. Positions were located by radar fixes to an accurately positioned radar transponder buoy.

The recent glacial sediments on Flemish Cap appear to cover even its steepest slopes. Investigations of the samples may reveal their source areas; they were presumably ice-rafted from the north.

San Pablo Seamount was surveyed and sampled; good hauls were made both on the top and on the slopes, at various depths from 500-1000 fathoms; in all cases samples of an unusual stratified manganese-iron ore were recovered. In the hope of gaining additional information in the immediate sample area, one of the dredges had been previously modified to accommodate underwater photographic equipment.

X-ray chemical analyses indicate that the ore contains 20 to 25 per cent MnO_2, with similar amounts of Fe_2O_3. Since bottom photographs indicate that these deposits form a continuous cover 1 foot to 3 feet thick over most of the seamount, it is estimated that there are ore reserves in the order of 10 to 30 M tons above 1,000 fathoms.



Aumento and Lawrence, 143

The feasibility of a camera dredge combination was demonstrated on San Pablo. Equipment behaviour was carefully studied in addition to taking acceptable photos and collecting a number of specimens. Photos from the dredge mounted camera have the additional interest of being oblique shots; these reveal aspects not seen in normal plan view bottom photos.

144. INVESTIGATIONS OF MINERAL OCCURRENCES BUCKINGHAM, MONT-LAURIER, HAWKSBURY, ONTARIO AND QUEBEC

Ann P. Sabina

An examination was made of about 165 mineral and rock localities along the Lièvre River between Buckingham and Mont-Laurier, and in the area from Mont-Laurier to Lachute, Hawkesbury and Ottawa. The purpose was to obtain up-to-date information on deposits of interest to tourists and collectors. A guidebook describing the localities and giving detailed directions to reach them is being prepared.

Most of the mines and quarries visited are no longer in operation. In the Lièvre River district, the old mica-apatite, feldspar and graphite mines supply a variety of specimens. Between Mont-Laurier and Lachute, there are granite and crystalline limestone quarries, and a few graphite, kaolinite, garnet and ilmenite mines. Specimens suitable for lapidary purposes are limited to the serpentine marbles found at Poltimore, St-Jovite and Kilmar. Fossils may be collected in limestone quarries and exposures between Hawkesbury and Ottawa.

GEOLOGICAL COLLECTING

Although the collecting of rocks, mineral fossils, and other geological data form an important aspect of most field programs, several field projects in 1967 were directed exclusively to such objectives. As a result only the collecting phase can be reported at this time; some of these collections will be used for laboratory studies and will form the basis for future reports.

Eight collecting projects are listed below.

W.F. Fahrig carried out preliminary sampling on three previously unsampled dyke swarms in the Torngat Mountain area of Labrador. A swarm striking at roughly right angles to the coast of Labrador may prove to be of special interest in examining the question of continental drift as this swarm might have a correlative on the coast of Greenland if Labrador and Greenland were once a single land mass.

C.H. Gauthier and S.M. Larose collected more than 22 tons of minerals, rocks and ores used in the preparation of various educational and other collections from about 60 localities in Ontario and Quebec.

Samples for zirem age determination were collected from five localities.

H.J. Hofman continued the study of Precambrian fossils and pseudofossils in Canada, begun in 1966, with visits to many of the localities of finds reported in the literature during the last 100 years. These allowed the collection of topotype material and study of the local geological setting; some occurrences could not be relocated.

The following types of stromatolites were encountered:

Animikie Group:	acervate encrusting forms
Green Head Group:	deformed branching columnar forms (*Archaeozoon acadiense* Matthew)
Manitounuk Group:	domal, undular, acervate, and branching columnar forms
Sibley Group:	columnar stromatolites of the *Conophyton* group.

Non-stromatolite material was obtained from the Steeprock, Animikie, Cobalt, Greenville, and Cabot Groups and the Random Formation.

R.D. Howie collected oil and gas well data from the provincial Mines Departments in Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador and from the Bedford Institute of Oceanography and the Nova Scotia Research Foundation. Rotary and cable tool samples for a number of wells were also collected. Three weeks were spent at the Institute of Sedimentary and Petroleum Geology examining core samples and conferring with oil companies conducting oil and gas exploration in Eastern Canada.

H.R. Steacy collected specimens of rare minerals at several localities in Ontario and Quebec for the National Mineral Collection's Systematic Reference Series, for which the Geological Survey of Canada is responsible. Such collecting is done to extend and improve the representation of Canadian minerals in the National Mineral Collection and to provide material for study and for exchange.

E.T. Tozer joined Dr. N.J. Silberling of Stanford University in a re-examination of the Upper Karnian ammonoid beds in the Hosselkus Limestone of the Squaw Creek area, Shasta County, California. This work provided collections and data that will assist in the interpretation of contemporary rocks in British Columbia.

T.T. Uyeno and C.R. Barnes, University of Waterloo, collected the Lévis Formation (Lower Ordovician) of the type area at Lévis, Quebec, for conodont biostratigraphic study.

T.T. Uyeno collected Middle and Upper Devonian rocks of Manitoba for conodont biostratigraphic study.

GEOPHYSICS

145. DC RESISTIVITY SURVEY, OTTAWA-CORNWALL AREA, ONTARIO (31 G)

P. Andrieux

The purpose of the project is to assess the capabilities and limitations of DC resistivity as a means of determining geological structure in this area including fault extensions, and to determine the electrical resistivity of various rocks in the map-area.

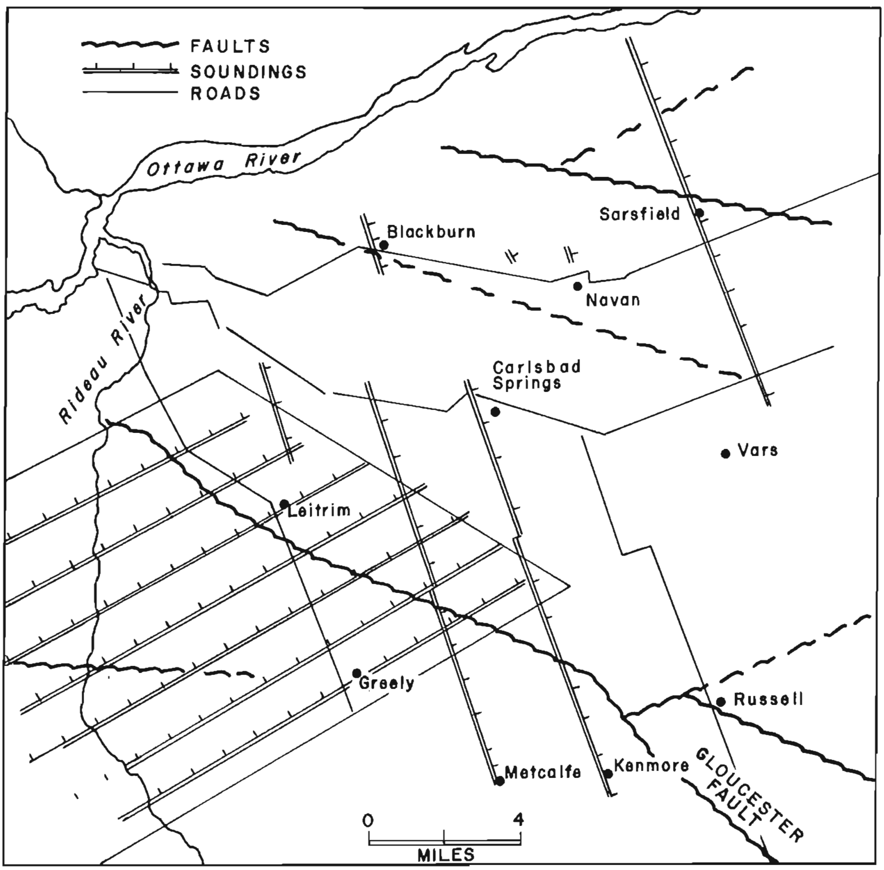


Figure 1. The Ottawa area.

The Schlumberger array was used. To study the general electrical behaviour of the area, 7 electrical soundings were made on various outcrops of the area and 34 soundings were made every mile on a line running SSE-NNW from Kenmore to the Ottawa River and a second line parallel to the first spaced 2 miles to the west (Fig. 1). After this preliminary work, it was decided to carry out a systematic survey over the Precambrian area southwest of the Gloucester Fault which would entail 70 vertical electrical soundings (see Fig. 1).

The measured resistivities on the outcrops are the following:
Precambrian crystalline limestone....... 1800 to 2400 ohm metres
Oxford Formation limestone............. 4500 ohm metres
March Formation sandstone .... 800 ohm metres

As the March Formation is more conductive than the overlying Oxford Formation, the possibility of mapping the depth to the top of the Precambrian appears feasible over the entire area southwest of the Gloucester Fault. A Schlumberger configuration with a maximum spread of 2 km could be used.

North of the Gloucester Fault, all the curves obtained in the area are similar. Where the soil is not too thick, three layers can be identified: the Carlsbad Shales (90 ohm metres), the Billings Shales (50 ohm metres) and the Ottawa Limestone (1000 ohm metres). The top of the Ottawa Formation can be followed with a Schlumberger configuration of maximum spread of the order of 4 to 5 km where the soil is not thicker than 20 m.

Southeast of the Ottawa River, the Ottawa Formation (1500 ohm metres) is underlain by a more conductive layer. The thickness of the Ottawa Formation can be determined in this area with a Schlumberger configuration of maximum spread of the order of 2.5 to 3 km.

AUTHOR INDEX

LOCATION INDEX