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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 67-1
Part A

REPORT OF ACTIVITIES,

Part A: May to October, 1966

Edited by S.E. Jenness

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1967

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ABSTRACT

This report presents 138 brief papers on field work undertaken in 1966 by members of the Geological Survey of Canada, and 16 additional statements on mineralogical, palaeontological, and palynological collecting projects.

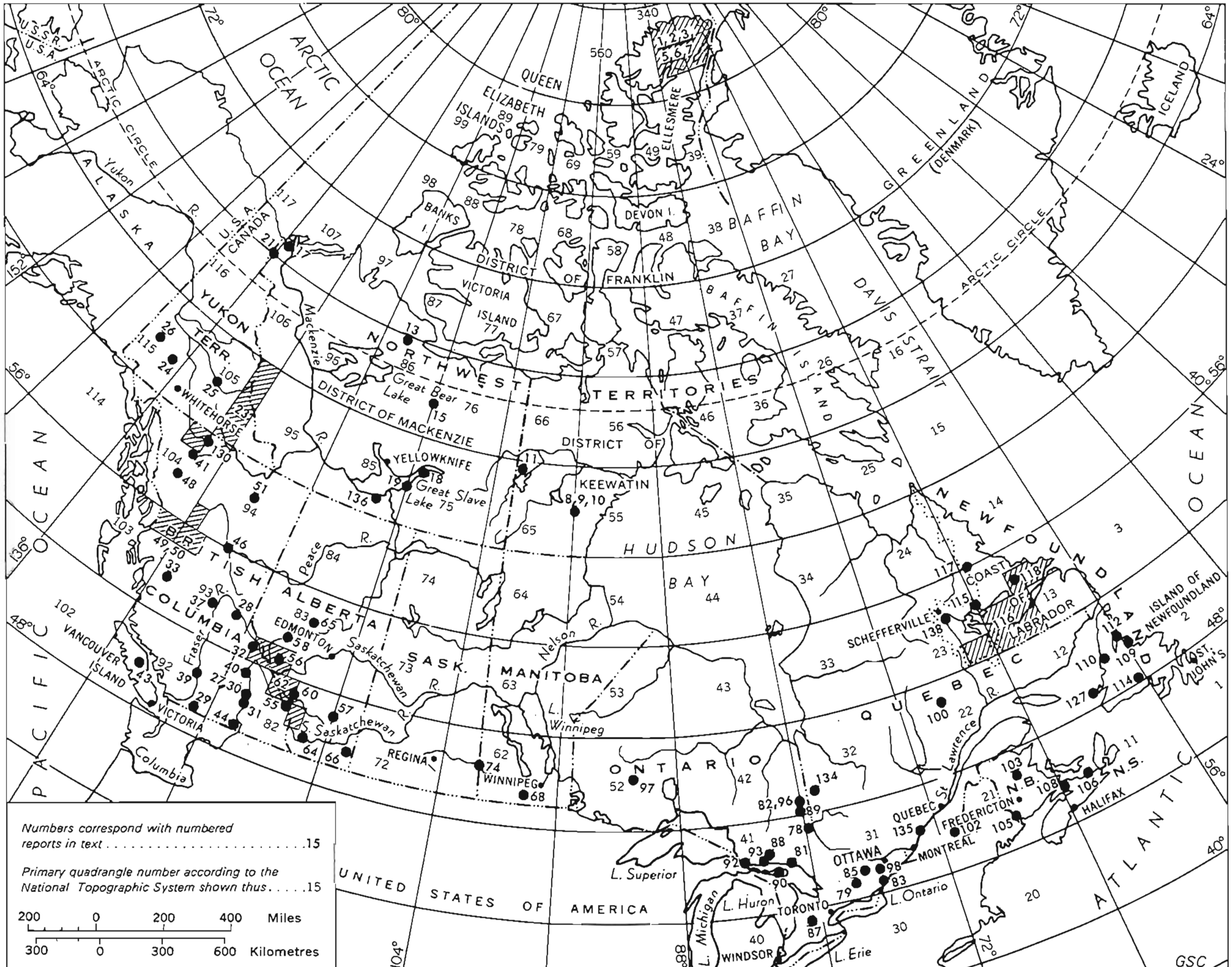

Figure 1. Distribution of most of the 1966 Geological Survey field parties

REPORT OF ACTIVITIES: MAY TO OCTOBER, 1966

INTRODUCTION

The Geological Survey of Canada places more than 100 field parties throughout the country each year from May to October to obtain basic data on the geology of Canada. Brief accounts of their activities and findings are submitted by the field officers upon their return from the field in order that they may be released to the public shortly after the New Year.

Reports presented on the following pages were given only cursory editing in order to expedite publication. It is hoped that the information they contain may help guide those engaged in the search for and development of metallic and non-metallic mineral deposits, fuels, and construction materials. These reports are arranged primarily by geographic unit (province, territory, or district) and secondarily by alphabetical order of authors' surnames. Accompanying maps and diagrams were drafted by the authors. Map-areas are generally designated according to the National Topographic System as revised in 1960. All statements concerning the results of field work are subject to confirmation by office and laboratory studies.

Details of many of the activities and data mentioned in this report, when assembled and interpreted, will be published as maps and/or reports of the Geological Survey, the release dates of which are announced from time to time by postcards mailed free of charge to all persons or organizations 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.

This year the Geological Survey's activities between May and October, 1966, appear as Part A of G.S.C. Paper 67-1; activities carried out or reported on between November 1966 and April 1967 will comprise Part B of this paper, which will be published sometime after April 1967. An index of publications, a compilation of abstracts of papers by Geological Survey personnel in non-Survey publications, and papers containing the results of the Survey's radiocarbon and isotopic dating activities will also appear later in 1967, collectively providing an annual accounting of most of the scientific activities of the Geological Survey.

An author index and a general subject index are included for easy reference. The locations of most of the field parties are shown on Figure 1.

DISTRICT OF FRANKLIN

1. OPERATION GRANT LAND (1966), NORTHERN ELLESMERE ISLAND

R.L. Christie

The second and final year of Operation Grant Land, an air-supported reconnaissance and stratigraphic investigation of some 40,000 square miles of northern Ellesmere Island and northern Greenland, was carried out from a base camp at Lake Hazen, about 80 miles southwest of Alert. The project included parties led by H.P. Trettin (Palaeozoic eugeosyncline), W.W. Nassichuk (Permo-Carboniferous to Tertiary stratigraphy), T. Frisch (metamorphic terrane), P.R. Dawes of the Greenland Geological Survey (stratigraphy of Hall and Nyeboe's Lands in northern Greenland), and B.S. Norford (palaeontological collecting at certain lower Palaeozoic sections on Judge Daly Promontory and in Hall and Washington Lands). R.L. Christie was in charge of the operation and in the field examined the stratigraphy and structure of Judge Daly Promontory.

The project was supported by a float-equipped Bell G-4 helicopter, a Piper Super Cub, and a Beaver aircraft. The fixed-wing aircraft were on oversize tires.

The project area includes diverse geological provinces: a north coastal metamorphic belt of possibly Precambrian 'basement' rocks, a complex geosynclinal belt (Franklinian geosyncline) of late Precambrian and lower Palaeozoic sedimentary and volcanic rocks, a mountain belt of folded basinal rocks (Sverdrup Basin) of Permo-Carboniferous to Cretaceous age, and scattered small areas of continental Tertiary clastic beds. The tight folding of the geosynclinal belt dies out southeastward, where also the geosynclinal clastic sedimentary facies pass into a thinner, shelf-type carbonate sequence.

Dr. J.H. Allaart's work in Greenland in 1965, and Dr. Dawes' in 1966, are part of a cooperative program between the Geological Survey of Greenland and the Geological Survey of Canada to relate structural and stratigraphic features across Nares Strait, the narrow body of water separating Ellesmere Island and northwestern Greenland.

The reports of Dawes, Frisch, Nassichuk, Norford, and Trettin follow.

On Judge Daly Promontory, the writer traced northeastward stratigraphic units established by J.W. Kerr (pers. comm.) and obtained data on the complex folds of the southeastern part of the peninsula. Major faults have displaced large fold-structures, but movement of great magnitude (i.e. such as would occur if continental blocks were to shift tens or hundreds of kilometres) evidently has not occurred. Highly folded beds underlying lower Ordovician formations[1] are evidently late Precambrian and Cambrian beds of the geosyncline. The late Precambrian and early Palaeozoic beds form a structurally conformable sequence with a total thickness estimated to be near 20,000 feet thick.

A few data were obtained from Mesozoic and Tertiary beds of the Lake Hazen region to add to those collected by A.A. Petryk[2] in 1965. Triassic beds have been superimposed upon Tertiary strata with structural conformity by a bedded thrust fault nearly parallel to the north shore of Lake Hazen; identification of this fault solves a minor stratigraphic enigma[3] in which presumed Tertiary coal-bearing beds appeared to be overlain in an unbroken sedimentary succession by Triassic beds. From re-examination of 'boulder gravel' hills[1] northeast of Lake Hazen and the discovery of some other, weakly cemented boulder conglomerate it is concluded that: a) the boulder gravel hills are remnants of a late Tertiary rather than a Pleistocene deposit, b) the boulder gravels may be interpreted as 'molasse' deposits, and probably mark an important tectonic episode, the locus of movement perhaps being the nearby Lake Hazen fault zone. These interesting boulder deposits and the underlying beds potentially provide excellent control in dating the latest (Alpine?) mountain-building movements in northern Ellesmere Island and Greenland.

---

[1]Christie, R.L.: Geological reconnaissance of northeastern Ellesmere Island, District of Franklin; Geol. Surv. Can., Mem. 331, p. 28 (1964).

[2]Petryk, A.A.: Mesozoic and Tertiary sediments, northern Ellesmere Island; <u>in</u> Report of Activities, 1965; Geol. Surv. Can., Paper 66-1, p. 5 (1966).

[3]Christie, R.L.: op. cit., p. 46.

2. LOWER PALAEOZOIC ROCKS, WESTERN PART OF THE NORTH GREENLAND FOLD BELT

P.R. Dawes

(Greenland Geological Survey)

Following the mapping of Polaris Promontory in 1965, investigations this summer were confined to Nyeboe Land and Hendrik Island with cursory examination of the west coast of Wulff Land and the islands in Sherard Osborn Fjord. In two summers a broad view of the western part of the North Greenland Fold Belt i.e. west of Peary Land, has been obtained. Both the unfolded rocks of the south towards the Inland Ice and the folded rocks of the north bordering Robeson Channel and the Lincoln Sea, were studied.

The Rocks

A sedimentary succession of at least 2,000 metres exists in the area and this varies markedly in facies in lateral as well as in vertical extent. The oldest rocks exposed, possibly Cambrian in age, are unfossiliferous pinkish-white quartzites and quartzitic conglomerates and these form a striking succession on the northwest coast of Wulff Land. In northern Nyeboe Land, possible Late Cambrian rocks are represented by some grey and yellow dolomites containing in part a trilobite fauna. These dolomites pass upwards into Ordovician limestones and dolomitic limestones of many types. Some conglomerates and limestone breccias occur. Ordovician dolomites occur in southern Nyeboe Land, north of the Inland Ice and these rocks can be directly correlated with the characteristic black dolomites forming the lowest part of the succession discovered in 1965 in northern Polaris Promontory.

Silurian rocks differ strikingly in facies in the northern and southern parts of Nyeboe Land. In the south the Ordovician black dolomites pass upwards into lighter coloured massive Silurian limestones containing an abundant fauna of corals, crinoids, brachiopods, gastropods, trilobites, and cephalopods. The youngest Silurian rocks in the south are calcareous shales and black compact limestones containing a dense fauna of brachiopods, corals, crinoids, and trilobites. In northern Nyeboe Land, the Silurian is represented by a thick sequence of clastic rocks; the lower part contains some calcareous sandstones and shales and the top is a turbidite series displaying excellent sedimentary structures. On Hendrik Island, the Silurian sandstones contain a distinct conglomerate zone up to 200 metres thick - the Hendrik Conglomerate. It is composed mainly of pebbles of chert and quartzite, but some pebbles of granite and gneiss, presumably from the Precambrian basement, exist. Lying above the conglomerate is a sequence of calcareous grey shales and black graptolitic shales containing species of Monograptus.

The facies boundary between the Silurian limestone rocks of the south and the clastic sandstones of the north is clear and mappable.

It seems necessary to critically revise Koch's[1] division of the Lower Palaeozoic rocks in this part of North Greenland. In Nyeboe Land it is impossible to recognize the Offley Island Formation and the Cape Tyson Formation as distinct units and the existence of a marked unconformity separating the Ordovician rocks from the Silurian is not upheld. Koch's Lower Palaeozoic Polaris Harbour Formation was found in its type locality, in 1965, to consist of Quaternary moraines.

The Structures

The boundary between folded and unfolded rocks is well defined and can be traced from northern Polaris Bay in western Hall Land, across Nyeboe Land, Hendrik Island, and Wulff Land, striking in a general east-northeast direction. The style of folding changes in relation to this boundary and fold zones characterized by fold style can be recognized. These are well seen in Nyeboe Land where in the south, the rocks vary from flat-lying to gently dipping northwestwards. These pass northwestwards into zones characterized by monoclines, then asymmetrical folds and farther to the northwest by isoclinal and in places chevron folds. The folds are commonly overturned towards the northwest with axial planes dipping southeastwards.

Some faults and thrusts parallel to bedding occur in northern Nyeboe Land.

Metamorphism

Only in the northern part of Nyeboe Land do the rocks in places take on a metamorphic appearance. There the sandstones have developed a schistosity, which seems to be connected with a secondary production of mica.

Basic Intrusions

No basic intrusions were observed on the ground in the area mapped, but from the air, basic dykes were noted on the east side of Victoria Fjord (Nares Land) and these must represent the farthest west intrusions in the North Greenland Fold Belt.

Historical

During the summer, cairns and campsites of earlier expeditions to the Robeson Channel area were visited and examined. Nine written records pertaining to the following expeditions were recovered; United States North Polar Expedition, U.S.S. Polaris, commanded by C.F. Hall 1871-1873; the British Arctic Expedition, H.M.S. "Alert" and "Discovery", commanded by G.S. Nares 1875-1876; United States Lady Franklin Bay Expedition, commanded by A.W. Greely, 1881-1884; the Danish 2nd. Thule Expedition, leader Knud Rasmussen 1916-1918; and the Danish Bicentenary Jubilee Expedition, leader Lauge Koch, 1920-1923. Interesting relics recovered include the leather belt and knife (inscribed "L.A. Beaumont") and other belongings of Lieutenant L.A. Beaumont and party, found at Repulse Bay. These were abandoned by Beaumont during the heroic retreat along the North Greenland coast in 1876.

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[1]Koch, Lauge: Stratigraphy of Greenland; in Geology of Greenland, Medd. om Grønland, bd. 73, 2nd afd., nr. 2, pp. 205-320 (1929).

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3. IGNEOUS AND METAMORPHIC ROCKS, NORTHERN ELLESMERE ISLAND

Thomas Frisch

The region between M'Clintock and Phillips Inlets on the north coast of Ellesmere Island was examined in 1966.

Continuous cliffs on Yelverton Bay and Yelverton Inlet (the bay lies at the mouth and north of the inlet) provide the best exposures known of the metamorphic rocks of the Cape Columbia Group[1], which there are quartz-biotite-feldspar gneisses, migmatites, and amphibolites. The gneisses and amphibolites are in places garnetiferous. West of Yelverton Bay, the Cape Columbia Group is in possible thrust fault contact with unmetamorphosed volcanic and carbonate rocks, and east of the bay, in contact with low-grade metamorphic rocks. At the southern end of Yelverton Inlet, the Cape Columbia rocks appear to pass gradationally into lower-grade schists, phyllites, slates, and carbonate-rocks; this second group of low-grade metamorphic rocks is distinct from those east of Yelverton Bay, and is tentatively correlated with the Mount Disraeli Group[1].

The low-grade metamorphic rocks at the head of Yelverton Inlet are overlain unconformably by Permo-Carboniferous beds.

In Milne and Ayles Fiords, as in Yelverton Inlet, rocks of the Cape Columbia Group grade southward into lower-grade metamorphic rocks that may be assigned to the Mount Disraeli Group.

The south side of the large, pre-Carboniferous ultramafic pluton west of M'Clintock Inlet[2] is in probable fault contact with low-grade metamorphic rocks presumed to belong to the Cape Columbia Group.

The pluton[3] south of Cape Richards and the quartz monzonite stock on Phillips Inlet were re-examined. The Cape Richards body is zoned, with a core of coarse-grained syenite-diorite surrounded by an epidote-rich granite. Both plutons are unmetamorphosed, are essentially undeformed, and have discordant, clearly intrusive contacts with the surrounding low-grade metamorphic rocks. They are interpreted as high-level intrusions.

---

[1]Blackadar, R.G.: Geological reconnaissance, north coast of Ellesmere Island; Geol. Surv. Can., Paper 53-10, pp. 8, 10 (1954).

[2]Trettin, H.P.: Precambrian to Carboniferous rocks of M'Clintock Inlet region, northeastern Ellesmere Island; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 10 (1966).

[3]Christie, R.L.: Geological reconnaissance of the north coast of Ellesmere Island; Geol. Surv. Can., Paper 56-9, p. 24 (1957).

4. WINTER HARBOUR MORAINE, MELVILLE ISLAND

J.G. Fyles

The Winter Harbour moraine, on the south coast of Melville Island, marks a segment of the northwest margin of the Laurentide (continental) ice-sheet and probably was formed at the maximum stand of the ice-sheet during the last (Classical Wisconsin) glaciation. Preliminary information about the moraine was gathered during a hurried reconnaissance in 1964[1]. With logistic support from the Polar Continental Shelf Project, further investigation of the moraine, and particularly of its relationship to emergent marine features, was undertaken during the last week of July and first week of August, 1966. Two tracked vehicles were used for transportation and proved to be well suited to our needs and to the terrain.

The moraine comprises a belt of hilly and ridged topography up to 350 feet above sea-level, 50 miles long, and averaging 2 miles wide; it consists of bouldery drift and stratified silt, sand, and gravel. Along part of its length, the moraine is bordered on the northwest by patches of pale-coloured clayey till with subdued relief that gives the impression of being markedly older than the moraine. Hills of stony drift, gravel, and sand in a northeast-trending belt a few miles to the northwest appear to be still older and to constitute erosional remnants of an important pre-Wisconsin Laurentide moraine.

Marine silt and sand containing abundant shells of Hiatella arctica occur along the inland (west) side of the Winter Harbour moraine at altitudes of up to about 200 feet, whereas marine features along the seaward (southeast) face of the moraine are markedly lower. Reconnaissance barometric observations in 1964 suggested that the marine limit on the seaward side of the moraine increases progressively in altitude, from southwest to northeast, from 50 feet to 100 feet in a distance of about 20 miles. More detailed observations coupled with instrumental levelling have confirmed this trend in very general terms, but have also demonstrated erratic variations in the altitude of the highest shore features. Although some of the highest shore features plot in an aligned sequence, the marine-limit features clearly do not all belong on a single water-plane. Moreover, tilting was nowhere demonstrated unequivocally along any single continuous shoreline. Levels on a prominent lower beach, about 30 feet above present sea-level, revealed no tilt over a distance of several miles.

Marine shells from silt on the inland side of the moraine have yielded radiocarbon dates of 10,340 ± 150 and 10,900 ± 160 years (GSC-278, 363) whereas shells close to the marine limit on the seaward side of the moraine have a radiocarbon age of 9550 ± 160 years (GSC-339). On the basis of these dates, the ice-sheet margin is inferred to have stood in the vicinity of the moraine 10,000 or 11,000 years ago. Shell fragments on the crest of the moraine, which probably have been transported into this locality by the ice-sheet from a source to the southeast, have yielded a date of approximately 30,000 years (GSC-667).

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[1]Fyles, J.G.: Surficial geology, Western Queen Elizabeth Islands; in Report of Activities: Field, 1964; Geol. Surv. Can., Paper 65-1, pp. 3-5 (1965).

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5. STUDIES OF PERMO-CARBONIFEROUS AND MESOZOIC STRATA ON NORTHERN ELLESMERE ISLAND

W.W. Nassichuk

During the final year of Operation Grant Land on northern Ellesmere Island (see report by R.L. Christie, p. 2), stratigraphic and biostratigraphic relationships of Permo-Carboniferous and Mesozoic units were studied in five selected areas in the United States Range. Permo-Carboniferous rocks received particular attention in the following areas: (a) east of Van Hauen Pass on the north side of Hare Fiord; (b) Yelverton Pass; (c) north of Lake Hazen in the vicinity of Henrietta Nesmith glacier; and (d) between M'Clintock Inlet and Markham Bay on the north coast of Ellesmere Island. Mesozoic rocks were studied in the vicinity of Ekblaw Lake (e).

In all areas where Permo-Carboniferous rocks were studied, many new occurrences of time-sensitive fusulinids were discovered. These fossils, as well as brachiopods, corals, and representatives of other biostratigraphically less-significant fossil groups were collected in abundance. Ammonoids were collected only in the immediate vicinity of Hare Fiord, and critical study of these fossils has allowed definitive biostratigraphic assignments to be made for Pennsylvanian strata in that area. North of Hare Fiord on Ellesmere Island, Permo-Carboniferous ammonoids are not known to occur and for this reason resolution of biostratigraphic relationships must depend largely on the study of fusulinids.

A. Hare Fiord

Upper Palaeozoic strata were examined on the north side of Hare Fiord between Van Hauen Pass and a point about 15 miles eastward. Particular emphasis was given to an unnamed, essentially argillaceous and bioclastic limestone formation, known to contain Lower Permian fossils in its upper part, that rests on a thick deposit of bedded evaporites. From a small bioherm near the base of the above carbonate sequence, about 12 miles east of Van Hauen Pass (lat. 81°07.5'N, long. 84°17'W), Nassichuk and Furnish[1] reported a number of Middle Pennsylvanian ammonoid genera that indicate an Atokan (Moscovian) age. A new taxon from this locality was described by Nassichuk[2]. Many of the ammonoids found in the above bioherm, including Neodimorphoceras Schmidt, Bisatoceras Miller and Owen, Syngastrioceras Librovitch, Metapronorites Librovitch, and Pseudoparalegoceras Miller, are now also known to occur in thin-bedded argillaceous limestone 75 feet above the base of the same formation at Van Hauen Pass. Fifty feet above the base, Diaboloceras Miller was collected.

An Upper Pennsylvanian (Jigulian) ammonoid Parashumardites Ruzhencev was recovered from a light grey bioclastic limestone 3 miles northeast of the previously mentioned bioherm. Stratigraphically, this bioclastic limestone is several hundred feet above the bioherm. Previously, Parashumardites has been recorded only from the southern midcontinent and from Upper Carboniferous strata in the Russian Platform and Ural Mountain areas of the Soviet Union.

B. Yelverton Pass

Permo-Carboniferous rocks at Yelverton Pass are approximately 4000 feet thick. The lowermost unit, comprising 2500 feet of unfossiliferous red and green-weathering shale, sandstone, and conglomerate is tentatively assigned to the Canyon Fiord Formation on the basis of lithology. It rests with structural discordance on massive Lower Palaeozoic carbonates that contain an abundance of corals and stromatoporoids. According to B.S. Norford (personal communication) this unit is of Silurian age. The Canyon Fiord Formation is overlain disconformably by about 1000 feet of well-bedded fusulinid-bearing limestone and cherty limestone. These limestones are overlain by at least 100 feet of brachiopod-rich calcareous sandstone and minor glauconitic sandstone. The Permo-Carboniferous sequence is overlain disconformably by fossiliferous sandstones of the Triassic Schei Point Formation.

C. Henrietta Nesmith glacier area

About 10 miles north of Lake Hazen, in the vicinity of Henrietta Nesmith glacier, the Canyon Fiord Formation consists of sandstones and conglomerates with minor limestone interbeds. It is 2000 feet thick and lies unconformably upon slates and quartzites mapped as Cape Rawson Group[3]. Overlying the Canyon Fiord Formation is a thick sequence of coralline, fusulinid-rich limestone assigned to the Belcher Channel Formation. This formation is overlain disconformably by at least 500 feet of light-grey quartzose sandstones, in part fossiliferous, that are probably equivalent to the Sabine Bay Formation.

D. North Coast of Ellesmere Island

Between Markham Bay and M'Clintock Inlet a number of aerially small and isolated but thick exposures of clastic rocks, evaporites, and carbonates were studied. Only the clastic sequence (Canyon Fiord Formation) can be readily recognized by its lithology elsewhere on Ellesmere Island. Carbonate units at Ward Hunt Island, Cape Nares, on the west side of Markham Bay, and near the head of M'Clintock Inlet contain a variety of Pennsylvanian and/or Permian fusulinids. Because of incomplete exposures due to faulting and apparent rapid facies changes in this area, correlation of carbonate units even on a local scale must await a detailed study of the collected fusulinids. Certain carbonates, such as those exposed at Ward Hunt Island and Cape Nares contain fusulinids that according to Thompson[4] are of Middle Pennsylvanian age. This age assignment suggests at least a partial correlation with Pennsylvanian carbonate sequences at Hare Fiord[1,2] and on northern Axel Heiberg Island[5].

E. Ekblaw Lake

Three gently folded, structurally conformable Mesozoic formations are exposed north of Ekblaw Lake. Well-bedded sandstones of the upper part of the Triassic Heiberg Formation are overlain by an as yet unnamed Jurassic unit, some 1500 feet thick, that is composed essentially of recessive black shales with minor concretionary siltstone bands. This latter unit is overlain by the Isachsen Formation, at least 500 feet of quartzose sandstones capped by a sill that in some places is 100 feet thick. Ammonoids were found at several localities in the upper 25 feet of the Heiberg Formation and in the lower 100 feet of the Jurassic black shales.

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[1]Nassichuk, W.W., and Furnish, W.M.: Christioceras, a new Pennsylvanian ammonoid from the Canadian Arctic; J. Paleontol., vol. 39, No. 4 (1965).

[2]Nassichuk, W.W.: A morphologic character new to ammonoids portrayed by Clistoceras Gen. Nov. from the Pennsylvanian of Arctic Canada; J. Paleontol. (in press).

[3]Christie, R.L.: Geological reconnaissance of northeastern Ellesmere Island, District of Franklin; Geol. Surv. Can., Mem. 331 (1964).

[4]Thompson, M.L.: Pennsylvanian fusulinids from Ward Hunt Island; J. Paleontol., vol. 35, No. 6 (1961).

[5]Thorsteinsson, R., and Tozer, E.T.: Summary account of structural history of the Canadian Arctic Archipelago since Precambrian time; Geol. Surv. Can., Paper 60-7 (1960).

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6. BIOSTRATIGRAPHIC STUDIES, NORTHEAST ELLESMERE ISLAND AND ADJACENT GREENLAND

B.S. Norford

A short field season was spent in northeast Ellesmere Island and adjacent Greenland as part of Operation Grant Land (see report by R.L. Christie). In Ellesmere, a stratigraphic section studied near Daly River shows that a thick sequence of shallow water carbonate sediments was deposited during much of Middle Ordovician time. The sections at Cape Schuchert and Cape Tyson in coastal Greenland indicate that the Silurian rocks of northwest Greenland consist of complexly intertonguing reefal, off-reefal, and graptolitic facies.

7. GEOLOGY OF PRE-MISSISSIPPIAN "EUGEOSYNCLINAL" ROCKS IN SELECTED AREAS OF NORTHERN ELLESMERE ISLAND

H.P. Trettin

Part of the field season was used for the completion of stratigraphic and structural studies, and reconnaissance mapping, begun in 1965 and 1962 respectively, in the M'Clintock, Phillips Inlet, and Tanquary Fiord regions. The balance of the season was devoted to a sedimentological study of the Cape Rawson 'Group' on the southeastern Hazen Plateau. The main results are briefly summarized below in chronological order.

Sedimentary Units of Pre-Middle Ordovician Basement Complex

An unfossiliferous, schistose limestone (Fig. 1, loc. 1), and a unit composed of volcanic rocks and limestone (loc. 2), both southwest of Phillips Inlet, are comparable to sub-units 1c and 1d respectively of the Rens Fiord Complex of northern Axel Heiberg Island[1] (loc. 3).

A belt of deltaic sediments has been traced from Hare Fiord (loc. 4; investigated in 1962) via the head of Tanquary Fiord (loc. 5) to north of Lake Hazen (loc. 6). The strata, containing coarse microcline and abundant quartz, differ in detrital mineralogy from all known Ordovician to Devonian units of the "eugeosyncline", but have affinities with sub-unit 1b of the Rens Fiord Complex[1]. On the southeast, these beds are bounded by the Lake Hazen fault zone[2], and its southwestern extension.

Pre-Middle Ordovician Age of Ultrabasic Intrusions

On Bromley Island, northern Ellesmere Island (loc. 7), basic to ultrabasic intrusions are unconformably overlain by Middle Ordovician (Wildernessian) carbonates. The age of these intrusions[2,3,1] was uncertain, because their contacts with the lower Palaeozoic sediments are mostly faulted.

Unconformity Between Ordovician Strata and Basement Rocks in Northern Ellesmere Island Confirmed by Presence of Basal Conglomerate

At several localities on Bromley Island, M'Clintock region (loc. 7), and on the peninsula immediately to the west (loc. 8), the Middle Ordovician carbonates (ref. 3, Fig. 2, unit 1) are underlain by up to 220 feet of conglomerate and sandstone. The contact between the carbonates and the clastic sediments is concordant, but may represent a disconformity. The clastic sediments (and the carbonates, where the clastic sediments are absent) rest on diverse volcanic, sedimentary, and metamorphic rocks with an angular discordance ranging up to 90 degrees. The fact that the basal

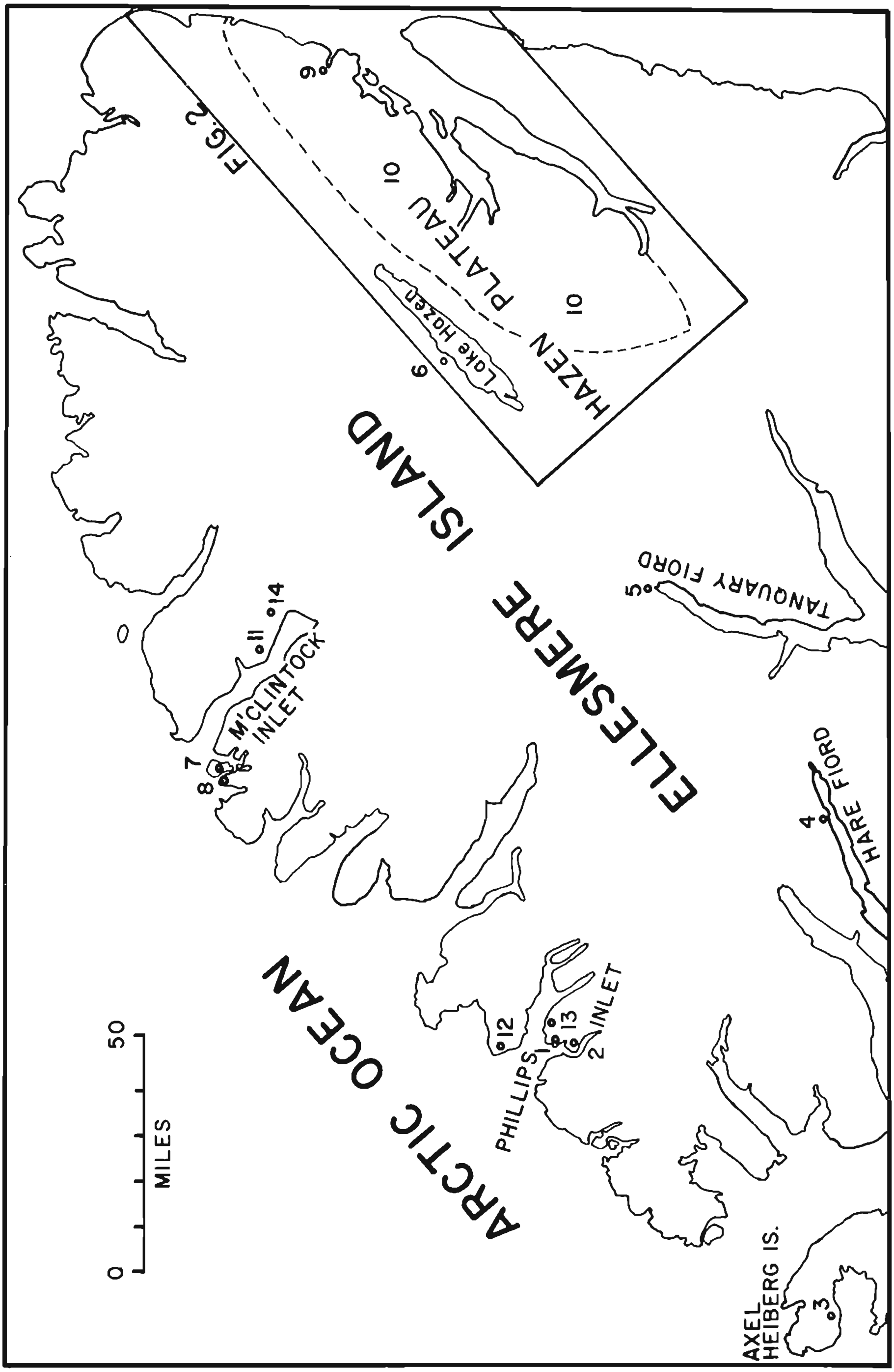

Figure 1: Index Map

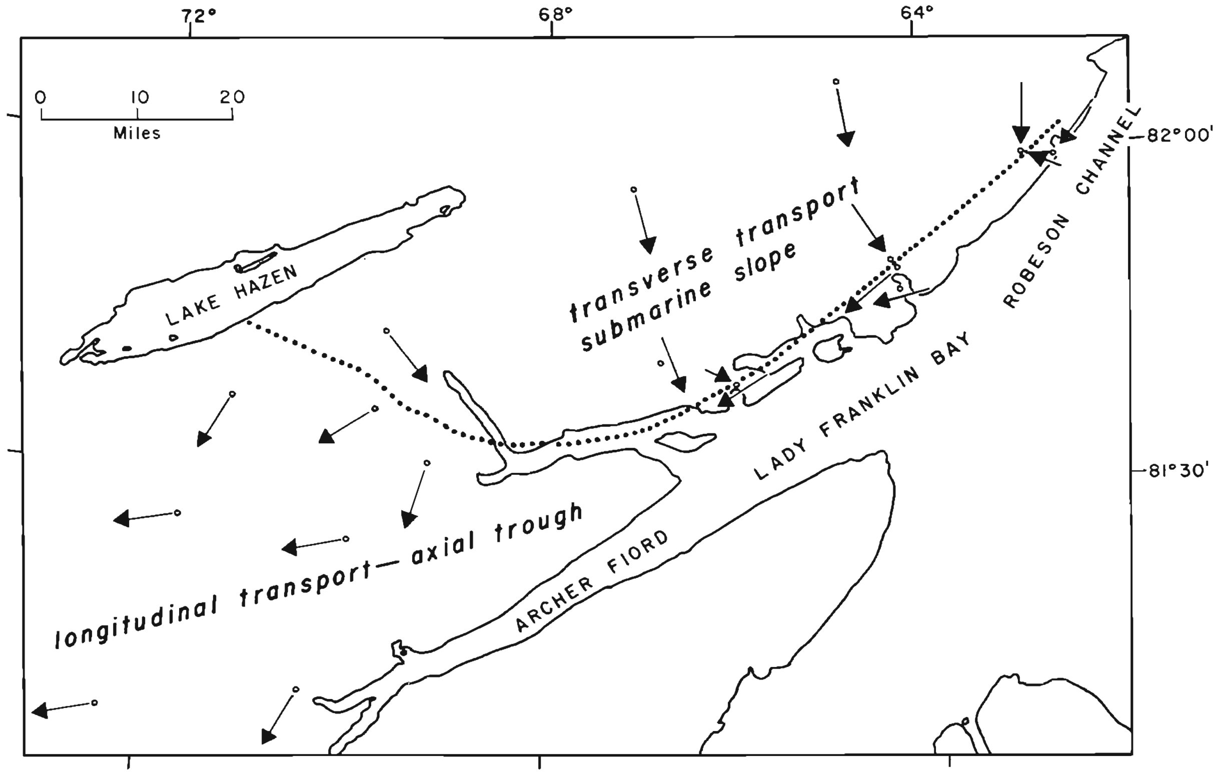

Figure 2: Directions of Transport of Llandoverian Sediments. Small circles represent stations; long arrows represent arithmetic mean azimuths of predominant directions, and short arrows those of divergent subordinate directions. Bimodal distributions are confined to the boundary zone between longitudinal and transverse transportation.

The Upper Ordovician graptolitic shales and bedded (radiolarian?) cherts of Lady Franklin Bay probably represent deeper water than equivalent calcareous and shaly strata in northern Ellesmere Island (ref. 1, Fig. 2, unit 5), and carbonates in central Ellesmere Island; therefore the trough inferred for the Early Silurian probably existed during the Late Ordovician as well.

Granitic or ultrabasic intrusions, volcanic rocks, and metamorphic effects have not been observed in the axial area of the geosyncline; they are confined to the northern coasts of Ellesmere and Axel Heiberg Islands.

Upper Silurian Limestone of M'Clintock Inlet Area

A Silurian limestone in the M'Clintock area (loc. 11; see ref. 3, Fig. 2, unit 7) consists of about 600 feet of micrite and biomicrite, with lesser proportions of calcareous sandstone, and stromatoporoidal patch reefs. A large species of Conchidium, probably of Ludlowian age (B.S. Norford, pers. comm.) occurs throughout the unit, which is overlain by more than 300 feet of quartzose sandstone with minor limestone, the youngest known pre-Pennsylvanian strata in the area.

Devonian or Mississippian Granitic Intrusions and Metamorphism in Phillips Inlet Area

A granitic stock exposed at the entrance of Phillips Inlet (loc. 13) first mapped by Christie[6] (loc. 12), intrudes Lower Silurian sediments. In addition to contact metamorphism, and metasomatism by this intrusion, the Silurian rocks of Phillips Inlet area show the effects of incipient regional metamorphism. Intrusion and metamorphism probably took place between Middle Devonian and Late Mississippian times[1].

Middle Pennsylvanian Strata of M'Clintock Area

Fossil identifications by M.S. Barss, W.A. Bell, and M.J. Copeland indicate that the sediments tentatively considered as Late Devonian or Mississippian[3] in fact are equivalent to the lower part of the Middle Pennsylvanian and younger Canyon Fiord Formation[7], which here is unusually thick, varied in lithology, and complex in structure. Twenty palaeocurrent determinations show that the clastic sediments were derived from northerly directions, mainly the northwest.

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[1]Trettin, H.P.: Pre-Mississippian rocks of Nansen Sound area, District of Franklin; Geol. Surv. Can., Paper 64-25 (1964).

conglomerate contains fragments of the immediately underlying basement rocks precludes a fault relationship. The basement rocks appear to be low-rank equivalents of the Cape Columbia Complex, which recrystallized in Early Cambrian or Proterozoic time[4].

Upper Ordovician and Lower Silurian Strata of the Southeastern Hazen Plateau

Most of the southeastern Hazen Plateau (loc. 10) is underlain by calcareous siltstone, calcareous lithic arenite, and shale. The lithology, primary structures, and graptolites indicate that these strata are deep-water equivalents of the shallow marine Imina Formation of northwestern Ellesmere Island[1,3], which is mainly Llandoverian. Along the coast of Lady Franklin Bay (e.g. at loc. 9), these strata are underlain, in anticlinal structures, by bedded chert and graptolitic black shale of Late Ordovician age. Both units have been mapped as Cape Rawson "Group"[2], a reconnaissance term.

Position of the Axis of the Franklinian Geosyncline in Late Ordovician and Early Silurian Time

Because of tight folding, and the scarcity of fossils and marker beds, the Cape Rawson "Group" of the Hazen Plateau is not suited for stratigraphic section work. However, the Llandoverian series contains a few per cent of interbedded sandstone turbidites with excellent directional sole markings, a statistical study of which has been made. Figure 2, a preliminary presentation of 1585 readings from 17 stations, indicates that the turbidity currents flowed down a submarine slope in southward directions until they reached a southwestward-plunging trough, in which they were deflected to the southwest, parallel with regional strike.

These data are in agreement with previous studies on the north coast [1,3], indicating that the Middle Ordovician to Upper Silurian strata there are mainly of shallow marine and deltaic origin, and that the clastic sediments in them were derived from an intermittently positive source in the Arctic Ocean region. The fact that the north coast of Ellesmere Island, and the adjacent Arctic Ocean region were intermittently positive is also apparent from the sub-Ordovician unconformity described above, the magnitude of pre-Middle Pennsylvanian erosion in parts of this region, and the northerly provenance of the Middle Pennsylvanian clastic rocks (see below).

The northern limit of the Early Silurian trough has been traced for about 100 miles, but the trough is probably much more extensive. The southern limit has not yet been delineated, but must lie somewhere between the Lady Franklin Bay-Archer Fiord region, and an ancient shelf area in central Ellesmere Island marked by the carbonates of the Allen Bay and Read Bay Formations[5].

[2]Christie, R.L.: Geological reconnaissance of northeastern Ellesmere Island, District of Franklin; Geol. Surv. Can., Mem. 331 (1964).

[3]Trettin, H.P.: Precambrian to Carboniferous rocks of M'Clintock Inlet region, northeastern Ellesmere Island; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 7-11 (1966).

[4]Blackadar, R.G.: The age of the metamorphic complex of northernmost Ellesmere Island, District of Franklin; Arctic, vol. 13, p. 51, (1960).

[5]Thorsteinsson, R. and Kerr, J.W.: Selected areas of Ellesmere Island; Geol. Surv. Can., Map 39-1962 (1962).

[6]Christie, R.L.: Geological reconnaissance of the north coast of Ellesmere Island, District of Franklin, Northwest Territories; Geol. Surv. Can., Paper 56-9 (1957).

[7]Tozer, E.T. and Thorsteinsson, R.: Western Queen Elizabeth Islands, Arctic Archipelago; Geol. Surv. Can., Mem. 332, p. 93-95 (1964).

DISTRICT OF KEEWATIN

8. PRELIMINARY INVESTIGATION OF THE PLUTONIC ROCKS WITHIN THE ENNADAI - RANKIN INLET GREENSTONE BELT

A. Davidson

Two months field work, carried out in conjunction with W.W. Heywood, involved an initial examination of the plutonic rocks within the Ennadai - Rankin Inlet greenstone belt. The area was first mapped on a reconnaissance scale (1 inch to 8 miles) by Lord (1953). This northeast-trending greenstone belt, which is bounded by extensive areas underlain predominantly by gneissic and granitic rocks on the northwest and southeast, contains several isolated granitic plutons. Many of these plutons were examined by reconnaissance ground traverses; others were visited by air.

The main objectives of this summer's work were: 1) to investigate the nature of the plutonic rocks; 2) to establish whether or not there are any apparent similarities between the individual plutonic masses; and 3) to select areas of extensive outcrop that are suitable for more detailed studies. Ground traverses showed that a wide variety of plutonic rock types are present, and that many of the plutonic masses can be divided into units of different composition and age. Rock compositions range from gabbro to granite. Common rock types are hornblende gabbro, hornblende diorite, hornblende biotite tonalite, and porphyritic (K-feldspar) granite. Small masses of pyroxenite, pyroxene gabbro, hornblendite, biotite granodiorite, biotite adamellite, and hornblende syenite occur more locally, but may be present more extensively in areas not yet examined. Veined gneiss and agmatite are locally developed between plutonic masses of different compositions, and age relations can be deduced from these. So far as can be ascertained at present, the basic hornblendic rocks are early in the plutonic sequence, and the true granites are invariably late. Future work will probably be concentrated at first near Gill Lake and especially north and east of Kaminak Lake, where the varied assemblage of plutonic rocks is well exposed. (See Map 53-22 in Lord, 1953, for localities)[1].

Contact relations between the plutonic and country rocks are clear-cut in places where they are exposed. The contact rock is commonly pillowed greenstone or dark green, fine-grained amphibolite. Interbedded metagreywacke, phyllite, and iron-formation are the contact rocks of part of the plutonic complex near Gill Lake. Most contacts are sharp and regionally concordant, but locally some are discordant and steeply dipping. Narrow zones of injection gneiss and migmatite have developed in places. More complex relations are displayed at the southeast side of Kaminak Lake where arcuate bands of gneiss and amphibolite separate different plutonic masses.

Many of the plutonic bodies are composed of fresh and massive rocks; others are deformed and have a secondary foliation developed within them. The deformed plutonic rocks are commonly much altered and contain abundant chlorite and epidote. The deformation of the plutonic rocks is possibly related to folding of a sequence of quartzite beds that occurs in narrow troughs throughout the greenstone belt. This quartzite is mostly white, ripple-marked, and pure. Much of it is deformed into gently plunging, northeast-trending, closed folds. Faults commonly separate the quartzite from the granitic and metavolcanic rocks. In a few places where it is less deformed, the quartzite appears to lie unconformably upon granitic and metavolcanic rocks. At one notable locality just south of Last Lake the quartzite dips shallowly to the southeast and lies unconformably upon a steeply dipping contact between pillowed greenstone flows and altered quartz diorite.

Future work will attempt: 1) to clarify the relations between the various plutonic rocks; 2) to establish the nature of their setting within the greenstones; and 3) to relate their post-intrusive deformation to structures in the country rocks, especially the quartzite.

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[1]Lord, C.S.: Geological notes on Southern District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 53-22, 11 p. (1953).

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9. RANKIN-ENNADAI OROGENIC BELT

W.W. Heywood

Reconnaissance field work was undertaken in about 15,000 square miles of the northeastern end of the Rankin-Ennadai orogenic belt, in southeastern District of Keewatin. Widely spaced flights were made throughout the area in a Cessna 180 aircraft at various altitudes. This preliminary work was directed toward geological, operational and logistical problems for present and future investigations of the region. The stratigraphy, structure, and metamorphic phenomena of the sedimentary and volcanic rocks were examined in several areas and numerous spot landings were made to examine and sample the various rock types.

10. PYRITIC QUARTZ PEBBLE CONGLOMERATE IN THE HURWITZ GROUP, DISTRICT OF KEEWATIN

W.W. Heywood and S.M. Roscoe

The name Hurwitz Group was applied by Wright[1] to white quartzite and associated impure quartzite, greywacke, conglomerate, slate, and dolomite in the District of Keewatin. White- to pink-weathering quartzite that forms prominent hills and ridges is the basal unit[2], although locally it is underlain by conglomerate. Lenses and bands of conglomerate or pebbly quartzite as much as 25 feet thick are interbedded with the quartzite between Padlei and Bray Lake[3] and in the Kognak River area[2,4]. The overlying units of this group outcrop poorly. The total thickness of the Hurwitz Group is not known; however, the basal quartzite ranges from 700 to 4,000 feet thick[2].

During the course of preliminary field work in the Rankin-Ennadai fold belt several areas underlain by rocks of the Hurwitz Group were examined. One sample of a pyrite-bearing quartz pebble conglomerate about 4 feet thick was collected from the Padlei area (96°46'W; 61°46'N). This layer is probably several hundred feet above the base of the unit, but its stratigraphic position is not precisely known. This rock consists of rounded, one-half inch pebbles of quartz and a few of chert and jasper, well-packed in a matrix of quartz, feldspar, sericite, and pyrite. Pyrite comprises 5 per cent of the rock and occurs in discrete grains a few tenths of a millimetre in diameter. Other heavy minerals – rutile, goethite, zircon, apatite, and chalcopyrite – also occur within the matrix and comprise nearly 1 per cent of the rock. No highly radioactive minerals were detected; much of the weak radioactivity in the sample appears to be associated with rutile. The sample contains 0.0013 per cent U_3O_8, 0.0035 per cent ThO_2, and 0.0025 ounces Au per ton*. These amounts are only a few times greater than might be expected in common rocks and two orders of magnitude less than concentrations required in uranium and gold ores. Nonetheless, the occurrence does indicate that concentration processes similar to those that formed Elliot Lake and Witwatersrand ores may have occurred in Hurwitz rocks of the region.

The Hurwitz Group of the southern and central District of Keewatin, the Chantrey Group of the northern District of Keewatin, and the Penrhyn Group of Melville Peninsula have many lithologic similarities and may be of the same age. Their occurrence and distribution are noted in the reconnaissance reports of Lord[3], Wright[1], and Heywood[5,6,7]. Eade[2,4] has made detailed studies of the Hurwitz rocks in the Henik Lakes area.

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*Analyses by Mineral Sciences and Extraction Metallurgy Division, Mines Branch, Ottawa.

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

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

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

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

[5]Heywood, W.W.: Geological notes, Northern District of Keewatin; Geol. Surv. Can., Paper 61-18 (1961).

[6]Heywood, W.W.: Geological notes on Operation Wager, Northwest Territories; Geol. Surv. Can., Paper 66-10 (1966).

[7]Heywood, W.W.: Geological notes on the northeastern District of Keewatin and Melville Peninsula, District of Franklin, Northwest Territories; Geol. Surv. Can., Paper 66-40 (in press).

DISTRICTS OF KEEWATIN AND MACKENZIE

11. STUDY OF THE DUBAWNT GROUP

J.A. Donaldson

Field work during this season, the last in a three-season stratigraphic and sedimentological study, was concentrated in areas of the Thelon Plain underlain by post-volcanic sedimentary rocks of the Dubawnt Group. For most of a one-month period in which a helicopter was available, however, attention was given to regional mapping of two standard 4-mile areas (66 B, 66 C).

The three-fold division of the Proterozoic Dubawnt Group into lower immature red bed sequence, middle volcanic sequence, and upper mature clastic sequence[1] has proven to be practical and geologically meaningful. The three sequences may now be regarded as legitimate sub-groups.

Sandstones of the Kazan and Thelon Formations, respectively belonging to the lower and upper sedimentary sequences, show distinct contrasts in mineralogical and textural maturity, but display many similarities in contained primary structures. Similar depositional environments (fluviatile to shallow marine) are inferred: the contrasts in maturity are attributed to differences in tectonism during sedimentation.

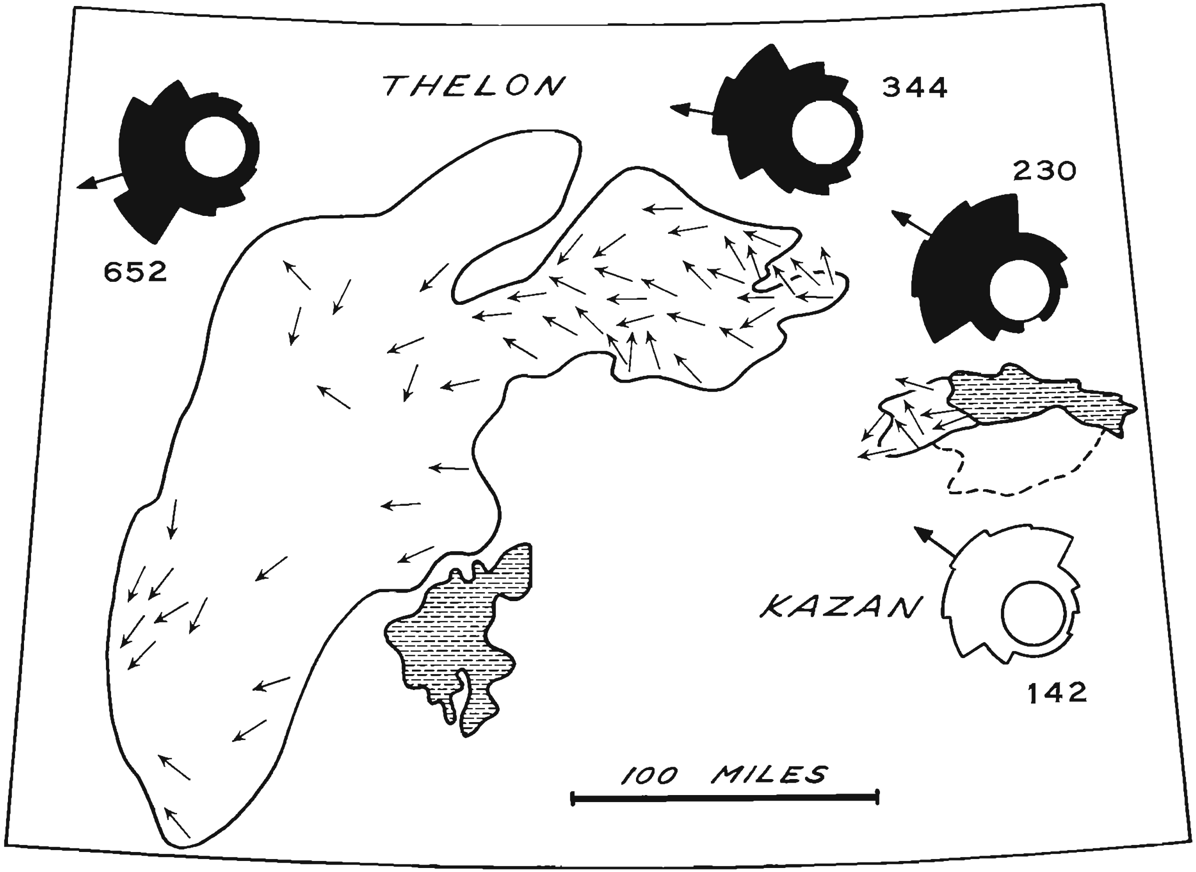
The western edge of the group is in fault contact with basement rocks for much of its length. This boundary fault shows right-hand offset along a major northeasterly trending fault (probably the extension of the McDonald Fault) near Hanbury River.

The area underlain by dolomite, uppermost unit of the Dubawnt Group, has been significantly extended.

The regolith at the base of the Thelon Formation has been recognized in numerous additional localities.

Crossbedding data substantiate and amplify the pattern of transport earlier established for Thelon sandstones. Figure 1 summarizes about half the data in terms of representative station means for the Thelon Formation, and circular histograms for both Kazan Formation (dashed outline) and three sub-areas of the Thelon Formation (solid outline).

Northwestward decrease in clast size for basal Thelon conglomerates corresponds to the palaeocurrent trends deduced from crossbedding.



Donaldson

Figure 1. Dubawnt Group palaeocurrents.

Distributions of clast long axes in pebble beds of the Thelon Formation commonly are bimodal, with modes parallel and perpendicular to current direction inferred from crossbedding.

Downcurrent directions for current-ripple marks in the Thelon Formation show greater variability than crossbedding azimuths, but generally conform to the overall pattern. Symmetrical ripples show much greater variability, but locally are parallel to current i.e. their crests are normal to crestal trends of associated asymmetrical ripples. This relationship was observed in many places along the banks of the modern Thelon River, and may prove to be a criterion for recognition of fluviatile deposition.

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[1]Donaldson, J.A.: The Dubawnt Group, Districts of Keewatin and Mackenzie; Geol. Surv. Can., Paper 64-20 (1965).

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12. ESKERS WEST OF HUDSON BAY IN DISTRICTS OF KEEWATIN AND MACKENZIE

J.G. Fyles

A brief survey of eskers in the Dubawnt River-Thelon River region was carried out in mid-August by J.G. Fyles and B.G. Craig, supplementing earlier observations in this area[1,2]. This survey was designed to provide general information about the eskers to serve as background in planning and carrying out more detailed studies.

Aerial reconnaissance from a small float aircraft yielded numerous observations on the composition, form, and topographic relationships of a considerable number of eskers northwest of the Keewatin ice divide. To gain preliminary information on source and distance of transport of the material comprising the eskers, pebble counts of the surface esker gravel were made at a few sites adjacent to and 'downstream' from distinct changes in bedrock lithology. In connection with these pebble counts, it was noted that distinctive beds of white quartzite north of Schultz Lake contribute less material to the eskers than to adjoining till.

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[1]Fyles, J.G.: Pleistocene features; in Geological notes on central District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 55-13 (1955).

[2]Craig, B.G.: Surficial geology of east-central District of Mackenzie; Geol. Surv. Can., Bull. 99 (1964).

DISTRICT OF MACKENZIE

13. VOLCANIC STUDIES: COPPERMINE RIVER BASALTIC FLOWS

W.R.A. Baragar

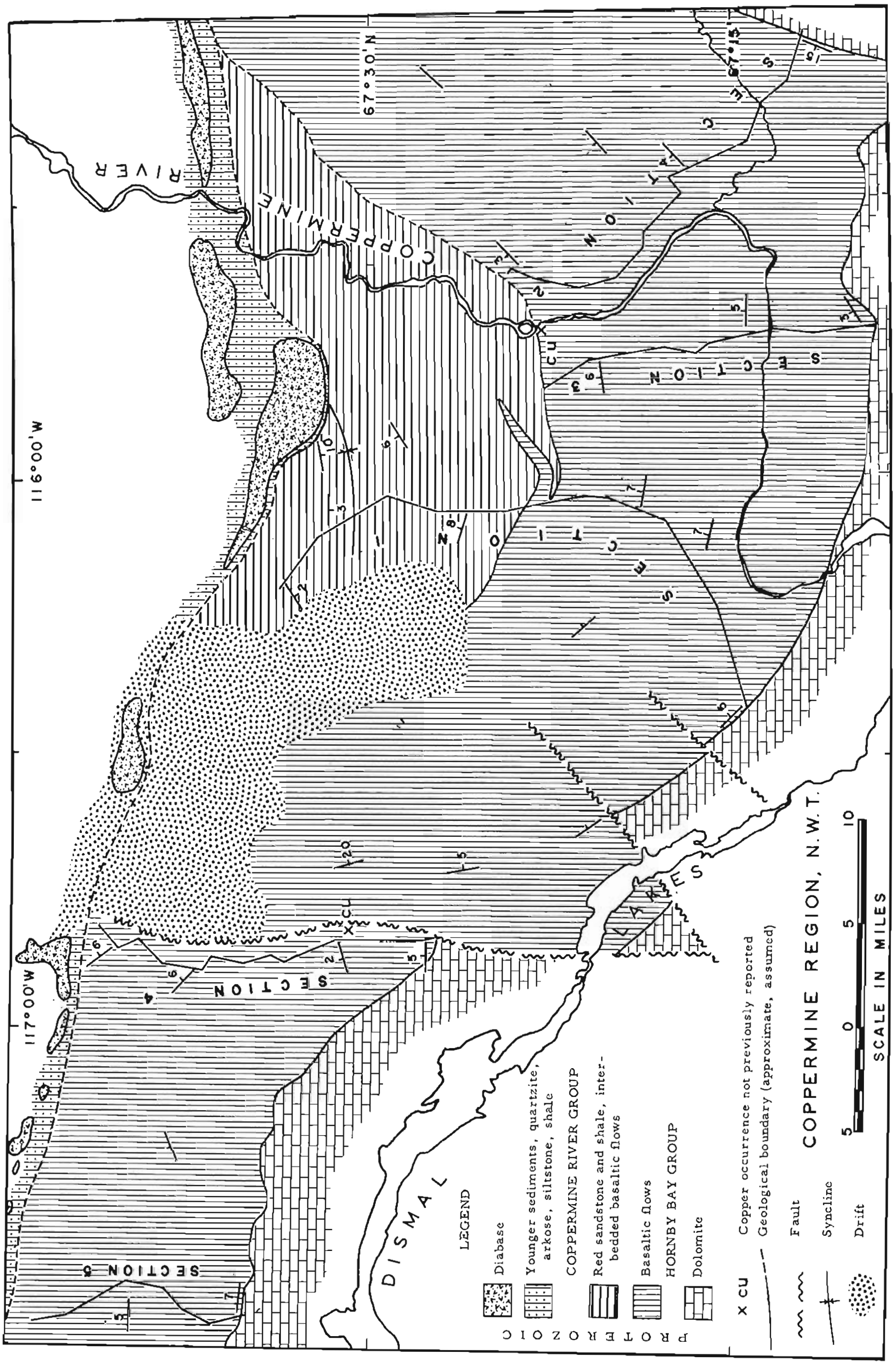
This summer's work on the Coppermine River basaltic flows is a further phase of the study of volcanic rocks in the Canadian Shield being undertaken by the Geological Survey. It contrasts with previous studies in that it involves fresh plateau basalts of middle or late Proterozoic age as opposed to metamorphosed, geosynclinal volcanic rocks of Archean age, but the methods of study are similar and the results should be comparable.

Five profiles were mapped across the Coppermine River Group (Fig. 1) and the lava flows along these were sampled at intervals, where practical, of about 200 stratigraphic feet. Each of the sections was chained and elevations recorded by barometer at 300-foot intervals and at marked breaks in slope. Geological mapping on the profiles was done at a scale of 1 inch to 400 feet. The samples will be analysed for major and minor elements and will be studied petrographically.

The geology of the region containing the five sections is summarized in Figure 1. It is based on the geology of the profiles, reconnaissance between profiles, and on previously published work[1].

The Coppermine River Group rests conformably on Hornby Bay dolomite and dips generally from 1 to 10 degrees northward. It is composed of a lower division of basaltic flows and an upper division of interbedded basaltic flows and red hematitic sandstones and shales. A succession of thin-bedded, light grey quartzites, arkoses, siltstones, and shales overlies the Coppermine River Group unconformably. The unconformity is well defined in the vicinity of the north end of section 1 where a broad, open fold in the Coppermine River Group strikes towards and evidently passes beneath the younger sediments. At the contact the Coppermine River flows and sediments have dips of up to 40 degrees whereas the immediately overlying grey sediments dip north at 3 degrees. Elsewhere the unconformity is less evident, but a diabase sill that intrudes the younger sediments a few tens of feet above their base can be traced across the area in a succession of seemingly isolated erosional remnants and presumably shows roughly the position of the unconformity. On this basis its position has been sketched on the accompanying map.

The Coppermine River Group is a minimum of 12,000 feet thick in the thickest section exposed in this area, section 1. It there comprises a lower 8000-foot thick, volcanic zone and an upper approximately 4000-foot thick, interlayered volcanic-sedimentary zone. The highest stratigraphic level reached is in the trough of the syncline.


LEGEND
PROTEROZOIC
Diabase
Younger sediments, quartzite, arkose, siltstone, shale
COPPERMINE RIVER GROUP
Red sandstone and shale, interbedded basaltic flows
Basaltic flows
HORNBY BAY GROUP
Dolomite
X CU Copper occurrence not previously reported
Geological boundary (approximate, assumed)
Fault
Syncline
Drift
COPPERMINE REGION, N.W.T.
5 0 5 10
SCALE IN MILES
117°00'W
116°00'W
67°30'N
67°15'
COPPERMINE RIVER
DISMAL LAKES
SECTION 5
SECTION
SECTION
SECTION
SECTION
X CU
CU

Correlation of volcanic units from section to section is thought to be possible, but the distinctions upon which they are based are very subtle. A fairly thick zone of volcanic flows at the base of the series appears to have in common a green and purple mottling with distinctive green pyroxene crystals and clusters of crystals. Higher in the sequence a broad zone of massive green lavas can be recognized in all sections. Sparse blebs of native copper in massive basalt seem to mark another distinctive zone at about the stratigraphic centre of the lower member. Petrographic and chemical work should help to define more clearly these and other possible units.

Copper, mainly in the forms of chalcocite, bornite, and native metal, was found in a variety of environments and places in the course of field work. None of these was obviously of economic importance and only two might warrant any further investigation (marked as copper sites on the accompanying map). On Coppermine River a northeasterly striking quartz-carbonate vein as much as 5 inches wide contains scattered masses of native copper. One weighed about 15 pounds. The limits of the vein are unknown. Adjoining section 4 chalcocite float was found in the north bank of a creek at a point where it emerges from highlands to the west into the valley occupied by the fault. The float consists of amygdaloidal basalt, of the type found in flow-tops, heavily mineralized with and in places completely obscured by massive chalcocite. The area in which the float was found is only a few square feet and the amount of float observed is not impressive. The occurrence deserves mention only because of the massive character of the sulphide and its apparent relationship to a flow-top. Elsewhere chalcocite and more rarely bornite and native copper are found in numerous small quartz veins and fractures. In a few places chalcocite and/or native copper are present in minor amounts in amygdules at the tops of flows.

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

14. WHOLDAIA LAKE (75 A)

H.H. Bostock

Mapping at 1 inch to 4 miles employing canoe and foot traverses was begun in 1959[1]. The project was completed during the last two weeks of August, 1966, using a helicopter to set out traverse teams and to search for and check isolated outcrops.

Previously unmapped regions in the central and northern parts of the map-area are mostly extensively covered by glacial deposits and muskeg. These are underlain chiefly by massive and gneissic granitic rocks.

The south-central and western regions previously unmapped are mostly underlain by granitic gneisses and meta-sediments, but medium-grained basic plutonic rocks are prominent locally. These are mostly dioritic to gabbroic rocks, but include some amphibolite and minor gabbroic anorthosite(?) and peridotite(?). A series of small basic bodies extends from Pascal Lake northeast to the northwest end of Selwyn Lake. Disseminated pyrrhotite and some chalcopyrite are visible in rocks drilled at either end of this series.

East of Selwyn Lake, basic sills intrude garnetiferous quartzite. Pyrite-bearing zones are commonly present in the quartzite beneath these sills. Farther east garnetiferous quartzite passes gradationally into foliated granitic rocks. Laminated fine-grained basic rocks, granitic gneiss, and paragneiss are poorly exposed northwest of Striding Lake.

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[1]Taylor, F.C.: Wholdaia Lake West; Geol. Surv. Can., Map 9-1959 (1959).

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15. ITCHEN LAKE MAP-AREA

H.H. Bostock

Mapping of metamorphic rocks of the Yellowknife Group at 1 inch to 4 miles in the vicinity of Point Lake and immediately west of Itchen Lake[1] was completed.

At the western margin of the Yellowknife Group, which underlies the greater part of the map-area, a variable thickness of laminated, fine-grained, basic sediments (map-unit 2 on Figure 1) appears to overlie more siliceous gneisses and granitic rocks (A). Remnants of siliceous paragneiss near the contact are thought to be stratigraphically equivalent to similar

LEGEND

YELLOWKNIFE GROUP (2-6)

6	Chiefly knotted schist and greywacke without gossan-bearing amphibolite zones
5	Chiefly slate, argillite, greywacke with gossan-bearing amphibolite zones or iron-formation; 5a, metamorphic rocks equivalent to 5, chiefly knotted schist and greywacke with gossan-bearing amphibolite zones
4	Conglomerate, some greywacke
3	Massive and pillowed basic volcanic rocks; some schistose to laminated basic sediments; minor acid volcanic rocks (in part of age equivalent to 4 and in part equivalent to 2)
2	Laminated to schistose basic sediments, amphibolite, some massive volcanic rocks
1	Feldspathic quartzite, biotite quartz feldspar gneiss

PLUTONIC ROCKS

B	Hybrid rocks consisting of (a) granitic rocks and remnants of units 2 and 3 intruded by numerous fine-to medium-grained dioritic bodies; (b) remnants of units 2 and 3 intruded by granitic rocks
A	Massive granitic rocks, gneiss, migmatite, some quartzite(?), and amphibolite

Symbols

— — —	Geological contact (approximate)
. . . . .	Geological contact (assumed)
~~ ~~~	Fault
▬	Iron-formation
×	Iron sulphide gossan

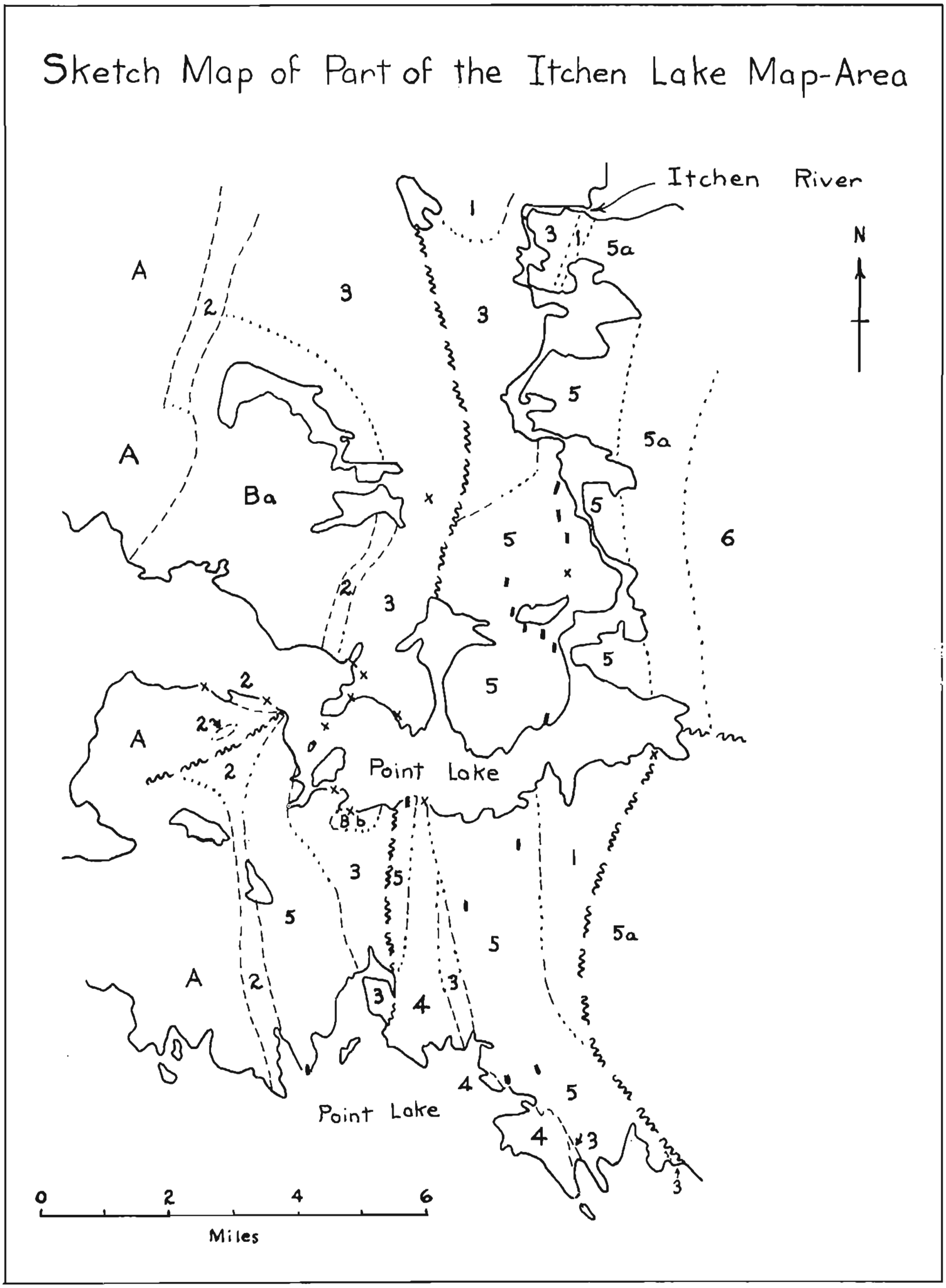
Sketch Map of Part of the Itchen Lake Map-Area
Itchen River
N
A
A
A
A
Ba
Bb
1
2
3
4
5
5a
6
Point Lake
Point Lake
0
2
4
6
Miles

Figure 2
Conglomerate (4) containing a volcanic bomb with chilled margin.

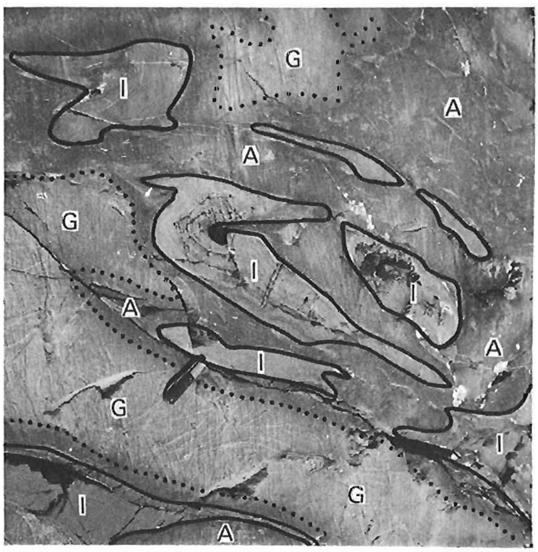

Figure 3
Contorted fragments of disjointed siliceous magnetic iron formation in greywacke. Note that amphibolite (A) along margins of contorted fragments of iron formation (I) is gradational outward into greywacke (G) suggesting migration of iron into greywacke (?).

rocks (1) to the east. A few small bodies of fine-grained, sea-green, light-brown-weathering ultramafic rock (?) are also present near the contact. The basic sediments (2) are overlain by massive to pillowed, dark green greenstones (3) with minor local quartz porphyry. Basic sediments are present within areas of dark green volcanic rock, and medium- to coarse-grained basic sills have been intruded locally.

South of Point Lake the dark green greenstones are overlain by lighter green to grey volcanic rocks (included in unit 3 on Fig. 1), conglomerate (4), and some greywacke (4). The conglomerate is composed mostly of well rounded boulders, cobbles and pebbles, and volcanic bombs (Fig. 2) in a fine-grained greenish matrix. Boulders, cobbles and pebbles are composed chiefly of massive to foliated granitic to dioritic rocks and vein quartz; some granitic gneiss and locally quartzite are represented. The K-Ar age[2] of muscovite from a granitic boulder is 2660 ± 75 million years. Bombs display chilled margins (Fig. 2) and in rare cases are slightly porphyritic.

Slate, argillite, and greywacke (5) near the mouth of Itchen River are thought to overlie the conglomerate and greenstone, but may be in part contemporaneous with them. Thin beds of siliceous magnetic iron-formation typically less than 5 feet thick have been found locally within greywacke-argillite (see Figs. 1 and 3). Since these rocks have been completely folded it is possible that all the iron-formation belongs to one zone about 500 feet thick. Amphibolite is commonly developed along contacts between iron-formation and greywacke, apparently by migration of iron into the surrounding greywacke (?) (Fig. 3). Garnet-bearing amphibolite bodies with associated pyrrhotite appear on strike with, but have not been traced directly into, siliceous iron-formation.

Rocks of all units have been intruded by diabase and gabbro dykes.

Numerous small pyrrhotite-chalcopyrite gossans are scattered through the basic volcanic rocks in the vicinity of Point Lake and to the south. Near the north arm of Point Lake small massive pyrite gossans are present in the volcanic rocks (3). Arsenopyrite (with some gold reported) has been found in association with banded amphibolite southeast of the north arm of Point Lake. Further attention is drawn to the north arm of Point Lake as favourable ground for prospecting by the intersection of two fault zones there: a north-northwest-oriented zone stretching from south of Point Lake to west of Itchen Lake; and a southwest-to-west-oriented zone that may be inferred to extend from the gold-bearing area northeast of Contwoyto Lake to the north arm of Point Lake.

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[1]Bostock, H.H.: Geological notes, Itchen Lake map-area, District of Mackenzie; Geol. Surv. Can., Paper 66-24 (1966).

[2]Age determination by the Isotope Geology Section, Geol. Surv. Can.

16. STUDY OF THE EPWORTH GROUP

J.A. Fraser

Two weeks were spent examining key exposures and sections of Epworth strata in the Rocknest Lake (86 G/NE, H/NW, I/SW, J/SE) map-area. The data obtained confirm and amplify conclusions drawn from observations made by the writer in this region in 1964 and 1965[1].

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[1]Fraser, J.A.: Study of the Epworth Group; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 29 (1966).

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17. MACKENZIE DELTA AND ARCTIC COASTAL PLAIN

J.G. Fyles

Investigations during the 1966 season were concentrated in the southern Eskimo Lakes, East Channel, and Richards Island areas and dealt principally with 1) stratigraphy of the interglacial (?) deposits; 2) the possibility that Richards Island and parts of the "Tuk" Peninsula were not overridden by ice during the last glaciation; and 3) the chronological and ecological sequence recorded by terrace and pond deposits formed since glaciation.

The numerous exposures of interglacial (?) deposits in the Richards Island, East Channel, and south Eskimo Lakes areas consist principally of rather uniform medium to fine sand that locally contains pieces of wood and rare bones of terrestrial vertebrates, and in a few places enclosed beds of organic silt, peat, and plant detritus. On some islands northwest of Richards Island, the deposits are dominantly silty and include marine as well as non-marine materials. Where silts are present, reconstruction of the stratigraphic sequence is complicated by the presence of deformed structures and of segregated ground-ice bodies[1]. Nonetheless, in a few places it appears that the silts lie beneath sands similar to, and perhaps equivalent to, the interglacial (?) sands to the east and south. Reworking of the interglacial (?) sand by glaciofluvial action has also complicated the stratigraphic record, at least in the southern Eskimo Lakes. In this part of the area virtually identical wood-bearing sand occurs above and below the thin till or boulder lag gravel that represents the last glaciation. A wood sample collected in 1965 from interglacial (?) sand in the southern Eskimo Lakes has yielded an 'infinite' radiocarbon date (GSC-491 greater than 39,600 years). Wood from the sand in Ibyuk Pingo at Tuktoyaktuk, dated in an attempt to duplicate the finite radiocarbon age of Müller[2] (Be-49; 28,000 ± 2,000 years), likewise yielded infinite dates (GSC-485 greater than 42,900 years; GSC-486 greater than 37,500 years).

Terrace deposits in several parts of the area, as well as widespread bog and pond deposits provide a record of events since deglaciation and clues regarding the age of glaciation. Terraces bordering the southern part of the Eskimo Lakes[3] include spits and other shoreline features formed around water bodies a few feet to tens of feet above the present lake (sea) level. Some of the sandy spit deposits contain mats of plant material, wood, and small trees, but none of the terrace materials has yielded marine fossils.

Gravel terraces[3] along the East Channel below Tununuk record river levels up to several tens of feet above present water level. Although these deposits contain almost no organic materials, wood and spruce cones were encountered in them at one locality. Sandy terrace deposits west of Richards Island contain numerous shells of marine molluscs and appear to be remnants of an extensive estuarine fill 30 feet above present sea-level. A sample of the shells has yielded an "infinite" radiocarbon date.

Pond and bog deposits exposed in river banks, coastal bluffs, and pingos throughout the area range up to about 20 feet in thickness and include peat, organic silt and clay, and, locally, basal till-like material enclosing lenses of peat. Peat occurring as small pods in such till-like material on Ibyuk Pingo at Tuktoyaktuk yielded radiocarbon dates of 17,860 ± 260 years (GSC-481) and 14,130 ± 444 years (GSC-512).

The deposits that yielded the dated peat from Ibyuk Pingo and the dated marine shells west of Richards Island originated subsequent to glaciation of the parts of the area in which they occur. Thus, if the radiocarbon dates correctly indicate the age of these deposits, this glaciation and the morphologically subdued 'surface' glacial features are older than the last (classical Wisconsin) maximum of the Laurentide ice sheet. In contrast, fresh morainal topography around the Eskimo Lakes and drumlinoid landforms near Inuvik are logically the product of the last Laurentide ice. Possibly, during the last glacial maximum, the ice sheet was separated by the Cariboo Hills into two tongues, one extending northwest along the trough now occupied by Mackenzie Delta proper and Mackenzie Bay and the other northeast along the Eskimo Lakes with its northern (lateral) margin at the hilly moraine immediately north of the lakes.

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[1]Mackay, J.R.: Segregated epigenetic ice and slumps in permafrost, Mackenzie Delta area, N.W.T.; Geograph. Bull. (Can.), vol. 8, No. 1, pp. 59-79 (1966).

[2]Müller, Fritz: Analysis of some stratigraphic observations and C14 dates from two pingos in the Mackenzie Delta, N.W.T.; Arctic, vol. 15, pp. 278-288 (1962).

[3]Mackay, J.R.: The Mackenzie Delta area, N.W.T.; Dept. Mines and Technical Surveys, Geograph. Br. Memoir 8 (1963).

18. STRATIGRAPHY, SEDIMENTOLOGY, AND PALEOCURRENTS IN THE EAST ARM OF GREAT SLAVE LAKE

P.F. Hoffman

A study of Proterozoic stratigraphy, sedimentology, and paleocurrents was begun in the East Arm Fold Belt, Great Slave Lake. Field work was concentrated in the northern and western parts of the area.

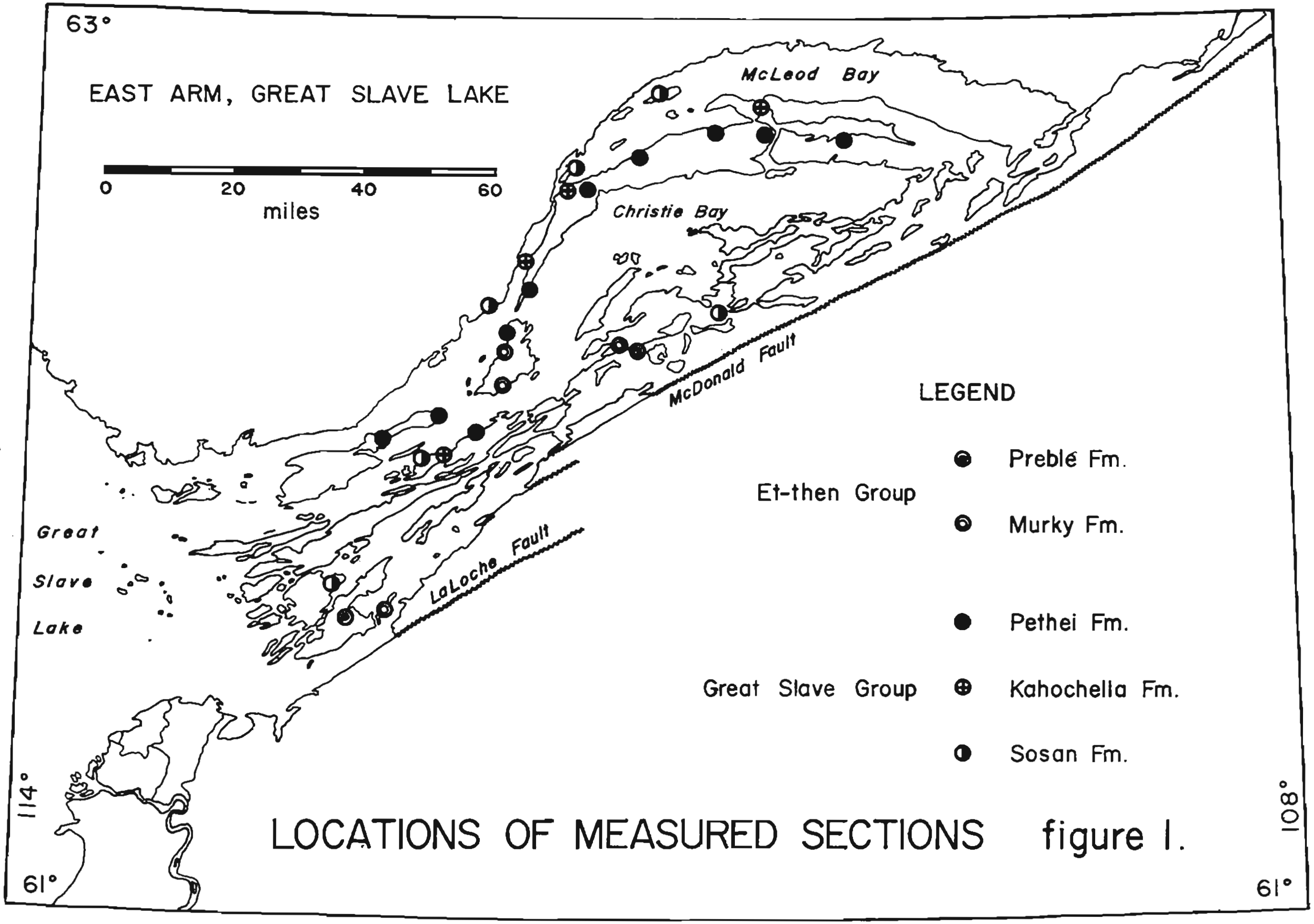
Objectives include refinement of the existing stratigraphic descriptions[1,2], determination of the source areas, dispersal patterns, and depositional environments of the sedimentary fill, and interpretation of the paleogeographic history of the basin.

Stockwell[2] recognized two groups of Proterozoic strata separated by an erosional unconformity. The older Great Slave Group comprised, in ascending order, the Sosan, Kahochella, Pethei, Stark, Tochatwi, and Pearson Formations. The younger Et-then Group consisted of the Murky and Preble Formations. These stratigraphic divisions proved to be entirely satisfactory. All formations are recognizable despite important facies changes, which occur away from the type areas.

Figure 1 shows the locations of measured sections, and Figure 2 gives a summary of all paleocurrent data so far collected.

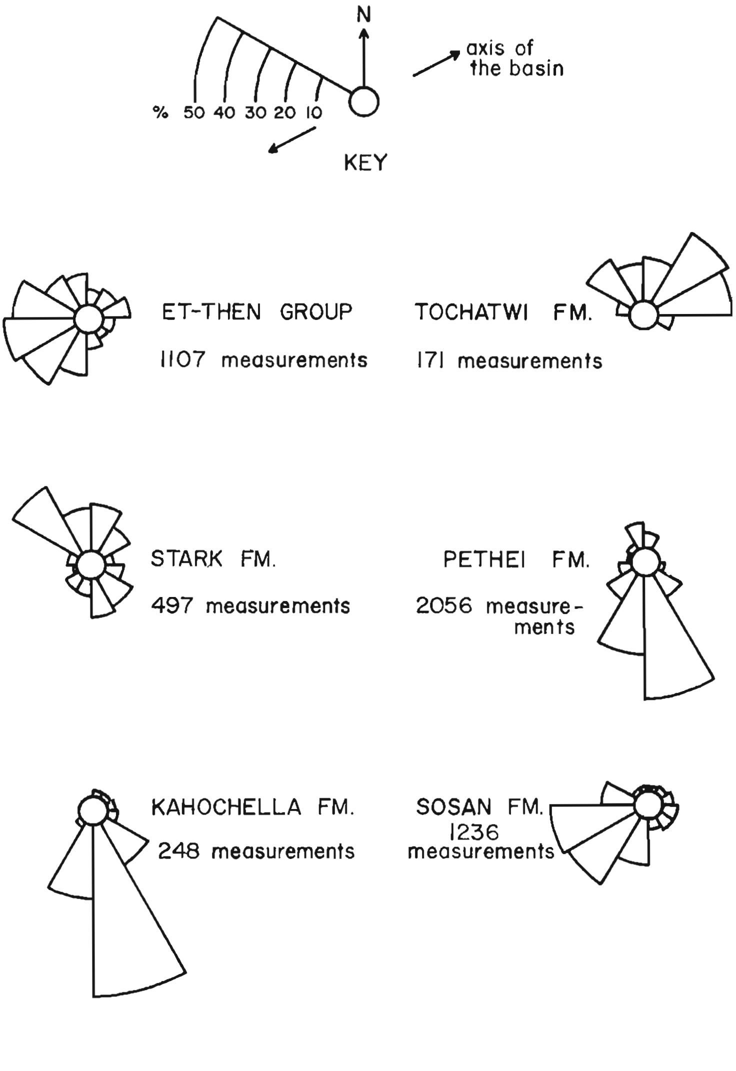
Variations in thickness occur in several formations. The Sosan Formation is less than 100 feet thick west of Sachowia Point on the north margin of the basin, but is more than 4500 feet thick north of Lac Duhamel near the southern margin. The Kahochella Formation, 1100 feet thick on Pethei Peninsula east of Taltheilei Narrows, thickens to the south to nearly 8000 feet near Seton Island because of the addition of volcanic and tuffaceous sedimentary rocks. Four large volcanic vents and part of an exhumed cinder cone were found between Taltheilei Narrows and Utsingi Point. Abrupt variation in thickness of the Murky Formation results from topographic relief of the surface on which it was deposited. The formation is but a few hundred feet thick east of Basile Lake where it overlies the resistant Wilson Island Group (Archean) quartzites, but just 2 miles to the north, along the Murky Channel, it is more than 3000 feet thick where it rests on the easily eroded Kahochella slates.

The probable marine units, the Kahochella, Pethei, and parts of the Stark Formations all yield paleocurrent directions perpendicular to the axis of the basin. The non-marine sandstones of the Sosan and Tochatwi Formations and the Et-then Group were deposited by predominantly southwesterly, northerly, and westerly flowing current systems respectively.



LOCATIONS OF MEASURED SECTIONS figure I.

SUMMARY OF PALEOCURRENTS
East Arm, Great Slave Lake, N.W.T.
figure 2.



Boulders in the Murky Formation, up to 4 feet in diameter on Preble Island, decrease in size exponentially to the northwest away from the major faults along the southern margin of the basin. The Sosan Formation sandstones, however, increase in grain size in the down-current direction, indicating a time transgressive character.

Algal stromatolites occur in the Sosan, Kahochella, Pethei, Stark, and Murky Formations. Diminutive forms are associated with oolitic hematite and chert in the Kahochella Formation, and distinct ellipsoidal, colonial masses from 1 inch to 8 feet in diameter were found in a single red siltstone-shale horizon interbedded with boulder conglomerate in the Murky Formation. Stromatolites are most varied and abundant in the Pethei Formation, ranging from simple oncolites to complex reef-like assemblages up to 150 feet across and 50 feet thick surrounded by very coarse grained, clastic carbonate beds. The strong correlation of stromatolite form to paleocurrent direction was documented by over 2000 measurements from this formation alone. Structures possibly produced by burrowing organisms were found in the Pethei and Sosan Formations, the former associated with extensive deposits containing relict, desiccated algal mats.

Information bearing on the evolution of the Precambrian atmosphere and sea water include the occurrence of rocks of the "red bed facies", deposits of oolitic hematite of the "Clinton type", the presence of crystal casts of penecontemporaneous gypsum in the Kahochella Formation, and the occurrence of halite crystal casts at many horizons in the Stark Formation as first reported by Stockwell[1].

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[1]Stockwell, C.H.: Great Slave Lake - Coppermine River area, Northwest Territories; Geol. Surv. Can., Summ. Rept. Pt. C, pp. 37-63 (1932).

[2]Stockwell, C.H.: East Arm of Great Slave Lake, east half and west half, Northwest Territories; Geol. Surv. Can., Maps 377A and 378A (with descriptive notes) (1936).

19. THUBUN LAKES AREA

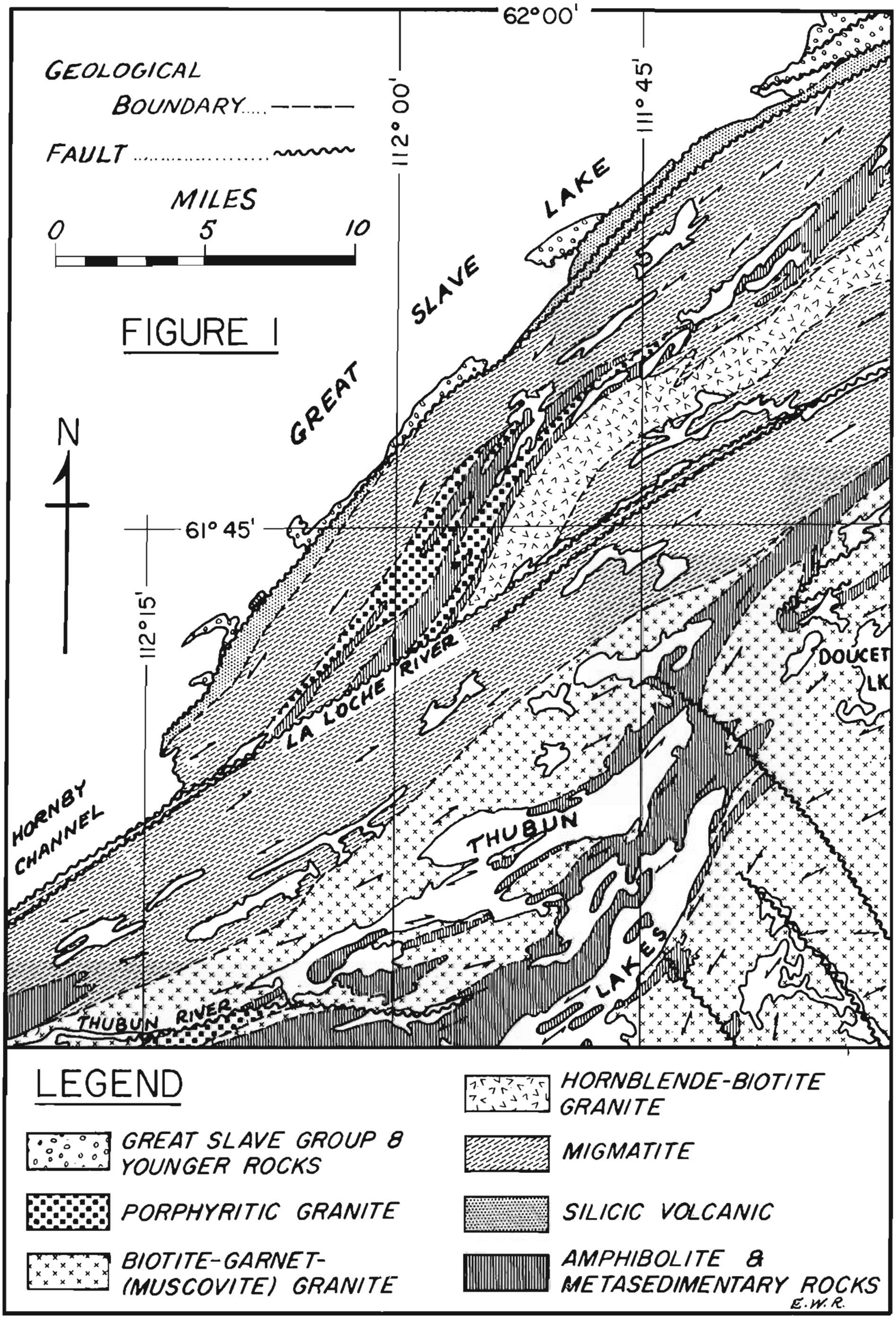
E.W. Reinhardt

Geological mapping was completed this summer in 75 E/12, 75 E/13, and part of 85 H/9. In addition, a brief examination was made of selected parts of the Wilson Island Group [1,2]. The object of the investigations was to obtain data on: 1) the distribution, character, and correlation of metamorphic rocks and migmatites; 2) the extent and type of deformation imposed on these rocks, particularly as it relates to movement along the McDonald and associated faults; and 3) the nature of the boundary between the Slave and Churchill structural Provinces. The generalized geology for most of the examined area appears on the accompanying sketch map (Fig. 1).

The amphibolites in the map-area are typically foliated, medium- to fine-grained, dark rocks that conform with metasedimentary gneisses and schists. Many show compositional layering and a few display relict subophitic textures, good examples of which were found north of the Thubun River. Hornblende-biotite gneisses are associated with some of the amphibolites. The metasedimentary rocks include pelitic gneisses, pelitic schists, minor amounts of marble, and calc-silicate rock. Biotite, garnet, cordierite, and sillimanite were recognized in the quartzo-feldspathic pelitic gneisses. Although the major episode of metamorphic recrystallization of these gneisses is indicated by the association, garnet-biotite-sillimanite, retrograde metamorphism accompanying shearing has produced chlorite and muscovite without the attainment of complete phase equilibrium. The pelitic rocks of South Thubun Lake are predominantly schistose and exhibit much evidence of granulation. Sparse thin layers of marble occur as interbands within the pelitic rocks and amphibolites.

Deformed rocks considered to be metamorphosed silicic volcanics occur as a belt along the south shore of Great Slave Lake. These rocks are composed of quartz, feldspar, muscovite, and chlorite and are similar to some of the rocks included in the Wilson Island Group [1,2] near Petitot Island, west of the map-area. They are partly bounded on the north side by narrow discontinuous zones of a rock consisting of coarse subangular quartz and feldspar fragments in a medium-grained matrix of chlorite and mica. This rock is probably of sedimentary origin, but strong cataclasis precludes positive identification in outcrops. A few bands of granite occur within the silicic volcanic unit. Towards the southwest end of the belt, the volcanics along the southeast contact pass conformably into layered granitic migmatite.

Migmatites composed of major proportions of pink granitic rock interbanded with lesser amounts of amphibolite and metasedimentary gneiss form two broad belts separated by a major fault through La Loche River.


62°00'
GEOLOGICAL
BOUNDARY.....
FAULT
MILES
0
5
10
FIGURE I
N
112°00'
111°45'
61°45'
112°15'
GREAT
SLAVE
LAKE
LA LOCHE RIVER
HORNBY
CHANNEL
THUBUN
LAKES
THUBUN RIVER
DOUCET
LK
LEGEND
GREAT SLAVE GROUP & YOUNGER ROCKS
PORPHYRITIC GRANITE
BIOTITE-GARNET-(MUSCOVITE) GRANITE
HORNBLENDE-BIOTITE GRANITE
MIGMATITE
SILICIC VOLCANIC
AMPHIBOLITE & METASEDIMENTARY ROCKS
E.W.R.

The two belts differ slightly in the type and proportion of nongranitic component. These migmatites display steeply dipping stratiform foliation that strikes northeastward; mylonitization along certain layers prevails throughout the southern belt and along the north side of the northern belt. Amphibolite inclusions were commonly observed in the thicker granitic interbands, indicating that the granitic component was once mobile.

A northeastward-trending concordant body of medium-grained massive hornblende-biotite granite occurs north of La Loche River. At its contacts the granite is gneissic and grades into migmatites, which enclose the mass.

Grey and cream weathering granites occupy a large area south of La Loche River. Near North Thubun Lake they are characteristically grey, medium grained, gneissic, and contain biotite, garnet, and muscovite. Changes to the south include: coarsening of grain size, local disappearance of muscovite and garnet, colour variations with a tendency to weather cream or pink, and local development of pyroxene.

Pink, porphyritic, hornblende-biotite granite extends for an undetermined distance southwest of the map-area. Sill-like masses of this granite exist north of La Loche River. The observed contact relations between this granite and the grey medium-grained type were not conclusive in establishing the relative ages. However, the presence of elongate masses of the grey type in the porphyritic type are interpreted as representing undigested strands rather than apophyses.

For most of the distances along the south shore of Great Slave Lake rocks of the Lower Great Slave Group[1] are in fault contact with the belt of silicic volcanics. In a few places, however, unmetamorphosed sediments of the Great Slave Group unconformably overlie metamorphosed and mylonitized rocks.

The majority of both primary and secondary foliations in the map-area strike northeast and dip steeply. Shallow-dipping stratiform foliation was occasionally observed around the noses of folds, but these are usually obscured by the penetrative secondary deformation related to faulting. The manner in which metasedimentary and metavolcanic rocks mantle and define envelopes about domal masses of granite in the southern part of the area suggests that a period of folding accompanied granite emplacement. The fold structures thus developed are intricate and inconsistent in axial plunge. The difficulty in analyzing the style of folding is further increased by the obliteration of related minor structures through shear, and the possibility that further folding accompanied fault movements. It is also likely, in view of the large proportion of granite, that high-grade metamorphism was contemporaneous with syntectonic granite intrusion.

At least three periods of faulting are recognized in the map-area. The first is represented by major transcurrent dextral movement along northeastward-striking faults such as the McDonald and La Loche River Faults. This intense faulting is marked by extensive mylonitization of rocks adjacent the main breaks, especially where the layering in these rocks was oriented parallel to the major faults. The direction of movement is indicated by gently dipping, northeastward-plunging lineations consisting of quartz streaks on the foliation planes of mylonitic gneisses.

The second period appears to be made up of dominantly upward movements (the south being the upward side) along the pre-existing fractures formed by the earlier transcurrent faulting. This period of faulting is marked by extensive brecciation and evidently followed deposition of the Great Slave Group and younger rocks.

The last period of faulting is marked by vertical fractures that have a northwesterly strike. Displacements are minor and sinistral and many of the fractures formed during this period are occupied by diabase dykes and quartz veins.

Numerous claims were staked in the map-area in 1965 and 1966. Mineralization consists chiefly of pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena. It is likely that faults provided access for the introduction of ore minerals. No new important indication of mineralization was discovered during the course of geological mapping.

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[1]Stockwell, C.H.: Eastern portion of Great Slave Lake (west half); Geol. Surv. Can., Map 377A (1936).

[2]Brown, I.C.: Preliminary map, Fort Resolution, Northwest Territories; Geol. Surv. Can., Paper 50-28 (1950).

DISTRICT OF MACKENZIE AND YUKON TERRITORY

20. SEKWI MOUNTAIN, NAHANNI AND FRANCES LAKE MAP-AREAS

S.L. Blusson

As part of Operation Selwyn begun in 1965, field work was continued in Sekwi and completed in Nahanni and Frances Lake map-areas.

A preliminary map for Frances Lake area has been completed and those for Sekwi and Nahanni map-areas are in preparation.

Sekwi Mountain Map-area

Proterozoic rocks probably correlative in part with the Rapitan Formation of the Mackenzie Mountains central ranges[1] are exposed in southwestern Sekwi area between Intga River and the headwaters of Tsichu River. At least 7,000 feet of shales, siltstone, and fine-grained quartzite are present. The upper beds grade laterally eastward into medium- and coarse-grained orthoquartzite as much as 3,500 feet thick that underlies fossiliferous Lower Cambrian rocks east of O'Grady Lake.

With the exception of the Lower Cambrian, which persists as orange- and grey-weathering carbonate, all younger units to Devono-Mississippian in age change from carbonate to shale facies in the western and southwestern parts of the map-area. Devono-Mississippian strata comprise mainly black shale throughout the region, but contain much quartzite and chert pebble conglomerate west of June Lake.

Several Lower Cambrian sections were studied in detail by R.C. Handfield in Sekwi and Nahanni map-areas (see summary by Handfield, elsewhere in this report).

Nahanni Map-area

Lower Cambrian and older strata are exposed in two broad northwest-trending anticlines in the northeastern part of the area and are correlated with rocks previously mapped north of the big bend in the South Nahanni River[2]. Strata of Middle Cambrian to Devonian age are readily correlated with units on trend in Glacier Lake map-area[1]. Ordovician to Devonian dolomites change facies locally to black shaly limestones and shales, but in a general way become more shaly southwestward.

Much of the black shale assemblage, map-unit (9)[2], originally considered Ordovician and Silurian in age is now known to be Devono-Mississippian. In northeastern Nahanni map-area graptolitic, commonly calcareous black shales are separated from a much thicker sequence of non-calcareous, Devono-Mississippian shales by several hundred feet of light brown silty and shaly limestone containing Middle Devonian fossils. Owing to lack of marker units the extensive shale basin in the western part of the map-area is not readily divisible, but contains much coarse chert pebble conglomerate, characteristic of Devono-Mississippian strata in the adjacent Sekwi and Frances Lake map-areas.

Frances Lake Map-area

The thick assemblage of gritty and feldspathic arenites and shales (map-unit 1) that underlies much of Frances Lake and Nahanni map-areas[2,3] appears correlative with shaly Rapitan-like strata in southwestern Sekwi Mountain map-area, suggesting a westerly source for this material. Unit 1 contains much volcanic detritus in southwesternmost Frances Lake area and in its lower part in Nahanni map-area.

Several localities were visited in the metamorphic units A and C of Finlayson Lake area and unit 7 of Tay River area. Similarities in rocks of these units and unit 1 of Frances Lake area suggest the possibility that they are correlative and differ only in metamorphic grade. Base-metal deposits of the Vangorda region, chiefly developed in unit 7, and those of Frances Lake area in unit 1 likewise have many features in common.

A large body of pyroxenite accounts for the high magnetic anomaly between Klatza and Tyers Rivers, southwest of Frances Lake.

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[1]Gabrielse, H., Roddick, J.A., and Blusson, S.L.: Flat River, Glacier Lake, and Wrigley Lake, District of Mackenzie and Yukon Territory; Geol. Surv. Can., Paper 64-52 (1965).

[2]Green, L.H., and Roddick, J.A.: Nahanni map-area; Geol. Surv. Can., Map 14-1961 (1961).

[3]Blusson, S.L.: Frances Lake map-area; Geol. Surv. Can., Map 6-1966 (1966).

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21. TECTONIC ANALYSIS OF THE NORTHERN CORDILLERA

D.K. Norris and A. Larochelle

In the 1966 field season a project was initiated to investigate the tectonic significance of the changes in structural trend among the mountain ranges of the northern Cordillera. The objectives are threefold: 1) to establish the kinematic and dynamic significance of the structural fabric of the rock mass in relation to these changes in trend; 2) to establish the control of the pre-Laramide shape of the sedimentary basin and its contents on the final deformational pattern in the northern Cordillera; and 3) to establish the sequence of intrusive and extrusive events in relation to orogenesis and epeirogenesis in the area.

Approximately two weeks were devoted to the collection of samples of dykes, sills, and lava flows in sedimentary rocks of Proterozoic and early Palaeozoic age from the Canadian Cordillera between latitudes 58 and 66 degrees north. One hundred and thirty-eight samples were collected from 27 localities. The number of oriented specimens at each locality ranged from 1 to 6, depending on local structural conditions; additional fresh material was collected for radiometric dating and petrographic studies.

YUKON TERRITORY

22. STUDY OF ULTRAMAFIC ROCKS, YUKON TERRITORY

D.C. Findlay

As part of the continuing study of Canadian ultramafic rocks, several Yukon ultramafic occurrences were briefly examined during the 1966 field season, and reference sample suites collected. Areas visited included; Haines Junction (NTS 115A - Dezadeash); Quill Creek and White River (NTS 115G & F E 1/2 - Kluane); and; Dunite Mountain and Tower Peak (NTS 105E - Quiet Lake). Most intrusions examined are sill- or lens-like serpentinized peridotites with minor associated feldspathic rocks. Near Haines Junction, partly serpentinized dunite is poorly exposed. The Dunite Mountain body is about 4 miles by 5 miles in size, roughly oval-shaped in plan and contains mainly partly serpentinized dunite exposed over a vertical distance of 1500 feet. Chromite (magnetic) is common in small lenses and pods and rare chromite layering occurs. No economic amounts of the mineral were noted. At higher elevations within the intrusion, thin, wispy, clinopyroxene-rich bands are rarely present. This intrusion appears to have some of the characteristics of Alaskan-type zoned ultramafic bodies.

23. OPERATION SELWYN, 1966

H. Gabrielse

During the field season reconnaissance mapping was continued in Watson Lake (105 A) and Jennings River (104 O) map-areas as part of Operation Selwyn[1,2] (see also S.L. Blusson and R.C. Handfield in this report).

Further work in Watson Lake map-area has revealed a structural culmination involving strata on and near the Tom Lake lead-zinc showings. The mineralized zones occur in Cambrian rocks including fossiliferous limestone, calcareous phyllite, and phyllite. These rocks are overlain by calcareous phyllites and well bedded platy siltstones, possibly of Ordovician and Silurian age, which are in turn overlain by quartzites, pebble conglomerates, and phyllitic argillaceous rocks of Late Devonian and(?) Mississippian age. In this area strata have been intensely deformed and the sub Devono-Mississippian rocks display a strongly developed strain-slip cleavage and tight northerly trending folds.

In general the stratigraphy in Watson Lake map-area east of longitude 128°30' is similar to that in northwestern Rabbit River map-area[3], whereas the stratigraphy west of longitude 128°30' is similar to that in western McDame[4] and northeastern Jennings River map-areas.

Near Klinkit Lake in Jennings River map-area a sequence of Mississippian rocks includes thick units of bedded chert, well bedded tuff, argillite, fossiliferous limestone, massive mafic volcanics, and conglomerate. These rocks trend southeasterly into Tuya Range, where they are strongly metamorphosed (Oblique Creek Formation)[5].

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[1]Gabrielse, H.: Operation Selwyn; in Report of activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 42-45 (1966).

[2]Blusson, S.L.: Sekwi Mountain, Nahanni, and Frances Lake map-area; in Report of activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 38-41 (1966).

[3]Gabrielse, H.: Rabbit River map-area, British Columbia; Geol. Surv. Can., Map 46-1962 (1962).

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

[5]Watson, K. DeP., and Mathews W.H.: The Tuya-Teslin area, northern British Columbia; B.C. Dept. of Mines, Bull. No. 19 (1944).

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24. SURFICIAL GEOLOGY STUDIES, AISHIHIK LAKE MAP-AREA

O.L. Hughes

Mapping of surficial deposits and a study of Pleistocene stratigraphy of Aishihik Lake (115 H) map-area was initiated. Airphoto interpretation by R.B. Campbell and the writer in advance of field work indicated: 1) well-preserved ice-marginal features marking an advance equivalent to the McConnell advance defined by Bostock[1] in central Yukon; 2) subdued but still distinct features of an older more extensive advance equivalent to the Reid advance of Bostock; 3) poorly-preserved glacial features outside the limit of the Reid advance, indicating still older and more extensive glaciation, possibly equivalent to the Klaza and/or Nansen advances of Bostock.

Field work confirmed the interpretation and showed that at least locally the McConnell advance was two-fold.

In pre-Reid glaciation(s), ice moved generally north-northwest, covering all but the unglaciated northwest extremity of the area, and a few high nunatak areas to the south. Each succeeding advance was more restricted than its predecessor, the McConnell ice being restricted mainly to major valleys. In each of the advances, ice moving north-northwest from southern Yukon Plateau was augmented by ice from St. Elias Mountains to the south, and from cirques in mountains within the map-area.

Well-preserved shorelines indicate that during the McConnell advance, numerous glacial lakes were impounded in tributary valleys by ice occupying major valleys. With ice retreat following the McConnell advance, the valleys now occupied by Sekulman and Aishihik Lakes were occupied by a higher level lake that discharged northward into Nisling River. At the north end of Aishihik Lake, the abandoned shorelines are tilted up to the south at about 6 feet per mile; the tilt increases to about 12 feet per mile at the south end of the lake (aneroid determinations, subject to correction).

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[1]Bostock, H.S.: Notes on glaciation in central Yukon Territory; Geol. Surv. Can., Paper 65-36 (1966).

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25. ENGINEERING GEOLOGY INVESTIGATIONS OF DAM SITES, YUKON TERRITORY

E.B. Owen

The lack of stream flow during the winter months is an important factor in planning the construction of a hydroelectric power installation in Northern Canada. Any dam designed to produce hydroelectric power must have adequate storage to provide sufficient water during these periods of low water.

Two dam sites have been tentatively selected as possible sources of hydroelectric power for the Vangorda Creek - Ross River area, where recent mineral exploration has indicated large orebodies may exist. One site is located at Five Finger Rapids on Yukon River and the other at Granite Canyon on Pelly River. There is sufficient water in Yukon River for the Five Finger Rapids installation, but the cost of this project would be greatly increased because of the necessity of relocating the community of Carmacks, the bridge over Yukon River, and part of the Whitehorse-Dawson road.

The quantity of water available for an installation at Granite Canyon is less than half that at Five Finger Rapids. This deficiency could be overcome in part by increasing the height of the dam and by constructing storage dams on some of the streams tributary to Pelly River.

Field work during the 1966 season consisted of examination of two storage dam sites on Lapie River (Upper and Lower Lapie Canyon sites) and one on Ross River (Prevost Canyon site). The Lapie River sites are located on the southwest side of Tintina Trench. The Upper Canyon site is situated on the edge of the Trench where Lapie River flows out of Pelly Mountains, and the Lower Canyon site about 5 miles downstream on the floor of the Trench. Bedrock at these sites is not considered suitable for foundation or abutment material. At the upper site it consists of intensely deformed shales and phyllites, which are cut by numerous small faults and at the lower site of highly weathered limestone. Bedrock at Prevost Canyon site consists chiefly of massive sandstone and quartzite, which should be satisfactory for dam construction.

26. PLEISTOCENE GEOLOGY, SNAG-KLUANE LAKE, SOUTHWESTERN YUKON

V.N. Rampton

The second year of field studies was devoted to the establishment of a Pleistocene chronology and development of a technique for meaningful quantitative description of glacial moraines within an area in the southwestern Yukon defined by longitudes 140°30'W and 141°00'W, and by latitudes 61°30'N and 62°45'N.

Techniques of slope analysis were carried out on three moraines of pre-Hypsithermal age and on two moraines of Neoglacial or post-Hypsithermal age, to test the feasibility of these techniques for differentiating the extent of different ice advances, approximating the age of moraines that are older than the limit of radiocarbon dating, and correlating moraines from different montane areas. The most effective technique involved the measurement of slope at 200 points within a 4,000,000 square foot morainic area with no external drainage.

A reconnaissance of the Neoglacial moraines adjacent to the snouts of the Klutlan and Natazhat glaciers was carried out to assess the feasibility of lichenometric and dendrochronologic techniques in dating these moraines. These Neoglacial moraines range in age from the present to less than 1400 years B.P. The latter date is based on the relationship to a volcanic ash dated at 1400 B.P.[1]. This same volcanic ash has buried and killed extensive areas of trees in its area of maximum thickness near the Natazhat glacier. Dead tree stumps were noted at elevations 300 feet higher than the present tree line. A sample of the volcanic ash was collected for E.B. Owen for testing as a component of concrete.

Several days were spent attempting to unravel the stratigraphy of a badly slumped and covered exposure on the west bank of the White River north of the Alaska Highway bridge. For most of the exposure length a unit of unweathered till is overlain by peat and underlain by highly weathered till and gravels. Along one portion of the section there is a suggestion of a 'mud-flow' deposit between the weathered and unweathered till; it contains organic materials as well as angular stones of local lithology.

Organic materials were collected for radiocarbon dating from localities where Neoglacial till overlies organic strata containing the volcanic ash dated at 1,400 years B.P., from the base of peat sections immediately overlying late Wisconsin tills, from till sections having peat stringers drawn up into their base, and from 'mud-flow' deposits containing logs and layers of organic material.

At several localities ash layers stratigraphically lower than the ash dated at 1,400 years B.P. have been collected for chronologic studies of Yukon ash falls by O.L. Hughes.

In a valley bottom north of the limit of glaciation, 18 feet of inter-stratified woody peat and silt (the former predominating) overlie 12 feet of a gyttja having a high shell content.

Regional variations in altitude of the highest occurrence of glacial erratics suggest that the most extensive ice-sheet sloped to the northwest. An anomaly in the height of erratics on the flanks of the Shakwak Valley was found near the White River bridge. Those on the southwestern flanks were approximately 1000 feet higher than those on the northeastern flank.

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[1]Stuiver, M., Borns, H.W., and Denton, G.H.: Age of a widespread layer of volcanic ash in the southwestern Yukon Territory; Arctic, vol. 17, pp. 259-260 (1965).

BRITISH COLUMBIA

27. STRATIGRAPHY, PALAEONTOLOGY, AND PALAEOECOLOGY OF THE BURGESS SHALE

J.D. Aitken, W.H. Fritz, and H.B. Whittington*

The main objectives of the investigation in 1966 were to determine whether anything remains of the beds that have yielded the unique and famous fossils of soft-bodied animals, and if so, to develop efficient methods for obtaining a large, complete collection.

At the site of Walcott's quarry, about 400 cubic feet of beds representing a stratigraphic thickness of 12 feet was removed bed-by-bed and examined exhaustively. In the lower half, which corresponds to the phyllopod bed[1], it was possible to recognize each of the fossiliferous layers described by Walcott[1]. Large numbers of well-preserved impressions of soft-bodied forms were recovered from the fossiliferous layers. These include nearly all of the genera recorded by Walcott, and possibly one or more new forms. The fossiliferous layers persist laterally into ground that can be quarried by the methods used this year, and it should be possible next year to obtain much larger collections.

Preliminary quarrying at Raymond's locality, about 70 feet above Walcott's quarry, yielded some excellent specimens, including forms not found at the lower quarry. Work will be continued next year at this higher site.

The entire Burgess Shale section, which includes both quarries, was collected in detail for trilobites and microfossils.

The immediate area of Mount Field-Mount Wapta-Mount Burgess was mapped in detail. Although faults preclude the establishment of a direct stratigraphic tie, it will be possible to establish a lithological and palaeontological tie between the 435-foot section in the block containing the quarries and a section of the Stephen Formation studied on the south face of Mount Field.

Large samples were collected for subsequent petrographic and geochemical studies, to be related to the macro-stratigraphy and palaeontology in an attempt to understand the palaeoecology of the Burgess Shale.

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[1]Walcott, C.D.: Cambrian of the Kicking Horse Valley, British Columbia; Geol. Surv. Can., Summ. Rept. 1911, pp. 188-191 (1912).

*Department of Geology, University of Cambridge, Cambridge, England.

28. MCBRIDE (93H) MAP-AREA

R.B. Campbell

Field work during 1966 was done in the southern half of the map-area and in the northern half near the west boundary. Some of the south-western part of the area was mapped previously by Sutherland Brown[1,2], Holland[3], Hanson[4,5], and Johnston and Uglow[6]. The stratigraphy and structure for much of the southwestern part of the area is described in detail by Sutherland Brown[1 and 2]. Original work by the writer is confined mainly to the eastern and northern parts of the southern half of the map-area.

A sedimentary section of late Precambrian and early Palaeozoic rocks, which may exceed 25,000 feet in thickness (see Fig. 1), is exposed in the northern Cariboo Mountains. This section, from the Kaza Group to the Midas Formation, corresponds to that given by Sutherland Brown[2], but the carbonate unit and succeeding shale unit above the Midas Formation have not been previously described. The newly recognized carbonate unit was found to contain abundant archaeocyathids whereas the Cunningham Limestone has not yielded fossils where its stratigraphic relationships can be determined with certainty. This leads to the speculation that Sutherland Brown[2] and the writer[7] have inadvertently mapped the two carbonates as a single unit in the region extending north and southeast from Spectacle Lake. Possibly, however, both the Cunningham Limestone and the younger carbonate unit contain similar fossils, though they are separated by more than 4,500 feet of beds.

The discovery of the younger carbonate permits a tentative correlation of the rocks in the Cariboo Mountains with those in the Rocky Mountains near Mount Robson (Mountjoy[8] and Mountjoy, personal communication, 1966) (see Fig. 1). Grossly, the sections correspond well, and if the correlation is correct this implies that much of the Cambrian quartzite in the Rockies changes to shale to the west.

In the region between Isaac Lake and the Rocky Mountain Trench the strata of the Kaza Group are deformed into large similar folds, which have well developed axial plane cleavage and plunge gently to the northwest. Many of these folds can be traced continuously for more than 30 miles, but cannot be followed far into the thick, incompetent Isaac Formation. Along a line of section from south of Isaac Lake to the mouth of Doré River the attitudes of the axial planes of the folds change continuously. In the south-west folds are inclined or overturned toward the southwest, that is, the axial planes dip northeast. Farther northeast the folds are symmetrical and upright and near the Trench they are inclined toward the northeast with south-west-dipping axial planes. The folds become progressively tighter or more nearly isoclinal from southwest to northeast. In the newly studied part of

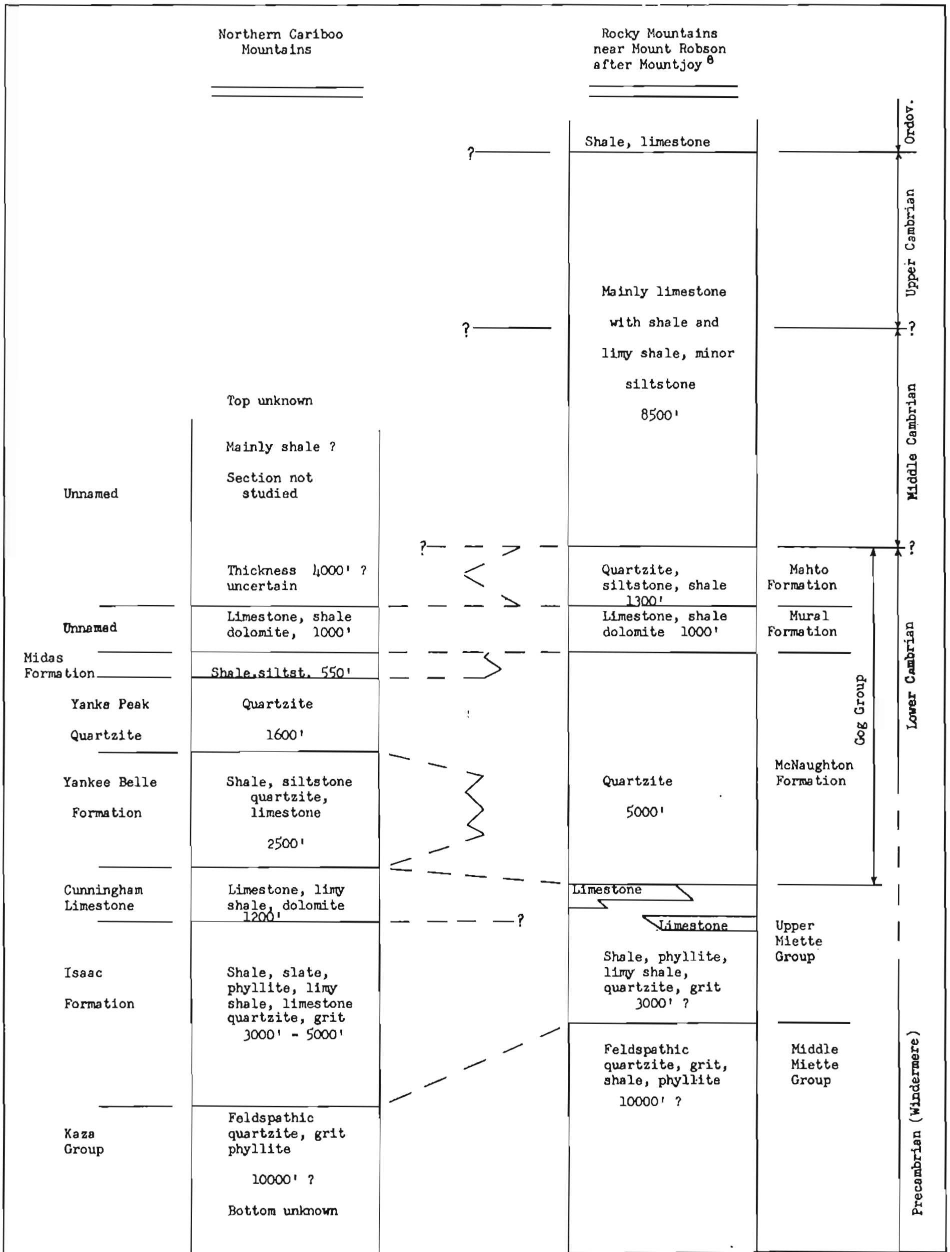

FIGURE 1

Tentative Stratigraphic Correlation

Northern Cariboo Mountains and Rocky Mountains near Mount Robson, B.C.

the map-area the section from the Cunningham Limestone upward is exposed in a narrow belt just east of Isaac Lake, but is otherwise restricted to the region north of Goat River. The prominent folds of the Kaza Group do not extend upward into the younger rocks; they apparently die out in the Isaac Formation and are replaced by a complex series of grabens and horsts developed on a large number of strike faults. Folds are not prominent and such folds as do occur seem to result at least partly from movement of fault blocks. The rocks generally are uncleaved.

The Antler Formation, the upper unit of the Slide Mountain Group[1,2], consisting primarily of pillow basalt, covers a large area north and west of its previously known extent. It extends from Big Valley north to Purden Lake and perhaps beyond, and from 2 to 3 miles east of Bowron River to the western boundary of the map-area.

The only observed indication of mineralization of possible economic interest is a large zone of sparse pyrite with possibly some copper minerals in Antler Formation greenstone, 1.5 miles southwest of the west end of Stony Lake.

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

[2]Sutherland Brown, A.: Geology of the Cariboo River area, B.C.; B.C. Dept. Mines, Bull. 47 (1963).

[3]Holland, S.S.: Report on the Stanley area, Cariboo Mining Division, B.C.; B.C. Dept. Mines, Bull. 26 (1948).

[4]Hanson, G.: Willow River sheet (west half); Geol. Surv. Can., Map 335A (1938).

[5]Hanson, G.: Willow River sheet (east half); Geol. Surv. Can., Map 336A (1938).

[6]Johnston, W.A. and Uglow, W.L.: Placer and vein gold deposits of Barkerville, B.C.; Geol. Surv. Can., Mem. 149 (1926).

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

[8]Mountjoy, E.W.: Mount Robson (southeast) map-area, Rocky Mountains of Alberta and British Columbia; Geol. Surv. Can., Paper 61-31 (1962).

29. MANNING PARK AREA (92H), CASCADE MOUNTAINS

J.A. Coates

Investigation of the Dewdney Creek and Pasayten Groups was continued during 1966, mainly in Manning Park area. These two groups, as mapped by Rice[1], together form a northwest-trending belt of Mesozoic rocks that underlies much of the Hozameen Range of the Cascade Mountains. The biostratigraphic succession in the Dewdney Creek Group has been further defined by the discovery of ammonoid faunas of Early and Middle Jurassic age, referred to the Sinemurian and Bajocian stages respectively[2]. Several distinct Early Cretaceous neritic faunas are indicative of the Hauterivian, Barremian, and Albian Stages[3]. Plant fossils, not yet dated, were found in rocks included with the Dewdney Creek Group on the basis of lithological similarity.

The basin of deposition appears to have been a trough whose borders correspond approximately to the position of the present map boundaries of the group. Centres of volcanism were marginal to the trough, during its early history, and these contributed abundant volcanic debris. The entire Jurassic succession is characterized by 'flysch-type' accumulations of thin-bedded, fine-grained clastic rocks with interbedded greywackes. Lower and Middle Jurassic greywackes are composed largely of volcanic material with some admixture of sedimentary rock. Younger greywackes include also minor amounts of material derived from metamorphic and granitic terranes. The Cretaceous succession in the Dewdney Creek Group is composed largely of thick accumulations of polymictic conglomerate, sandstone, and finer grained clastic rocks that become more arkosic up-section, and are apparently derived from a terrain rich in plutonic rocks.

The Hozameen fault[1], bounding the Dewdney Creek Group on the west, remains relatively little known because of scarce exposure. A small quartz-diorite intrusion, which transects the Hozameen fault was dated by the K-Ar method at 84 ± 6 m.y. The Chuwanten Fault[1] between the Dewdney Creek and Pasayten Groups is a major structural feature, along which rocks of Early and Middle Jurassic and Early Cretaceous age appear as narrow fault slices in a belt from 1 mile to 1 1/2 miles wide. The Gibson Fault, as mapped by Rice[1], roughly corresponds to another broad fault zone characterized by very steep dips together with structural and stratigraphic discordance over a width of up to 1 mile. The synclinorial structure suggested for the Dewdney Creek Group[4] is supported by the distribution of biostratigraphic units, but severe faulting complicated the structural pattern. Lower and Middle Jurassic rocks appear on both flanks of the synclinorium; younger rocks appear on the western flank and in a central anticline, but are apparently absent on the eastern flank; and Lower Cretaceous rocks appear on both flanks and in the central region.

The Pasayten Group is a fault-bounded belt of Lower Cretaceous rocks adjoining the Dewdney Creek Group on the east. Formerly thought to be continental in origin the Pasayten Group was found to be partly marine. The lower part of the section is unfossiliferous but contains carbonaceous seams. The first marine fossils appear 5,000 feet above the 'base' of the group at the bottom of a marine section that thickens northward from 2,000 feet to about 6,000 feet. A few of the marine fossils collected have been assigned an Albian age by Jeletzky[3]. This agrees with the Albian (late Early Cretaceous) age determined by Bell[1] on the basis of plant fossils.

The Pasayten Group, which is about 17,000 feet in thickness, consists mainly of arkose and sub-arkose with minor conglomerate and siltstone. An abrupt change in lithology occurs about 2,000 feet below the top of the section with the appearance of a heterogeneous assemblage of red, poorly sorted sedimentary rocks containing much volcanic material. The red beds are in turn overlain by up to 1,000 feet of grey lithic sandstone and conglomerate derived from a terrain rich in chert, light-coloured fine-grained volcanic rocks and rare plutonic rocks.

Longitudinal faults divide the group into westward tilted fault blocks, which are further dissected by east- and northeast-trending fault systems. Along the Chuwanten fault the Pasayten Group has been severely disturbed, and there vertical or steep easterly dips are common. Strips of sedimentary and volcanic rock of unknown age, greatly different in lithology and attitude from members of the Pasayten Group, lie between the latter and the Eagle Granodiorite to the east.

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[1]Rice, H.M.A.: Geology and mineral deposits of the Princeton map-area, British Columbia; Geol. Surv. Can., Mem. 243 (1947).

[2]Frebold, Hans: Oral communication, 1966.

[3]Jeletzky, J.A.: Written communication, Nov. 1965.

[4]Coates, J.A.: Manning Park area, Cascade Mountains; <u>in</u> Report of Activities: May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 55-56 (1966).

30. CAMBRIAN BIOSTRATIGRAPHIC STUDIES IN THE CANADIAN CORDILLERA

W.H. Fritz

Near Field, B.C., approximately one month was spent on the Burgess project (see also report by Aitken, Fritz, and Whittington elsewhere in this publication). The type Burgess Shale between Mount Field and Mount Wapta was collected for trilobites, which were found at 93 localities. Reconnaissance was done on Mount Stephen and Mount Field to locate a favorable section of the Stephen Formation to be collected in detail next year. Trilobites were collected from 15 localities on Mount Stephen.

One week was spent on Mount Kerkeslin, Alberta, collecting 54 localities representing the Upper Olenellus, Plagiura-Poliella, Albertella, and Glossopleura zones. Collection of equivalent faunas near Sunwapta Peak, Alberta, was also started.

Two weeks were spent at the sites of Walcott's classical Lower and Middle Cambrian localities in Idaho, Utah, and Nevada. Most of the 55 collections made at these sites were stratigraphically allocated. These collections will provide valuable comparative material, aid in interpreting the stratigraphic position of Walcott's published collections, and provide lateral control for the zonation being perfected in Canada.

One day was spent with D.K. Norris collecting a Middle Cambrian fauna on Windsor Mountain, Alberta.

31. QUATERNARY GEOLOGY, COLUMBIA RIVER VALLEY

R.J. Fulton

At the suggestion of the British Columbia Department of Lands, Forests and Water Resources the Geological Survey is undertaking a study of the Quaternary Geology of the Columbia River System with special emphasis being placed on areas to be flooded by Columbia Treaty dams. The purposes of this study are to outline areas that could create problems or hazards after flooding, to provide data pertinent to future development of the Columbia River System, and to salvage areal information regarding the Quaternary history of the areas to be flooded.

Duncan Dam Area, Purcell Trench

Geological examination of the Duncan Dam area - the first reservoir scheduled for flooding - was completed in the 1966 field season. The Duncan Dam is being constructed across the Purcell Trench between Kootenay and Duncan Lakes (50°15'N Lat. 116°57'W Long.). In late-glacial time this part of the Trench was occupied by a series of lakes. The lowest occupied an area slightly greater than Kootenay Lake and had a surface elevation of about 1,790 feet (45 feet higher than Kootenay Lake). The best documented higher lake stood at an elevation of about 1,960 feet and extended north in the Purcell Trench beyond the proposed reservoir. The highest lake level of regional importance stood at about 2,000 feet. There is evidence of higher lake levels, but these appear to have been of local importance only. The lowest kame terraces or other ice marginal features lie between 2,100 and 2,300 feet.

A sequence of Olympia Interglacial[1] silt, sand, and gravel is exposed between two tills in the main borrow pit at the Duncan Dam. These deposits, including a well developed soil, peat, wood, and volcanic ash, appear to have formed in environments comparable to those of all present in the area today. The local base-level, however, was up to 300 feet above the present base-level (Kootenay Lake). Wood from near the top of the sequence has been dated at 32,710 ± 800 (GSC 493) and 33,700 ± 330 (GSC 542).

Columbia River Delta Sedimentation

M.J. Pullen completed the field work for a study of sedimentation at the head of Upper Arrow Lake in 1965. This phase of the Columbia Valley Project was designed to determine the nature, rate, and geometry of sedimentation at the head of Upper Arrow Lake prior to completion of the Columbia Treaty dams.

Sediments of the Columbia and Incomappleux River deltas and adjacent areas of Upper Arrow Lake were sampled and the area criss-crossed with a series of echograms. Analyses of the bottom samples will elucidate the pattern of sedimentation. The echo sounding data is being used to draw up a depth contour map of the north end of the lake. An estimate of the rate of growth of the Columbia River delta will be obtained by comparing this map with one prepared fourteen years ago by the Department of Public Works.

Mabel Lake - Shuswap River Valleys

Investigations of deglaciation of the Mabel Lake and Shuswap River valleys has been undertaken as part of the Columbia project with the objective of correlating the sequence in the Columbia River System with that to the west. G.W. Smith is using this study for a doctorate thesis at Ohio State University, and submitted the following account.

Deglaciation in the Mabel Lake and Shuswap River valleys was characterized by downwasting of isolated bodies of ice within the major valleys. As the ice dissipated drainage was impounded, forming a succession of temporary ice-marginal lakes. Several of these former lake basins were outlined in a general manner by mapping the distribution of lacustrine silt in the main valleys; however, delineation of the different levels of these lakes awaits a careful study of the raised terraces in tributary valleys and analysis of the lacustrine sediment.

Two tills, separated by a variable thickness of outwash gravel and sand, are exposed near Cherryville. A soil zone developed on the lower till contains two (?) layers of volcanic ash and disseminated organic material.

Probable proglacial outwash and interglacial lacustrine deposits are exposed in the valley of Bessette Creek north of Lumby. Three tills above the interglacial deposits probably record minor fluctuations of the last ice to occupy the valley.

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[1]Armstrong, J.E., Crandell, D.R., Easterbrook, D.J. and Noble, J.B.: Late Pleistocene stratigraphy and chronology in southwestern British Columbia and northwestern Washington; Bull. Geol. Soc. Amer., vol. 76, pp. 321-330 (1965).

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32. STRUCTURAL RELATIONSHIPS OF THE METAMORPHIC ROCKS ALONG THE ROCKY MOUNTAIN TRENCH AT CANOE RIVER

C.A. Giovanella

Highly deformed gneissic rocks of uncertain age oocur in the northern Monashee Mountains and adjacent Selwyn Range of the Rocky Mountains. The gross geologic features of the gneissic complex and its enclosing rocks has been outlined by Campbell[1,2], and Price and Mountjoy[3]. Detailed structural studies were begun during the past season to determine the tectonic relationship of the gneisses with the adjacent schists of late Precambrian to Cambrian age.

Within the Selwyn Range, a salient of the gneiss complex is in fault (?) contact with quartzites and schistose clastic rocks of the Cambrian Gog Formation, which pass northeastwardly into pelitic schists and quartzo-feldspathic gritty schists of the late Precambrian Miette Group. The Miette rocks are metamorphosed in the kyanite zone nearest the gneisses, and the grade decreases to the biotite zone within 4 to 6 miles to the northeast.

A host of minor structures in the Miette pelites were observed and recorded. The most prevalent are:

1) small, tightly pressed folds trending southeast and overturned to the northeast;

2) widespread, southwest-dipping cleavage parallel to bedding planes on fold limbs and parallel to axial planes in fold hinges;

3) a later cleavage, also southwest-dipping, but inclined at low to moderate angles to bedding planes;

4) ubiquitous crenulations on schistosity planes, plunging southwest and lying in an approximately vertical plane;

5) gentle "cross-folds" and warps on east-west axes, in the southwestern part of the Miette outcrop area.

The later cleavage, the crenulations, and presumably the open east-west folds, appear to post-date the main metamorphic crystallization.

The gneissic terrane within the Monashee Mountains is a heterogeneous assemblage of schists and gneisses composed mainly of biotite, hornblende, plagioclase, and quartz in different proportions. Lenses of deformed quartz monzonitic augen gneiss containing feldspar grains up to 1 1/2 inches are abundant in some areas.

Up to four phases of deformation are indicated or suggested in the gneiss complex. The earliest episode cannot yet be demonstrated, but is suggested by the discontinuous, lensoid character of the layering in the gneisses, and by minor discordances in the gneissosity, which superficially resemble crossbedding. The second (?) deformation is recorded by a strong southeast lineation in all lithologies, which is marked by mullions, mineral streaks, parallel hornblende prisms, and some minor fold hinges. The next tectonic episode, dominantly post-crystalline, produced numerous folds ranging in amplitude from a few tens of feet (in thicker leucocratic layers) to less than an inch (in micaceous schists). Axes of these later folds are typically inclined at low to moderate angles to the mineral lineation and are probably subparallel to it at many localities. The latest structures are broad open folds on southeast axes, which reverse the areal dips from southwest to northeast.

The late Precambrian Kaza rocks, lying to the south of the gneisses, have not yet been studied in detail. The contact between Kaza rocks and gneiss was seen to be sharply discordant at several localities, and appears to be a low-angle fault plane.

[1]Campbell, R.B.: Canoe River (West Half) map-area; in Report of Activities: Field, 1964; Geol. Surv. Can., Paper 65-1; pp. 43-46.

[2]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).

[3]Price, R.A., and Mountjoy, E.W.: Operation Bow-Athabasca, Alberta and British Columbia; in Report of Activities: May to October, 1965; Geol. Surv. Can., Paper 66-1; pp. 116-121 (1966).

33. SEISMIC INVESTIGATIONS, SOUTHERN BRITISH COLUMBIA

G.D. Hobson

A hammer seismograph survey was conducted near the confluence of Trapping Creek and West Kettle River as part of the drainage studies within the mountain valleys. Four reversed profiles were surveyed to determine the thickness of surficial materials overlying the granite bedrock. Wind and flowing water noise hindered the acquisition of good data. However, an interpretation has been made of the poor quality data so that topsoil overlying gravel overlying bedrock can be defined. The small area surveyed appears to have an overburden thickness not in excess of 25 feet, most of which is gravel.

Two seismic reflection profiles were shot across the Rocky Mountain Trench during August and September. One line paralleled Wolf Creek near Wasa Lake, while the other was shot along the Whiteswan Lake road south of Canal Flats. Both lines were shot under contract and the data have not been processed for presentation at this time.

Seismic refraction profiles will be shot during September - October 1966 across selected valleys within the Okanagan and Thompson watersheds to determine the depth and shape of some of the major valleys and to determine the stratigraphy and history of the unconsolidated fill in these valleys.

34. PRINCE RUPERT - SKEENA MAP-AREA

W.W. Hutchison

Key areas in Prince Rupert map-area were visited during the field season. On Porcher Island the field evidence suggests that gently folded, volcanic strata of map-unit 5[1], are probably equivalent to the more highly deformed and metamorphosed rocks of map-unit 4. Volcanic flows and thinly bedded limestone and chert gently folded about north-south axes can be traced eastwards on Porcher Island till they are more highly deformed by minor northwest-trending small folds. A short distance farther east the rocks are tightly folded, with greater amplitude about northwest axes whose axial planes dip steeply northeast.

Heavy snow in 1964 obscured much detail of the structural relationships between flat-lying migmatite and plutonic rocks in the Alastair Lake region in the southeastern corner of Prince Rupert map-area. With the lack of snow in 1966, the plutonic rock could be seen to form a large recumbent fold about which the rusty weathering gneiss and migmatite form an envelope (see Fig. 1). This confirms that at least part of the western sector of Alastair Lake pluton forms a flat-lying, tongue-like mass, which seems to occupy the core of westerly directed, knappe-like structure.

By contrast, at its eastern margin, Alastair Lake pluton, or a phase of it, intrudes with sharp contacts diorite and dioritized volcanic rocks, into which it sends anastamosing dykes into the country rocks. There is evidence of dilation and the dykes commonly have finer grained margins up to 1 foot wide.

The overall structure of Alastair Lake pluton is therefore similar in a number of respects to Ponder pluton[1], north of Skeena River.

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[1]Hutchison, W.W.: Prince Rupert - Skeena map-area, B.C.; Geol. Surv. Can., Paper 66-33 (in press).

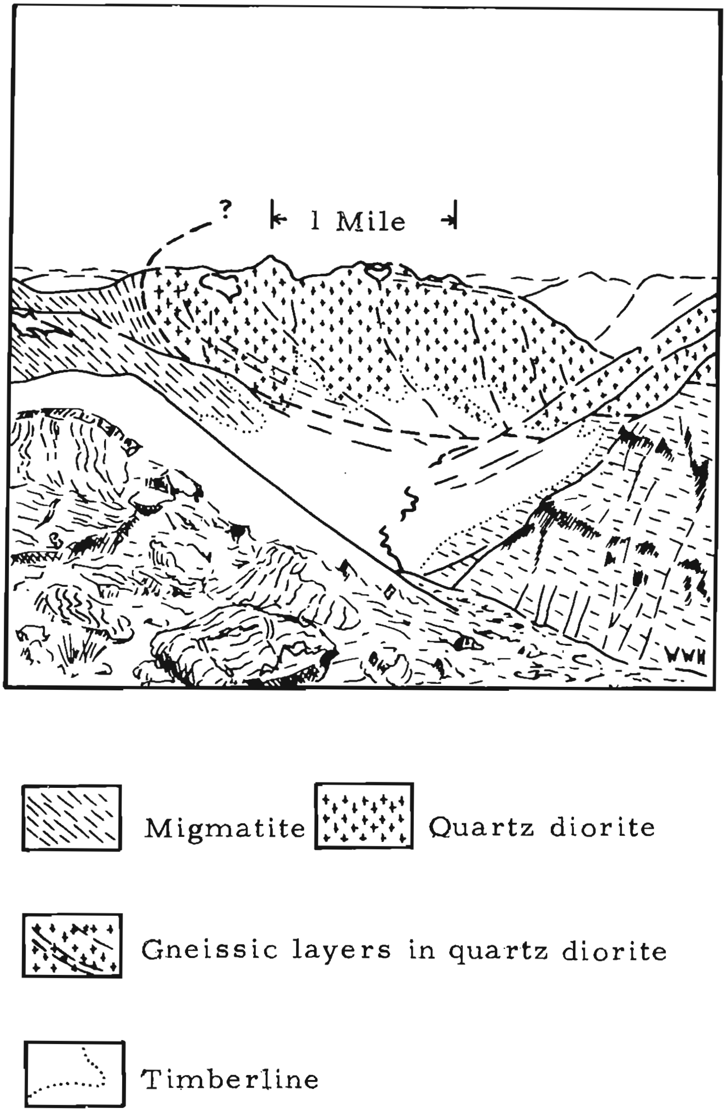

Figure 1. Recumbent structure in quartz diorite with an apparent sheath of rusty weathering migmatite. Migmatite in foreground. Vertical relief on ridge in middle background is 6,000 feet. Sketch made from photograph.

Looking north down Kadeen Creek from a point 4 miles west of the south tip of Alastair Lake.

35. STRATIGRAPHY AND PALAEONTOLOGY OF LOWER CRETACEOUS AND UPPER JURASSIC ROCKS OF TASEKO LAKES (92-O) AND PEMBERTON (92-J) MAP-AREAS

J.A. Jeletzky

Two months of 1966 field season were spent in the continuation of a detailed stratigraphical-palaeontological study of the Lower Cretaceous and Upper Jurassic (Buchia-bearing beds only) rocks of the southern part of Taseko Lakes map-area, and adjacent parts of the Pemberton map-area[1,2,3].

Yohetta Lake - Tchaikazan River area

In the southwestern corner of Taseko Lakes map-area, a thick succession of lower to middle (Homolsomites oregonensis and Simbirskites (Hollisites) lucasi - Speetoniceras cf. agnessense zones) and (?) upper Hauterivian rocks was studied atop an 8,500-foot-high mountain range (Tchaikazan Range) between Rainbow Creek, Tchaikazan River, and Yohetta Lake. The strongly dislocated, incomplete lower to middle Hauterivian succession is at least 2,800 to 3,000 feet thick. These rocks are largely represented by more or less sandy and tuffaceous siltstones, and more or less tuffaceous greywackes with minor interbeds of coarser, tuffaceous clastic rocks, waterlain pyroclastic rocks, and lavas. Their uppermost 500 feet exposed consists mainly of the commonly waterlain, purple and greenish grey volcanic tuffs and breccias with considerable interbeds of poorly rounded and sorted, pebble to boulder volcanic conglomerates, tuffaceous greywacke, and siltstones. Top and base of this succession are invariably cut off by major faults.

An apparently younger, at least 1,000 feet thick succession of middle and (?) upper Hauterivian rocks is largely built of volcanic tuffs, breccias, and conglomerates lithologically similar to the uppermost 500 feet of the above discussed lower to middle Hauterivian succession. The basal 300 feet of this unit consists predominantly of more or less tuffaceous siltstones; they have yielded Inoceramus n. sp., Acroteuthis ex gr. impressa, and Simbirskites (Hollisites) sp. indet. The younger predominantly volcanic beds did not yield any fossils. The top and base of this succession are invariably faulted.

No Barremian, Aptian, or Valanginian strata were observed in any of the sections studied. However, the discovery of large, probably locally derived boulders of greywacke replete with Buchia pacifica suggests the presence of mid-Valanginian marine rocks somewhere in the vicinity.

The widespread Albian rocks were not studied in any detail by the writer. However, Anahoplites yakounense (Whiteaves) was found in the Brewericeras hulenense zone. This is the first authentic record of this species on the mainland of British Columbia.

Spruce Lake - Leckie Creek area

The lower to middle Hauterivian age of a thick siltstone-greywacke succession extensively outcropping along the western shore of Spruce Lake[3] was confirmed. These complexly folded and strongly faulted rocks consist of a cyclical alternation of about equally thick (400 to 600 feet) members of more or less strongly tuffaceous greywacke with often more or less tuffaceous siliceous siltstones and shales. Thin bands and concretions of clay ironstone and impure limestone are common in siltstone and shale members. The exposed thickness of these Hauterivian rocks appears to be in order of 4,500 feet and their complete thickness is almost certainly considerably greater. Their basal member, about 500 feet thick, was found to be built predominantly of the waterlain volcanic tuffs and breccias rather than of a tuffaceous greywacke as formerly thought[3]. The top of the Hauterivian rocks is invariably faulted and the upper Hauterivian beds are believed to be absent.

The often pebbly and gritty, arenaceous coquina limestones and greywackes of Buchia pacifica zone underlying conformably the above described Hauterivian rocks appear to be 600 to 650 feet thick. Approximately 60 feet of fine to medium pebble conglomerate occur in their lower third. What appears to be poorly exposed topmost beds of Buchia tolmatschowi zone (mixed fauna of B. pacifica and Buchia tolmatschowi) is represented by the same rocks at the base of one of the sections of Buchia pacifica zone. In contrast, only shales and siltstones of Buchia pacifica zone have been observed in the northern walls of Leckie Creek canyon, 3 to 4 miles south of Spruce Lake. The neritic facies of Buchia pacifica zone appears, therefore, to grade laterally into a deeper water facies in this direction.

Two thousand feet or more of black Albian shales and siltstones outcrop in Gun Creek valley for about 2 miles upstream from the point opposite the upper end of Spruce Lake and in Leckie Creek canyon.

Relay Mountain area

A probable thrust sheet, exposing about 500 feet of multicoloured Kimmeridgian and Portlandian (?) siltstones, thinly bedded to laminated, with some interbeds of tuffaceous greywacke and grit, occurs on the northwestern slope of Relay Mountain within a large outcrop area of Lower Cretaceous rocks. The lithology and fauna of these allochthonous rocks are quite unlike those of any other contemporary rocks observed in the area.

Strongly dislocated but apparently uninterrupted and complete Hauterivian sections occurring on the northwestern slope of Relay Mountain consist predominantly of dark grey shale and siltstone with bands and concretions of impure limestone. Except for an upper Hauterivian pebble conglomerate, about 200 feet thick, which forms the top part of the succession, these rocks include only minor interbeds of tuffaceous greywacke and fine to very fine volcanic tuff; they are about 1,600 feet thick in contrast to the equivalent rocks of Spruce and Yohetta Lake areas, which are much thicker in spite of their sections being obviously less complete.

The above described changes of thickness and facies of the Hauterivian rocks within Taseko Lakes map-area agree well with the general palaeogeographical setting of Tyaughton Trough postulated by Jeletzky and Tipper[3]. The Yohetta Lake - Tchaikazan River area must have been situated in close proximity to a mountainous tectonic land, which formed its southwestern margin and was intermittently volcanically active during the Hauterivian time. The Spruce Lake area was apparently farther away from this land. Therefore, it received less greywacke and little volcanic sediments as compared with the Yohetta Lake - Tchaikazan River area. The Relay Mountain area, finally, was situated in the central part of Tyaughton Trough and consequently received but little medium to coarse clastic and volcanic deposits, except during the acme of the Upper Hauterivian tectonic phase. Because of the above described facies changes, the Hauterivian rocks of different parts of Taseko Lakes map-area can only be correlated on the palaeontological basis.

A specimen of <u>Mortoniceras</u> (<u>Deiradoceras</u>) sp. found loose on the northwestern slopes of Relay Mountain indicates the presence of Upper Albian rocks there. However, only older <u>Brewericeras hulenense</u> fauna was found in the investigated, largely shaly Albian sections of this area.

Lower Yalakom River area

Several fault slices of <u>Buchia</u>-bearing upper Oxfordian to Upper Portlandian s. str., Upper Tithonian and early to (?) middle Valanginian unmetamorphosed shale and siltsone were found on the western slope of Camelsfoot Range between Ore and Junction Creeks. The almost complete absence of coarser rock types in these sections indicates that the northeastern margin of the late Oxfordian to mid-Valanginian Tyaughton Trough was situated considerably farther eastward than believed by Jeletzky and Tipper[3]. The unfossiliferous coarser clastic rocks interpreted by these workers as the marginal facies of <u>Buchia pacifica</u> zone are probably of the late Hauterivian or Barremian age.

Several thousand feet of apparently unfossiliferous, unmetamorphosed siltstones, greywackes and shales occur east of Buchia-bearing beds in several sections (e.g., in headwaters of Ore Creek). These sedimentary rocks are invariably in a fault contact with the Buchia-bearing beds; they are believed to be mid-Early Cretaceous or Albian in age.

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[1]Jeletzky, J.A.: Stratigraphy and correlation of Late Upper Jurassic and Lower Cretaceous rocks of Taseko Lakes map-area; in Summary of Activities: Field, 1963; Geol. Surv. Can., Paper 64-1, pp. 20-21 (1964).

[2]Jeletzky, J.A.: Palaeontological and stratigraphic studies of Upper Jurassic and Lower Cretaceous rocks in Taseko Lakes (92-O) map-area; in Report of Activities: Field, 1964; Geol. Surv. Can., Paper 65-1, pp. 54-55 (1965).

[3]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 (in preparation).

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36. BIOCHRONOLOGY OF THE LOWER PART OF NANAIMO GROUP (MID-UPPER CRETACEOUS), EASTERN VANCOUVER ISLAND (92F, 92G).

J.A. Jeletzky

Detailed stratigraphical-palaeontological study of several key sections of the Nanaimo Group in Nanaimo and Comox basins was started to assist its mapping by J.E. Muller, which is now in progress.

Results obtained to date necessitate a revision of the palaeontological zonation of the lower part of the Nanaimo Group and the correlation of its individual formations with one another proposed previously by Usher[1].

The following tentative zonal subdivision of the lower part of the Nanaimo Group (Comox, Benson, Haslam, Trent River, and Extension Formations), based on the ammonite and Inoceramus species is suggested (Table I).

This zonal subdivision of the lower part of Nanaimo Group indicates the following correlation of its individual formations in Nanaimo and Comox basins:

1. Benson Formation is approximately equivalent to Comox Formation. However, medium to coarse clastic rocks of the Benson Formation may locally range up to and replace laterally the lower and (?) middle parts of the Haslam Formation (e.g. in Brannan Creek area).

2. The lower part of Haslam Formation is equivalent to the basal part of Trent River Formation.

3. The middle part of Haslam Formation is equivalent to the higher beds of the lower part of Trent River Formation.

4. The sandy and silty facies of the upper part of Haslam Formation (e.g. on Benson (=Brannan) Creek, in Northwest Bay and on Little Qualicum River) appears to correspond to the unfossiliferous or poorly fossiliferous shales of the middle part of Trent River Formation, in part at least. More field work is needed, however, to establish a more detailed correlation of these beds.

5. The Cedar District Formation does not seem to be contemporary with any of the Comox basin beds mentioned under items 2-4 above. It could be either geologically contemporary with the overlying upper part of Trent River Formation exposed on Denman Island or younger. Alternatively, it could be only represented by a hiatus or unfossiliferous conglomerates in the Comox basin. The biochronological data now available are inconclusive and further field work is needed to solve this problem.

Table I. Tentative Zonal Subdivision of Lower Part of Nanaimo Group

International Standard Stages	Regional fossil zones: Nanaimo basin		Regional fossil zones: Comox basin
Lower to	*Inoceramus schmidti* f. typ. (large, flat forms) *Inoceramus* aff. *schmidti* (beds at Blunden Point only)		Unknown Possibly absent because of subsequent erosion
Middle	*Inoceramus elegans* (predominates) *Inoceramus schmidti* (small forms only, less common), *I.* cf. *sachalinensis* (rare)		or (?) non-deposition ? ?
Lower Campanian	*Pachydiscus multisulcatus* *Pachydiscus newberryanus* *Pseudoschloenbachia brannani*		*Pseudoschloenbachia* cf. *umbulazi*
	Pseudoxybeloceras cf. *lineatum*		*Pseudoxybeloceras* cf. *lineatum*
?	*Inoceramus orientalis* *Pachydiscus haradai*	*Bostrychoceras elongatum* *Diplomoceras*? *subcompressum*	Unfossiliferous beds *Inoceramus orientalis* *Pachydiscus haradai*
Upper Santonian and ? older	*Pachydiscus perplicatus* (upper beds only?) *Inoceramus* aff. *japonicus* *Inoceramus* ex aff. *lobatus*	*Inoceramus naumanni* s. lato (rare in upper half of zone)	*Pachydiscus perplicatus* (upper beds only?) *Inoceramus* aff. *japonicus* *Inoceramus* ex aff. *lobatus*
	Non-marine lower parts of Benson and Comox formations		

[1]Usher, J.L.: Ammonite faunas of the Upper Cretaceous rocks of Vancouver Island, British Columbia; Geol. Surv. Can., Bull. 21 (1952).

37. SURFICIAL GEOLOGY, PRINCE GEORGE (93G) MAP-AREA

S.F. Leaming

The exposed surficial deposits in Prince George map-area mainly record the advance and decay of the last Cordilleran ice-sheet and the post-glacial processes. Evidence for possibly older glaciations is found in only a few places. Three till sheets outcrop in the Big Slide on the Fraser River about 10 miles north of Quesnel and on the south bank of the Fraser River at south Fort George. A thick section of silt, sand, and gravel with peat beds exposed in the Big Slide area below the tills may be early Pleistocene or late Tertiary.

Till is the most widespread glacial material in the map-area. In most places it forms drumlinoid ridges of lodgement till, which indicate the direction of ice movement as having been mainly northeasterly. Ablation till also occurs, especially where no drumlinoid ridges are found. Drill holes in the Prince George area have penetrated as much as 100 feet of till, but the average thickness is about 30 feet. Much of the lodgement till has a clay-rich matrix, but silty and sand phases are common. The ablation tills are sandy and gravelly.

Recessional outwash is widespread and consists of eskers, ice-contact deposits, and small areas of deltaic sand and gravel marginal to former glacial lakes. Meltwater channels are numerous and some, occupied by modern streams, were of major proportions. The Nechako, Chilako, and Blackwater Rivers occupy former meltwater channels, as probably does the Fraser River.

Glacial lake deposits up to 300 feet thick are found in many parts of the map-area, indicating large glacial lakes during the glaciation in the northwest corner of the map-area as part of the Vanderhoof basin, in the north as part of the Prince George basin, and in the south as part of the Quesnel basin. The lake deposits consist of thinly bedded (1/4" to 10") silt and clay with sandy facies, and beach deposits along former strand lines. Beaches are best developed on tills along the 2,500-foot contour and this marks the general maximum stand of the level of these large lakes. The clay member of the lake deposits commonly exhibits varve-like beds; as many as 200 beds have been counted in a section near south Fort George. The clay which may be up to 50 feet thick overlies till in most places, but in some places overlies recessional outwash.

38. CRETACEOUS STRATA IN THE WEST FACE OF THE ROCKY MOUNTAINS

G.B. Leech

Cretaceous strata occur in a fault zone in Proterozoic and Lower Palaeozoic strata in the west face of the Rocky Mountains (Stanford Range) near latitude 50°27'N, longitude 115°52'W, 5 miles easterly from Windermere. The occurrence is far to the west, structurally and geographically, of any other occurrence near this latitude.

The exposures are parts of fault slices in a fault zone on the west side of the Redwall fault zone. The northwestern and southeastern exposures are about 5,000 feet apart and the highest exposure is about 500 feet above the lowest one. They were uncovered by bulldozers during a logging operation.

The dimensions of the southern fault slice, as inferred from three exposure localities, from float, and from physiography are: width, up to 300 feet; length, at least 1,500 to 2,000 feet; surface relief, 750 feet. This slice strikes northwest and probably dips steeply southwest. It is faulted on the east against Jubilee (Cambrian) and McKay (Cambro-Ordovician) strata and on the west against Jubilee strata. It pinches out uphill to the south in Jubilee strata; its northern limit is uncertain. It contains the major Cretaceous exposure of the area, a transverse bulldozer cut in which 60 feet of section are exposed well and another 35 feet exposed intermittently. The strata are siltstone (chiefly), fine-grained sandstone, mudstone, in part pebbly, and a 6-foot bed of conglomerate of closely packed pebbles of cherts and quartzites. Coaly plant remains occur throughout.

The central occurrence is 1,500 feet northerly from the limit to which the southern slice can be inferred and it is probably in a separate slice, structurally farther east. It is within poorly exposed Cambro-Ordovician strata and contacts are hidden. There is, in addition to rubble, a 5-foot section of limestone, siltstone, and sandstone that contains coaly plant remains and a shell fauna.

The northern occurrence is 1,500 feet still farther northwest and no outcrops intervene. It is a single exposure of about 5 feet of impure limestone containing plant remains and shells, chiefly gastropods. This slice, which cannot be more than about 100 feet wide, is faulted against Beaverfoot strata (Ordovician-Silurian) on the east and Horsethief Creek strata (Proterozoic, Windermere) on the west. The western fault probably dips steeply west. A preliminary analysis by Dr. S.A.J. Pocock of microflora collected by the writer from this outcrop indicates a late Early Cretaceous age.

Among the salient features of these strata are the dominance of siltstone and mudstone in the largest exposure, and the abundance of chert and quartz pebbles, but paucity or lack of phanerocrystalline igneous pebbles in the conglomerate. Coaly plant remains are ubiquitous and gastropods are abundant in very impure limestone. In spite of their occurrence as fault slices these generally incompetent strata are not intensely and pervasively deformed.

These sediments were deposited far to the west of their present site, and were moved eastward by the thrust faults that are a main structural feature of the Rockies. These exotic chips within Precambrian and lower Palaeozoic rocks must have moved into their immediate position from another structural level, as no other occurrence of Cretaceous strata is known near this region.

Their derivation from a lower thrust plate, which by implication might also contain Carboniferous strata, seems unlikely. The nearest fault with Cretaceous strata outcropping in its footwall is far to the east, in the Front Ranges of the Rockies, and as the thrust faults characteristically cut progressively lower stratigraphically on their footwall down their (original) dip to the west it is unlikely that one of them could still involve Cretaceous strata here. It is possible, however, that the Cretaceous strata at Windermere were brought up from a fault plate whose Cretaceous beds do not outcrop, because of being truncated up-dip by an overlying thrust that, contrary to the usual pattern, cut stratigraphically downward in its footwall in that direction for part of its course.

The presence of east-dipping faults beneath west-facing overturned strata in the Stanford Range east of the Cretaceous rock near Windermere does not imply that the latter may be derived from the eastern part of some thrust sheet that was somehow thrust up "backward" to the west. The writer believes that the westward overturns in the Stanford Range are a consequence of the development of a major fan-form anticline above a zone of decollement during eastward transport far above the structural level of the faults, which in the Front Ranges involve Cretaceous strata.

The Cretaceous strata near Windermere most likely came downward from a higher structural level. The structural distance involved is unknown; there are no other strata that might indicate what the Cretaceous erosion levels were relative to the rocks in which the Cretaceous strata now sit. The intricacy of the mosaic of faults in this area suggests the likelihood of relative vertical movements of different ages and allows for the possibility that even some of the rocks now seen were at one time near the Cretaceous surface.

The examination of a series of palaeontological collections from these strata is now in progress and the results should aid in the interpretation of their palaeogeographic significance.

39. CHILLIWACK GROUP, HARRISON LAKE AREA

B.E. Lowes

The map-area lies east of Harrison Lake and can be subdivided from east to west into three units:

(1) A gently folded assemblage of intermediate flows and pyroclastic rocks with minor limestone and siltstone, containing Jurassic and Cretaceous fossils[1], which form Echo Island, Cascade Peninsula, and the southeastern part of Long Island.

(2) Phyllitic lavas, pyroclastic rocks, derived volcanic greywackes, and intercalated cherts and slaty beds extending from Harrison Lake to Ruby Creek. Coarse-grained sedimentary and pyroclastic members dominate the lower part of this sequence whereas moderately schistose meta-volcanic rocks predominate in the upper part, northeastward from Slollicum Lake.

(3) Medium- to high-grade metamorphic schists and amphibolites occurring east of Ruby and Talc Creeks and between the Chilliwack batholith and the Custer Gneiss, west of the Fraser Canyon. The metamorphic grade ranges from staurolite zone northwest of Cogburn Creek and along the west side of the Custer Gneiss to kyanite-sillimanite zone in the central part of this unit between Garnet Creek, Old Settler Mountain, and the Fraser Canyon. Isograds do not appear to be related to the granitic plutons intruding this unit.

The transition from gently folded Mesozoic strata to the overlying foliated rocks to the east is featured by imbricate structures and elongated fossils marking a zone along which the Chilliwack Group apparently has been thrust westward over the Mesozoic rocks. Strongly schistose zones and small serpentinite bodies along Garnet Creek may mark the northward continuation of the Shuksan Thrust previously defined to the south by Misch[2] and Monger[3]. Planar bodies of serpentine and talc schist on Old Settler Mountain and along Talc Creek possibly mark a further extension of the Shuksan thrust zone to the northwest. The foliation swings from north-northwest in the southern and western parts of the area to westerly in the northeastern part.

At least two stages of deformation are recorded. The early structures are nearly isoclinal shear folds that plunge to the north and north-east. The late folds are upright and trend northwesterly.

Intrusive rocks of several ages are widespread throughout the area, the latest of which is quartz diorite and the Chilliwack batholith of Miocene[4] age. Contact effects of the latter are small.

[1]Crickmay, C.H.: Fossils from Harrison Lake area, B.C.; Nat. Mus. Can., Bull. 63 (1930).

[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., spec. vol. No. 8, pp. 101-148 (1966).

[3]Monger, J.W.H.: Stratigraphy and Structure of the type area of the Chilliwack Group, Southwestern British Columbia; unpub. Ph.D. thesis, Univ. of B.C. (1966).

[4]Baadsgaard, H., Folinsbee, R.E., and Lipson, J.: Potassium-argon dates of biotites from Cordilleran granites; Bull. Geol. Soc. Am., vol. 72, pp. 689-701 (1961).

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40. RATCHFORD CREEK AREA

W.J. McMillan

The area under study covers part of the west flank of the Frenchman's cap gneiss dome[1]. Work begun in 1965 was continued and extended eastward across Perry River valley.

It is concluded that early nearly isoclinal folds, with axial planes almost parallel to the foliation, were deformed about southeast-trending steeply dipping axial planes during a later episode of tectonic activity. Moreover structural features are continuous across the Perry valley.

Unit A gneiss[1], which was thought to grade laterally into unit D rocks[1] on the basis of last season's work[2], is now considered to be a separate unit. It occupies the cores of some of the early folds and was involved along with unit D rocks in the later deformation. In the northern part of the area the unit D/unit A boundary is marked by a prominent zone of quartzite. Southward, the quartzite thins but continues as far as mapping was extended. Near the ridge crest west of the Perry River, a fairly extensive layer of weakly to well foliated nepheline-bearing syenitic rocks structurally overlies the quartzite. The layer, which is exposed for a strike length of about 5 miles, pinches out to the south.

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[1]Wheeler, J.O.: Big Bend map-area, British Columbia; Geol. Surv. Can., Paper 64-32 (1965).

[2]McMillan, W.J.: Cordilleran structure project: Ratchford Creek map-area; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 74 (1966).

41. ATLIN HORST PROJECT

J.W.H. Monger

Investigation of the stratigraphy and structure of late Palaeozoic and early Mesozoic rocks of the Atlin Horst[1] was begun in 1966, with detailed mapping in the northeastern part of Dease Lake (104J) map-area. The ultimate object of this study is to establish a reference section for late Palaeozoic rocks in northern British Columbia.

The structurally lowest, and apparently oldest sequence, whose base is not recognized, consists of silica-rich phyllites and slates, grading locally into thin-bedded cherts with slaty partings or chloritic schists. However, greywackes and volcanic sandstones locally interbedded with these phyllitic rocks are lithologically undistinguishable in hand specimens from Lower Jurassic clastic rocks[2,3], exposed south and southeast of the area studied. In addition, recrystallized, unfossiliferous, locally argillaceous limestones are present towards the top of the sequence, and at the top, thin-bedded, buff-weathering cherts predominate.

These rocks are conformably overlain by greenstone and volcanic rocks, or, less commonly, by limestone. The limestone is typically recrystallized, locally dolomitic, and the upper part is composed largely of crinoid and brachiopod fragments, and contains a fusulinid fauna composed mainly of large schwagerinids, which is probably of mid-Permian age. Maximum apparent thickness of the limestone is 300 feet. The volcanic rocks, which in places gradationally overlie this limestone, are maroon to green, aphanitic flow rocks, locally containing jasper, and maroon, foliated lithic tuff and agglomerate. This volcanic sequence varies considerably in thickness, but has a maximum apparent thickness of about 2,000 feet.

Upper Permian limestone, characterized where primary textures are preserved by limestone breccia or thin-bedded aphanitic, siliceous limestone featured by graded bedding, load casts, and injection structures, overlies and typically is gradational with the underlying volcanic rocks. In general, where this limestone is pure, it has been recrystallized and these primary textures are apparent only where the limestone has been partly dolomitized or silicified. Fusulinid faunas consisting predominantly of neoschwagerinids are locally abundant. The apparent thickness approaches 2,000 feet, but in general is much less than this.

Conformably above this limestone is a sequence, at least 3,000 feet in thickness. Its lower part consists of chert and interbedded phyllite or slate and foliated grey-green tuffs containing local limestone lenses, and it grades upwards into massive greenstone and pillow lavas that apparently are the youngest rocks present in the Atlin Horst in the area studied.

Minor structures in these rocks result from two periods of deformation. The earliest secondary structures in thinly bedded cherts and phyllites are tight, nearly isoclinal folds, with an axial plane cleavage parallel to the foliation of the phyllites. Minor folds are rarely observed in the more massive volcanic rocks although tuffs and agglomerates have a foliation that is sub-parallel to bedding. Chert folia present in massive limestones in places outline flow folds. Orientation of fold axes of these early minor structures is variable, but no consistent pattern to this variation has been recognized. These early structures are deformed by irregular asymmetrical minor folds that are locally associated with strain-slip cleavage and minor reverse faults. Trend of the later structures is approximately N60°W and the distribution of major stratigraphic units appears to be largely controlled by these structures.

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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] Gabrielse, H., Souther, J.G., and Roots, E.F.: Dease Lake map-area, British Columbia; Geol. Surv. Can., Prel. Map 21-1962 (1962).

[3] Gabrielse, H.: Cry Lake map-area, British Columbia; Geol. Surv. Can., Prel. Map 29-1962 (1962).

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42. PINE PASS AREA

J.E. Muller

About 4 weeks in August and September were spent in the Pine Pass area to re-examine exposures to be flooded by the Peace River dam and to review some questions raised since the publication of preliminary map 11-1961[1]. Changes made since 1961 are incorporated in the accompanying table and briefly discussed.

Lower Cambrian limestone, sandy dolomite, and quartzitic sandstone with Archeocyathus of the Misinchinka Range are now known to overlie black slates and quartzites of the Misinchinka Group. They are roughly correlative to the basal Cambrian quartzite of the Murray Range and to the Gog Group of the Mount Robson area. It is still conceivable that unfossiliferous limestone of the Mount West and adjacent areas represent an older Precambrian limestone within the Misinchinka Group.

PINE PASS AREA: FORMATIONS OF ROCKY MOUNTAIN TRENCH, ROCKY MOUNTAINS, AND FOOTHILLS

SYSTEM (U=UPPER, M=MIDDLE, L=LOWER)	GROUP	FORMATION (tentative correlations in brackets)	STAGE	LITHOLOGY	THICKNESS
TERTIARY		SIFTON	EOCENE TO PALEOCENE	sandstone, sand, shale, clay, conglomerate	700' +
U.CRETACEOUS		DUNVEGAN	CENOMANIAN	sandstone, coarse- to fine-grained, minor shale	300 - 1,200
L.CRETACEOUS	FORT ST. JOHN GROUP	CRUISER	LATE ALBIAN	shale, ironstone concretions; some sandstone	350 - 800
		GOODRICH		sandstone, finegrained, minor shale	100 - 1,350
		HASLER	MIDDLE ALBIAN	shale, silty, with ironstone concretions; some sandstone	500 - 900
		COMMOTION		sandstone, interbedded with shale; sandstone, conglomerate	1,100 - 1,600
		MOOSEBAR		shale, ironstone concretions, sandstone, glauconite	100 - 1,000
	BULLHEAD GROUP	GETHING-(CADOMIN)	ALBIAN TO HAUTERIVIAN	sandstone, siltstone, shale, carbonaceous, coal; quartz-chert grit and minor conglomerate	1,000 - 3,000
		MONACH-BEATTIE PEAKS	LATE TO MIDDLE VALANGINIAN	sandstone, siltstone, shale; mainly sandstone in Monach; mainly shale in Beattie Peaks	0 - 400 600 - 1,400
		MONTEITH	EARLY VALANGINIAN TO BERRIASIAN	sandstone, in part quartzitic, minor shale	to 2,500
U. JURASSIC	FERNIE GROUP	(PASSAGE-POKER)	PORTLANDIAN (AND OLDER)	shale, shaly siltstone	900
L. JURASSIC		(NORDEGG)	SINEMURIAN	limestone, cherty, calcareous shale	150
U. TRIASSIC		PARDONET "GREY BEDS" (BALDONNEL-CHARLIE LAKE-HALFWAY)	NORIAN-KARNIAN-LATE LADINIAN	limestone, shale and siltstone, calcareous limestone, dolomite, sandstone, calcareous	500 - 750 800 - 1,100

M. TRIASSIC L. TRIASSIC	LIARD- TOAD- GRAYLING	LADINIAN- ANISIAN SCYTHIAN	siltstone, calcareous, minor shale	1,400 - 2,200
PERMIAN ?	(FANTASQUE)		chert, thick-bedded to massive	10 - 120
MISSISSIPPIAN	STODDART	CHESTERIAN	limestone, shaly, and calcareous shale minor chert	0 - 430
	PROPHET-RUNDLE (BANFF ?)	MERAMECIAN- OSAGEAN	limestone, massive, limestone shaly, black chert, minor shale; lower 550 feet thin bedded and more silty, shaly "Banff"?	to 2,300
U. DEVONIAN	BESA RIVER	KINDERHOOKIAN- FRASNIAN	argillite and shale, black, in part calcareous, thin limestone beds	?
M. DEVONIAN	(RAMPARTS)	GIVETIAN EIFELIAN	limestone, shaly, interbedded with calcareous shale	600 +
L. DEVONIAN-	(MUNCHO- (McCONNELL-)		dolomite, partly siliceous; dolomitic sandstone	900 - 2,175
SILURIAN U.ORDOVICIAN M.ORDOVICIAN	(RONNING) (WONAH)		quartzite, siliceous quartz sandstone	to 1,520
L.ORDOVICIAN U.CAMBRIAN	(KECHIKA- McKAY)	CANADIAN- FRANCONIAN	limestone, silty to shaly, partly nodular, partly schistose	1,400 - 3,200
M. CAMBRIAN	(JUBILEE)		dolomite, partly silty; minor shale, slate	100 - 900
	(EAGER)		shale and siltstone, brick-red to buff, silty dolomite	400
L. CAMBRIAN	GOG GROUP		quartzite, coarse grained, crossbedded, in west with dolomite, limestone, slate	1,700 - 2,300
PRECAMBRIAN	MISINCHINKA GROUP — UPPER		slate, greywacke, impure quartzite, quartz-grit; mainly dark-coloured and schistose	2,500 +
	MISINCHINKA GROUP — LOWER		chlorite-sericite schist, stretched sericitic quartz-grit and conglomerate	

The Devono-Mississippian Besa River Formation, consisting of highly incompetent black argillite with minor thin limestone bands was not recognized in the original mapping. Conglomeratic beds with plants, found on Clearwater Creek, suggested to the writer a Mesozoic age, but according to G.E. Rouse (verbal communication), carry fragments suggesting Calamites and Lepidodendron, indicating a late Palaeozoic age. This revision invalidates the previously assumed structural window in the Clearwater-Callazon-Burnt River depression.

Cherty limestone overlying beds with Monotis subcircularis south of Peace River is perhaps equivalent to the Lower Jurassic Nordegg Formation.

The Lower Cretaceous Bullhead Group of the area has recently been discussed in various papers by D.F. Stott and by J.E. Hughes. Regional evidence suggests that a disconformity, farther south marked by the Cadomin conglomerate, should be present between the "marine Bullhead" and the "continental Bullhead". Subdivision of the former into Monteith, Beattie Peaks, and Monach is only possible in the Carbon Creek Basin.

For mapping purposes the Lower Cretaceous appears to be divisible largely into a marine, Berriasian-to-Middle Valanginian group, and a continental, coal-bearing Aptian-and-older formation or group. Subdivision of the marine part is locally possible on lithologic and palaeontologic bases.

The disconformity would occur between coal-bearing beds and beds with marine fossils, and is possibly marked by coarse-grained to gritty, commonly quartzitic beds, perhaps representing the Cadomin conglomerate.

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[1] Muller, J.E.: Geology, Pine Pass, British Columbia; Geol. Surv. Can., Map 11-1961 (1961).

43. PORT MCNEILL AREA AND NANAIMO BASIN, VANCOUVER ISLAND

J.E. Muller

Field work consisted mainly in geological mapping and stratigraphic work on the Upper Cretaceous Nanaimo Group (Fig. 1).

The small and separate occurrence of Nanaimo Group rocks of the Port McNeill area, near the northern tip of the Island, was examined early in the summer. As in the Nanaimo-Comox region, Cretaceous rocks occur in coastal lowlands and are largely drift-covered. Only the basal Cretaceous formation, which consists mainly of sandstone beds, with minor shale and conglomerate beds and the Suquash Coal seam, is exposed to any extent. These beds are similar in lithology and stratigraphic position to the coal-bearing Comox Formation of the Comox area and according to W.A. Bell the plants suggest similar age.

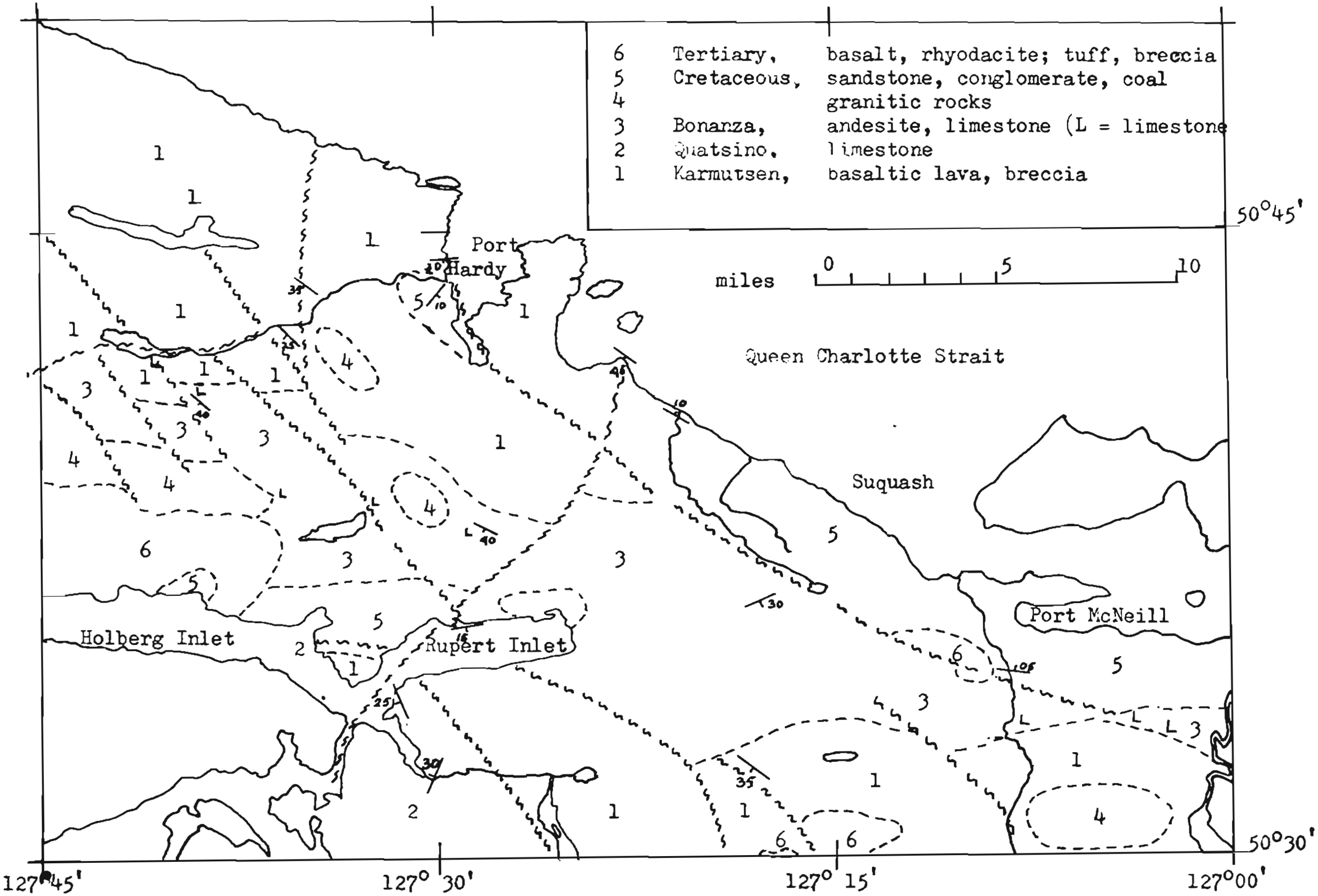
G.M. Dawson has reported an ammonite from shale on Keogh River; this may possibly be a marine shale, roughly equivalent to the Trent River Formation. No mappable marine shale unit was discovered at this locality or elsewhere, but both plants and marine pelecypods were collected from localities in the Suquash sandstone.

The Port McNeill area (92 L/11) and the eastern part of the Quatsino area (92 L/12) were mapped in some detail. The rocks are mainly: (1) Karmutsen Group (Triassic basaltic lava and breccia); (2) Quatsino Formation (Upper Triassic massive limestone); (3) Bonanza Group (Upper Triassic to (?) Jurassic shale, limestone, and andesitic volcanic rocks); (4) Nanaimo Group sediments; and (5) Tertiary volcanic rocks. The Karmutsen, Quatsino, and Bonanza rocks have been intruded by granitic bodies.

Known mineral occurrences are most commonly associated with the limestones and andesitic rocks (mainly dykes and sills) of the Bonanza Group near intrusive contacts. Several mining companies were actively engaged in prospecting and drilling in the area.

Tertiary volcanic rocks had previously been noted by G.M. Dawson on a small island and on some hills near Port McNeill. It was found that fresh basalt flows and poorly consolidated brick-red and brown tuffs and breccias, in appearance and lithology identical to other known Tertiary volcanic rocks, occur also on Straggling Islands and parts of the coast of Holberg Inlet, and as a cap on Twin Peaks. Light-coloured rhyodacitic volcanic rocks cover an extensive area north of Holberg Inlet; outcrops along the inlet have been staked and in one place quarried for silica.

GEOLOGICAL SKETCH-MAP, QUATSINO-PORT McNEILL AREA, VANCOUVER ISLAND



The structure of the area consists of tilted blocks, separated by two or three sets of normal faults, trending northwest, north, and northeast.

General agreement was found between aeromagnetic maps and bedrock geology. Nanaimo sediments and Karmutsen volcanic rocks are in areas of magnetic readings below 4,000 gammas. Granitic intrusions are mainly in areas between 3,500 and 4,500 gammas, and the Bonanza Group with its many tactite occurrences is revealed as a belt of values from 4,000 to a maximum of 5,800 gammas.

Work in the Nanaimo basin involved some revision of areas previously mapped by C.H. Clapp in order to establish the general stratigraphy. The structural pattern of the entire basin, including the Cowichan-Duncan, Gulf Islands region, is one of gently northeastward-tilted blocks, separated by northwest-trending faults, downthrown on the southwest side. Along these faults the Nanaimo Group rocks are tightly compressed and highly disturbed; elsewhere they generally dip gently, mainly to the northeast. These faults are 2 to 5 miles apart in the southwest part of the basin, which is the main coal mining area, but at about quarter-mile intervals in a belt with mainly steeply northeast-dipping to vertical beds, running from east of Ladysmith through the north part of Saltspring and through Prevost and Pender Islands. Another belt of steep beds and faults passes through the south of Mayne and the middle of Saturna Island. Possibly these many faults are splays of one or several major steep faults along the east coast of Vancouver Island.

The northwest-trending system of normal faults is transected by northeast-trending faults with apparent strike-slip movement, in places offsetting the former and bringing Nanaimo Group rocks in juxtaposition with intrusive and Sicker Group rocks.

Further stratigraphic sections were measured in the upper part of the Nanaimo Group. The work of J.A. Jeletzky who, during the summer, visited the area to study and collect fossils on Nanaimo Group type sections, will be essential for detailed stratigraphic correlation. As previously reported[1], the Comox coal-bearing beds are equivalent to the basal Benson beds of the Nanaimo area. The overlying Trent River and Haslam Formations are palaeontologically equivalent, though the base is somewhat diachronic. The coal-bearing beds of the Nanaimo area (Extension to Protection Formations) appear to be represented in the Comox area by conglomerate and sandstone, mainly known from drill holes, but outcropping north of Tsable River. The base of this formation is disconformable. In places it overlies the Trent River Formation, but it cuts down into the Comox Formation and locally the latter has been removed almost entirely.

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[1]Muller, J.E.: Central Vancouver Island area (parts of 92 F, 92 G, 92 K); <u>in</u> Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 75 (1966).

44. GRAND FORKS W1/2 MAP-AREA

V.A. Preto

Geological mapping of the part of the Grand Forks W1/2 map-area lying east of the Granby River, and of a small part of the adjoining Grand Forks E1/2 area was completed this summer.

Rocks of the Grand Forks Group[1] are part of the Shuswap Terrane and form a complex of highly metamorphosed sedimentary and igneous rocks, which are bound to the east by the Kettle River Fault and to the west by the Granby River Fault. Sedimentary and volcanic rocks, the counterpart of which may be found in the Greenwood area[2], lie west of the Granby River Fault.

In the southern part of the area the metamorphic complex features a large east-west trending antiform, flanked to the south by a complex synform and to the north by a very broad synformal warp. Near Grand Forks the plunge of these structures is gentle to the west-northwest, but on going eastward it becomes shallower and changes to the east-southeast.

Approximately in the middle of the map-area, a structural culmination is centered on the highest point of the land. From this point the foliation in the metasedimentary gneisses dips moderately to the east, south, and west, roughly paralleling the slope of the land.

In the northern part of the map-area, the trend of the foliation is again roughly east-west, and an open synformal structure plunging gently east has been outlined 1 1/2 miles north of Xenia Lake.

The foliation outlining these structures is the compositional layering of the gneisses, which, in sections displaying variable lithology, can be observed on a large scale. On this S-surface, a strong mineral lineation that plunges west-northwest and east-southeast, is ubiquitously displayed. Parallel to this lineation are the axes of minor folds, which deform the compositional layering. The style of these folds ranges from sub-isoclinal to more open structures with rounded or even flat hinges depending on the competency of the rocks involved. Whichever the style, these structures have been found to be co-axial and the sense of movement shown by them is consistent and in keeping with the pattern shown by the larger structures described above.

Throughout the map-area, warping of east-west structures about north- and northeast-trending axes is reflected by warps in the main foliation and gentle reversals in plunge of the mineral lineation. At widely separated localities, minor folds paralleling this trend have been observed together with a disruption of earlier structures. The above are the principal structural features; other local and less important ones may be found within the complex.

The strata involved in this part of the Shuswap Terrane form a recognizable sequence in the southern part of the map-area. Here a succession of calc-silicate gneiss with minor marble grades upward into limy schists and then into a sillimanite-rich paragneiss, which is in turn overlain by a white and pinkish, coarse-grained, massive, pure quartzite with thin sillimanite-bearing seams and minor interlayered schist. A discontinuous layer of marble with minor limy schist overlies the quartzite and is in turn overlain by a sequence of sillimanite-garnet-biotite schists and amphibolite gneisses. In the extreme southwest corner of the map-area, there is a small isolated exposure of fine-grained amphibolitic schist and staurolite-bearing schist. In the central and northern part of the area, a thick sequence of metasedimentary gneisses extensively invaded by pegmatite, underlies a quartzite identical to and probably correlative of the main quartzite to the south. It may be suggested that the main quartzite is equivalent to part of the Hamill Group and that the rocks above and below it correspond to the Lardeau Group and to the Horsethief Group respectively.

In the southeastern corner of the map-area, several bodies of garnetiferous granitic gneiss of quartz monzonite to granodiorite composition cut through the metasedimentary rocks, but the foliation and the fold structures in the gneiss are in keeping with similar structures in the metasediments. Part of this unit continues southeast in the Orient area in the State of Washington where it is called Cascade Granodiorite[3].

One mile north of Grand Forks, a sill-like body of leucocratic granitic rock is folded with the metasediments around the hinge of the main east-west antiform. Where observed, the contact with the metasedimentary gneisses is conformable, and small subsidiary sills are folded with the gneisses on a small scale.

Structurally above this sill, a sub-conformable body of biotite-hornblende granodiorite gneiss also appears to be folded around the main antiform.

Along the east slopes of the Granby River Valley, the western limit of the metamorphic complex is marked by a north-trending zone of crushed and mylonitized rock ranging in composition from granodiorite to leucogranite.

Numerous stocks and dykes of Tertiary intrusive rocks, some of which are correlative of the Long Alec Creek Intrusions[4], cut through the metamorphic complex.

Mining activity in the area is confined to the Mesozoic and Palaeozoic rocks west of the Granby River Fault, where active exploration by geophysical methods and drilling is being carried out.

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[1]Little, H.W.: Kettle River E1/2, B.C.; Geol. Surv. Can., Map 6-1957 (1957).

[2]Little, H.W. and Thorpe, R.I.: Greenwood map-area; Geol. Surv. Can., Paper 65-1 (1965).

[3]Bowman, E.C.: Stratigraphy and structure of the Orient area, Washington; unpublished Ph.D. Thesis, Harvard Univ. (1950).

[4]Parker, R.L. and Calkins, J.A.: Geology of the Curlew Quadrangle, Ferry County, Wash.; U.S.G.S., Bull. 1169.

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45. AN EXTENSIVE TERTIARY SECTION IN THE PARSNIP RIVER VALLEY

N.W. Rutter and J.E. Muller

About 2 1/2 miles down the Parsnip River from the Parsnip bridge on the John Hart highway, more than 650 feet of Tertiary sediments are exposed in high bluffs on the northeast side of the river. The beds strike N10°E, dipping 10° to 19° N80°W, and are overlain and truncated by glacial deposits. Massive, poorly sorted, "semi-consolidated", partly oxidized gravel consisting mostly of subangular to rounded quartzite pebbles with a sandy matrix make up most of the section. Interbedded with the gravel are beds and lenses of sand, silt, and clay, and lenses of siltstone. Detrital coal is found in most beds and abundant fossilized deciduous leaves are contained in the siltstone.

This section is of interest in that the strata may be younger than Paleocene and, hence, the deformation younger than previously recognized in this part of the Rocky Mountain Trench.

46. SURFICIAL GEOLOGY OF THE PEACE RIVER DAM AND RESERVOIR AREA, BRITISH COLUMBIA

N.W. Rutter

The geological study and mapping (1/50,000 scale) of glacial deposits and morphology of the Peace River Dam and Reservoir area were undertaken, and about half of the project area was examined during the field season. The area covered includes the part of the Peace River valley from Finlay Forks to Portage Mountain and the Parsnip River valley from Windy Point to the Nation River. Finlay River valley south of Ware and Parsnip River valley, north of the Nation River remain to be investigated.

Pleistocene deposits are abundant in the broad Parsnip River valley, which is an expression of the Rocky Mountain Trench. A good cross-section of these deposits is provided by the widely meandering Parsnip River, with bluffs up to 200 feet high exposing a variety of glacial deposits. Some of the more important sections consist in part of two distinct tills separated by gravel inferred to be glacial outwash. The deposits forming the surface display typical deglaciation features such as kames, eskers, sand dunes, and lake and outwash plains. These units are generally unconformable with the underlying glacial deposits. The lower contact of the underlying deposits is generally obscured by colluvium or falls below the waterline along the Parsnip River. In a few places it was seen to truncate Tertiary gravel or older bedrock.

In the narrow Peace River valley, the surficial deposits are almost entirely of fluvial and glacio-fluvial origin. Four major sets of terraces up to more than 500 feet above the uncontrolled river level, can be traced, although not continuously, from Finlay Forks to Portage Mountain. Generally, the terraces are underlain by silty to gravelly material with some of the higher terraces pocketed by kettles. Near Portage Mountain, certain terraces are capped by lacustrine silt. Little is known about unconsolidated material below the river level although over 1,000 feet of such material has been reported from borings near Portage Mountain. The deposits beneath the terraces are partly aggradational, related to the terraces themselves, and are partly erosional, remnants of pre-existing deposits. Beneath at least the three lower major terraces a distinct unconformity separates overlying, fairly flat lying, moderately well sorted gravel and sand from underlying, highly contorted steeply dipping beds of poorly sorted gravel interbedded with sand and silt. Within this lower unit, restricted unconformities are common. The implication of these two distinct units found beneath terraces is that subsequent to down-cutting of each terrace, there was a period of aggradation.

Till of restricted extent was found interbedded with the contorted sediments in two locations. In another place till occurs beneath the contorted sediments and overlies gravel that may be Tertiary.

Until further study is carried out, and radiocarbon dates are available, only general conclusions on the glacial history can be presented. The two tills found in succession in the Parsnip area clearly indicate two glacial advances. A third advance is indicated by the upper till of certain outcrops found in the uplands, which may be higher stratigraphically than the two tills commonly found in succession along the Parsnip River banks.

In the Peace River valley the till interbedded with the contorted sediments indicates at least one advance, with an indication of another where till overlies and truncates Tertiary (?) gravel.

The four well preserved terraces in the Peace River valley formed after ice withdrew from the valley. They may relate to three periods of glacier fluctuation outside the Peace River valley, or water level control from damming, perhaps when the Peace River changed course and cut the canyon adjacent to Portage Mountain.

Combining the information from the Peace and Parsnip areas, there is direct evidence for at least one ice advance extending from the Rocky Mountain Trench down the Peace River valley and at least two advances within the Parsnip River area, one perhaps equivalent to the advance that extended down the Peace.

During a flight through the Finlay Valley in October 1965, J.G. Fyles noticed the following: 1) extensive deposits of hummocked and kettled gravel; 2) abandoned meltwater channels along the eastern margin of the Trench that carried glacial meltwater southward along the face of the Rockies and eastward through them; 3) deltas of a former glacial lake or lakes that occupied the broad valley floor; 4) thick widespread deposits of laminated silt and clay capped by sand; 5) local occurrences of somewhat disturbed sand and silt separated from the laminated silt and clay by a glaciated surface. Plant debris from the latter deposit collected from the east bank of Finlay River 18 miles upstream from Ospika River yielded a radiocarbon age of 25,940 ± 340 years (GSC 573).

47. CONTROL OF A FLOWING WELL AT VERNON

J.S. Scott

During the 1965 field season an artesian aquifer was encountered, during a stratigraphic test boring program, at a depth of 200 feet in unconsolidated Pleistocene sediments in the Coldstream Valley near Vernon. The initial flow from the hole was approximately 500 i.g.p.m. with a surface pressure of from 40 to 50 p.s.i.

Several attempts were made during 1965 to seal the flow from the hole by the injection of weighted drilling mud, sawdust, lost circulation gum, in addition to portland and gypsum cement grouts. These attempts were unsuccessful in spite of the use of relief wells, as the flow and pressure of the groundwater combined with the non-cohesive character of the near-surface strata prevented the retention of the injected materials.

Control of the artesian flow was accomplished during the 1966 field season by the driving of a 30-inch diameter casing to a depth of 150 feet. The casing was driven in 10-foot lengths by a Becker model BDT 250 Hammer Drill. Each joint of the 30-inch casing had been fitted with an inner and outer ring at one end to form an insert joint that was seal welded in the field.

Consolidation of the soil surrounding the 30-inch casing is to be accomplished through use of portland cement and chemical grout. Final shut-off of the flow will be achieved with the use of a 10-inch gate valve fitted to the discharge part in the side of the cap on the 30-inch casing.

48. CORDILLERAN VOLCANIC STUDY, 1966

J.G. Souther

Detailed mapping of the Mount Edziza volcanic complex, begun in 1965, was continued with emphasis on the stratigraphy of flows exposed on the outer margins of the main volcanic pile. A study was also made of rock alteration within the central vent of Mount Edziza and of subvolcanic structures west of the volcano, along Mess Creek valley. In addition a geothermal drilling program was carried out in conjunction with the Seismology Division of the Dominion Observatory.

The stratigraphy at the outer limits of the volcanic pile reflects the main sequence of events as determined in the source area[1], but profound facies changes have occurred and many events that produced thick flow-units near the source of eruption are represented on the flanks of the volcano by thin layers of ash, mud flows, or welded tuffs. Conversely the marginal sections include thick layers of fluvial and glacial-fluvial deposits that are absent on the higher reaches of the volcano. Figure 1 illustrates a typical section measured on the west-facing escarpment of Mess Creek valley, 12 miles southwest of the central crater of Mount Edziza. The initial outpouring of fluid basaltic lava (unit 1) was followed by alternate eruption of rhyolite

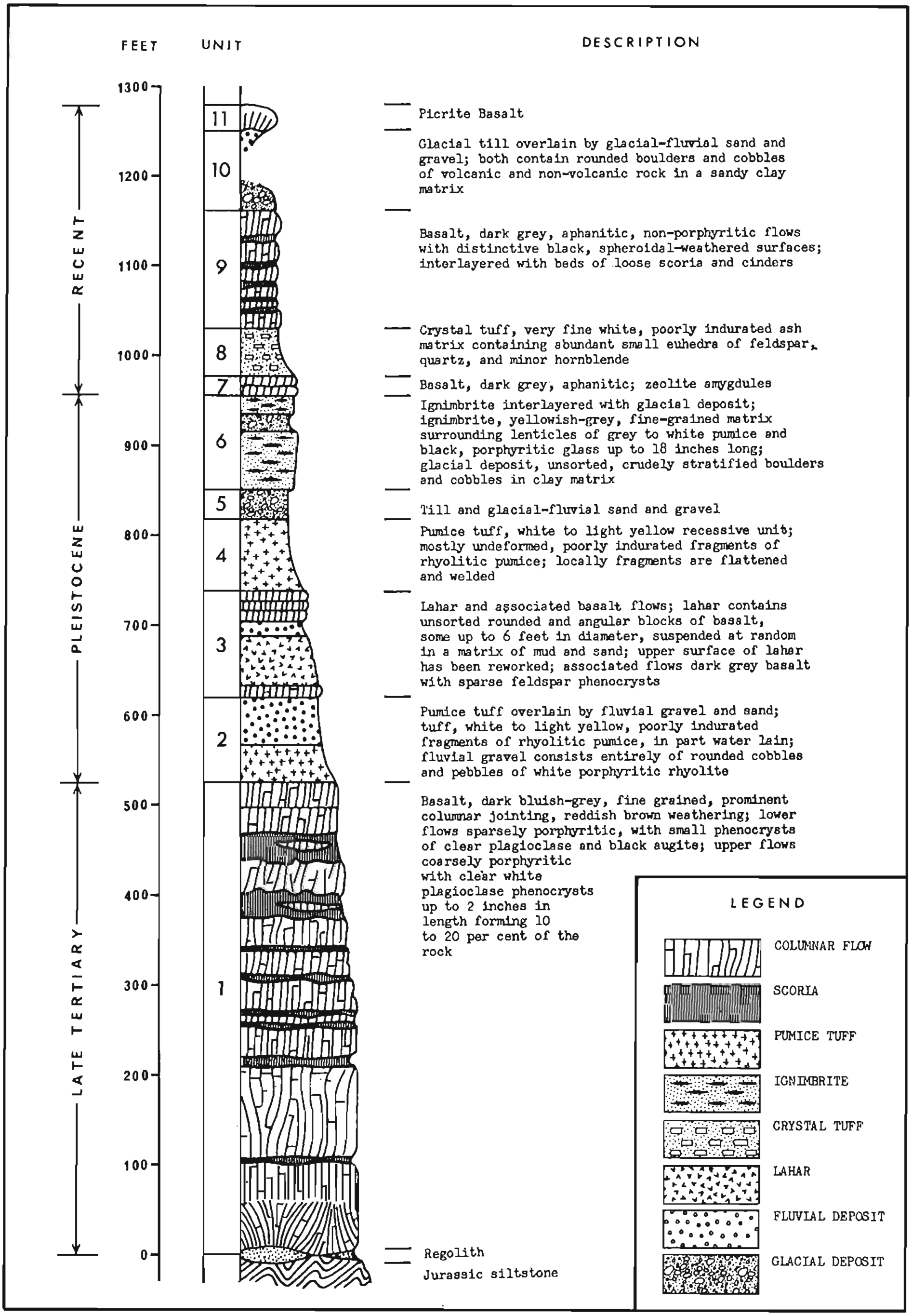

Figure 1. Mount Edziza volcanics; section measured 12 miles southwest of central crater.

and basalt. Of special interest is the nature of the rhyolitic deposits which, unlike the thick flows and domes near their source, are here represented entirely by pumice tuff, both welded and unwelded (units 2 and 4), and by ignimbrite (unit 6) with large lenticles of obsidian in a welded vitroclastic matrix. The thick flows, laccoliths, and domes of green dacite and latite that form the upper carapace of Mount Edziza[1] are believed to be represented in this section by a thin layer of crystal tuff (unit 8). The Lahar (unit 3) is one of several large volcanic mud-flows associated with narrow tongues of basalt along the western margin of the volcano. The youngest flows (unit 11) issued from vents around the periphery of the main cone and flowed out onto an old tundra surface covered with low vegetation. Charred twigs preserved below scoria beds related to these flows give a radiocarbon date of 1,300 $\pm$ 130 years B.P.

The Mount Edziza volcanic complex is bounded on the west by Mess Creek valley, a long narrow, graben-like depression bounded by a complex system of north-trending vertical faults. Faults along the eastern edge of this structure cut the Mount Edziza volcanics, and there is evidence that movement on at least one of the faults was contemporaneous with volcanic activity. This fault, which has been traced for more than 15 miles, has a vertical displacement (west side down) of 300 to 400 feet on the lower basalt succession (unit 1) and progressively less displacement on younger units. The youngest rocks involved are of post-Pleistocene age (unit 9) and have a vertical displacement of 50 to 70 feet. Valley filling flows (unit 11) cross the fault, but show no displacement. The recent movement on this fault may be due to collapse of magma chambers drained during eruptions of the adjacent volcano.

The central vent of Mount Edziza is a circular, ice-filled depression approximately 2 miles in diameter, flanked by nunataks of green dacite that represent remnants of the crater rim. On the east side a deep glacial valley has eroded almost to the centre of the volcano, exposing the rocks in the main conduit through a vertical distance of 1,500 feet. The upper 300 feet comprise thick, horizontal layers of columnar basalt formed from lava lakes that froze in the crater. Below this the breccias, dykes, and pods of lava that formerly occupied the lower part of the conduit have all been altered by solfataric action to pure white, sugary-textured rock containing from 5 per cent to 50 per cent finely disseminated pyrite. Assuming that the conduit rocks are altered only down to the base of the volcanic pile their volume would exceed 0.6 cubic mile. It is probable that the altered zone extends well below the base of the pile and involves many times this volume of rock. Specimens were collected for chemical and petrographic study and an attempt is being made to determine the amount and rate of sulphide precipitation.

The joint Geological Survey - Dominion Observatory geothermal research program involved drilling three holes for the determination of heat flow in different tectonic environments at varying distances from the centre of recent volcanic activity. The first hole, 956 feet deep, is located near the Cassiar-Stewart road on the east side of Dease Lake. It is midway between the bounding faults of the Atlin Horst[2], a tectonically high block of older rocks associated with ultramafic intrusions. Data from this hole is expected to provide information on heat flow in a recently uplifted segment of the earth's crust. The second hole, with a depth of 1,401 feet, is also located near the Cassiar-Stewart road, about 10 miles north of Stikine River. It is entirely in granitic rocks of the Triassic (K/A 193 m.y.)[3] Hotailuh batholith. This is a relatively stable tectonic environment and the hole is expected to have an average heat flow for the region. The third hole, drilled to a depth of 1,400 feet, is located one half mile west of Buckley Lake. It is on a northern extension of the Mess Creek Graben and about 1 mile west of the base of Mount Edziza. Thermal data from this hole will provide information on residual heat and possible heat-flow variations related to volcanic activity. Temperature profiles will be measured on all three holes during the 1967 field season.

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[1]Souther, J.G.: Cordillera volcanic study; in Report of Activities: May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 87-89 (1966).

[2]Souther, J.G. and Armstrong, J.E.: North-central belt of the Cordillera of British Columbia; in Tectonic history and mineral deposits of the western Cordillera; Can. Inst. Mining Met., spec. vol. No. 8, pp. 171-184 (1966).

[3]Gabrielse, H. and Reesor, J.: Geochronology of plutonic rocks in two areas of the Canadian Cordillera; Roy. Soc. Can., spec. pub. No. 8, pp. 96-138 (1964).

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49. TASEKO LAKES (92 O) MAP-AREA

H.W. Tipper

The sedimentary and volcanic rocks exposed between Taseko and Chilco Lakes were re-examined. They consist of a thick section of interbedded marine and non-marine sedimentary rocks of mid-Early Cretaceous to early Late Cretaceous age (Hauterivian to Cenomanian). The volcanic rocks were previously mapped as one map-unit of Lower and Upper Cretaceous age[1], but they have now been subdivided into three or more volcanic units separated by marine and non-marine sedimentary rocks. The certain recognition of the different units is dependent on the discovery of index fossils. Rocks of Barremian or Aptian age have not been recognized, but may be partly or entirely represented by an unfossiliferous volcanic unit; to the east along Tyaughton Creek this time span has been proved to be a period of uplift and erosion.

The major structure of the area around Taseko Lakes is a zone of strike-slip faults that extends along upper Taseko River, across the south end of Taseko Lakes, northwesterly across the range north of Tchaikazan River, and beyond the area. All evidence indicates that the southwest side of the main fault and of parallel minor subsidiary faults moved northwest relative to the northeast side. The displacement on the fault is not known, but is believed to be in excess of 25 miles. Movement on the fault occurred mainly prior to Tertiary time, although early Tertiary rocks appear to have been involved in later movements.

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[1] Tipper, H.W.: Taseko Lakes map-area, British Columbia; Geol. Surv. Can., Map 29-1963 (1963).

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50. HAZELTON (93 M) MAP-AREA

H.W. Tipper

A brief examination of the area around Hazelton was undertaken as a preliminary to the study of the whole region. Much of the area studied in earlier reports[1,2] was re-examined and the stratigraphic relations of established map-units were clarified.

The Upper Jurassic and Lower Cretaceous sedimentary division of the Hazelton Group provided some new information. West of Skeena Crossing a fossiliferous marine section of mid-Early Cretaceous age (late Hauterivian to Aptian) underlies non-marine strata that contain Blairmore flora. Presumably this marine section overlies the thick sedimentary section that carries Kootenay flora and, if this be the case, it probably is equivalent to Member B of the Red Rose Formation in the Rocher Deboule Range[2]. The strata carrying Kootenay flora (Member A of the Red Rose Formation[2]) contains marine shells in places. A collection from Nine Mile Mountain is tentatively dated as early Late Jurassic and is thought to date the early part of the division. Because of the great thickness of sediments and fossils contained therein, this sedimentary division is thought to represent early Late Jurassic to mid-Early Cretaceous time, but whether or not this is a complete section is not known.

In the mountains east of Moricetown the Upper Jurassic and Lower Cretaceous sedimentary division displays a coarse boulder conglomerate at its base and rests unconformably on the Middle or Upper Jurassic volcanic division of the Hazelton Group[1]. The angular discordance at this locality is not great but elsewhere, in the Kispiox Valley and near Kisgegas, this volcanic division is missing and the Upper Jurassic and Lower Cretaceous sedimentary division rests directly on the early Middle Jurassic sedimentary division. These two sedimentary divisions appear to be distinct in that the older displays a pronounced slaty cleavage that is lacking in the younger division. This unconformable relation adds support to a similar relation in Terrace map-area where Upper Jurassic Bowser Group rocks overlie Middle Jurassic Hazelton rocks unconformably.

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[1]Armstrong, J.E.: Hazelton, British Columbia; Geol. Surv. Can., Prel. Map 44-24 (1944).

[2]Sutherland Brown, A.: Geology of the Rocher Deboule Range; B.C. Dept. Mines and Pet. Res., Bull. 43 (1960).

[3]Duffell, S. and Souther, J.G.: Geology of Terrace map-area, British Columbia; Geol. Surv. Can., Mem. 329 (1964).

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51. TRIASSIC BIOSTRATIGRAPHIC STUDIES, FORT NELSON (94 J) AND TRUTCH (94 G) MAP-AREAS, NORTHEASTERN BRITISH COLUMBIA

E.T. Tozer

On Chischa River in Fort Nelson map-area, several sections of the Toad Formation were examined in detail. The section 10 miles west of Muskwa River[1] shows a sequence of four Anisian zones. The lower three zones, characterized by "*Hungarites*" *caurus* McLearn, "*Gymnotoceras*" *varium* McLearn, and *Gymnotoceras deleeni* McLearn have already been briefly described[2]. The highest zone, above the *Gymnotoceras deleeni* zone, is characterized by *Gymnotoceras* n. sp. aff. *G. laqueatum* (Lindström).

In Trutch area sections were examined at Mount Wooliever, Mount Withrow, and Mount Stearns. Good collections were obtained from the Ladinian and Norian strata at these localities.

[1]Pelletier, B.R.: Triassic stratigraphy, Rocky Mountain Foothills, northeastern British Columbia; Geol. Surv. Can., Paper 60-2, p. 21 (1960).

[2]Tozer, E.T.: Triassic biostratigraphic studies in northeastern British Columbia; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 96 (1966).

52. NORTHEAST QUARTER, ROGERS PASS (82 N W 1/2) MAP-AREA

J.O. Wheeler

Two weeks were spent in the northeast quarter of Rogers Pass map-area[1] mapping with the aid of a helicopter in the Rocky Mountains northeast of the Stephen-Dennis fault. The mapping, formerly done at a scale of 1 inch to 4 miles, was raised to a standard of 1 inch to 1 mile to mesh with that being done on Operation Bow-Athabasca.

Two points of interest result from the present revision: 1) the Upper Devonian Fairholme Group is composed principally of a carbonate sequence just southwest of the B.C.-Alberta boundary, but is predominantly clastic about 10 miles to the southwest south of Bush and Valenciennes Rivers; 2) the terrain formerly mapped entirely as the Lower Cambrian Gog Group southwest of the Chatter Creek fault is actually underlain approximately equally by the Gog Group and the Proterozoic Miette Group.

[1]Wheeler, J.O.: Rogers Pass map-area, British Columbia; Geol. Surv. Can., Paper 62-32 (1963).

ALBERTA

53. PRE-DEVONIAN STRATIGRAPHY, SOUTHERN ROCKY MOUNTAINS

J.D. Aitken

This year's stratigraphic studies, like last year's, were carried out in conjunction with Operation Bow-Athabasca (see R.A. Price, elsewhere in this report).

Studies of the carbonate-dominated "shelf" facies of the Middle and Upper Cambrian are complete, having been extended to the most westerly occurrences, at Mount Tsar and Mount Robson. Preparation of these studies for publication will begin immediately, commencing with the Middle Cambrian.

The minor amount of work done on the Ordovician was of a confirmatory nature; the utility of rock-units established by Norford (unpublished manuscript) and Aitken and Norford (unpublished manuscript) was confirmed.

Studies of the shale-dominated sequence of the Cambrian of the Western Ranges met with mixed success. In the Blaeberry River region, the long-suspected correspondence of the Ottertail and Lyell Formations was confirmed. A thick, shaly, fossiliferous, tripartite sub-Ottertail formation (part of the Chancellor Formation) appears to correspond closely to the Sullivan Formation. This is underlain by a formation of limestone and dolomite, which may correspond to the Waterfowl Formation, which in turn overlies a shaly sequence of probable Middle Cambrian age.

A sequence similar to the Blaeberry River sequence is recognizable to the east, but not to the west, of Vermilion River. West of the river, the Ottertail Formation is underlain by a thick sequence of slates with minor limestone interbeds, which so far has defied subdivision into practicable units for mapping. The slate sequence overlies a unit corresponding lithologically to rocks at Tokumm Creek, which are a transitional phase in the westward change of the Pika Formation (carbonates) to a black slate - siltstone - carbonate unit. The latter in turn overlies limestones that may correspond to the Eldon Formation.

One stratigraphic section of Late Precambrian (Windermere) rocks of the Horsethief Creek Group was studied at Spillimacheen Mountain. Similarity, indeed, near-identity of lithology and sequence leaves little doubt that the Late Precambrian sequence near Lake Louise (Hector and Corral Creek Formations) is to be correlated with the Horsethief Creek, as suggested by Reesor[1] and others.

[1]Reesor, J.E.: The Proterozoic of the Cordillera in southeastern British Columbia and southwestern Alberta; in The Proterozoic in Canada; Roy. Soc. Can., spec. pub. No. 2, pp. 150-177 (1957).

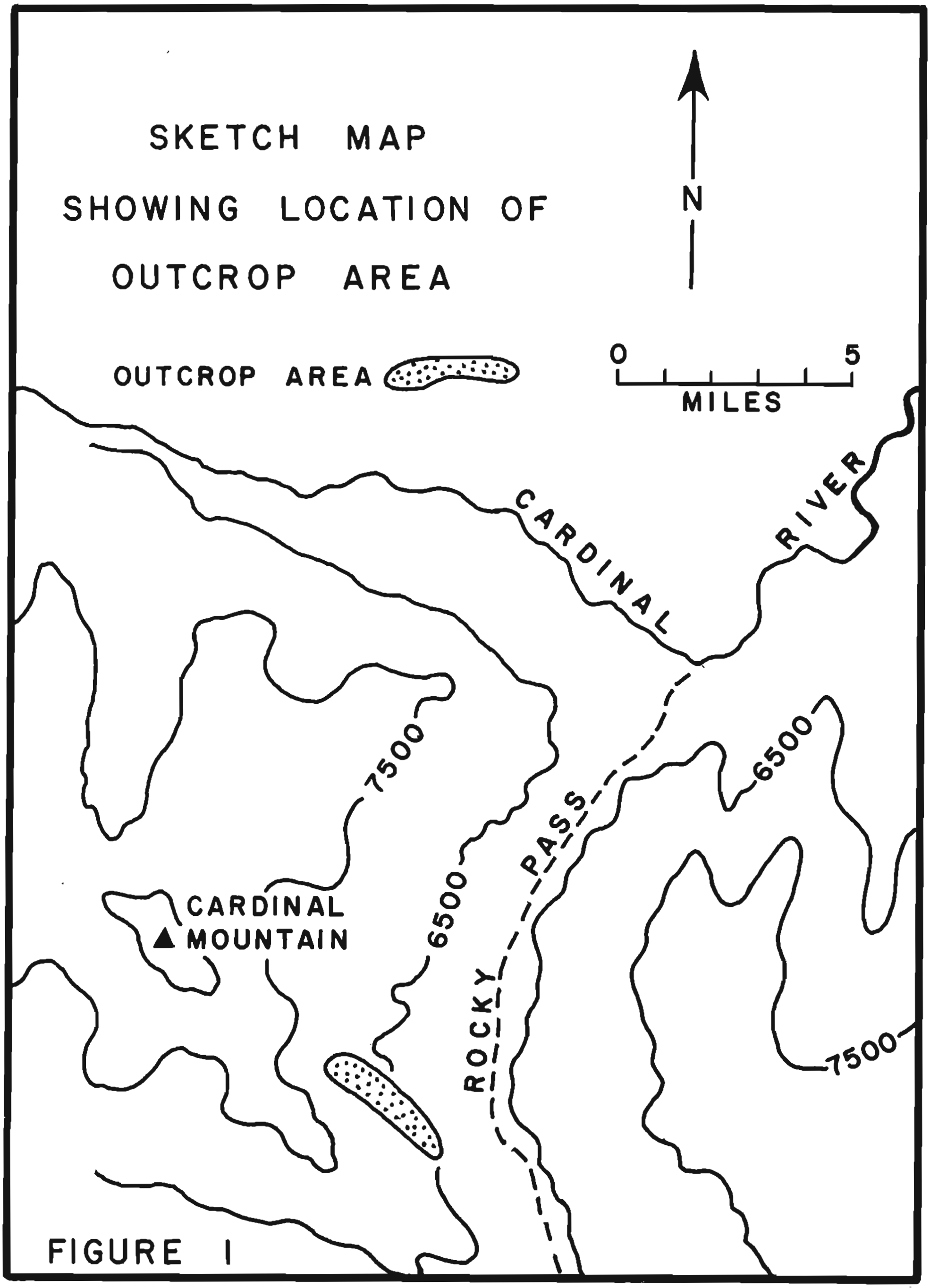
54. ORGANIC GROWTH IN CARBONATE TONGUES

Helen R. Belyea and W.S. MacKenzie

The primary constituents of widespread dolomite tongues in the Winterburn and upper part of Woodbend Groups and their equivalents in mountain outcrops of the Fairholme Group have long been discussed among Alberta geologists. Although most subsurface observations suggest that Nisku Formation carbonates consist dominantly of dolomitized lime mud and granular or pelletoid material[1] (Belyea, personal observations), many have rather casually been called biostromes[2], but no definite evidence has heretofore been published.

Outcrops of Fairholme Group strata examined during the summer of 1966 in Rocky Pass just west of Cardinal Mountain, in Mountain Park (83 C/14) map-area, southwestern Alberta, show that coral growth can begin on a substrate of granular lime mud and suggest that coral colonies may form at least the basal layer of some ancient limestone tongues. Non-coral-bearing carbonate lenses in the same area, although granular in nature, also contained traces of algal tubules. The easily accessible outcrops occur close to the floor of Rocky Pass near its southern limit (Fig. 1). The limestone outcrops consist predominantly of dark grey, mottled, argillaceous, and frequently granular lime muds in which dolomite commonly occurs as finely disseminated crystals. Coral colonies are concentrated along the upper part of the outcrop and can be traced continuously for a considerable distance along the hillside. They occur as small 1- to 2-foot isolated lenses (Plate 1-1), in thin encrusting sheets whose approximate exposed dimensions are about 6 feet by 4 inches (Plate 1-2), as hemispherical mounds up to 2 feet in diameter (Plate 1-3), and as vertically elongate dome-shaped build-ups from 2 to 3 feet in height (Plate 1-4). The colonies are presumably in growth position; thin encrusting sheets, for example, are not likely to have been transported and the vertically elongate build-ups are obviously in place.

Small isolated coral colonies, a few inches in maximum dimension, provide an insight into the nature of the medium in which they lived and of the substrate on which they began to grow. They terminated upward in


SKETCH MAP
SHOWING LOCATION OF
OUTCROP AREA
N
OUTCROP AREA
0
5
MILES
CARDINAL
RIVER
7500
6500
6500
7500
CARDINAL
MOUNTAIN
ROCKY
PASS
FIGURE I

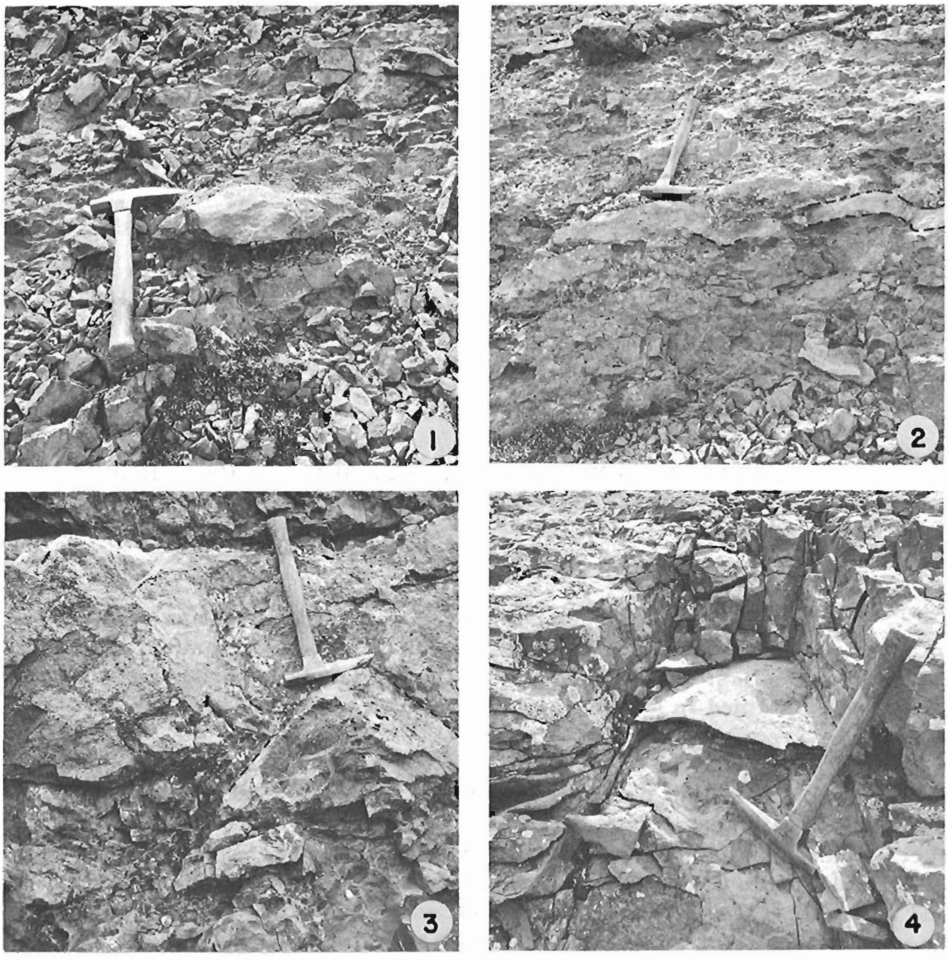


Plate I. Coral colonies in Fairholme Group, Rocky Pass.

argillaceous sediment or beneath layers of encrusting stromatoporoids. Growth apparently began on a soft muddy bottom.

In such reef-margin areas changes in environment from time to time favoured the growth of encrusting stromatoporoids or permitted the development of coral colonies. Periodic influxes of argillaceous sediment destroyed almost all organic life.

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[1]Kirker, W.P.: Devonian reef and off-reef relationships in the Drumheller area; Alta. Soc. Petrol. Geol., Guidebook 9th Ann. Field Conf., pp. 92-102 (1959).

[2]Imperial Oil Limited Geological Staff: Devonian nomenclature in Edmonton area, Alberta; Bull. Am. Assoc. Petrol. Geol., pp. 1807-1825 (1950).

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55. STRUCTURAL ANALYSIS OF THE RUNDLE THRUST SHEET, SOUTHERN ROCKY MOUNTAINS

H.V. Bielenstein

Field work has been completed for a structural analysis, based on the mesoscopic fabric of the Rundle thrust sheet. Approximately 100 fabric samples scattered stratigraphically and laterally throughout the thrust sheet were obtained in Kananaskis Lakes (82 J) and Calgary West Half (82 O W 1/2) map-area, Alberta.

The lateral extent of the thrust sheet is about 75 miles, exposing Cambrian strata near Canmore. Northwestward the Rundle thrust cuts up-section until it is lost in an anticline/syncline sequence, including the Spray River and Fernie Groups along Cuthead Creek; to the southeast the Rundle and Misty thrusts are intimately related and die out together in Fernie/ Kootenay strata at the south end of the Misty Range.

The Rundle thrust is seldom a single surface; usually a number of fault slices represent the total displacement. Transverse faults on a megascopic scale are common within the thrust sheet in the Opal and Misty Ranges. Northwestward this megascopic element is almost absent, but can be traced in the mesoscopic fabric as far north as Banff.

The author attempted to obtain mesoscopic fabric samples from various stratigraphic units in order to compare their fabric and outline domains of homogeneity. Massive units such as the Devonian Palliser and Mississippian Livingstone Formations yielded very little information. Excellent fabric measurements were taken in the Mississippian Exshaw, uppermost Lower Banff and Etherington Formations. The remainder of the stratigraphic section was rather unpredictable as to measurable mesoscopic fabric.

56. TRIASSIC STRATIGRAPHY BETWEEN THE ATHABASCA AND BRAZEAU RIVERS

D.W. Gibson

With field support provided by Operation Bow-Athabasca (see report by R.A. Price, this paper), detailed Triassic stratigraphic and petrologic investigations begun in 1962 by the writer between the Athabasca and Smoky Rivers, were extended southeast to the Brazeau River.

The Whitehorse Formation, comprising a variable sequence of carbonates, sandstones, and minor siltstones, collapse breccias, and gypsum, is generally divisible into three distinct lithofacies, which are in descending order: 1) a white to red-brown weathering carbonate facies; 2) a well indurated quartzite facies; and 3) a dolomite-limestone-evaporite facies. Units 1 and 3 are traceable throughout the area, and are recognizable northwest of the Athabasca River[1]. Similarly, unit 2 is traceable throughout most of the region studied; however, it has not been observed northwest of the Athabasca River, nor east of the Fiddle River. White sugary gypsum up to 150 feet thick occurs 3 miles northwest of Helmet Mountain near the top of unit 3. The deposit, however, lies within the confines of Jasper National Park.

The Sulphur Mountain Formation[1], comprising a monotonous assemblage of grey to rusty brown weathering siltstone, silty shale, and minor sandstone and dolomite, is divisible into four distinct lithologic units, similar to those recognized northwest of the Athabasca River[1]. However, in some sections the lowest unit of the formation displays two distinct lithofacies, which are absent northwest of the Athabasca River. One facies consists of a medium-bedded, resistant-weathering sequence of dolomitic siltstone, which is lithologically similar to strata in the overlying member. The other lithofacies consists of a yellow weathering, porous, bioclastic dolomite, observed only in the vicinity of Whitehorse Creek near Cadomin. The Sulphur Mountain Formation, like the Whitehorse Formation, displays a stratigraphic thinning toward the northeast, across the structural strike of the region.

[1]Gibson, D.W.: Triassic stratigraphy near the northern boundary of Jasper National Park, Alberta; Geol. Surv. Can., Paper 64-9 (1965).

57. STRATIGRAPHIC AND STRUCTURAL STUDIES OF THE UPPER CRETACEOUS OF THE SOUTHERN ALBERTA PLAINS

E.J.W. Irish

Stratigraphic and structural studies of the Upper Cretaceous formations of the southern Alberta Plains were continued. Surface geological mapping was done in several parts of southern Alberta and that in two map-areas, Drumheller (82 P) and Oyen (72 M), was completed.

The exposed strata in the Drumheller and Oyen map-areas belong to the Oldman, Bearpaw, and Edmonton Formations of Late Cretaceous age and to the Paskapoo Formation of early Tertiary age. Both of the upland regions known as the Hand Hills and Wintering Hills are capped with remnants of gravel and associated conglomerate of late Tertiary age.

Lithologic units equivalent to the Whitemud Formation and the overlying Battle Formation of the Cypress Hills region were mapped throughout Drumheller map-area. These two distinctive units with the included Kneehills tuff form the only reliable lithologic marker throughout the Edmonton Formation of this area. Shell beds and coal seams can be used for correlation over limited distances only.

Much of Oyen map-area is covered by thick deposits of glacial silt, sand, till, and gravel. Bedrock exposures are very scarce.

Preliminary studies were started in areas south of Bow River. The strata there belong to the Foremost, Oldman, Bearpaw, St. Mary River, Willow Creek, and Porcupine Hills Formations.

58. MISSISSIPPIAN STRATIGRAPHY, SOUTHERN ROCKY MOUNTAINS AND FOOTHILLS

R.W. Macqueen

The writer's 1966 field program consisted of two phases: 1) Upper Palaeozoic stratigraphic data (emphasis on Mississippian) were collected in the Rocky Mountain Foothills and Front Ranges from the area east of Jasper to the North Saskatchewan River; 2) further study of Banff - Rundle contact relationships and correlations was made in the Bow Valley - Lake Minnewanka area.

Foothills and Front Ranges, North Saskatchewan River to Jasper Area

1. The Banff Formation averages 600 to 700 feet thick, and can locally be divided into a lower calcareous and dolomitic shale unit, a middle shaly echinoderm limestone unit, and an upper shaly carbonate unit.

2. The Banff - Rundle contact is easily recognized over the entire area, and is marked by the appearance in the section of massively bedded, light grey resistant-weathering echinoderm limestones characteristic of the lower part of the Rundle. Cerioid lithostrotionid corals commonly occur in uppermost Banff or lowermost Rundle strata.

3. Pekisko, Shunda, "Turner Valley", and "Mount Head" Formations form the Rundle Group (precise relationships between "Turner Valley" and "Mount Head" strata and the type sections of these formations are unclear at present). In general the Pekisko and "Turner Valley" Formations are composed of echinoderm or micritic limestones or their dolomitized equivalents, whereas the Shunda Formation consists of micritic limestones, microcrystalline dolomites, and shaly dolomites. Breccias interpreted to be produced by solution of evaporites are abundant in the upper part of the Shunda Formation in easterly sections. The "Mount Head" Formation is composed of microcrystalline dolomite and fine- to medium-crystalline dolomite.

Bow Valley - Lake Minnewanka Area

1. In the Front Range, the Banff Formation decreases in thickness from about 1,200 feet in the Bow Valley to 850 feet along Ghost River, 5 miles northwest of Devils Head Mountain. The lower member retains a relatively constant thickness and lithology; the thickness reduction takes place in the middle and upper members of the formation. Lithostrotionid corals and brachiopods collected from a series of stratigraphic sections in the Front Range indicate that the Banff - Rundle contact is approximately the same age from the Bow Valley to Ghost River, i.e. the Pekisko and Shunda Formations are neither the time nor the rock equivalents of the middle and upper members of the Banff Formation, as has been previously suggested.

2. The Banff - Rundle sequence exposed near the junction of Sawback Creek and the Cascade River is closely comparable to the type Banff - Rundle sequence on Mount Rundle and Tunnel Mountain. Grey-weathering echinoderm limestones that occur at the top of the middle member of the Banff Formation are neither lithological nor palaeontological correlatives of the Pekisko Formation as developed north and east of this locality.

59. LAKE MINNEWANKA EAST (82 O/6, EAST HALF) MAP-AREA

N.C. Ollerenshaw

The geological mapping of the Foothills portion of the Lake Minnewanka East map-area has been completed on a scale of 1 inch to 1 mile.

The main northwest- to southeast-trending structural elements of the Burnt Timber Creek area[1] to the north continue through the Lake Minnewanka East area. From northeast to southwest, the main structural elements are the Burnt Timber Thrust, the Waiparous Thrust, and the McConnell Thrust. The Burnt Timber and Waiparous thrusts superimpose Lower Cretaceous strata on to Upper Cretaceous non-marine sandstones, siltstones, and mudstones of the Brazeau Formation. The latter forms about 70 per cent of the bedrock in the Foothills part of the area. The McConnell Thrust places Palaeozoic strata (predominantly carbonates) over the Brazeau Formation and its surface trace marks the Mountains-Foothills contact.

A minor cover of glacial drift increases significantly southwards and obscures most of the bedrock in that direction.

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[1] Ollerenshaw, N.C.: Burnt Timber Creek, Alberta; Geol. Surv. Can., Map 65-11 (1965).

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60. LAKE MINNEWANKA WEST (82 O/6, WEST HALF) MAP-AREA

N.C. Ollerenshaw

The geological mapping of the Foothills portion of the Lake Minnewanka West map-area has been completed on a scale of 1 inch to 1 mile. This region constitutes the southern half of the "Panther Dome" periclinal structure.

The arcuate (concave northwards) surface trace of the McConnell Thrust forms the southern boundary of the "Panther Dome" and the Mountain-Foothills contact. The McConnell Thrust superimposes Palaeozoic strata on to Mesozoic strata. The "Panther Dome" consists of a pericline overturned along its eastern flank. Further overturning in the Mesozoic strata occurs near the McConnell Thrust and follows the arcuate trace of that thrust, implying structures folded by the pericline. These minor structures and the major McConnell Thrust structure were apparently in existence prior to the formation of the pericline or dome.

61. MISSISSIPPIAN FORAMINIFERA OF SOUTHWESTERN ALBERTA

A.A. Petryk

The study of the systematics and distribution of foraminifera within Mississippian rocks of southwestern Alberta was begun, with the object of zoning these rocks. About 700 samples were selected for thin sectioning from a total of 6,070 taken from 32 stratigraphic sections studied by R.W. Macqueen. The selection was facilitated by a preliminary thin section study of all lithological samples from a complete Livingstone and Mount Head Formations sequence. Approximately 30 per cent of the thin sections from the Livingstone Formation and 85 per cent from the Mount Head and Etherington Formations contain foraminifera.

The following fossils were noted; Foraminifera: Earlandia, Endothyra, Stacheia, Stacheoides, Tournayella, Brunsia, Brunsiina, Archaediscus, Permodiscus, Ammodiscus, Archaesphaera, Glomospirella?, Palaeotextularia?, Tetrataxis?; algae: Koninckopora, Pycnostroma, Pseudochaetetes; other: calcispheres, echinoderm, ostracod, brachiopod and mollusk fragments, bryozoans, corals, radiolarians, fish fragments.

62. OPERATION BOW-ATHABASCA, ALBERTA AND BRITISH COLUMBIA

R.A. Price

Field work for a helicopter-supported reconnaissance study of the bedrock geology of about 12,000 square miles of the Rocky Mountains south of Mount Robson was completed during the 1966 field season with the study of the southwestern and northern parts of the area. The geologic structure and other aspects of the regional geology were investigated by R.A. Price, E.W. Mountjoy, D.G. Cook, H.R. Balkwill, and J.D. Aitken. These studies were supplemented by the results of concurrent more detailed studies of the structural relations between the carbonate and slate facies of the Lower Palaeozoic rocks near Field, B.C. by D.G. Cook, the pre-Devonian stratigraphy by J.D. Aitken, the Permo-Carboniferous stratigraphy by R.W. Macqueen, the Triassic stratigraphy by D.W. Gibson, and Cambrian biostratigraphy by W.H. Fritz.

The geology of the northern part of the area is outlined on Figures 1, 2, and 3.

A prominent structural culmination occurs in the Main Ranges of the Rockies in the region where Highway 16 crosses the mountains via the Yellowhead Pass (see Fig. 3). In the vicinity of the culmination, the structural grain of the Main Ranges (but not of the Front Ranges) shows a local westerly (left-hand) kink; and an extensive area of regional metamorphism extends into the western Rockies from the Selkirk and Monashee Mountains. The metamorphism affects rocks ranging from the Late Precambrian Miette Group to the Lower Cambrian Gog Group and the carbonate and pelitic rocks of Middle Cambrian age, and is superposed discordantly upon the large-scale structure. It increases in intensity from chlorite grade in the eastern Main Ranges to staurolite and kyanite grade along the east side of the Rocky Mountain Trench adjacent to the Canoe and Columbia Rivers. The lower grade metamorphism is, at least in part, post-kinematic, and has been superposed on rocks that had a prior complex history of penetrative deformation. For example, biotite porphyroblasts occur with random orientation in rocks in which an early axial plane slaty cleavage is folded about later axial planes marked by stain-slip and crenulation cleavage. The higher grade metamorphism is in part pre-kinematic in that the coarse-grained micas in quartz-feldspar augen gneiss and staurolite or garnet schist are crumpled on a small scale along axes parallel with those of folds in bedding. Argillaceous feldspathic quartz sandstones and pebble and granule conglomerates of the Miette and Gog Groups grade, with increasing metamorphism, through phyllitic and schistose rocks in which there is pronounced flattening or elongation of phenoclasts, to quartz-feldspar-biotite gneiss and augen gneiss in which it is difficult to distinguish between the effects of metamorphic segration and those of extreme deformation of phenoclasts. The superposition of folds with several different sets of axial planes has produced complex overprinting of small-scale structures throughout much of the western part of the Main Ranges, and the orientation of the axes of folds in bedding is highly variable.

An enigmatic assemblage of quartz-feldspar-biotite gneiss, mica schist, amphibolite, and gneissic granite occurs along the western edge of the Rockies north and south of Hugh Allan Creek. The granite appears to be restricted to the area south and west of the lower part of Hugh Allan Creek and occurs as tabular lenses that are conformable with the compositional layering in a sequence of amphibolites and quartz-feldspar-biotite gneisses. It has been suggested that this entire assemblage of gneissic rocks has been thrust northeastward over metamorphosed Miette and Cambrian strata[1,2]. Although this hypothesis is tenable, no fault has been observed, and at least locally the quartz-feldspar-biotite gneisses and mica schists in the western Rockies are the lateral metamorphic equivalents of Gog and Miette clastic rocks. Accordingly, the gneissic rocks near Hugh Allan Creek might equally well be considered to be the metamorphic equivalents of Gog strata as shown in Figure 3.

The geology of the southwestern part of the area, in the region embracing the Kickinghorse Pass and southern Dogtooth Mountains, is dominated by an abrupt and pronounced southwesterly change from a carbonate facies to a slate and shale facies in the Middle and Upper Cambrian and the Ordovician succession. The facies boundary is marked by a correspondingly abrupt change in structural style from broad, open folds in which there is little conspicuous penetrative deformation on a mesoscopic scale to a zone of tight, near isoclinal folds in highly cleaved rocks that are characterized by their penetrative deformation. Both thrust and gravity faults are common in the boundary zone, but it is not marked by any single through-going fault, and the two facies do not consistently lie in juxtaposition across a fault. Moreover where the boundary is marked by a fault the stratigraphic separation is relatively small. Thrust faults extending into the zone from the northwest represent the southern end of the Chatter Creek fault[3] and other less prominent thrusts northeast of it. They abut a series of north-trending gravity faults that extends into the headwaters of the Amiskwi and Yoho Rivers from Howse Pass. These gravity faults terminate southward and are replaced with right-hand en échelon offset by other north-trending gravity faults among which are faults extending through Biddle Pass, Opabin Pass, down Tokumm Creek, and across the headwaters of Hawk Creek.

Southwest of the facies boundary the structure is dominated by a synclinorium that follows Split Creek, and Otterhead and Ottertail Rivers, and by a fan-shaped anticlinorium that follows Redburn and Porcupine Creeks. A depression occurs along the axis of the synclinorium in Van Horne Range where the core consists of Ordovician rocks of the McKay or

LEGEND

MESOZOIC	**TRIASSIC, JURASSIC, AND CRETACEOUS**	
	6	Spray River Group, Fernie Group, Nikanassin Formation, Blairmore Group, Alberta Group, and Brazeau Formation
PALAEOZOIC	**DEVONIAN, MISSISSIPPIAN, PENNSYLVANIAN, AND PERMIAN**	
	5	Fairholme Group, Alexo Formation, Palliser Formation, Exshaw Formation, Banff Formation, Rundle Group, Rocky Mountain Group, and equivalent strata
	UPPER CAMBRIAN AND ORDOVICIAN	
	4	Unnamed carbonate unit, Sullivan Formation, Lyell Formation, unnamed shale unit, unnamed carbonate unit, Mons Formation, Sarbach Formation, Skoki Formation, Mount Wilson Formation, Beaverfoot-Brisco Formation, and equivalent strata
	MIDDLE CAMBRIAN	
	3	Mount Whyte Formation, Cathedral Formation, Stephen Formation, Eldon Formation, Pika Formation, Arctomys Formation, and equivalent strata
	LOWER CAMBRIAN	
	2	Gog Group and equivalent strata
PRECAMBRIAN	**WINDERMERE**	
	1	Miette Group and equivalent strata

Geological contact . . . .

Thrust fault . . . .

Gravity fault . . . .

Fault (undifferentiated) . . . .

Anticline . . . .

Syncline . . . .

Biotite isograd . . . .

Garnet isograd . . . .

Staurolite-kyanite isograd . . . .

Occurrence of tabular bodies of leucocratic quartz-feldspar-biotite orthogneiss . . . . G

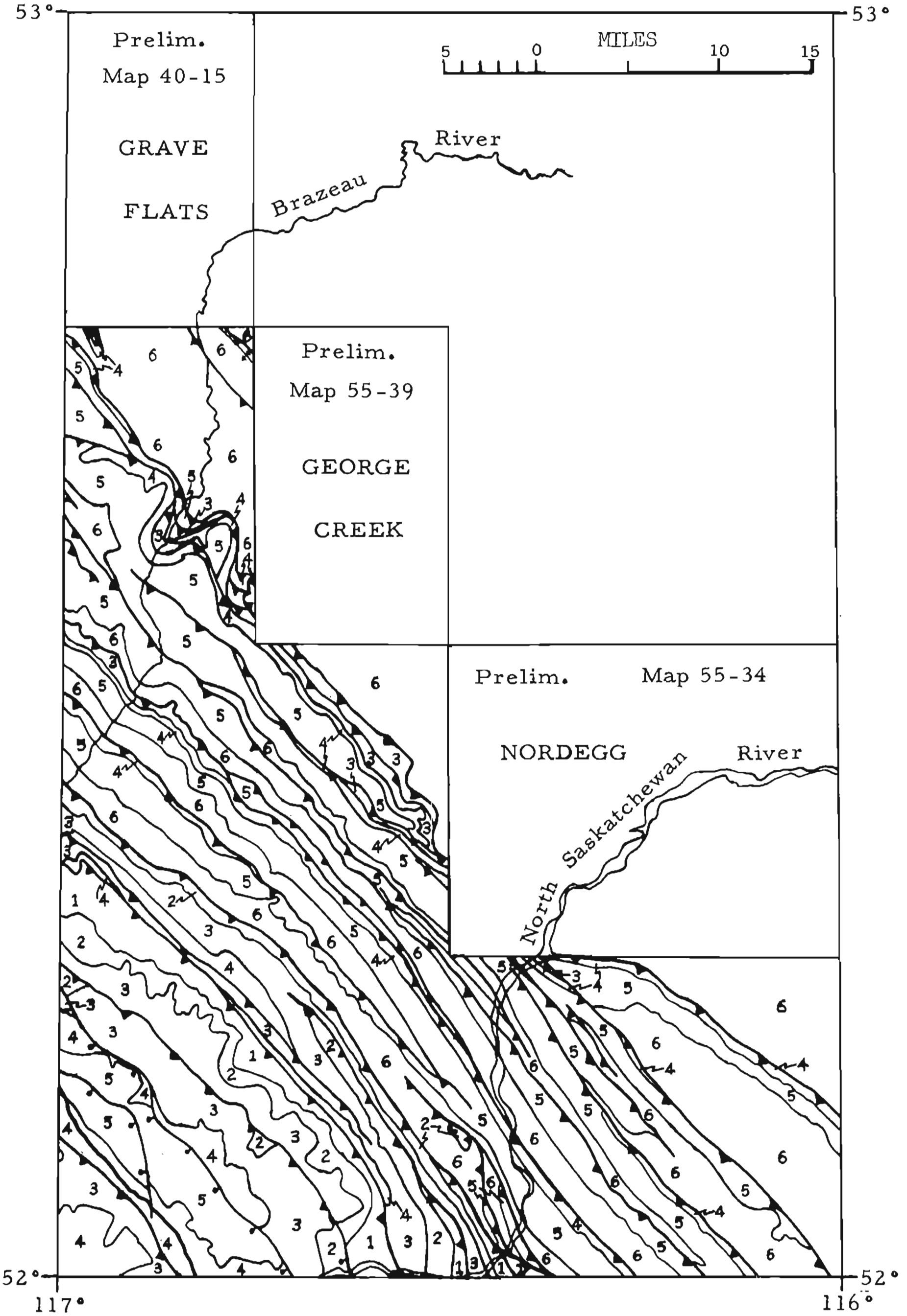

Figure 1. Sketch map of Brazeau, East Half, Alberta, 83C E 1/2.

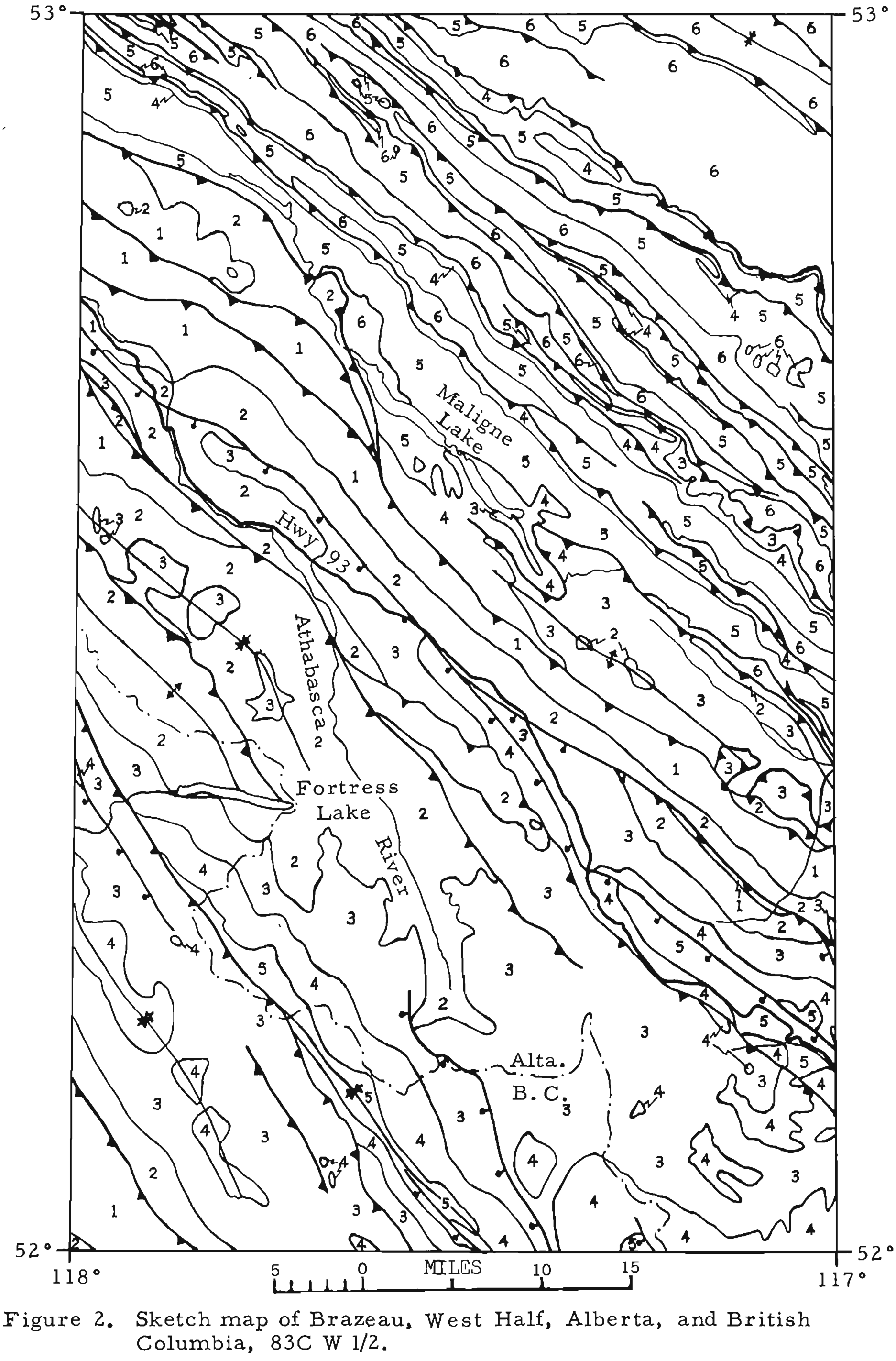

Figure 2. Sketch map of Brazeau, West Half, Alberta, and British Columbia, 83C W 1/2.

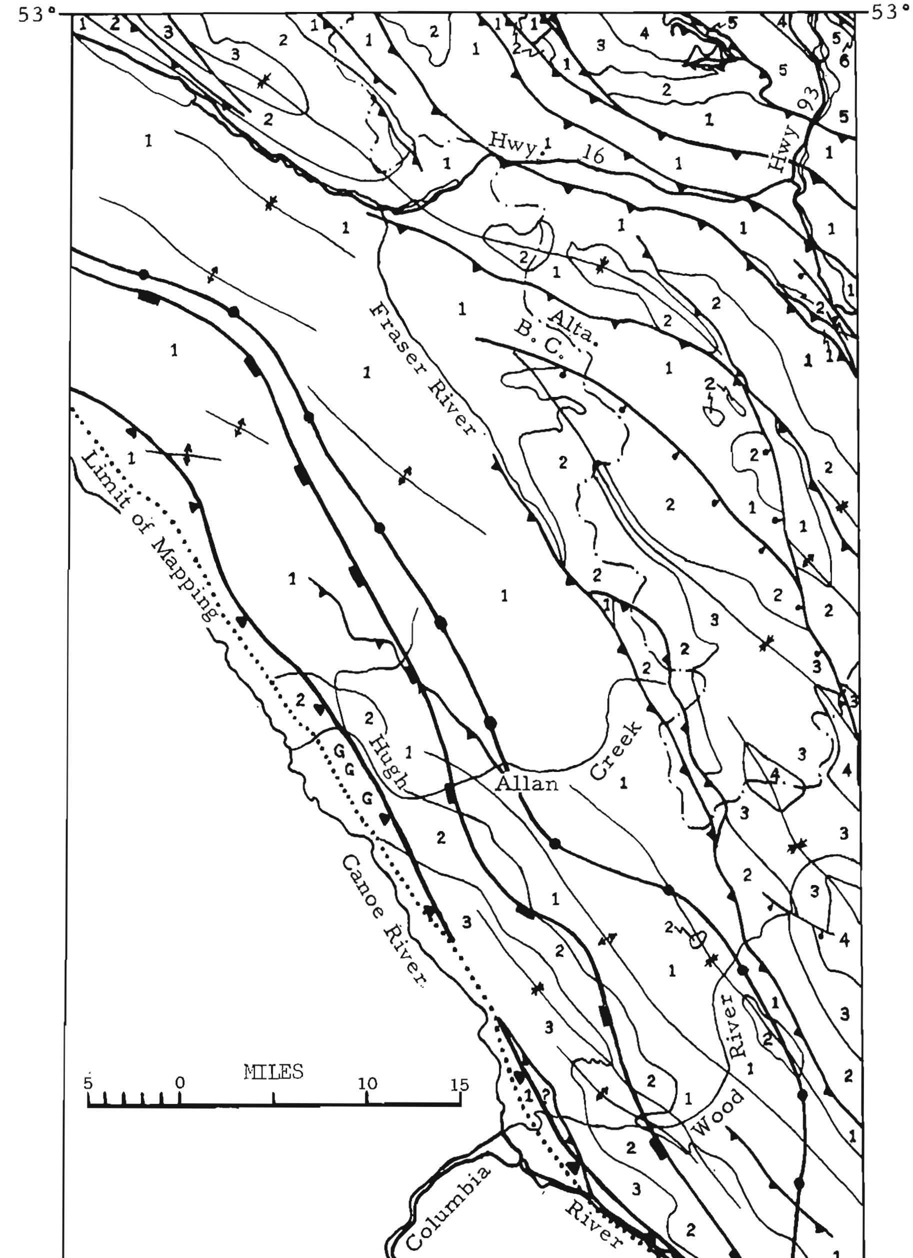

Figure 3. Sketch map of Canoe River, East Half, British Columbia and Alberta, 83D E 1/2.

Goodsir Group. The anticlinorium has an asymmetric fan-shaped profile. The Chancellor and Ottertail strata forming the more markedly overturned southwest limb are structurally continuous with the McKay and younger strata to the west. Although minor folds and faults are common in the overturned limb no major faults corresponding to the Chancellor fault and White River break of North and Henderson[4] were observed.

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

[2]Price, R.A. and Mountjoy, E.W.: Operation Bow-Athabasca, Alberta and British Columbia; <u>in</u> Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 116-121 (1966).

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

[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).

63. SURFICIAL GEOLOGY ALONG THE BOW RIVER VALLEY BETWEEN THE KANANASKIS RIVER AND COCHRANE

N.W. Rutter

Three weeks of the 1966 field season were devoted in the study of the glacial geology along the Bow River valley west of Kananaskis River as a continuation of an earlier study of the Banff area[1]. The ultimate goal is the determination of the relationship between the deposits left by the Cordilleran and Laurentide ice sheets. The most significant discoveries include a section with two distinct Cordilleran tills, and another section containing a volcanic ash layer overlying a buried soil.

The till succession is exposed in a bluff on the south side of the Bow River about 3 miles southwest of Morley. This is the first observation by the writer of two distinct Cordilleran tills in succession within the Bow River valley, west of the Continental Divide. The succession includes, in descending order: 57 1/2 feet of glacial outwash gravels; 6 1/2 feet of buff-coloured till; 2 1/2 feet of outwash; at least 32 1/2 feet of grey till; and bedrock. The upper till unit is correlative with either the Bow Valley advance or re-advance[1].

A 3-inch volcanic ash layer was found under 6 1/2 feet of gravelly outwash interbedded with silt, below a terrace surface on the north side of the Bow River 3 miles northwest of Cochrane. The ash layer forms a sharp boundary with an underlying paleosol, which overlies at least 1 foot of silt and gravel.

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[1]Rutter, N.W.: Surficial geology of the Banff Area, Alberta; unpub. Ph.D. thesis, Univ. Alta. (1966).

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64. QUATERNARY STUDIES IN THE SOUTHWESTERN PRAIRIES

A.M. Stalker

Field work during the summer of 1966 was confined chiefly to study of recent deposits at Smashed-in-the-Head Buffalo Jump (Fort MacLeod), and of Pleistocene stratigraphy at Medicine Hat, Alberta and to a lesser extent at Stewart Valley, Saskatchewan.

Smashed-in-the Head archaeological site has been studied for a number of years by Dr. R.G. Forbis of University of Calgary and Glenbow Foundation of Calgary, and by Mr. B. Reeves, also of Calgary. This year a cooperative attempt was made to obtain a geological and archaeological section through the recent deposits. Mr. Hugh Gwyn undertook the geological studies. Bedrock was shallower than expected, and though this turned out to be a broad, thin sheet that had slid eastward for more than 100 feet from the nearby cliff, it effectively destroyed hopes of obtaining either archaeological or geological information about the first half of the Recent Epoch. The bedrock slide overrode a 10-foot thick till sheet, which in turn covered a pre-classical Wisconsin soil developed on bedrock.

Stratigraphic investigations at Medicine Hat and Stewart Valley were done in association with Dr. C.S. Churcher of the University of Toronto, who studied the vertebrate paleontology. Dr. J.C. Ritchie of Trent University was attached to the party for a week to collect paleobotanical samples. The excellent exposures along South Saskatchewan River north of Medicine Hat yielded abundant bones. These came from some ten horizons ranging in age from preglacial to postglacial. Elephant, camel, and horse are present in most of the horizons, and bison in the upper ones. In addition, good bone specimens were collected from preglacial (?) gravel and sand. Specimens collected during 1965 from Pleistocene beds of greater age than Classical Wisconsin at the 'Island Bluff' exposure (sec. 32, tp. 14, rge. 5, W. 4th mer.) included Cynomys cf. ludovicianus; Citellus? richardsonii; Rodentia indet.; Canis sp.; Vulpes sp.; Proboscidea indet.; Cervus canadensis; Ovis cf. canadensis; Equus sp.; Canachites? canadensis (identified by C.S. Churcher).

The chief bone-bearing bed at Stewart Valley is poorly sorted gravel and sand lying between bedrock and the bottom till. It appears to be of early Pleistocene age. Fossils collected there in 1965 and earlier included ?Mammuthus sp.; Platygonus sp.; Camelid, ?Camelops sp.; Equus sp.

Two or three small stones that appeared hand worked were collected near Medicine Hat in 1965. These came from sand and gravel lying below the Classical Wisconsin till. Additional, and better, specimens were obtained during the past summer at several separate sites, thus confirming presence of man. The artifact bed lies beneath 60 to 150 feet of till and alluvium. The estimated age of the artifacts is 30,000 to 35,000 years. This discovery has led the writer to review the setting of a human skull found near Taber in 1961, some 60 feet below Prairie level and beneath till, outwash, and alluvium, in view of the possibility that it is older (25,000-30,000 years B.P.?) than Classical Wisconsin. He previously suggested a late Classical Wisconsin age for it[1].

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[1]Langston, Wann and Oschinsky, Lawrence: Notes on Taber "Early Man" Site; Anthropologica n.s. vol. 5, No. 2, Ottawa (1963).

65. QUARTERNARY GEOLOGY AND GEOMORPHOLOGY, WHITECOURT (83J) MAP-AREA

D.A. St. Onge

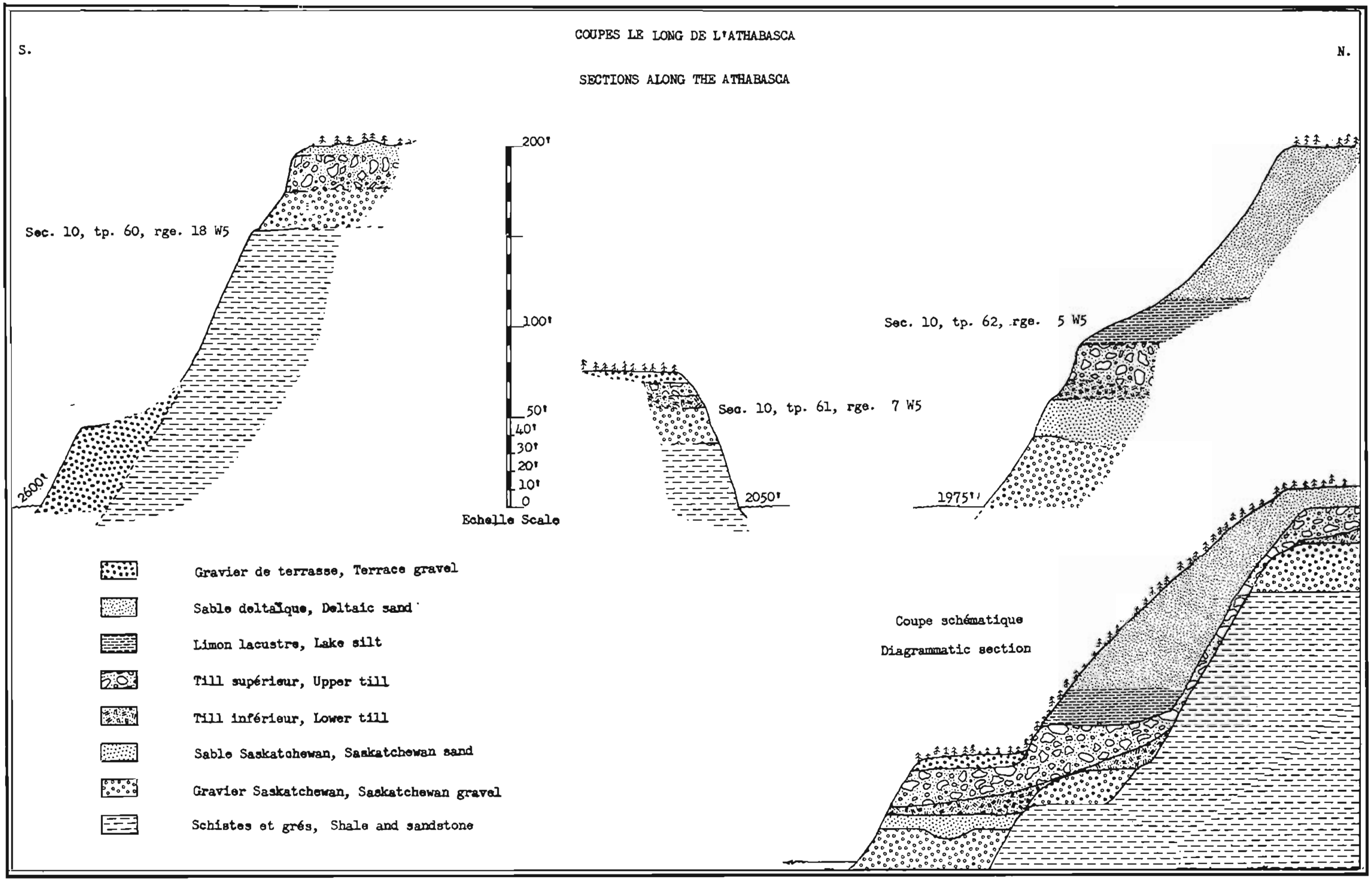
Mapping in the Whitecourt map-area was concentrated in the southern half of the region. Exposures along roads (including oil-well roads) were examined in detail. This information was supplemented by bore-holes up to 40 feet deep. All sections exposed along the Athabasca and Saskatchewan Rivers were examined during boat and helicopter traverses. A detailed geomorphological survey of the western half of Swan Hills 83 J/11 west map-area also was completed.

Within the southern half of the map-area, from the western limit of the area to Barrhead, hills consist of till over bedrock and intervening lowlands of lacustrine silts and deltaic sands. "Whitecourt Mountain" in township 58, range 12, west of 5th meridian, rises to 3,600 feet above sea-level. It is capped by quartzite, cobbles, gravels, and sands of Tertiary (?) age. The upper 10 feet of this deposit has been disturbed by the overriding glacial ice.

A terraced "preglacial" valley was traced along the present course of Athabasca River from the March Head Creek area[1] to Vega Ferry. The "Saskatchewan Gravels", which range in grain size from silty sand to cobbles 18 inches in diameter, cover the terraces and bottom of the preglacial valley, as shown in the three sections of Figure 1. They are overlain by two distinct till sheets, the lower of which is not everywhere present. The diagrammatic section of Figure 1 illustrates the relationship between these various deposits. Between Vega Ferry and Chisholm, till generally rests directly on bedrock. Downstream from Vega Ferry the ancestral Athabasca River probably followed an east-northeast course.

The two tills differ in texture and appearance, the lower being a black sandy clay containing few stones, while the upper is a grey to dark brown sandy silt containing numerous pebbles and boulders. Both contain granitic rocks indicating a Laurentide origin. The two tills are commonly in contact, but in a few sections they are separated by up to 60 feet of outwash gravels and sands. No material has been found to allow dating of the lower till.

As the ice retreated northeasterly, various glacial-lake levels were formed; these are marked by extensive deltas. The silts deposited in these lakes occur at progressively lower altitudes from west to east: from 2,650 feet above sea-level west of Whitecourt to 2,250 feet above sea-level around Barrhead. The sandy deltaic deposits have been reworked into large, well defined, generally parabolic dunes.


COUPES LE LONG DE L'ATHABASCA
SECTIONS ALONG THE ATHABASCA
S.
N.
Sec. 10, tp. 60, rge. 18 W5
2600'
200'
100'
50'
40'
30'
20'
10'
0
Echelle Scale
Sec. 10, tp. 61, rge. 7 W5
2050'
Sec. 10, tp. 62, rge. 5 W5
1975'
Coupe schématique
Diagrammatic section
Gravier de terrasse, Terrace gravel
Sable deltaïque, Deltaic sand
Limon lacustre, Lake silt
Till supérieur, Upper till
Till inférieur, Lower till
Sable Saskatchewan, Saskatchewan sand
Gravier Saskatchewan, Saskatchewan gravel
Schistes et grés, Shale and sandstone

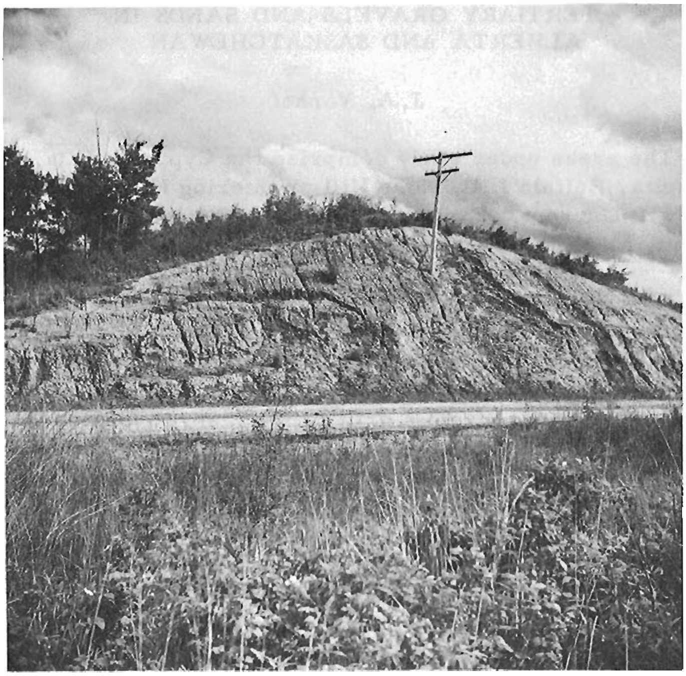


Figure 2. Silt mound in L.S.C. 12, sec. 18, tp. 59, rge. 6 W 5th.

Thirty-five feet of fossiliferous silt is exposed in this road cut. The slopes are from 18 to 22 degrees. .

In township 58, 59, and 60, ranges 6 and 7 west of 5th meridian, an ice frontal zone is defined by kames and silt mounds. The silt mounds are 15 to 45 feet high and generally steep sided (12° to 28°). Some have rounded (Fig. 2) or nearly flat summits, but others are marked by a central depression and doughnut-like form. The silt layers are commonly contorted, particularly in the case of the doughnut-shaped hills. Some contain shells of fresh-water molluscs. The silts were deposited between, and locally on top of ice blocks of a disintegrating ice front.

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[1]St. Onge, D.A.: Geomorphology and glacial geology studies in north-central Alberta; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 122 (1966).

66. TERTIARY GRAVELS AND SANDS IN ALBERTA AND SASKATCHEWAN

J.A. Vonhof

The areas under study comprise the Cypress Hills, and areas near Del Bonita, Buffalo Hill, Nose Hill, Wintering Hills, Hand Hills, Swan Hills, and Swift Current. Except for the Swift Current area, which is in Saskatchewan, all the above localities are in Alberta.

Data pertaining to the distribution, streamflow directions, and lithology were collected during the summer of 1966 in all but the Nose Hills and Buffalo Hill areas. Information on the distribution and lithology of the Cypress Hills Formation and the Swift Current Creek beds in the Swift Current area was obtained from a drilling program conducted in that area. Additional subsurface information in the Swift Current area, such as geological logs from boreholes, has been contributed by the Saskatchewan Research Council, whose support of the field program is gratefully acknowledged.

A preliminary evaluation of the data collected reveals that the Tertiary deposits in Alberta and Saskatchewan, based on the rock types present in the gravel component, can be placed in four lithological provinces. These are: 1) Cypress Hills; 2) Del Bonita; 3) Hand Hills; and 4) Swan Hills.

1. The Cypress Hills province covers southeastern Alberta, adjacent parts of Saskatchewan, and the Swift Current area. The Swift Current Creek beds, the Cypress Hills Formation, the Wood Mountain Formation, and the reworked deposits related to the above formations are included in this lithological province.

The gravel component of the Tertiary deposits in this province comprises mainly quartzites and chert. In addition pebbles of trachyte and other porphyritic rocks are present. The latter rock types are absent in the other lithological provinces.

2. The Del Bonita province covers an area in southwestern Alberta near the town of Del Bonita. The gravel component of the Tertiary deposits in this province is characterized by quartzites and green argillites and the absence of chert. In addition pebbles of diorite are present. The latter rock type was not found in the other provinces.

3. The Hand Hills province covers an area in central Alberta. Tertiary sand and gravel deposits occurring in the Hand Hills, Wintering Hills, Buffalo Hill, and Nose Hill are included in this province.

The gravel component of the Tertiary deposits in this province comprises mainly quartzite and chert. In addition a significant percentage (5-10 per cent) of limestone pebbles is present. No igneous rock types were found in this province.

4. The Swan Hills province covers an area in northwestern Alberta. Tertiary deposits of sand and gravel occurring in the Swan Hills, Whitecourt Mountain, and near the Mayberne firetower north of Edson are included in this lithological province. The gravel component in these deposits is characterized by a very high percentage (95 per cent or more) of quartzite and only a small percentage of other rock types such as chert and sandstone.

An assessment of the data obtained during the drilling program in the Swift Current area, Saskatchewan, shows that part of a Tertiary river channel is still present. The channel fill consists of gravels, sands, and clays. The thickness of the fill exceeds 250 feet in places. In one borehole, approximately 10 miles south of Swift Current, 200 feet of gravel was encountered.

SASKATCHEWAN

67. OBSERVATIONS IN FOND-DU-LAC AREA

A. J. Baer

Preliminary reconnaissance flights over Fond-du-Lac area (74 O) have shown large and numerous outcrops, except in the north-central part of the area, where drift is abundant.

A large amount of structural information can be gathered from the air and from airphotos. Most of the area is too heavily forested for helicopter work, but numerous lakes are accessible to fixed-wing aircraft.

68. A STUDY OF AMPLITUDE AND FREQUENCY CHARACTERISTICS OF SEISMIC WAVES IN SURFICIAL DEPOSITS OF THE CANADIAN PRAIRIES

K.B.S. Burke

A seismic field program was commenced to investigate the possibility of using parameters other than velocity in the identification of significant features in surficial deposits of the Canadian Prairies. Two areas in Saskatchewan - one near Stenen (62M T 34 R3 W2), the other near Frobisher (62E T5 R4 W2) - and an area around Winkler (62H T2, 3, 4, R4 WPM) in Manitoba were selected for investigation on the basis of available subsurface control. Broadband recordings (3-300 cps) of seismic waves along refraction and reflection profiles were made in each area using an S.I.E., 12 channel PT 100 amplifier system coupled to a P.M.R. 20 magnetic tape recorder. The magnetic tapes obtained are presently being played back and the amplitude and frequency characteristics of identifiable events will be determined.

In the Stenen area, uphole wavefront surveys demonstrated the lack of significant velocity changes associated with the surficial materials and bedrock. A gravel-filled bedrock depression of sharp vertical relief (change of bedrock elevation of 125 feet in 700 feet of horizontal distance) was outlined by concurrent test drilling. Changes in the character of reflections from horizons in the bedrock that are possibly associated with this gravel-filled depression are now being studied.

A relatively high frequency event has been tentatively associated with a sand and gravel deposit in the Winkler area, but the event is not persistent. Uphole wavefront surveys again confirmed the lack of significant velocity contrasts associated with most of the surficial deposits. A large transverse component of motion was recorded by the three component geophones in the early part of several of the records in this area, possibly caused by inhomogeneities at the shot point.

No extensive analysis has yet been made of the records obtained in the Frobisher area. However, large transverse components of motion were again noted in this area.

69. PRELIMINARY INVESTIGATION ON THE URANIUM CONTENT OF SASKATCHEWAN LIGNITES

A.R. Cameron

The field work covered in this summary consisted of ten days of reconnaissance and sampling to investigate the uranium possibilities of Saskatchewan lignites. In order to acquire background information on the occurrence of uranium in lignite part of the time was spent in a visit to areas of North and South Dakota where uranium occurs in lignite in commercial quantities. Lignite mines and concentration plants were visited in the vicinity of Belfield and Bowman, North Dakota, and the North Cave Hills of South Dakota.

The remaining days in the field were spent in testing lignite exposures in the Eastend, Shaunavon, Twelvemile Lake, and St. Victor areas of Saskatchewan, with the aid of a scintillation counter. Some of the exposures tested gave readings higher than background, although none was as high as those obtained in the Dakota lignites. At localities in Saskatchewan where anomalous readings were obtained a total of seventeen samples were collected for more accurate analyses in the laboratories at Ottawa.

70. HAMMER SEISMIC INVESTIGATIONS, GOOD SPIRIT LAKE AREA

G.D. Hobson

A model FS-3 (Huntec) portable hammer seismograph was used to determine depth to bedrock and to differentiate Pleistocene materials by seismic velocity criteria. The survey was conducted within the Good Spirit Lake drainage basin in two areas: one central area in an attempt to differentiate clay and till from shale bedrock, and one northern portion in an attempt to map the water-table.

It is difficult to define the clay or till-shale interface because the shale is probably weathered. It is also at a depth, which in some localities, exceeds the capabilities of the instrument. Sand and gravel can be differentiated from the underlying boulder glacial till with reasonable accuracy.

In general, the attempt to define the water-table in the northern part of the basin was inconclusive. Insufficient data were acquired to permit a water-table map to be contoured.

71. PALYNOLOGICAL STUDIES IN CENTRAL SASKATCHEWAN

R.J. Mott

Nine lakes were sampled as part of a project begun in 1965 to study late-glacial and post-glacial vegetational and climatic changes and geochronology in central Saskatchewan. Of special interest are the fluctuations of the forest-grassland boundary in post-glacial time. The location of the sampling sites as well as the present-day forest and grassland regions are shown in Figure 1.

Lakes were chosen for their location with respect to the vegetational regions, sediment content, water depth, and accessibility. All the lakes sampled contained fresh water and had a depth of less than 40 feet. Sediment depth varied from about 45 feet at location 5 to less than 5 feet at location 8. Sediment type also varied. The lake sediments within the grassland region, aspen grove section, and southern parts of the mixed forest section of the boreal forest region, are marl while those within the remainder of the boreal forest region are gyttja. All cores were obtained with a Livingstone piston sampler.

The following four radiocarbon dates on basal organic lake sediments have been obtained.

Site 1. G.S.C. 648 ------ 11,560 ± 640
Site 4. G.S.C. 642 ------ 11,090 ± 160
Site 6. G.S.C. 647 ------ 10,260 ± 170
Site 9. G.S.C. 643 ------ 8,520 ± 170

These dates indicate that ice recession in central Saskatchewan took place slightly earlier than is indicated by Christiansen[1].

[1] Christiansen, E.A.: Ice frontal positions in Saskatchewan; Sask. Res. Council, Map No. 2 (1965).

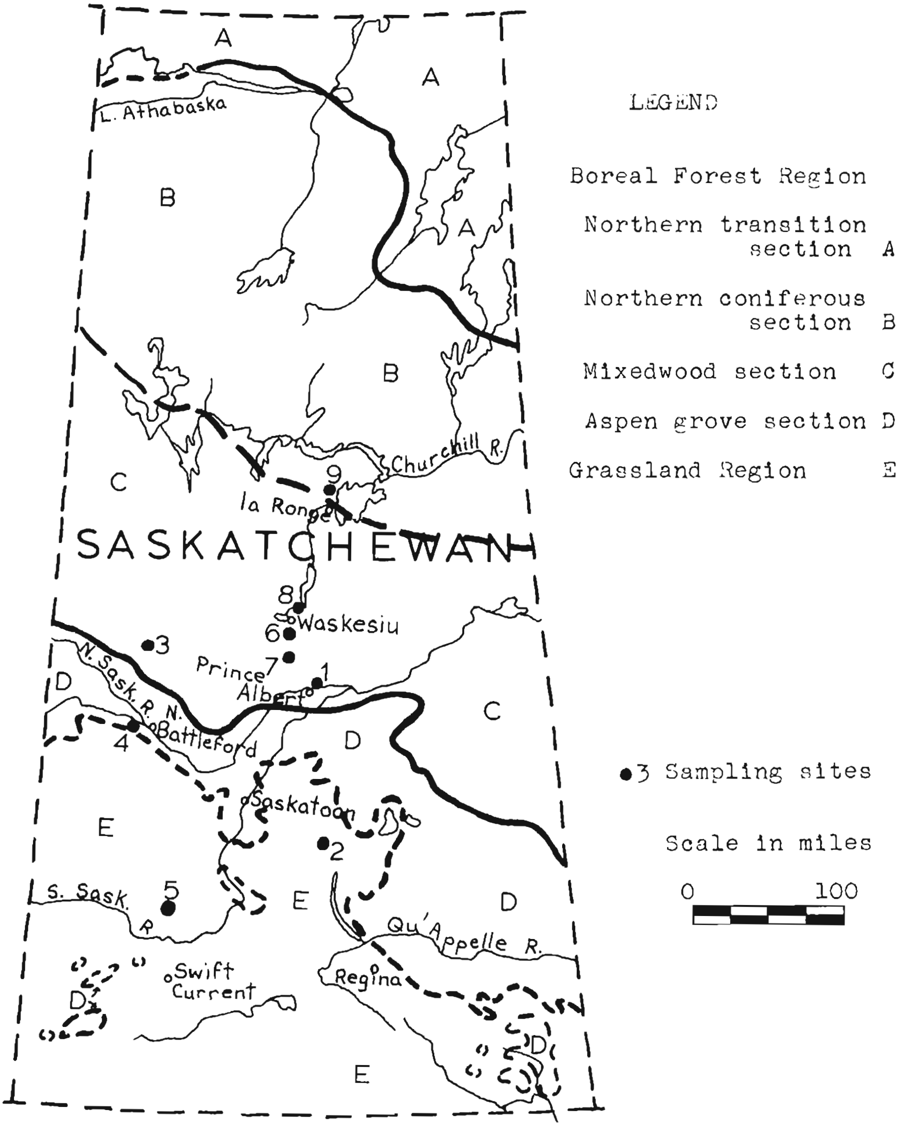

Figure 1. Sketch map of Saskatchewan showing location of sampling sites and forest and grassland regions.

72. LANDSLIDE INVESTIGATIONS, SOUTH SASKATCHEWAN RIVER RESERVOIR

J.S. Scott

Undisturbed sampling of the overconsolidated Bearpaw shale was carried out in an area of landslides adjacent to the South Saskatchewan River Reservoir. Samples were obtained with the use of a Pitcher Sampler (a double-wall core barrel) from a 30-foot interval from 92 to 112 feet below surface. The sampled interval is thought to contain the failure zone. Recovery of samples throughout the interval averaged 66 per cent.

A substantial increase in sample recovery could have been effected had the design of the sampler included a greater difference in diameter between the cutting bit and the outer barrel and greater clearance between the inner wall of the barrel and the outer wall of the sample tube in order to permit freer circulation of drill-fluid and cuttings and a consequent reduction in pump pressure required to maintain circulation.

Strength testing of the samples obtained is to be made by the Department of Civil Engineering, University of Alberta.

MANITOBA

73. A SEISMIC INVESTIGATION NEAR FLIN FLON

G.D. Hobson

Seismic reflection and refraction profiles were shot near Flin Flon to determine whether these techniques can detect interfaces between Precambrian rock units. The refraction spread was shot with explosives detonated in several lakes out to a distance of 20 miles on both sides of the detectors. The time vs distance graph shows one velocity of 19,500 feet per second. At least four reflection events were recorded with the deepest at 4 seconds two-way travel time.

74. SURFICIAL GEOLOGY AND GEOMORPHOLOGY OF THE ASSINIBOINE RIVER VALLEY AND ITS TRIBUTARIES

R.W. Klassen

The first two months of the field season were spent on a reconnaissance of the Assiniboine, Qu'Appelle, and Shell River valleys. The survey provided information concerning: 1) the relationship of valley development to regional glacial and post-glacial history, to geologic deposits, and to pre-existing landforms; 2) the classification of geologic deposits and landforms within the valleys as a basis for preparation of detailed maps of selected 'type segments' of the valleys; and 3) drift stratigraphy.

Twenty-seven testholes were drilled by rotary drill to bedrock at sites within and along the edge of Assiniboine River valley near Treherne, Brandon, Alexander, and Roblin in Manitoba, and near Esterhazy in Saskatchewan. A total footage of 6,000 feet was logged. Chip samples were taken at 10-foot intervals and continuous resistivity and self-potential logs were run. Samples of the stratigraphic units penetrated, other than coarse sand or gravel, were taken at 5-foot to 10-foot intervals by means of a sidewall core sampling device.

The lithology and landform of deposits in Qu'Appelle River valley within Esterhazy (62L/9) map-area were mapped on a scale of one inch to one mile.

Material for radiocarbon dating was collected in a number of localities from fill within the Assiniboine and Qu'Appelle River valleys. A clay unit between the surface till and an underlying till exposed along the edge of Shell River valley (NW 1/4 sec. 17, tp. 28, rge. 27 WPM) on the Duck Mountain Upland includes a marl bed and charcoal. A radiocarbon date from this material will indicate the maximal age of the surface till in this area.

Anomalous concentrations of quartzite pebbles were found within drift in two localities and are considered indicative of the close proximity or presence of preglacial valleys. A wood-bearing alluvial sand and gravel composed of 20 per cent quartzite rather than the 5 per cent common in other drift gravels was exposed along the east end of the Shellmouth dam across the Assiniboine River valley near Shellmouth, Manitoba. The stratigraphic position of this unit and the direction of current bedding, as well as evidence from nearby testholes, indicate that the Assiniboine River valley here crosses a broad buried valley that drained towards the northeast, as the writer has suggested earlier[1]. Along the Qu'Appelle River valley (NW 1/4 sec. 3, tp. 19, rge. 25, W 2nd mer.) north of Moose Jaw, a till about 50 feet thick above bedrock has markedly fewer stones than the tills higher in the section and contains 26 per cent quartzite pebbles rather than the 5 per cent found in the other tills.

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[1] Klassen, R.W.: The surficial geology of the Riding Mountain area, Manitoba-Saskatchewan; unpublished Ph.D. thesis, Univ. Sask., pp. 12-13 (1965).

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75. REGIONAL MAGNETIC SUSCEPTIBILITY SURVEY IN MANITOBA AND SASKATCHEWAN

L.J. Kornik

The area studied is in northwestern Manitoba and northeastern Saskatchewan (Fig. 1). A regional approach was deemed best suited to study the large-scale magnetic anomalies, which are continuous for hundreds of miles. A program of aircraft traverses across selected areas was carried out as a field check of this interpretation. The survey was undertaken to correlate the underlying bedrock geology and the magnetic properties of the rocks with the aeromagnetic anomalies in order to establish sources of aeromagnetic data and availability of lakes suitable for landing float-equipped aircraft.

A float-equipped Cessna 180 was used to travel between sample sites. In situ magnetic susceptibility determinations and oriented drill cores were collected at the sample sites (Fig. 1) as well as observations on the general rock types. The in situ susceptibility readings were made with a Sharpe SM 3 susceptibility meter. Oriented drill cores were collected with a portable diamond drill developed by the Geological Survey of Canada. A total of 218 locations were visited and 163 oriented drill cores were collected. The susceptibilities of these cores were determined in the laboratory

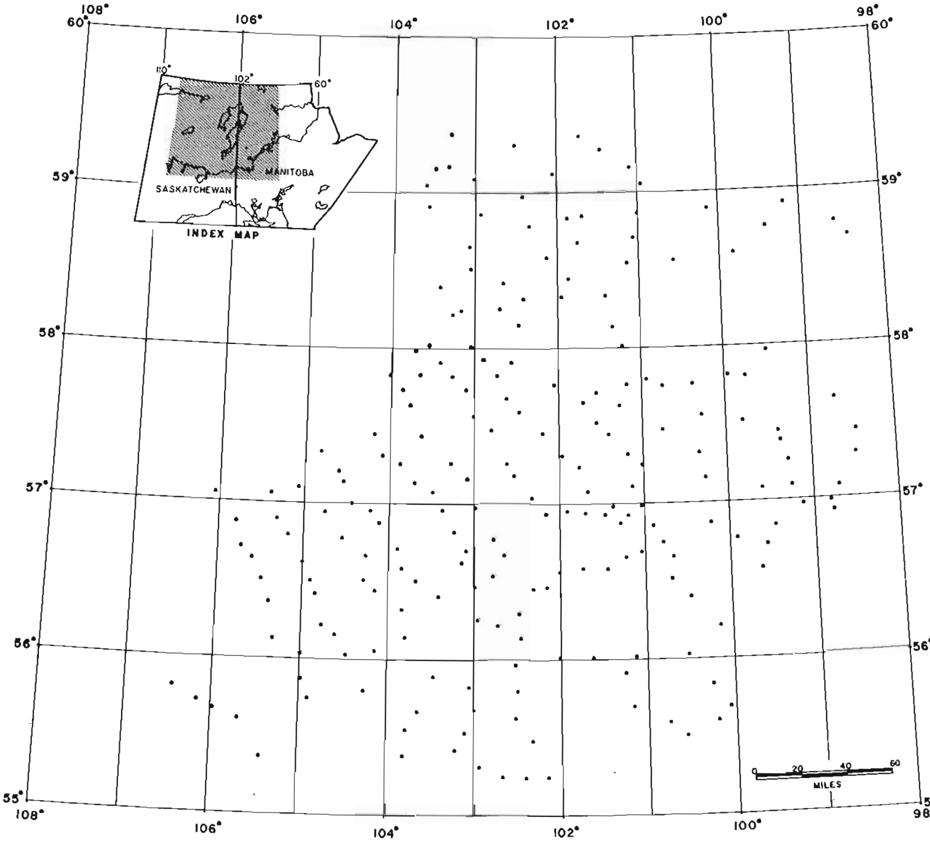

Figure 1. Map showing location of sample sites.

as a check on the field readings. The laboratory determinations were obtained with the cores in an upright position and in an inverted position and the average of the two readings used. Remanent magnetism determinations on the cores are to be completed by A. Larochelle.

In situ susceptibility readings determined on the outcrops in the field during the survey and susceptibility readings determined from drill cores in the office show good qualitative correlation. Sample points in areas of magnetic 'highs' have high magnetic susceptibility values and conversely, sample points in magnetic 'lows' are associated with low magnetic susceptibility values. Discrepancies in susceptibility values can be attributed to the inhomogeneous nature of the sampled rocks.

A regional compilation of all available aeromagnetic data in Manitoba, Saskatchewan, and the southern District of Keewatin, involving some fifty-two 4-mile map-areas, was assembled at a scale of 1 inch to 4 miles. It was coloured in eleven units of intensity with a 200 gamma colour interval. This coloured composite was then reduced photographically to black and white prints at a scale of 1 inch to 16 miles and an office interpretation of this composite was undertaken.

Results of this survey would suggest that the magnetic anomaly pattern can be correlated with the magnetic susceptibility of the underlying rocks. For example, large scale continuous magnetic features, such as the "Owl River 'high'"[1], can be traced westward by susceptibility determinations from the edge of Hudson Bay across Manitoba and half way across Saskatchewan, where this feature continues off the existing aeromagnetic coverage. A large elongated magnetic 'low' lying along the north side of this extensive magnetic 'high' is coincident with low values of magnetic susceptibility determinations. This is only a preliminary assessment and remanent magnetization determinations on the cores will enable a more accurate correlation of the rock types and their magnetic properties to the aeromagnetic patterns.

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[1]Kornik, L.J. and MacLaren, A.S.: Aeromagnetic Study of the Churchill-Superior Boundary in Northern Manitoba; Can. J. Earth Sci., vol. 3, pp. 547-557 (1966).

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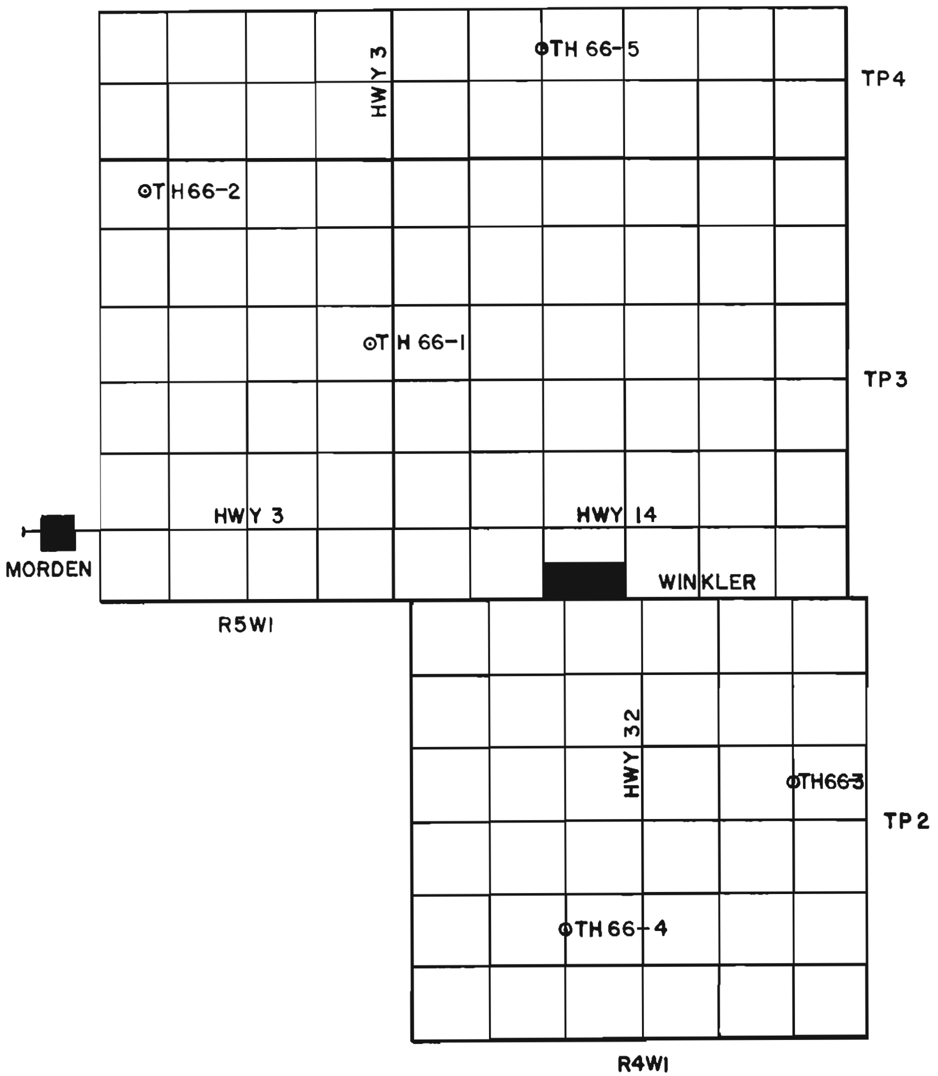
76. TESTING SIDE-WALL SAMPLER IN DRILL-HOLES COMPLETED IN PLEISTOCENE SEDIMENTS, WINKLER AREA

J.E. Wyder and L.S. Collett

A five-hole drilling program was completed near Winkler, Manitoba (see Fig. 1). The sites were selected by Collett, who used as a guide the results of his 1965 airborne INPUT resistivity mapping survey in the Winkler area. All holes entered bedrock. Total footage drilled was 1,476 feet. SP and resistivity logs were run on each hole.

The drill-holes were used to test the Geological Survey of Canada side-wall sampler, which was constructed under contract by the Saskatchewan Research Council. The sampler is capable of extracting from the side of a drill-hole a sample approximately 2" long by 3/4" diameter with a position in the hole accuracy of ± 1/2 foot. The sampler is capable of sampling to a maximum depth of 1,000 feet. About 90 samples were taken by the side-wall sampler. Portions of these samples were sealed in plastic vials to permit electrical conductivity measurements. The remaining portions will be studied for composition, texture, degree of oxidation, and to determine the contact between Pleistocene and Cretaceous strata.



LOCATION OF DRILL HOLE SITES, WINKLER AREA, MANITOBA, 1966.

ONTARIO

77. RADIO WAVE MAPPING OF GROUND CONDUCTIVITY ANOMALIES

A. Becker

This series of experiments constitutes the beginning of an investigation of the effects of shallow ground conductivity inhomogeneities on VLF (10-50 Kcs.) radio waves emitted by distant communication stations. The area chosen was the Gloucester fault[1] in the immediate vicinity of Leitrim, Ontario. It was expected that the younger formations on the downthrown side would be significantly more conductive than the Oxford dolomite on the other side of the fault.

The radio waves used originated from station NAA in Cutler, Maine, U.S.A. This is a 1000 Kw. transmitter, which broadcasts at 17.8 Kcs. throughout the day. The carrier wave is either phase or pulse-code modulated. Where the ground is homogeneous, the magnetic field of this transmitter is horizontal, the electric field is slightly inclined from the vertical.

Two measurement techniques were employed. The first one utilizes the EM 16, a commercial instrument produced by Geonics Ltd. of Toronto, Ontario. The operation of this equipment is based on the fact that sharp lateral conductivity discontinuities give rise to vertical magnetic fields in the vicinity of the contact. The magnitudes of the in-phase and quadrature components of the vertical magnetic field (usually expressed as a percentage of the horizontal field strength) are indicative of the presence and electrical quality of the anomalous structure.

The second technique is analogous to the classical telluric current method. The equipment consisted of two modified Navy VLF receivers, which were adapted to the measurement of the horizontal component of the electric field vector. In the VLF frequency range the strength of this component varies inversely with the square root of the conductivity. Thus relative field strength measurements can be readily translated into relative ground conductivity values.

The results of the test surveys are shown in Figure 1. It is evident that both methods indicate the presence of the fault zone. In addition, the electric field measurements show that the shales on the northeast side of the fault are about seven times as conductive as the limestones to the southwest.

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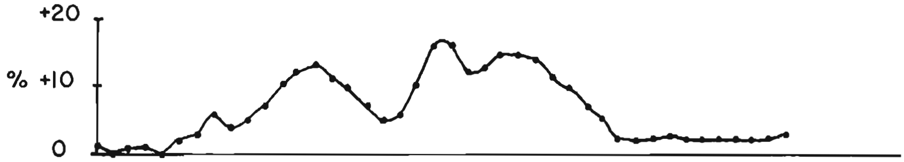
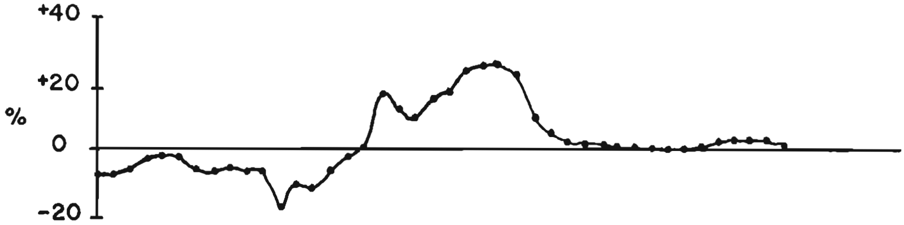
[1]Wilson, A.E.: Geology of the Ottawa-St. Lawrence Lowland, Ontario and Quebec; Geol. Surv. Can., Mem. 241 (1946).

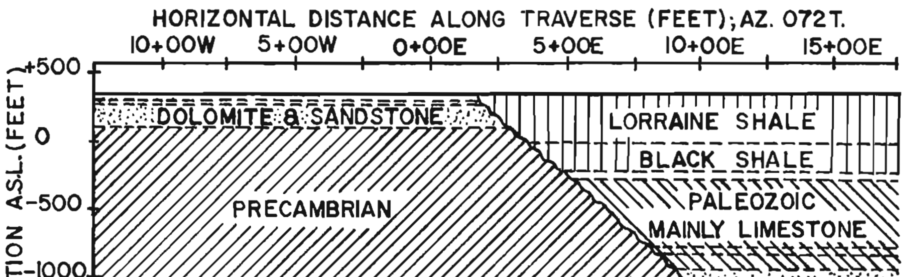


QUADRATURE COMPONENT OF VERTICAL MAGNETIC FIELD.



IN-PHASE COMPONENT OF VERTICAL MAGNETIC FIELD.

GROUND RESISTIVITY (RELATIVE TO 0+00)
FROM HORIZONTAL ELECTRIC FIELD STRENGTH.



APPROXIMATE GEOLOGICAL SECTION (AFTER A.E. WILSON).

78. SUMMARY REPORT OF GEOCHEMICAL FIELD WORK, COBALT AREA, ONTARIO

R.W. Boyle, A.S. Dass, J. Lynch, W. Dyck,
G. Mihailov, C. Durham, P.J. Lavergne, and D. Church.

Research in geochemical prospecting methods, including analyses of wall rocks in the vicinity of the silver veins, analyses of soils, tills, and glacial clay on traverses across the veins, analyses of stream, spring, and underground waters and their precipitates, and radiation surveys on traverses across the veins both underground and on the surface were carried out in the Cobalt area of Ontario during June, July, and August, 1966. The analytical work was done in the field utilizing field colorimetric and spectrographic laboratories.

The rocks, soils, tills, glacial clays, and precipitates from springs and underground waters were analyzed for Cu, Pb, Zn, Ag, Ni, Co, Mo, Hg, As, Sb, and Mn, and the stream, spring, and underground waters were analyzed for total heavy metals (mainly zinc), nickel, and cobalt in the field. The Eh, pH, and temperature of the spring, ground, and stream waters were also determined at each sample point, and samples of water were obtained for further work in the laboratories in Ottawa. A total of 2,461 samples of rock, soil, till, and spring precipitates was analyzed for the elements noted above, and a total of 360 samples of water was analyzed for total heavy metals, nickel, and cobalt.

In addition to the above work a detailed chemical investigation of the wall-rock alteration associated with the silver veins was commenced by A.S. Dass.

The following tentative conclusions on the various surveys seem warranted. Further details are given in Geological Survey of Canada Paper 66-46[1].

1. Analyses of clay and derived soils are not effective for prospecting for silver veins in the Cobalt area.

2. Analyses of till and derived soils should be effective for prospecting for silver veins in the Cobalt area. The A horizon gives the best response, but in some places the B horizon is likewise as good, especially where the till is relatively shallow. The best indicator elements in the till and derived soils are Ag, As, Sb, and Mn. Nickel and cobalt are also effective in some areas, and mercury may respond in a few places.

3. Both drill core samples and rock chips indicate the presence of veins and vein clusters. In the Cobalt sediments the dispersion of Ag, As, Sb, Ni, Co, Mn, and Hg is broad, and veins may be indicated as far as 100 feet away by these elements. A somewhat similar pattern is present for silver veins in Keewatin greenstones, but the dispersion is generally more restricted. In the diabase the dispersion is narrow and veins are indicated only a few feet away by a rise in Ag, As, Ni, and Co.

4. Radiometric surveys proved negative for locating veins, suggesting that this method is not applicable for soils, till, glacial clay, or rock.

5. Great care must be taken in the Cobalt area in using geochemical methods because of the great amount of contamination present from old mine dumps, trenches, and domestic refuse.

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[1]Boyle, R.W.: Geochemical prospecting research in 1966, Cobalt area, Ontario; Geol. Surv. Can., Paper 66-46 (1966).

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79. STRUCTURE AND METAMORPHISM, CENTRAL HASTINGS COUNTY, ONTARIO

D.M. Carmichael

An area of 70 square miles in Lake Township and southern Wollaston Township has been geologically mapped in detail. Metasedimentary and metavolcanic rocks are present in roughly equal proportions, and occur in an interbedded sequence of great stratigraphic complexity. Metagreywacke is abundant, and it grades through tuffaceous greywacke to crystal tuff. Impure carbonates are common, but quartzite is almost absent. Pelitic units are thin, and generally potash-poor. The metavolcanic rocks include basic varieties, with local pillow structure, and rhyolite grading to acid tuff.

Two important structural episodes have been distinguished. During the first structural episode, the rocks were folded isoclinally at a relatively low temperature. Deformed pebbles indicate that the rocks were greatly foreshortened perpendicular to the axial planes of these folds, and elongated parallel to the fold axes, but primary bedding is generally well preserved. At a later time, a new set of folds developed on steeply dipping, northeast-trending axial planes, and the temperature rose to a maximum. All of the plutonic rocks of the area had already been emplaced by this time.

The orientation of the early fold axes was modified both by the later folding and by the emplacement of the plutonic rocks, so that the initial orientation of the early folds cannot be determined with certainty. Some time after the onset of cooling, minor crinkles and crenulations having near-horizontal axial planes developed in the mica schists, but there was no further pervasive deformation or plutonic activity.

The metamorphic grade ranges from garnet zone in the southeast to sillimanite zone in the northwest. The isograds are straight and regular, and they trend northeastward, parallel to the axial traces of the late folds, and transverse to the early folds.

Barrow's classical kyanite zone is missing in this area. Almandine-staurolite-muscovite-biotite schist passes along strike directly into almandine-sillimanite-muscovite-biotite schist. However, within the staurolite zone, kyanite occurs with staurolite in pelites that do not carry almandine, and the kyanite to sillimanite transition has been mapped as an isograd 700 yards below the upper boundary of the staurolite zone. This indicates that the depth of burial was less in this area than in the Scottish Dalradian.

Preliminary study of compatible phase assemblages suggests that the reaction occurring at the staurolite isograd involves reaction between chlorite and muscovite to form staurolite and biotite. Chlorite and muscovite commonly occur together in the garnet zone, but they are mutually exclusive in the staurolite zone. The reaction occurring at the sillimanite isograd involves reaction between staurolite and muscovite to form almandine, sillimanite, and biotite. Staurolite occurs well above this isograd in rocks that do not contain muscovite.

The question of whether the two geometrically distinct structural episodes represent two separate orogenies, or merely two pulses of the same orogeny, cannot be answered decisively. Certainly all the rocks of the area were involved in both structural episodes. If there was a long period of uplift and erosion after the first structural episode, then it would seem that new subsidence and new sedimentation must have occurred prior to the second structural episode, in order for the rocks to have been buried to sufficient depth to produce the deep-seated metamorphism of the second structural episode. Then this hypothetical younger sedimentary sequence, folded only once on northeast-trending axes, must have been completely eroded so as to expose the doubly folded basement complex below.

80. AC RESISTIVITY EQUIPMENT

L.S. Collett

The equipment is designed to automatically plot the transfer function (i.e. output/input relationship) on an X-Y plotter using the Wenner or Schlumberger array. The frequency range is from 1 to 1000 cycles per second (cps). This range of frequency will be swept automatically at the rate of 0.1 cps over a 5-second duration period. The receiver across the potential pick-up electrodes is a remote-controlled differential amplifier whose output is recorded on an X-Y plotter. Frequency markers will interrupt the trace at approximately 10, 67, 100, 500, and 1000 cps. From this plot can be read off the resistive and reactive components of the received signal from the ground.

Design and construction is approximately 90 per cent complete. Field testing will commence as soon as the construction and laboratory testing is completed.

81. LAKE PANACHE (41 I/3) AND COLLINS INLET (41 H/14) MAP-AREAS

M.J. Frarey

Remapping of the Huronian, northwestern part of the map-areas was essentially completed in 1966. Major revisions in the stratigraphy and structure have been made for that part located between the Grenville Front and the line Baie Fine-Norway Lake. This belt is mostly underlain by the two uppermost formations of Collins[1], termed descriptively the "Banded Cherty Quartzite" and "Upper White Quartzite", rather than by the Gowganda and Lorraine Formations, as previously indicated[2]. At Threenarrows Lake, the core of the McGregor Bay anticline, previously shown as underlain only by Serpent Formation, also contains calcareous beds of the Espanola Formation, and previously unreported thin limestone beds were also encountered in the uppermost part of the Serpent Formation. The Serpent-Gowganda contact relationship is an abruptly interbedded one, and no unconformity is indicated.

A number of post-Huronian, post-Nipissing, diabase dykes, earlier thought to be Keweenawan in age, have been traced across the Grenville Front undisplaced and are thus post-Grenville in age. They probably represent an extension of the dyke swarm found throughout eastern Ontario and southern Quebec.

Hornfelsic metamorphism of Huronian pelitic and calcareous sediments was previously reported from localities adjacent to the Grenville Front. Earlier workers attributed these occurrences to intrusion of Killarney granite. However, the metamorphism appears to be much more widespread, and knotted and spotted beds occur at such localities, removed from the Front, as Threenarrows Lake and near the northwest corner of the area on Lake Panache. The occurrences are not spatially related to exposed igneous rocks, and apparently result from a thermal episode of regional dimensions, which, from the distribution of index minerals in this area, increased in intensity eastward and northeastward.

The Huronian rocks have been affected by two fold deformations and at least two periods of faulting. Associated with some post-Nipissing diabase faults are "Sudbury-type" diatreme (?) breccias, up to thousands of feet in long direction, and some small breccias, particularly in quartzite, can be related to sharp minor folds. Other breccias are difficult to relate to specific structural features.

On the southeastern, Grenville side of the Front, restudy of Collins Inlet map-area and adjacent parts of Lake Panache map-area was carried out by Dr. R.T. Cannon, National Research Council post-doctoral Fellow, with emphasis on metamorphic history. A multi-stage metamorphic-structural sequence has been proposed for the gneiss-granite terrain, including events at the Grenville Front. The latter is, as recognized by Quirke[2], essentially a modified igneous boundary between Huronian strata on the northwest and a strip of northeasterly trending granitic rocks on the southeast.

The gneiss complex comprises a paragneiss group including quartzo-feldspathic gneiss grading into quartzite, amphibolite, biotite-quartz-plagioclase gneiss, and calc-silicate gneiss, all of which may contain garnet and numerous potash feldspar porphyroblasts, and be intimately intruded by pegmatite and small granite bodies. Kyanite and sillimanite appear east of Collins Inlet. Derived from these gneisses along zones of intense movement are numerous strips of mylonitic to augen gneiss. Numerous granitic layers are intercalated with these gneisses. Mappable granitic rocks of probable igneous origin include medium- to coarse-grained, porphyritic to non-porphyritic granite, weakly to moderately foliated pink granite gneiss, uniform, massive, pink granite, and hornblende syenogranite. The gneiss complex, together with the associated pegmatite and intercalated granite layers, has been intricately folded in detail and in many places intensely sheared along foliation planes. The gneisses characteristically strike northeasterly and dip moderately to steeply southwest.

The area around Tyson Lake, 2 to 5 miles within the Grenville Province, is of special interest in that a sequence of Huronian formations was previously identified there and described by Quirke[2], in part forming the basis for the concept of the "disappearance of the Huronian" into Grenville Province through metamorphism. The writer has so far not been able to verify the sequence as mapped by Quirke; nevertheless, within that area, large quartzite remnants strongly resembling Huronian counterparts, are clearly preserved, and tillitic meta-conglomerate, meta-argillite, and lime-silicate and carbonate gneiss also occur, if rather irregularly. It seems evident that a sequence originally composed largely of feldspathic quartzite, impure sandstones, and argillaceous sediments, together with disperse conglomerate beds, a quantity of high-purity quartzite, and a restricted volume of impure calcareous beds, is represented around Tyson Lake. With these, the Huronian presents a ready and likely correlative. While the total evidence indicates a probable Huronian origin for the paragneisses, great difficulty was experienced in identifying individual formations and confirming Quirke's stratigraphic sequence because of widespread and extreme metamorphism involving extensive recrystallization, lack of continuity of lithologies, ever-present shearing, porphyroblastic growth, lit-par-lit development, and late faulting.

A small-scale quarrying operation for vein quartz was in progress in 1966 at Lake Panache. The material was shipped in crushed form for use in the pre-cast concrete industry. There was also interest in high-purity quartzite near Killarney, for refractory use and glass manufacture.

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

[2]Collins, W.H. and Quirke, T.T.: The disappearance of the Huronian; Geol. Surv. Can., Mem. 160 (1930).

82. VOLCANIC STUDIES IN THE TIMMINS-KIRKLAND LAKE-NORANDA REGION OF ONTARIO AND QUEBEC

A.M. Goodwin

The region under study, measuring 140 miles by 30 miles (Fig. 1), is underlain by folded and faulted Archaean volcanic and sedimentary rocks and younger intrusions. The Archaean assemblage was studied by means of suitably spaced stratigraphic sections. Volcanic components at approximately 1,000-foot stratigraphic spacings were carefully sampled for chemical and petrographic analyses. The purpose of the study is to: 1) investigate the regional stratigraphic relationships; 2) determine the sequential and chemical history of volcanic extrusions; and 3) relate known mineralization to the stratigraphic and volcanic frameworks.

Work Done

Eight stratigraphic sections were completed as summarized below (*see* also Fig. 1):

Area	Section	Length(mi.)	No. Samples	Average Sample Spacing (ft.)
Timmins	Godfrey	6	19	1600
	Tisdale	14	63	1150
	Shaw	11	40	1450
	Redstone River	11	43	1350
Kirkland Lake	Kenogami-Matheson	30	131	1200
Noranda	Dasserat	12	59	1070
	Rouyn	8	31	1360
	Waite-Clericy	13	74	930
	Total/Average	105	460	1200

In the Timmins area, 4 sections cover the highly folded, variably east-facing and east-trending lithologic assemblage. In the centre part, the Kenogami-Matheson section crosses both limbs of an east-trending regional syncline. In the Rouyn-Noranda area, 3 sections together with a pre-existing section to the north[1] provide preliminary coverage. A total of 460 samples was obtained.

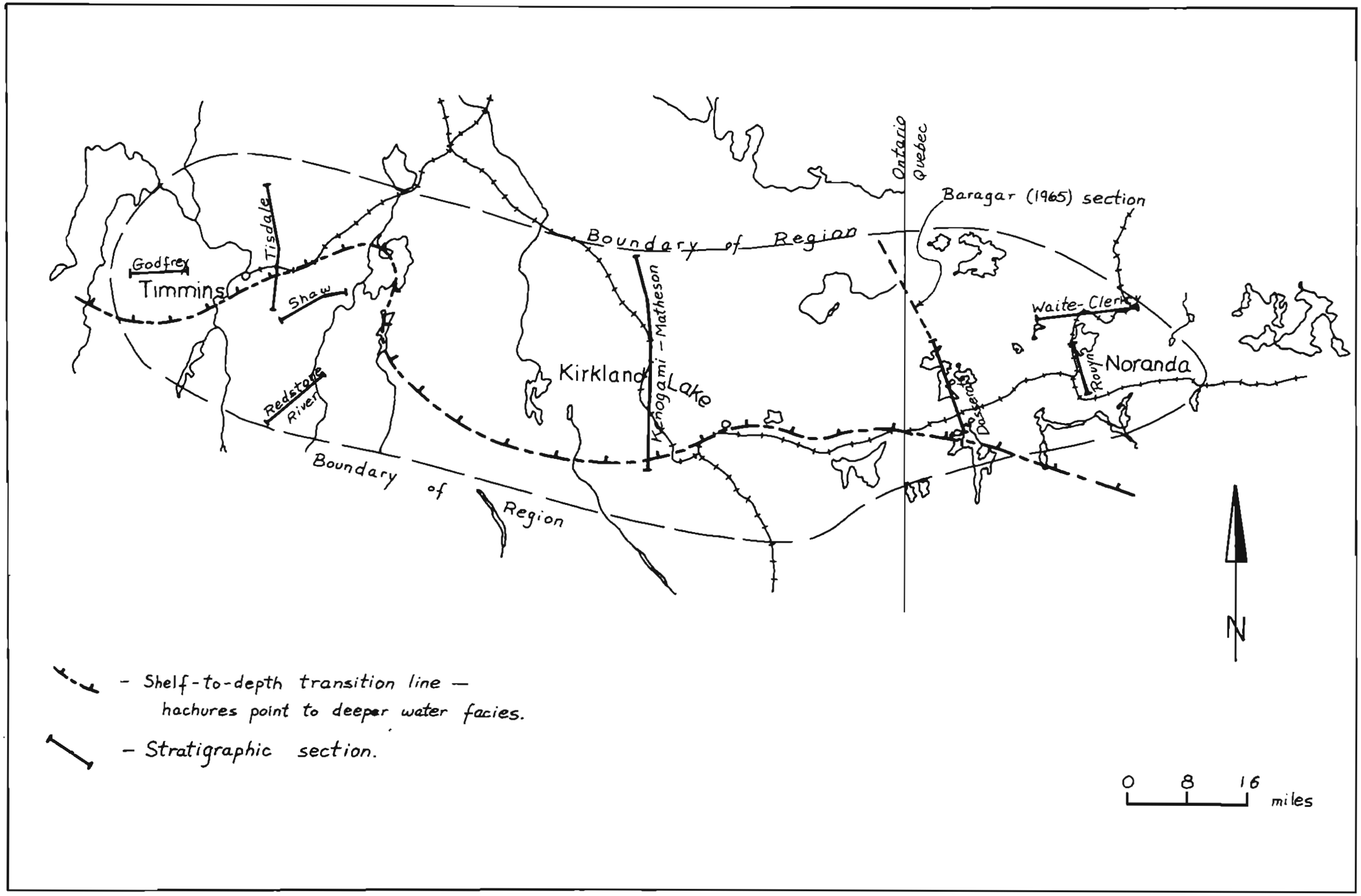

Figure 1. Location of stratigraphic sections and facies transitions in the Timmins - Kirkland Lake - Noranda region of Ontario and Quebec

Further stratigraphic sections are planned both between and within the three designated areas. Bedrock exposure across the region is adequate except for the northern part of the Timmins area, where extensive drift obscures relationships.

Volcanic Stratigraphy

Vertical Facies: The regional stratigraphic pile ranges from 20,000-40,000 feet thick. Thicker parts occur in the north. The stratigraphic sections typically progress upwards from predominant mafic to increasingly felsic volcanic components. Sedimentary bands and aprons occur in upper felsic parts and marginal to thick volcanic piles.

Great thicknesses of calc-alkalic basalts are common to the region at large. At the three centres of Timmins, Kirkland Lake, and Noranda, the upward, mafic-to-felsic progressions include substantial thicknesses of silicic volcanic rocks, notably rhyolite. Elsewhere in the region, rhyolites are absent, and basalt-andesite-dacite progressions only are represented. This central distribution pattern of the highly silicic volcanics suggests a central vent system of extrusion leading to coalescing volcanic piles rather than simple uniform fill.

In the Kirkland Lake area, trachytic ejectamenta and detritus form a narrow east-trending zone at the top of the succession. This localization of alkalic rocks may reflect local crustal rifting following the main period of calc-alkalic volcanism.

Lateral Facies: Two lateral facies present in the region are transitional one-to-the-other along an irregular, east-trending line (Fig. 1). The south facies, the thinner of the two, is characterized by: 1) cherty oxide iron-formation indicating a slightly to moderately oxidizing environment; 2) thick piles of coarse-grained sediments including conglomerate, breccia, and slide-detritus, indicating both crustal instability and proximity to centres of active erosion; and 3) the presence of felsic volcanics, notable rhyolite-dacite, in frothy, pumiceous, and other highly vesicular forms indicative of highly explosive, gas-charged derivation. These features taken together suggest a near-shore, shallow-water, slightly oxidizing, tectonically active shelf locale such as would occur in an island arc environment at a continental margin.

The thicker lighologic facies to the north is characterized by: 1) greater lateral continuity of individual mafic components, particularly variolitic lava flows; 2) absence of cherty iron-formation; and the presence of 3) thin, fine-grained, typically carbonaceous sediments, 4) widespread sulphide mineralization, including base metal deposits, and 5) massive to fragmental felsic volcanics of apparent lava flow and flow breccia origin in contrast to those highly vesicular forms attributable to highly explosive derivation. These features taken together suggest a deeper water, offshore, reducing environment removed from detrital source, under sufficient head of water to inhibit widespread explosive eruptions, and conducive to accumulation and preservation of carbonaceous and sulphide materials.

Lateral facies distribution, in brief, suggests a northward shelf-to-depth transition, in turn part of a larger, Archaean basin configuration. The original shelf-to-depth transition has been structurally obscured by strong compressive forces evidenced by isoclinal folding and high-angle shear zones. As a result, the facies are now in telescoped juxtaposition, a significant consideration in any attempt at facies reconstruction. Considerable further work is required to unravel the facies pattern of this region.

Mineralization

The vertical facies pattern has direct economic implications in terms of meta - volcanic relationships. In general, significant mineralization favoured the upper felsic parts of the successions (see further Goodwin[2]). In this manner, commercially attractive iron-formations are interbedded with upper felsic tuffs south of Kirkland Lake and to a lesser extent Timmins. The major base-metal deposits of the region (Noranda and Timmins) occur in upper zones at rhyolite-andesite contacts. Many gold deposits are associated with small porphyry plutons emplaced under structural control in or near upper felsic rocks along the shelf-to-depth transition line. Emplacement of these plutons along and adjacent to shelf edges and the rapid uplift accompanying their intrusion are viewed as being genetically related to formative extrusive-erosive events themselves parent to the regional volcanic-sedimentary piles.

The lateral facies pattern likewise has specific economic expression. Economic or sub-economic iron deposits – the richer parts of the iron-formations – are confined to the shelf facies in the south (Kirkland Lake and south Timmins). Base-metal sulphide deposits, on the other hand, favour the deeper water facies in the north (Noranda and north Timmins). The gold deposits, products of intrusive-tectonic overprint, favour the shelf-to-depth transition line.

The iron and base-metal deposits are viewed largely as strata-bound units formed by direct surface precipitation (iron and sulphides) or subsurface replacements (sulphides). The iron, sulphur, and base-metal constituents were introduced mainly by exhalative and related volcanic activities. Development of base-metal deposits entailed introduction of the iron-sulphur components to a deeper water, reducing environment conducive to sulphide accumulation and preservation. Introduction of similar iron-sulphur-bearing constituents to the shallower water, relatively oxidizing, shelf environment to the south presumably resulted in 1) precipitation of iron-formation and 2) dissipation of the sulphur in gaseous and water-soluble forms. In this manner, the sulphide minerals, including the ore deposits, may be viewed as the off-shelf, deeper water facies equivalents of cherty iron-formations.

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[1] Baragar, W.R.A.: Volcanic studies, Noranda region; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, p. 160 (1966).

[2] Goodwin, A.M.: Mineralized volcanic complexes in the Porcupine-Kirkland Lake-Noranda region, Canada; Econ. Geol., vol. 60, No. 5, p. 955-971 (1965).

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83. SURFICIAL DEPOSITS, ATHENS - CHARLESTON LAKE AREA OF EASTERN ONTARIO

E.P. Henderson

Glacial deposits throughout the map-area are thin - generally less than 3 feet thick, and locally less than 1 foot. This is particularly evident over large tracts with little relief east from Frankville and north of New Dublin. Generally deeper till deposits have formed only on the flanks of hills or in the lee of escarpments. Rock outcrops are prevalent everywhere, but most extensive exposures mapped represent rough ridges of Precambrian age. Flat-lying Palaeozoic rocks occur at the surface as many exposures of small or medium extent rather than large continuous outcrops.

Most striae and fluting west from Athens indicate movement of ice of the last glacial stage south of southwest towards the Lake Ontario basin. East from Athens, however, the last ice moved more to the south, and north of Brockville, at the most easterly point mapped, it flowed east of south. The few scattered drumlins present are similarly oriented. North of Brockville flow south and east may represent a late advance from the north and northwest, but more probably was caused by lobation following extensive calving into marine water as the Champlain Sea opened up to the east.

Glacio-fluvial sediments are present as eskers and kames. Though these are small and widely scattered over most of the area, thick, more extensive deposits are found near Grippen Lake and to a lesser extent near Elgin. The largest reserves of valuable granular materials are in a large esker between Highway 15 and Grippen Lake and in kames north from Grippen Lake towards Lower Beverly Lake.

Waters of a proglacial lake overspread the area during deglaciation as damming ice withdrew to the east and north. Lacustrine sands and clays were deposited in depressional areas of the lake floor, though in lessening amounts from west to east, possibly because of accelerated retreat as deglaciation proceeded. Areal distribution of lacustrine deposits suggests they were laid by cold, dense bottom currents, closely controlled by relief on the lake floor.

Marsh deposits are common throughout the area and cover much of the original lacustrine sediments. The largest marsh, one that drains from Forthton Station on Highway 29 northeast perpendicular to uplift isobases for 9 miles to the edge of the map-area, is largely underlain by unusually deep organic deposits. Rapid accumulation has apparently continued over a long period as isostatic recovery slowly raised the marsh outlet, spreading and perpetuating water-logging throughout the marsh area.

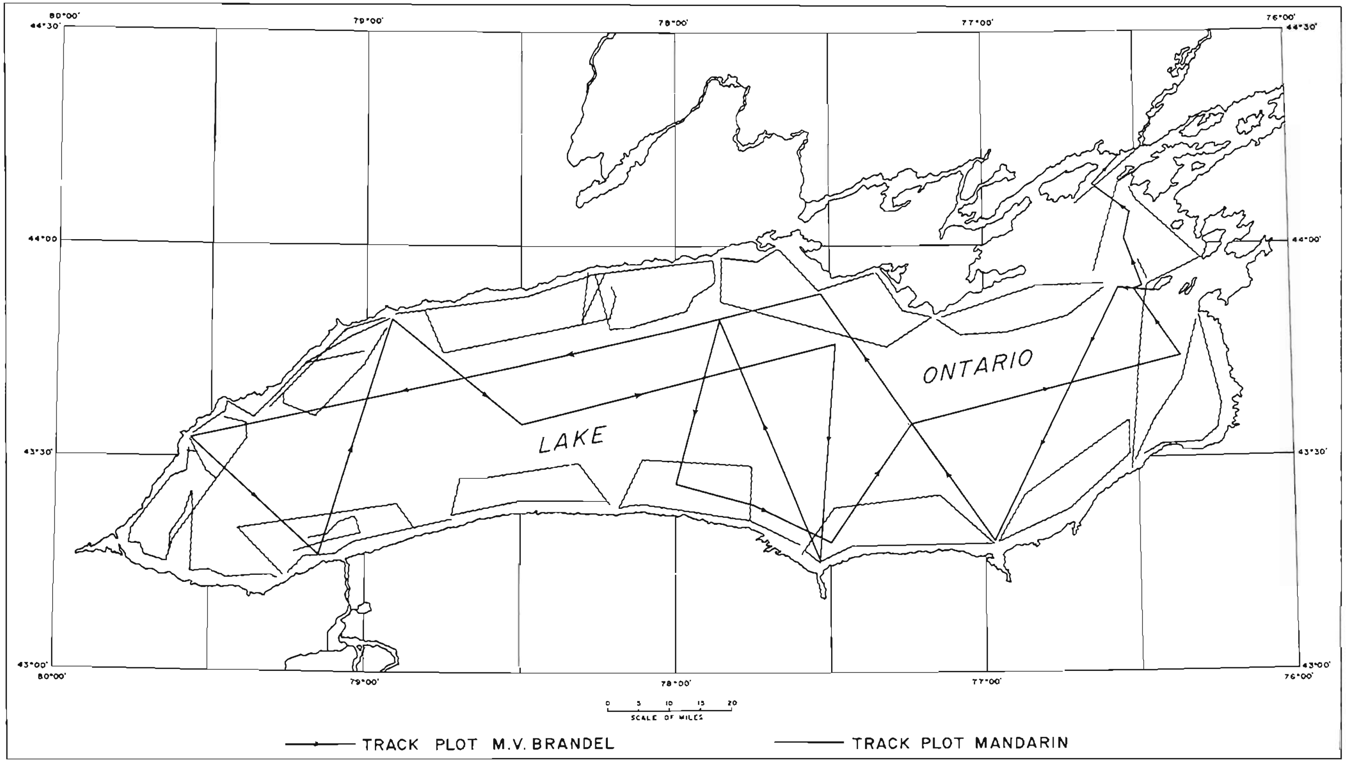
Beaches and bars attributed to the Champlain Sea first appear just east of Atkins Lake at elevations up to some 435 feet above sea-level. East from these marine shore features at lower elevations occur deposits of brown, sticky clays of a type not hitherto encountered. They are considered to be of salt or brackish water origin, though marine fossils have not yet been found in them.

84. MARINE SEISMIC SURVEY, LAKE ONTARIO

G.D. Hobson and E. Holzl

A continuous profiling marine seismic survey was conducted for about 2 1/2 months in Lake Ontario. The survey was conducted over selected lines (as shown on Fig. 1) to investigate the thickness and stratification of the unconsolidated sediments underlying the water and to investigate the nature, attitude, and stratification of the bedrock underlying the unconsolidated sediments. Reflection seismic techniques were employed.

The greater part of the survey was conducted from a 30-foot launch equipped with radar for fixing location from shore markers. One week of surveying was carried out from M.V. Brandel in the central areas of the lake, and navigation from this vessel was accomplished by gyro compass and radar fixes on shore markers.



Hobson and Holzl

Figure 1. Boomer profiles in Lake Ontario.

An E.G. & G. model 254-SN recorder portrayed the reflected signal. Signals were generated through an electro-mechanical "boomer" from a model 232 power supply and model 231 capacitor bank.

Excellent data were obtained. A cursory examination reveals that there are probably two main areas of sedimentation in Lake Ontario where approximately 100 feet of unconsolidated sediments overlie bedrock. Stratification within these sediments and within bedrock is evident on the records. There is an indication of a buried bedrock depression or channel extending northward into Lake Ontario from the south shore near Rochester, New York; this feature may be over 100 feet deep and 3 miles wide. Block faulting is indicated in the bedrock near Kingston, Ontario.

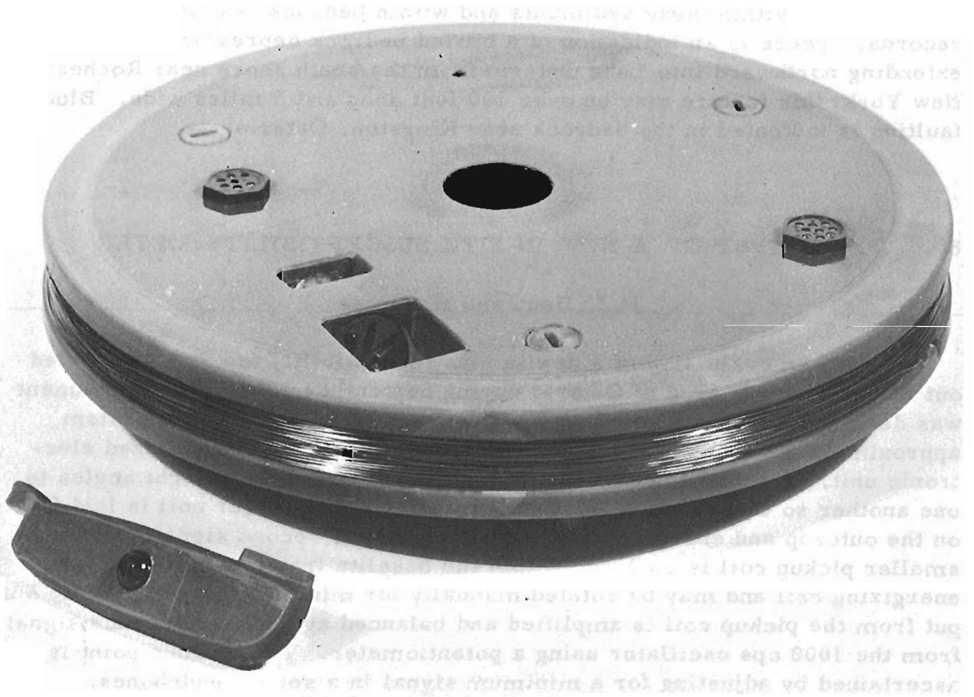
85. FIELD TEST OF A NEW IN SITU SUSCEPTIBILITY METER

P.J. Hood and H. Gross

An evaluation of a new in situ susceptibility meter was carried out in the Bancroft area of Ontario during September 1966. The instrument was designed and constructed by H. Gross and consists of a coil system approximately 8 inches in diameter (see Fig. 1) and a transistorized electronic unit. The in situ coil system consists of two coils at right angles to one another so that there is minimum coupling. The larger coil is laid flat on the outcrop and energized with a 1000 cycle per second signal; the much smaller pickup coil is enclosed within the bakelite frame comprising the energizing coil and may be rotated manually for minimum coupling. The output from the pickup coil is amplified and balanced against a reference signal from the 1000 cps oscillator using a potentiometer. The balance point is ascertained by adjusting for a minimum signal in a set of headphones.

The Geological Survey's in situ meter was compared with the SM-4 in situ susceptibility meter built by Sharpe Instruments of Canada Limited, which utilizes the Carey Foster mutual inductance bridge. The two instruments were placed in turn at exactly the same location on various outcrops of the Umfraville, Thanet, and Tudor gabbros, which occur along the old Hastings road and on Highway 62. The instruments responded to the varying susceptibilities of the underlying rocks in a like manner, although there was not perfect correlation, owing no doubt to the fact that different volumes of rock were sampled by each instrument, because the SM-4 susceptibility meter has much the larger set of coils. This evaluation also showed that the measuring range of the instrument was too compressed, i.e. the susceptibility meter was not sensitive enough; however, the required modification will only involve some relatively straight-forward design changes.

Notwithstanding this, the G.S.C. instrument is a simple one to operate, and the reading can be achieved in a much shorter time compared to the SM-4. It is also much lighter in weight, due mainly to a smaller coil system, and should therefore be a more convenient instrument to carry around in the field.



Hood and Gross 113685-B

Figure 1. In situ susceptibility meter.

86. SURFICIAL GEOLOGY ACTIVITIES, COCHRANE DISTRICT

O.L. Hughes

In company with Dr. I. Banerjee (NRC post-doctoral research fellow from the University of Calcutta), the writer spent eight days in Cochrane District, Ontario, examining Pleistocene deposits, especially varved glacial lake deposits. The varves are believed to be annual layers deposited from turbid glacial meltwater[1]. They exhibit distinct annual rhythms and possible diurnal rhythms. Individual varves can be correlated from locality to locality, permitting study of facies changes within the individual sheet-like layers. Dr. Banerjee will study samples collected to determine whether a sedimentologic study of the varves constitutes a feasible research project.

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[1]Hughes, O.L.: Surficial geology of part of the Cochrane District, Ontario; Geol. Soc. Am. Special Paper 84, pp. 535-565 (1965).

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87. TILLS OF THE STRATFORD-CONESTOGO (40 P/7, 10) AREA

P.F. Karrow

Investigation and mapping of the glacial geology of the Stratford-Conestogo area was continued in 1966. Recent mapping has yielded information on till sequences in separate parts of the area, but the interrelationships of these various sequences are not yet known.

So far almost all the surface tills of the area appear to be Cary in age, and therefore approximately equivalent to the Port Stanley Till of the Erie lobe. No true Port Stanley Till has been identified as yet, although it may be present in the southeastern part of the area.

Multiple till sequences have been identified in several parts of the area. Along the western edge of Stratford map-area, and south of the Milverton moraine, a gritty silt till occurs at the surface or under extensive shallow lake deposits. The southern edge of this till sheet has been located just south of Harmony. A series of low morainic ridges formed of this till trends northeast-southwest; Gadshill is located on one of these ridges. To the south, near the Trout Creek valley, the gritty till is underlain by a silt till, low in pebbles, which in turn is underlain by a cobbly sandy silt till believed to correlate with the Tazewell-age Catfish Creek Till. This lowest till has an abundance of Gowganda-type conglomerate cobbles. The part of the Milverton moraine so far mapped consists mostly of a nearly stone-free clay till, probably younger than the gritty silt till. The latter till has been traced eastward beyond Amulree and to the Nith River west of Wellesley; along the Nith it overlies a clay till.

In the vicinity of Conestogo Dam, near Glen Allen, a sequence of five tills occurs, all believed to have been deposited by ice of the Georgian Bay lobe flowing from the north. The lowest and thickest of these is a sandy till correlated with the Catfish Creek Till, while the upper four tills are thin and finer textured. The top till is clayey in texture and bears prominent surface flutings trending southeast.

Near New Hamburg, and west of the Nith River, the surface stratum is a gritty silt till. This overlies a clay till, which includes several extensive lenses or beds of silt, and the clay till in turn overlies presumed Catfish Creek Till. The clay till is the surface till east of the Nith River and laps up on extensive thick masses of fine moraine sand typical of the Waterloo sandhills; outliers of the clay till have been isolated by meltwater erosion and occur as caps on some higher tracts of ground. The prominent kame sands and gravels known as the Baden Hills rest on top of the clay till, which outcrops everywhere around their base.

One or two older tills are known from exposures of borings below the presumed Catfish Creek Till near New Hamburg, St. Jacobs, and Wallenstein. The age of these tills is an open question at present.

88. GAMMA-RAY SPECTROMETER SURVEY, ELLIOT LAKE

P.G. Killeen

Geophysical mapping of the distribution of uranium, thorium, and potassium in selected rocks of the Elliot Lake area was carried out using the Geological Survey's portable gamma-ray spectrometer. Calibration samples were collected to permit accurate calibration over a wide range of radioelement content. A calibration line for airborne gamma-ray spectrometric surveys was established with over 600 in situ analyses of U, Th, and K. The effect of elevation on in situ spectrometric analyses was investigated over a small test area. The interrelationship between ground and airborne observations and their mutual relationship to the geology is to be studied.

89. GLACIOFOCUS RESEARCH

H.A. Lee

A long range study using glacial methods of mineral exploration is being carried out in the Canadian Shield. The work to date has been done mainly in the Kirkland Lake region. The method involves measuring distribution of rock fragments, mineral grains, and elements within the separate layers of basal till and esker sands, and their relationship to original source in the bedrock. The method has been named glaciofocus[1]. The study will ultimately permit the preparation of an economic mineral map of the bedrock as determined by the glacial drift.

Several steps in this program have been completed. The relationship of discrete particles of gold dispersed in basal till to the orebody of the Kirkland Lake fault has been shown[2]. The use of eskers for reconnaissance mineral exploration has been shown[3].

In this past season (1966) the variation in abundance of rock fragments of serpentinized dunite (tracer rock) was measured in the Munro esker near Matheson, Ontario. A Bucyrus Erie backhoe was used to dig trenches at 2000-foot intervals along the direction of glaciation to expose a clean face 50 feet long and 12 feet deep. Variations in each trench were determined from a series of vertical channel samples extending from the surface to a depth of 12 feet, with the centre of one channel to the centre of the next being 8 feet. A statistical study has been carried out and the results will be reported on in due course. Early results show a dispersion of pebble size rock fragments along the esker but not across it. Of equal significance is that there were no vertical differences. The findings show that the sample can be taken from the top 4 feet of an esker. Two samples are needed at each locality for good control. The backhoe if mounted on a high clearance vehicle such as a timberjack would be recommended as a good piece of sampling equipment.

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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).

[2]Lee, H.A.: Glacial fans in till from the Kirkland Lake fault. A method of gold exploration; Geol. Surv. Can., Paper 63-45, 36 p. (1963).

[3]Lee, H.A.: Investigation of eskers for mineral exploration; Geol. Surv. Can., Paper 65-14, pp. 1-17 (1965).

90. POST-GLACIAL UPLIFT STUDIES IN NORTHERN LAKE HURON BASIN

C.F.M. Lewis

Detailed studies of post-glacial lacustrine and littoral features were undertaken at selected localities in the Manitoulin Island, Sault Ste. Marie, and North Bay areas in an effort to document changing lake levels relative to ground surface in the Lake Huron basin.

Beach ridges composed of cobbles, pebbles, coarse sand, and fine sand commonly occur along the southern and eastern coasts of Manitoulin Island at elevations ranging from the present Lake Huron level up to the Nipissing strandline. In Dominion, Dean, Province, and James Bays these were profiled and in selected places mapped using the stadia method to determine (a) the relationship between present lake level and elevation of the modern beach ridge, and (b) whether the sequence of ridges allows identification and correlation of post-Nipissing water level stands throughout the basin. There is an indication that ridges composed of coarse granular material occur at consistent altitudes above lake level, whereas the elevation of ridges composed of fine sand are erratically distributed owing to aeolian activity. The data in their present form are inconclusive with regard to objective (b).

An outstanding sequence of well-developed shore features abandoned by glacial and post-glacial lakes of the Huron-Superior basin is preserved in the surface expression of the unconsolidated deposits bordering the Precambrian highlands between Sault Ste. Marie and Gros Cap, Ontario. This sequence begins at the Lake Superior level (602 feet a.s.l.) and carries up to about 1020 feet a.s.l. Below 800 feet most shore features are wave-eroded terraces and bluffs cut into varved clay; above feet a.s.l. they commonly occur in sand and gravel both as erosional bluffs and as depositional bars, berms, and deltas. An instrumental survey of these strands, begun independently in 1965, was completed jointly by Dr. W.M. Tovell, Royal Ontario Museum, and the writer during a two-week period in late July. Basal organic sediments for pollen and radiocarbon analysis were collected from five bogs associated with a few of the surveyed beaches. It is hoped that this work will aid the development of late and post-Algonquin Great Lakes history by providing a reference for the correlation of abandoned water planes into the Huron and Superior basins.

Radiocarbon-dated basal organic sediments collected last year from small lakes standing well below the Nipissing strand raise the possibility that the Nipissing Great Lakes may be older than their currently accepted age of 4200-4300 years[1,2]. The lowermost gyttja from two lakes (Mary

Ann Lake near Sault Ste. Marie, and a small unnamed lake 3.3 miles southwest of Little Current on Sucker Creek Indian Reserve, Manitoulin Is.) yielded radiocarbon dates of 4700 years (4740 ± 170 GSC-567; 4710 ± 150 GSC-607) and 4400 years (4350 ± 170 GSC-558) respectively. The present water levels of both lakes are about 16 feet below the Nipissing water plane at each site. Other dates on material more directly related to Nipissing shore deposits in both the Huron and Superior basins suggest a possible age approaching 6000 years for this stage. The apparent discrepancy in the age of such a useful datum led the writer to investigate the outlet region of the Nipissing Great Lakes between the modern Lake Nipissing and Mattawa River. Reconnaissance and several instrumental beach surveys confirmed Taylor's[3] contention that Nipissing water levels at a present altitude of 697 feet were not controlled at North Bay, but rather 11 miles east of North Bay by a bedrock narrows between the present Trout and Turtle Lakes. Towards the close of the Nipissing Great Lakes stage, as differential uplift continued to warp the Huron-Georgian Bay basin, southern outlets at Port Huron and Chicago began to capture some of the basin discharge. During this transfer of drainage the ground surface began to rise relative to lake level in the north and three distinct but interconnected channels between bedrock knolls in the North Bay area carried the decreasing northern outflow into the Mattawa River system. Lacustrine sediments of nine small lakes, with surface elevations ranging from 650 feet to 700 feet a.s.l., now occupying local depressions in these abandoned channels, were cored with the help of Dr. J. Terasmae and party. Laboratory study of the cores may reveal both the date and rate of withdrawal of the late-Nipissing lake shore from North Bay and thereby date the close of the Nipissing phase.

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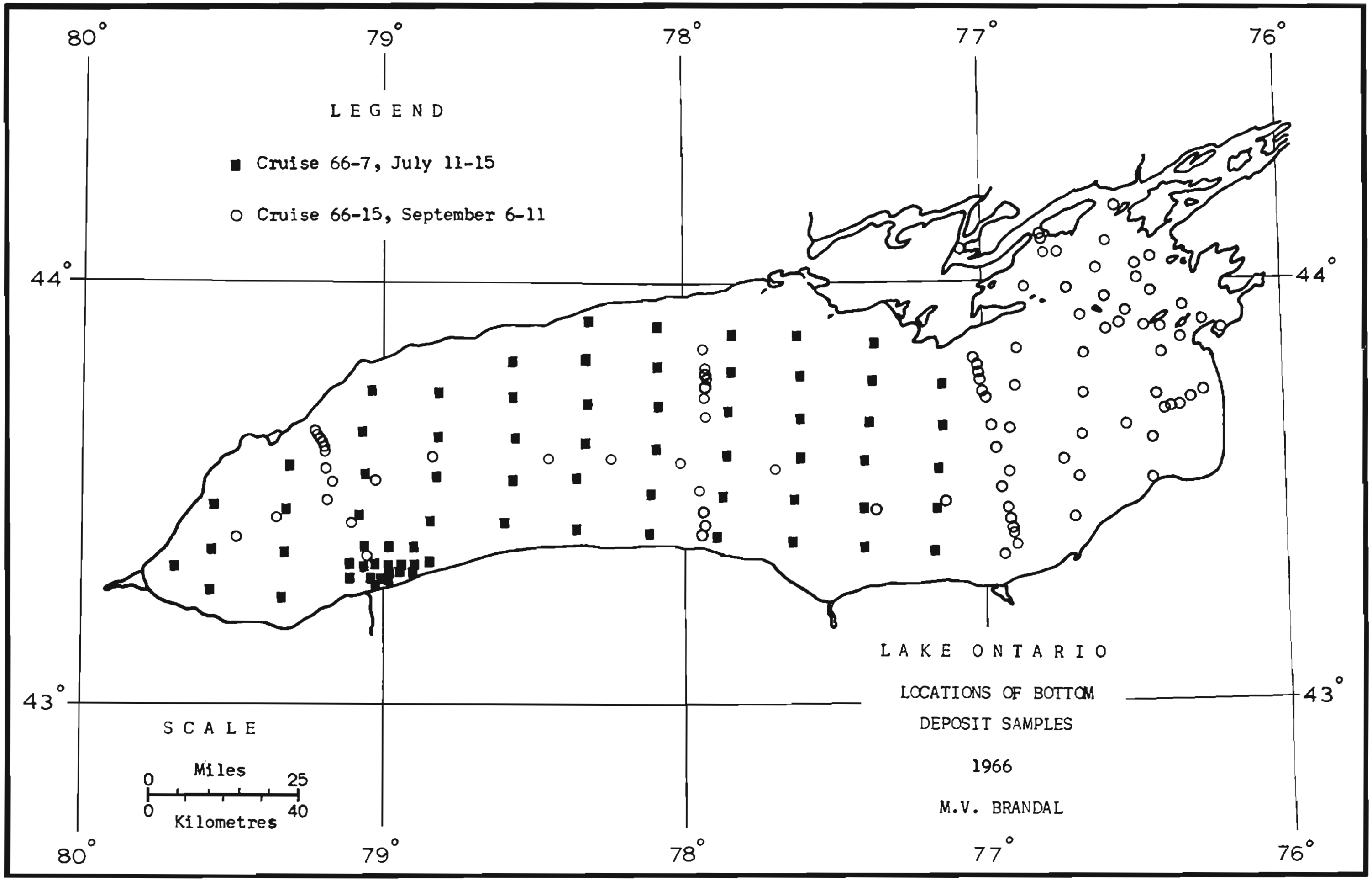
80°
79°
78°
77°
76°
44°
43°
LEGEND
■ Cruise 66-7, July 11-15
○ Cruise 66-15, September 6-11
SCALE
Miles
0
25
Kilometres
0
40
LAKE ONTARIO
LOCATIONS OF BOTTOM
DEPOSIT SAMPLES
1966
M.V. BRANDAL

91. LAKE ONTARIO BOTTOM DEPOSITS

C.F.M. Lewis

A reconnaissance offshore sampling program of bottom deposits was undertaken from the decks of M.V. Brandal, an oceanographic research vessel chartered by the Department for Great Lakes studies, to provide initial data on the distribution of sediment types as a basis for future enquiry into the nature and history of basin sedimentation.

The sample density as shown on Figure 1 was achieved during two one-week cruises in July and September using grab sampler, short light-weight gravity corer (1.2 m., 85 lb.), and a longer heavyweight gravity corer (3.6 m., 350 lb.). Drs. A. Kemp and N. Rukavina of the Water Research Branch, Department of Mines and Technical Surveys*, participated in the second cruise. Of the two cores collected from most stations one was retained for reference, the other was described and wherever possible its pH determined at 3 levels. Supplementary data from each cruise included continuous echograms along the ship's track, water temperature profiles, and conductivity, pH, turbidity, and dissolved oxygen measurements of the bottom water at each station.

In addition to the sand, gravel, bedrock, and till that were encountered at most nearshore stations, three types of surficial fine-grained sediment were tentatively recognized in the offshore areas. A soft compressible reduced clay occurring in deep water and commonly containing thin laminae of black sulphide and organic (?) material is probably a result of modern sedimentation. A firm reddish grey or grey clay devoid of visible organic remains but showing in places varve-like laminae and isolated pebbles and silt-clay balls may be a relict glacio-lacustrine deposit outcropping in a few local areas within the basin. A single bed of a stiff orange-brown limonitic (?) thinly laminated clay aggregate was observed close to the top of several cores of the soft reduced clay and enclosed within it. This sequence appeared to be associated with an underlying stratum or nearby occurrence of the glacio-lacustrine clay. There is a strong implication that clay sedimentation is proceeding at widely divergent rates within the basin.

A total of 153 surficial sediment grab samples were analyzed for organic matter by R.N. McNeely at Queen's University, Kingston, Ontario, using the Walkley-Black chromic acid oxidation method. The deepwater clay sediments commonly yielded between 4 and 5 per cent organic matter; organic contents of near-shore sediments were generally less. The greatest concentration of organic matter was encountered in the small eastern basin near the lake outlet (5 to 10 per cent) and in the Bay of Quinte (24 per cent).

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* Now Department of Energy, Mines and Resources.

92. STRATIGRAPHIC STUDIES OF MIDDLE ORDOVICIAN AND CAMBRIAN STRATA IN THE ST. JOSEPH ISLAND - SAULT STE. MARIE AREA

B.A. Liberty

The sandstone strata in this region are of Cambrian age, probably Upper Cambrian as dated from Northern Michigan. The Jacobsville and Munising Formations were traced into Ontario. The Jacobsville, however, was determined to outcrop much more restrictedly than previous maps have shown[1,2,3,4]. Much 'outcrop' was determined to be glacial erratics in the light of investigations conducted by city engineers of Sault Ste. Marie. The outcrop area has been extended northward to include Batchawana Island, Batchawana Point, and the islands to the south. The Munising Formation includes the sandstones on Campement d'Ours Island off the northeast tip of St. Joseph's Island.

The carbonate rocks all belong to the Simcoe Group of Middle Ordovician age. The Gull River Formation is well exposed at the north end of St. Joseph Island and includes true shale in its lowest part, soft argillaceous limestone, lithographic limestone, and claystone. This formation is quite fossiliferous. The Bobcaygeon Formation is moderately well exposed on Recollet Point. It is sparsely fossiliferous and includes *Receptaculites*, *Columnaria*, etc. The strata of these two formations are correlated lithically and faunally with strata of the Gull River and Bobcaygeon Formations on Manitoulin Island[5] and with units of the same names farther east in Central Ontario[6,7].

Cedar, Thessalon, Gull, Serpent, and Sulphur Islands were also visited. With the exception of Serpent Island (Bobcaygeon Fm.) the Palaeozoic strata on these islands belong to the Gull River Formation. Outliers of the Jacobsville Formation in the Echo Bay area were corroborated and a few new ones were found. The exposures of Palaeozoic (?) strata at Mica Bay and Mamainse Point were also visited and studies are presently being made on samples collected there.

The writer's interpretation of the areal distribution of the Cambrian formations is quite different to that of previous workers[1,2,3,4] for he has used considerable outcrop data in Michigan, data from the U.S. Corp. of Engineers in Sault Ste. Marie, Michigan, and water-well data in the Sault Ste. Marie - St. Joseph Island area. He considers the Palaeozoic rocks to underlie a much larger area than has heretofore been indicated. On the other hand he does not believe Silurian formations to be present at the south end of St. Joseph Island, as has been previously shown. Combined information from surface mapping, subsurface data, etc. indicates a marked increase in drift thickness, and a swinging of the strike. All these factors support the interpretation that Upper Ordovician beds constitute the youngest Palaeozoic strata on the island.

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93. SEISMIC STUDIES, ELLIOT LAKE AREA

A. Overton

During the period from May 16 to June 4, 1966, a seismic survey was conducted on the Huronian rocks of the Elliot Lake area, Ontario[1]. The purpose of the survey was to assess the feasibility of using seismic techniques for the measurement of strata thicknesses overlying the uranium pay zone.

Success of the method requires basically that the strata exhibit different acoustic velocities among themselves and with the pre-Huronian basement. Within the allotted field time, work was confined to the measurement of these velocities by the seismic refraction method, a measurement of the average velocity through the Huronian section at the Stanrock mine and numerous attempts to record reflections at locations between the Rio Algom Nordic and Stanleigh mines, along highway 108 between Elliot Lake and the Algom Quirke mine, and along the Stanrock mine road.

The refraction survey consisted of dynamite blasts in Nordic and Stollery Lakes, recorded by seismometer arrays along highway 108 between the lakes. The survey reveals little large-scale velocity difference between rocks in the Huronian syncline (19700 ft./sec.) and pre-Huronian rocks near Nordic Lake (21200 ft./sec.). This small velocity contrast is sufficient to cast doubt on the usefulness of the refraction method in measuring depths to the pre-Huronian basement of up to about 7000 ft. in the syncline of about 50000 ft. lateral extent. The travel time data confirm this doubt, showing little if any penetration of energy to depth. Most fluctuations in travel time are attributable to variations in overburden thickness along the profile.

The measurement of average velocity through the Huronian section at the Stanrock mine was obtained by recording surface blasts in the underground excavation. Three such measurements indicate an average velocity of 18850 ft./sec. for the section.

Instruments used for the reflection experiment were:

Amplifier system, Texas Instruments, 7000 B, a 12-channel system with dual, high level and low level outputs.

Oscillograph, Texas Instruments RS-8u.

Seismometers, Electrotech EVS-2A, 30 cps; single seismometers at each of 12 stations; station spacings used were 10 ft., 20 ft., 50 ft., and 100 ft.

Multiple seismometer stations were also tried, using three spaced at 25 ft. for the 50 ft. station interval, three spaced at 50 ft. for the 100 ft. station interval, nine spaced at 6 1/4 ft. for the 50 ft. station interval, and nine spaced at 12 1/2 ft. for the 100 ft. station interval.

Recording techniques: comparisons were made between records with and without mixing of outputs of the 12 instrument channels. Constant K filters were used, comparing records with pass bands of 30 to 215 cps, 60 to 215 cps, 90 to 215 cps, 90 to 120 cps, and 120 to 160 cps. Charge sizes ranged from 1 stick to 6 sticks of 60 per cent forcite at 5 ft. to 28 ft., water tamped, in drill holes.

In the discussion of the reflection experiment the term "coherent event" is meant to describe phases that may be correlated on a number of recorded traces, either on the basis of amplitude change, frequency change, simple continuity, or in combinations of these characters. A coherent event is not necessarily a reflection from an interface within the geological section. If sufficient number of events appear to be interesting, special field techniques must be used to determine their validity as reflections.

Early in the reflection program a problem common to the method was recognized – that record quality from explosions in, and seismometer arrays on gravel overburden were poor, discouraging hopes for recording coherent events at such locations. The overburden posed another operational problem in that numerous blasts were required in each hole for recording with different instrument settings and seismometer arrays to find a suitable recording technique. These holes had to be cased, but the first blast invariably blew the casing out, leaving no opportunity to experiment.

For these reasons the idea of a continuous reflection profile was abandoned in favour of discontinuous reflection experiments at accessible outcrops along roads. While reflections from such scattered observations may be uninterpretable in terms of highly variable structure, the experiment should show whether coherent events may be generally expected under the best available recording conditions with the recording techniques used; it may also provide a clue to recording techniques required to improve record quality under these conditions. Of 17 locations studied, 13 yielded some coherent events within the range expected for basement reflections. It must be emphasized that these coherences are generally poor, sometimes appearing on only a few traces, seldom exhibiting distinctive character, and often appearing as simple continuity of phases of similar frequency to the more random background disturbances.

The reflection experiment also yielded a measure of small scale velocity variations for the different bedrock types in the syncline. A cursory study shows these velocities to range from about 10000 ft./sec. to 23300 ft./sec.

A suggestion is offered here which would help greatly in assessing the usefulness of the reflection method in Precambrian environments. This is the use of a sonic logger in diamond-drill holes similar to the logger, which finds such indispensable use for correlation and analysis in the oil exploration industry. Unfortunately a sonic logging tool does not exist which will fit a 1-inch or 1 1/4-inch drill hole. Development of such a tool would prove to be a great asset.

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94. SEISMIC DETERMINATION OF OVERBURDEN THICKNESS AT TWO LOCATIONS, KIRKLAND LAKE AREA, ONTARIO

A. Overton and G.D. Hobson

This summary report describes the results from two seismic refraction profiles obtained in the Kirkland Lake area of Northern Ontario during 1966. These profiles were obtained using conventional seismic equipment with dynamite (C.I.L. 40 per cent forcite) as the energy source.

The first profile was situated at bore-hole 3 described by Lee[1]. This bore-hole was discontinued at a depth of 390 feet in glaciofluvial deposits. Overburden thickness computed from the seismic profile is 395 feet at the bore-hole site.

The second profile duplicated the portion of profile E-F that gave rise to an interpreted bedrock channel in west-central McElroy township north of the Misema River[2]. The purpose of this duplication was to check independently the channel which was interpreted from hammer seismic data. This year's profile confirms a channel coincident with that previously interpreted, but computed depths of 180 feet conflict with the 350 foot minimum previously interpreted.

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95. ENGINEERING GEOLOGY INVESTIGATIONS, WELLAND CANAL AREA

E.B. Owen

In the Welland Canal area soil samples and bedrock cores from test borings put down by the St. Lawrence Seaway Authority in the "Scheme X" area were examined. "Scheme X" includes the proposed new canal between Welland and Port Colborne, Ontario. At the same time a start was made in correlating the geological information derived from the borings with the surficial geology in adjacent areas. As this study progressed it became apparent the study of geology in large communities should be considered a long term, continuing project as fresh data provided by new construction will necessitate constant revision.

The test borings have revealed two tills separated by disturbed glacial lake sediments. The lower till is relatively dense and generally contains numerous, small, angular, bedrock fragments. In general it directly overlies bedrock. The upper till is softer and has a high clay content. Small irregular deposits of sand and gravel occur between the lower till and the overlying sediments and in depressions in bedrock surface. The latter sediments in places contain groundwater under considerable pressure.

96. KIRKLAND LAKE - LARDER LAKE VOLCANIC STRATIGRAPHY, ONTARIO

R.H. Ridler

The Kirkland Lake - Larder Lake greenstone belt (Fig. 1) may be conveniently divided into three geological units: 1) an east-trending, central belt of "Timiskaming" sediments and volcanics; 2) the volcanic assemblage north of the "Timiskaming" belt; and 3) the volcanic-sedimentary assemblage south of the "Timiskaming" belt. During the past field season, attention was directed mainly to structural and stratigraphic problems in the north and south belts. The "Timiskaming" belt received only cursory examination.

The north and south belts were studied mainly by means of 12 detailed traverses (see Fig. 1) suitably located with respect to abundant outcrops and ease of access. Some 140 volcanic units distributed along the traverses were carefully selected and sampled for chemical analyses.

North belt: The volcanics of the north belt have been folded into two major, relatively open folds, a north-trending, vertically plunging, south-closing syncline in the west part, and an east-trending, steeply plunging, elongate dome in the east part. The structural discordance with "Timiskaming" rocks to the south varies from zero to ninety degrees; its time significance may be slight.

Rock types present in the north belt are as follows: 1) andesite-basalt pillow lavas with their equivalent massive phases, individual flow units tending to be quite thick (1,000 feet) and persistent along strike (several miles); 2) sub-volcanic gabbroic sills, which vary greatly in thickness but range to 2,500 feet thick; 3) dacite-rhyodacite breccia, which form a number of lenses (maximum observed is 1,500 feet by 5,000 feet) in the

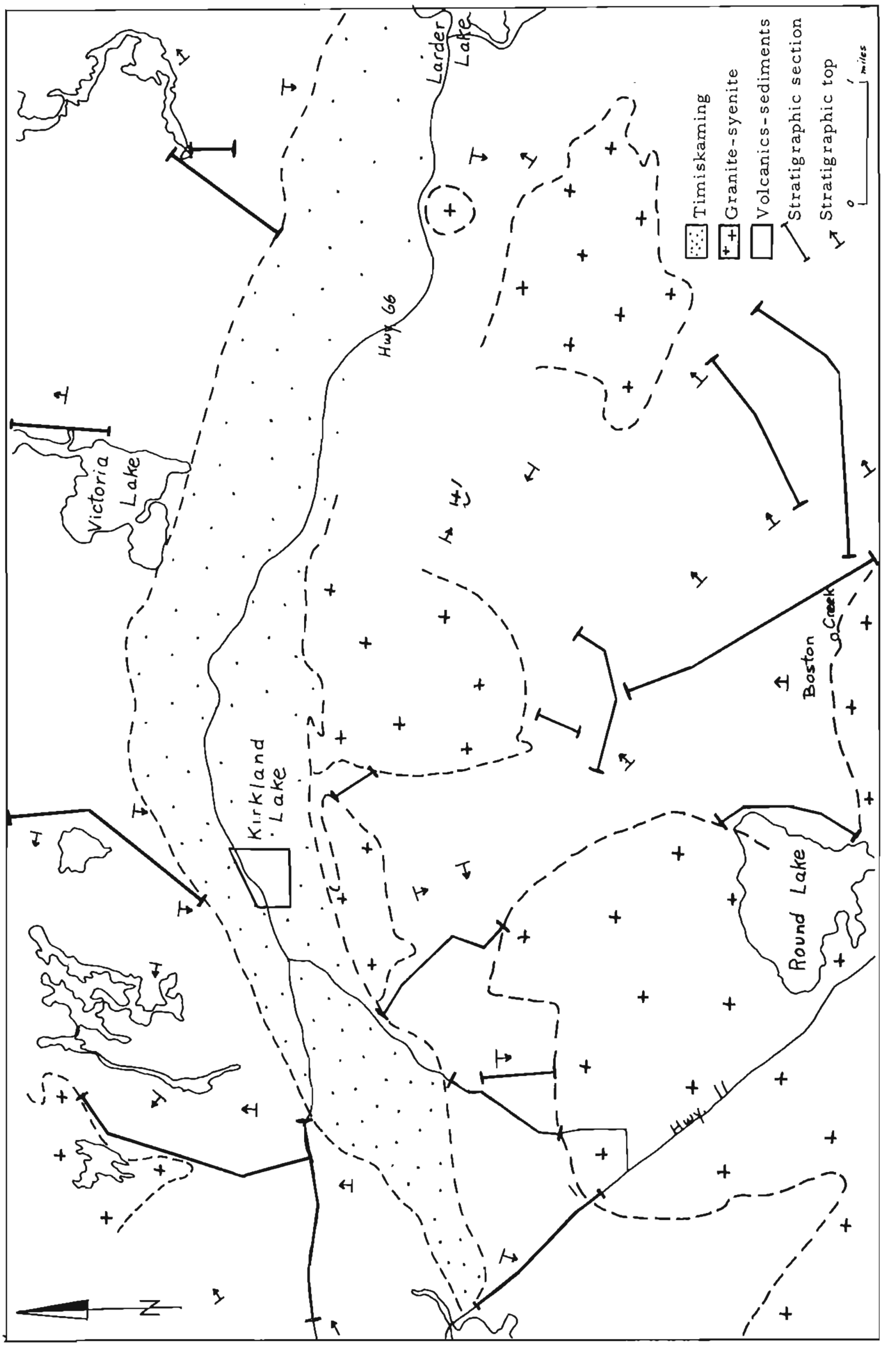

Figure 1. Location of stratigraphic sections and general geology of the Kirkland Lake-Larder Lake Area, Ontario.

syncline to the west as well as the core of the elongate dome to the east (at least 2,500 feet true thickness); and 4) a single granitic stock.

The generalized stratigraphic sequence in the north belt comprises, in ascending order, a relatively thin dacite breccia unit overlain by a thick sequence of mafic pillow lavas with occasional intercalated dacite breccia units and numerous penecontemporaneous gabbroic sills. The top of the mafic pillow lava sequence lies outside the area to the north. Total estimated thickness of the north belt volcanics within the map-area is 10,000 - 15,000 feet.

Minor gold-bearing quartz veins and sulphide (Cu, Zn, Fe) minerals are associated both with the single granitic intrusion and along the contact of the dacite and mafic volcanics.

South belt: The south belt volcanic sedimentary assemblage is structurally complex. Abundant diapir-like intrusions of syenite and granite have imposed a complex fold pattern dominated by northeast- and northwest-trending cross-folds. In general, sub-isoclinal synclines are present between adjoining plutons, the plutons being themselves central to open domical structures. Faults with considerable strike-slip displacement are present. The contact with "Timiskaming" rocks to the north is similar to that for the north belt volcanics.

Rock types present in the south belt are as follows: 1) abundant, thin (50 feet) basalt pillow lava flows having, in all cases examined, an upper pillowed phase and a lower massive phase; 2) thick, sub-volcanic gabbro sills; 3) differentiated mafic sills with lower peridotitic phases and upper gabbroic or pyroxenitic phases; 4) banded, possibly trachytic tuffs associated with feldspar porphyry dacite agglomerate; 5) interflow, pyritic, black shales, and tuffs, generally highly sheared; 6) banded chert-magnetite iron-formation with minor sulphide facies associated with dacite-rhyodacite tuff and breccia, some of which show sedimentary affinities; 7) greywacke and conglomerate; 8) syenite and granite stocks and batholiths with associated syenite, biotite lamprophyre, quartz-feldspar porphyry dykes, and small plutons; and 9) at the base of the sequence, a 2,500-foot-thick dacite-andesite banded tuff unit.

A representative stratigraphic sequence across the south belt assemblage, in ascending order, comprises: dacite-andesite tuff - 2,500 feet; basalt pillow flows - 12,000 feet increasing to 25,000 feet to the southeast; feldspar porphyry dacite agglomerate and trachytic (?) tuff - 2,500 feet; iron-formation and tuff or greywacke and conglomerate - 2,500 feet. Total estimated stratigraphic thickness - 19,000 to 32,000 feet. The rocks have been intruded by sub-volcanic gabbro or gabbro-peridotite sills. The later granitic, syenitic, and related intrusions have affected all the other rocks.

All significant mineralization (gold, copper, and iron) is associated either with the intermediate tuffs and agglomerates or the granite-syenite plutons.

Future work is planned to further investigate problems of volcanic stratigraphy in this area, including possible detailed correlation of the north belt and south belt assemblages.

97. SIOUX LOOKOUT (52 J) MAP-AREA

R. Skinner

This year's field work was a continuation of that done in 1964 and 1965, but was confined largely to the Savant Group of Archaean sedimentary and volcanic rocks in an attempt to determine the composition, origin, and mode of occurrence of the sediments and their relationship with associated volcanic rocks.

The basal formation of the Savant Group is mainly a boulder conglomerate composed of quartz-porphyry, rhyolite, greenstone, quartz-diorite, and minor quartzite and quartz clasts in a greywacke-textured matrix of the same materials. (Pebble counts of the conglomerate were made and will be reported on later). The conglomerate grades along strike into a thick section of rhyolite and dacite agglomerates and tuffs that outcrops along the road north of Wiggle Creek and in the area north of Iron Lake. The conglomerate and agglomerate appear to rest unconformably on Keewatin greenstones, although along the north shore of Kashaweogama Lake the conglomerate rests unconformably (?) on a quartz diorite stock. The conglomerate is intruded by granodiorite at Jutten Lake and the agglomerate by porphyritic granite north of Iron Lake.

A thick sequence of greywacke with minor interbedded slate, magnetic iron-formation, and greenstone overlies the basal conglomerate-agglomerate formation. This sequence is highly deformed owing to its position in the nose of a steeply plunging syncline and possibly because of major faults along the limbs of the syncline through Kashaweogama and Savant Lakes. These faults most likely account for the rapid thinning and disappearance of the formation to the west and south. The greywackes commonly have graded bedding from which top determinations confirm the synclinal structure of the group.

The upper formation of the Savant Group is composed of a very thick volcanic sequence of dacite agglomerates and tuffs intercalated with rhyolite and greenstone flows and tuffs, and is intruded on the south by granodiorite.

The structure of the group is complicated and difficult to decipher because of a lack of outcrop in critical areas and by the disappearance of units due to faulting or granitic intrusion. Between Fitchie and Savant Lakes is an isolated basin of Savant Group rocks whose relationship to the main area of the group is not known.

The granitic clasts in the conglomerate are leucocratic quartz diorites, apparently derived from stock-like bodies such as those at Heron Lake, southeast of Pickerel Lake and in Fairchild Lake. The quartz porphyry and rhyolite clasts apparently were derived from rhyolitic flows, tuffs, and sills intercalated with Keewatin greenstones. Very few if any of the clasts seen are similar to the granodiorite, granite, and granitic gneisses that surround and intrude the Keewatin greenstones.

There are two distinct types of iron-formation in the area: 1) that which is interbedded with Keewatin greenstone flows and tuffs; and 2) that interbedded with Savant Group greywackes and slates.

98. EXPERIMENTAL AERIAL PHOTOGRAPHY AROUND THE WESTERN SHORELINE OF LAKE ONTARIO

V.R. Slaney

Aerial photographs were taken at heights ranging from 2500 to 10000 feet with a Vinten 70 mm camera. Ektachrome Aero, Ektachrome Infra-red, Infra-red and Panchromatic films were exposed.

The photography was designed to provide experience in the working of the equipment, to carry out experiments with various film-lens-filter combinations, and to obtain medium to large scale photographs of a number of shore-line features.

Photographs were taken of several streams, canals, and pipe outlets discharging coloured, turbid, or heated water into the lake. Shallow water concentrations of phyto-plankton were also recorded.

A former channel of the Niagara River, now completely buried, was photographed with several types of film.

The photography was carried out over a period of 2 weeks in mid-September. A report will be prepared when the photographs have been processed and assessed.

99. PALYNOLOGICAL INVESTIGATIONS, 1966

J. Terasmae

In March, 1966, lake sediments were cored through ice in the Trenton-Belleville areas and drilling was extended down into glacial deposits (Ross Lake and Little Lake) and into bedrock in Oak Lake. This drilling project provided complete cores spanning the time of deposition from the present to deglaciation of the area studied.

In April the drilling project at Niagara Falls was completed. Drill cores of surficial deposits were obtained down to bedrock in the buried St. David's gorge. In one of the boreholes, plant-bearing beds were encountered beneath a glacial till layer. Studies of the samples taken will be made during the 1966-67 winter season.

In June a dendrochronological and dendroclimatological study was initiated in south-central British Columbia in co-operation with the Laboratory of Tree-Ring Research, University of Arizona. Dr. H.C. Fritts of that laboratory assisted in the field phase of the investigation and will study the core material collected.

A palynological surface sample transect was made from the grassland region near Kamloops, British Columbia, northward into the boreal forest, in aid of interpretation of postglacial fossil pollen assemblages.

Lake bottom sediments in 10 lakes were cored for geochronological purposes in the North Bay area and in the Kingston area in support of G.S.C. field projects by C.F.M. Lewis and E.P. Henderson.

Roger McNeely (Queen's University) was engaged in development and testing of instrumentation for limnological measurements, such as pH, conductivity, temperature, and oxygen content by using long cable leads (up to 100 ft.) on the measuring apparatus. This approach will save much time in making these measurements in lakes, whereas previously individual water samples had to be taken at all different depths studied. This work has been particularly important for gaining a better understanding of sedimentation processes and paleoecology of lakes.

A drilling project at Woodbridge, northwest of Toronto, has been completed. It was aimed at establishing the stratigraphic correlation of surficial deposits exposed in sections along the Humber River Valley. A study of the contained plant-bearing beds will be undertaken this winter. Preliminary results indicate that sand and gravel layers pre-dating the oldest known till unit (the York till) in the Toronto area may have been discovered in the boreholes.

QUEBEC

100. THE MANICOUAGAN CIRCULAR STRUCTURE

K.L. Currie

Field work was concentrated on the area of volcanic rocks previously defined[1]. Four major divisions of volcanic rocks have been established. In order of decreasing age these are: 1) tuff-breccia (suevite); intruded by 2) basalt, volcanic breccia and agglomerate (?); intruded by 3) diorite; intruded by 4) fine-grained andesite grading up to coarse-grained andesite. It is probable but unproved that each of these divisions comprises several subordinate units of slightly differing age. With the exception of unit 1, the major part of the igneous rocks was intruded as sills and dykes, with lesser amounts of actual volcanic effusion. With the volcanic rocks are associated peculiar metamorphic effects in the country rocks (shock metamorphism). Shock metamorphic effects occur in a NNW-trending belt about 25 miles wide, which extends at least 15 miles up the Mushalagan River outside the circular feature. The central uplift, Mont de Babel, shows spectacular development of zeolites, including thomsonite, analcite, and several others. Sills of igneous material intrude Mont de Babel. Its topographic level appears to have been little affected by the cratering process. It may be analogous to the central blocks in the Suswa and Toba cauldrons.

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101. POST-ULTRAMAFIC DYKES IN THE ASBESTOS MINING AREAS OF THE EASTERN TOWNSHIPS

Aniruddha De

A field study was made of a group of dykes that intrude the ultramafic rocks near Thetford Mines, Black Lake, and Asbestos, in the asbestos mining areas of the Eastern Townships of Quebec. The purpose of the field work was to map and sample these dykes of granitic, dioritic, and rodingitic nature and their reaction zones with the ultramafic rocks, especially in the open pit mines where they are well exposed.

The alteration associated with the contacts between ultramafic rocks and the Palaeozoic country rocks has been studied; in Asbestos the carbonaceous slates show the development of fine-grained diopside –

grossularite-bearing (rodingitic) assemblages near their contacts with the ultramafic rocks, which have altered to chlorite and talc zones. The dykes (granitic, pegmatitic, and dioritic rocks) show modification to syenitic and rodingitic assemblages near the contacts with the ultramafic rocks. Field observations indicate very clear structural control of emplacement of these dykes along joints and shear zones in the ultramafic rocks.

Petrological and chemical studies of the samples will establish the modifications that took place in the reaction zones between the acid dykes and the ultramafic rocks, and the origin and evolution of the various rock types grouped under the term "white dykes" or "acid dykes".

102. GLACIAL GEOLOGY OF EATON RIVER WATER SHED AND ADJACENT AREAS OF SOUTHEASTERN QUEBEC

B.C. McDonald

Glacial geology of the Eaton River watershed has been mapped on a scale of 1 inch to 1 mile to provide background data for the International Hydrological Decade project of the Quebec Department of Natural Resources, and to examine the Quaternary history of the region. Successive positions of a backwasting active ice-front are marked by moraines of till and stratified drift and by systems of parallel meltwater channels. The oldest such position, at an altitude of about 1600 feet, is 1 1/2 miles north of the International Boundary east of St-Isidore-d'Auckland. Moraines between altitudes of 1400 and 1800 feet outline glacial lobes that extended south past each flank of Mount Megantic; these moraines may be partly correlative with those east of St-Isidore. A younger system of ice-marginal features, at 700 feet to 900 feet altitude, has been traced from the Stoke Mountain Interlobate Moraine near Sand Hill northeast through Cookshire, Bury, and Gould.

Striations, till fabrics, and distribution of erratics indicate that the last glaciers in southeastern Quebec flowed from northwest to southeast. Heavy minerals from surface till are being examined for regional and local variations. No evidence supports ice advance northward into Quebec from New England. Indicator fans trail southeastward from bodies of peridotite and schist only one half mile north of the International Boundary near Woburn, and from the Mount Megantic syenite (nordmarkite). Several erratics of Mount Megantic syenite, as large as 20 feet diameter, have been found as far as 30 miles west-southwest of Mount Megantic. This supports other evidence from erratics, till fabrics, and striations that glaciers in the penultimate glacial episode advanced from the east-northeast.

Glacial sediments beneath a till sheet of northwest provenance are exposed in 30 sections in the Eaton River watershed. Glacial-lake silt and sand, younger than the till, are exposed at the surface and indicate that glacial lakes formed early during deglaciation and discharged southward into New England through Spillways on or near the International Boundary. As the ice-front retreated northwestward, lower cols were uncovered, which permitted lake drainage westward.

NEW BRUNSWICK

103. McKENDRICK LAKE (21 J/16) MAP-AREA

F.D. Anderson

Geological mapping of about 60 per cent of McKendrick Lake (21 J/16) map-area was completed suitable for publication on a scale of 1 inch to 1 mile. The map-area joins previous work by the Geological Survey of Canada to the north and south in the central New Brunswick mineral belt.

Rocks of the map-area are dominantly folded and faulted Ordovician and Silurian sediments and volcanics, which are intruded in the central and northwestern parts of the area by granitic and dioritic rocks and unconformably overlain in the southeast part of the area by Carboniferous sediments.

The northwestern half of the area is underlain by phyllites, schists, gneisses, and granulites, which are a continuation of metasedimentary and metavolcanic rocks of Cambrian and/or Ordovician strata in adjoining areas[1,2,3,4].

Overlying the metamorphic rocks with apparent unconformity, to the southeast, is a sequence of Ordovician and Silurian sediments and basic to intermediate volcanics. Fossils including graptolites were collected from four new localities in this sequence, but as yet no definite age has been assigned. The rocks are a continuation of Middle Ordovician to Middle Silurian rocks to the south[3,4].

Fossil flora collections were made from near-horizontal Carboniferous strata that unconformably overlie the Ordovician-Silurian sequence in the southeastern part of the map-area.

A major fault strikes east-northeasterly across the southern part of the map-area, and is a continuation of the large fault mapped along the northern edge of the Hayesville area[4]. Preliminary studies indicate that the fault is right lateral with a strike separation of about 5 miles.

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104. MINTO COALFIELD

P.A. Hacquebard

For the purpose of interpreting the type of basin in which the Minto Coal Seam was laid down, a study of the clastic sediments was undertaken in conjunction with a palyno-petrographic examination of the coal itself. The latter has been referred to in Paper 66-2[1].

In both operating and abandoned strip mines it was possible to measure 33 sections. These are in addition to another 57 sections that were obtained from the bore-holes put down in 1964 by the Dominion Coal Board. From these data it has been possible to construct a lithofacies map of the grey sediments overlying the Minto coal seam. The map shows that the depositional basin was probably an abandoned river valley, in which the fluvial sediments that terminated the ancient peat bog were brought in from the northeast. The parallel arrangement of four tongues of sandstone, all entering the basin on the northeast side, points to this. No closure of this valley is indicated on the present western margin of the coalfield. Exploration for additional reserves, therefore, should be undertaken on the west side of the field and not on the northeast, as was previously thought.

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105. GEOLOGY OF THE ST. STEPHEN-MOUNT PLEASANT AREA

A.A. Ruitenberg

The study area includes parts of St. Stephen map-area (21 G/3)[1,2], Rolling Dam (21 G/6)[1,3], and McDougall Lake (21 G/7)[4]. The objective of this study is to determine the relationships between geological structure, igneous activity, and mineralization in the area.

The dominant structure is a northeasterly trending, doubly plunging antiform. The axial region of this structure is occupied by black slates, minor quartzite, and metamorphic equivalents. These rocks extend from

Sorrell Ridge southwesterly beyond St. Stephen. They contain Early Ordovician graptolites on Cookson Island[5].

Silurian rocks occur on the flanks of the antiform, and extend northeasterly to the Mount Pleasant region, where they are truncated by Carboniferous volcanic rocks.

The Oak Bay conglomerate, at the base of the Silurian succession, appears to lie unconformably upon the Ordovician rocks. It contains well rounded boulders of quartzite, diorite, rhyolite, and slate. The formation is about 800 feet thick in the Oak Bay area, and thins northeastward to zero near Hewitt. A short, thin band of fine pebble conglomerate northeast of Moores Mills is believed to be the correlative of the Oak Bay conglomerate.

A formation of grey-green to grey slates, greywacke, and metamorphic equivalents gradationally overlies the Oak Bay conglomerate along the southern flank of the antiform. It contains Middle Silurian brachiopods in a few localities east of Oak Bay[5]. These rocks extend northeasterly into the Mount Pleasant area, and along the north flank of the antiform they grade into a formation of predominantly dark grey to dark olive-green greywacke and slate. Both these formations along the northern part of the study area grade upward into a formation of pale grey-green, thinly bedded, muscovite-rich sandstone and shale.

A northeasterly trending belt of intrusions, consisting of granite, granodiorite, diorite, and gabbro, occurs in the southern part of the study area. The intrusions are probably Devonian in age. The metamorphic sediments in the core of the antiform in the western part of the study area have been intruded by gabbroic and ultramafic rocks of the St. Stephen basic complex, believed to be Ordovician in age[6].

Several buff-coloured adamellite stocks and dykes cut the sedimentary rocks north of the main igneous complex. Most of them cut across the trend of the antiform. A few adamellite dykes intrude the older igneous rocks in the St. Patrick Lake area.

The Mount Pleasant rocks, in the eastern part of the study area, comprise chiefly an intensely altered intrusive volcanic complex composed of feldspar-quartz porphyry and feldspar porphyry of probable Mississippian age[7]. These rocks are cut by dykes and vent fillings composed of fine-grained pyroclastic rocks and breccias[8,9].

Two main phases of folding have been identified, and a third phase is evident in a few localities. Steeply dipping cleavage and/or schistosity planes (S_1), which trend roughly parallel with the antiformal structure, are associated with the first phase of folding. They form the axial planes of gently plunging minor folds (F_1). Isoclinal folds are most prominent in slaty rocks and open folds in the more competent beds.

The second phase of folding is evident in all strata except the thin micaceous beds on the north side of the area, but is best developed in the high-grade metamorphic facies of the oldest rocks. The axial-plane cleavage and/or schistosity planes (S_2) dip gently to steeply to the northeast, east, and southeast, and a few dip southwest. The most common associated folds are small knicks of the S_1 planes and well developed open chevron folds. Recumbent folds with subparallel limbs are prominent in some localities. They range in size from small crenulations to more than 100 feet across.

The S_2 planes have been crenulated or knicked in a few localities. The cleavage planes (S_3) associated with these minor folds (F_3) trend approximately east-west.

Gently plunging knick zones, which trend approximately parallel with the main antiformal structure, are very prominent in the micaceous beds on the north side of the study area, but their relationship to structures in the older formations is as yet inadequately understood.

Northwesterly to northerly trending faults are most prominent in the area. The strike-slip offsets vary between a few hundred to several thousand feet. Smaller westerly to southwesterly trending faults offset the northwesterly trending faults in some localities.

The Mount Pleasant tin-molybdenum prospect occurs in the eastern part of the study area. The metallic minerals occur in westerly to northwesterly trending fracture zones and breccia pipes. The latter occur at major fracture intersections and are predominantly of tectonic origin.

Numerous small mineral showings occur in the area between Mount Pleasant and St. Stephen. Several low-grade tin and molybdenum showings are associated with northwesterly trending fracture zones in and along adamellite intrusions. Several arsenopyrite- and pyrite-bearing fracture zones along the south flank of the antiform west of Rolling Dam, contain traces of gold. Several copper-nickel showings are associated with the basic intrusions in the western part of the area.

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NOVA SCOTIA

106. MERIGOMISH (11 E/9), MALIGNANT COVE (11 E/16), AND CAPE GEORGE (11 F/13) MAP-AREAS

D.G. Benson

The Ordovician and Lower Silurian rocks of the Antigonish Highlands represent an orogenic sequence (basic lavas and associated sedimentary rocks, intruded by granodioritic and later granitic plutons and overlain by rhyolitic flows) that has been intensely folded and faulted. Some rocks that were previously regarded as predominantly siliceous volcanics are now considered to be metamorphosed and sheared sediments. Several distinct greywacke beds are intercalated in thick pyroclastic assemblages. Some of these sediments have been traced for several miles. Basal Silurian, Beechhill Cove rocks were identified on Cape George, near Marshy Hope, and in new highway exposures, and south of the Hollow Fault on a branch of Doctors Brook.

Minor amounts of chalcopyrite were found in some of the granitic intrusions, notably the granites on Cape George.

An offshore search for part of the Arisaig Group missing from the type section was unsuccessful.

107. RECONNAISSANCE OF SUBMERGENCE PHENOMENA, NOVA SCOTIA

D.R. Grant

Rates of recent submergence of 1.4 to 2.0 feet per century have been reported for the coast of Nova Scotia[1]. Verification of the submergence rate will be essential to the planning of tidal power and causeway projects.

The Nova Scotia coast was examined in order to document the age, sequence, extent, and causes of recent changes of level responsible for regional submergence. Evidence bearing on the problem was provided by:

1. Drowned 'Forests'. Typically, tree stumps rooted in till or fresh-water peat outcrop at low tide, either on the seaward side of transgressing barrier beaches, or beneath low wave-cut banks of salt peat. Sites are most abundant on the southwestern shore and many new localities were noted, in addition to those figured by Taylor[2]. One 'forest' of stumps, on Cape Sable Island, was examined several hundred feet from shore, 30 feet below high tide. Generally, however, these exposures

of stumps are of limited extent and short-lived, changing and disappearing yearly.

2. Beach Morphology. Airphoto study revealed many prograding beach complexes with successively younger, higher ridges. This may be a response to rising base level (submergence) rather than a consequence of progradation[3].

3. Shoreline Recession. Erosion is particularly marked on Carboniferous outcrops and glacial drift. Numerous examples were noted of extensive cliff and beach retreat, resulting in significant loss of arable land, and necessitating repeated highway relocation.

4. Related Glacial Features. Emerged marine features were mapped to evaluate possible overlap of postglacial rebound on recent subsidence. Glacier flow directions in problematical areas, outlined during compilation of the Glacial Map of Canada in 1966, were noted to clarify the disposition of late ice. Notable contributions included: 1) verification of the absence of marine overlap outside the Fundy basin; 2) discovery of shells in till north of Yarmouth providing the first late-glacial and marine event in Nova Scotia, apparently representing a late advance of at least 20 miles down St. Mary's Bay; and 3) on Cape Breton Island, confirmation afforded by many exposures showing intersecting striae and miniature crag-and-tail of early, easterly, coastwise and onshore ice-flow, crossed by later southerly offshore movement, which locally deposited red till southeast of Bras d'Or Lake.

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108. COBEQUID MOUNTAINS

D.G. Kelley

During the 1966 field season the area of the Cobequid Mountains between Bass and Moose Rivers (approximately between longitudes 63°50' and 64°10') within the Bass River (11 E/5, W 1/2), Five Islands (21 H/8, E 1/2), Springhill (21 H/9, E 1/2) and Oxford (11 E/12, W 1/2) map-areas was examined.

Glacial striae, trending from 160° to 190°, provide additional evidence to that previously reported[1] that the Cobequids were covered by a south-flowing ice mass. The north slope of the Cobequids between Jackson and West Brook is covered by a thick blanket of glacial and glaciofluvial gravels, and bedrock exposures are scarce.

The northern flanks of the Cobequids consist chiefly of Devonian (?) granite and mixed diorite-granodiorite-granite rocks, and minor Silurian sedimentary and volcanic rocks and Devonian red beds and volcanic rocks. The relationship of one rock unit to another and the distribution of each is largely uncertain.

The central part of the Cobequids consists of the mixed rocks in contact with Devonian (?) acidic to basic volcanic rocks along a west-trending fault. These volcanic rocks extend in a belt across the area. Along Portapique River, about 2 miles east of Bass River, the Devonian (?) volcanic rocks stratigraphically overlie approximately 4,000 feet of overturned, fine-grained red beds, which are similar in lithology and stratigraphic position to the Lower Devonian Knoydart Formation of the Arisaig region. These red beds grade downward into grey, fossiliferous, Upper Silurian rocks, which are correlative with the Stonehouse Formation of the Arisaig region. Toward the south, down the section, the Silurian rocks become progressively more highly sheared and include increasing amounts of basic to acidic igneous rocks. These igneous rocks are, in part, intrusive, but probably also, in part, extrusive. The Silurian rocks are also cut by dioritic and granitic plutons. The Lower Devonian fine-grained red beds, which lack igneous rocks along Portapique River, include basic and acidic flows 2 miles to the west along Bass River and along a lumber road that trends south from Bass River Lake. Farther to the west, in an area whose southern boundary is near the west-flowing part of Economy River, occurs an assemblage of conglomerate, agglomerate, tuff, grey phyllite, andesitic and rhyolitic rocks, and fine-grained red beds that may be in part correlative with the red-bed sequence of Portapique River. These rocks occur in fault blocks, and the conglomeratic phases include granitic phenoclasts, which are lithologically similar to granite that cuts Silurian sedimentary rocks.

The belt of volcanic rocks and underlying Silurian sedimentary and volcanic rocks continues westward across the map-area, and is commonly broken by north-trending faults with left-lateral displacement of up to 4 miles.

The southern part of the Cobequids is structurally complex. The ages of the rocks are known only within wide limits, but several rock bodies have been delimited on the basis of their deformational fabrics. These structural units include either rocks of both known and unknown ages, or rocks of only unknown age.

During the past two field seasons G.H. Eisbacher has been gathering data on structures along the southern part of the Cobequids, and their relationship to deformational patterns within other parts of the Cobequids. This work will be the basis of a Ph.D. thesis at Princeton University.

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ISLAND OF NEWFOUNDLAND

109. SULPHIDES ASSOCIATED WITH EUGEOSYNCLINAL VOLCANIC ROCKS, NOTRE DAME BAY, NEWFOUNDLAND

D.J. Bachinski

About one month during the 1966 field season was devoted to sampling of sulphide deposits and their host rocks within the central Palaeozoic mobile belt in northeastern Newfoundland: 1) detailed underground sampling of the stratigraphic section between the Whalesback and Little Deer deposits of British Newfoundland Exploration, Ltd.; 2) sampling of ore and host rocks of the Little Deer, Colchester, Sullivan, and Pilleys Island deposits; 3) underground sampling of the East Mine, Consolidated Rambler Mines, Ltd., and 4) additional sampling of the Gullbridge and Tilt Cove deposits of First Maritime Mining Corporation. The York Harbour deposits (Big Nama Creek Mines, Ltd.), occurring within basic pillow lavas and forming part of the Taconic Klippe of Rodgers and Neale[1] were also sampled. Samples have been submitted for polished and thin sections, for chemical analysis, and for sulphide separations preparatory to sulphur isotope analyses.

A joint note (with K. Kanehira) was completed describing framboidal and colloform textures in the Tilt Cove ores. It is apparent that these sulphide deposits are only slightly metamorphosed and that they bear many resemblances to sulphide deposits associated with Cretaceous eugeosynclinal volcanic rocks in Cyprus.

Another joint paper with Kanehira, on the geology, mineralogy, and textures of the Whalesback Mine is being prepared. The Whalesback deposit occurs within a shear zone cutting basic pillow lavas; several textures indicative of dynamic metamorphism have been observed: e.g. brecciation of pyrite, 'pressure-shadow' chalcopyrite tails associated with pyrite crystals. X-ray diffraction studies are being carried out on the Whalesback pyrrhotite and on a'valleriite'-like mineral; the latter, on the basis of Elion microprobe analyses, appears to contain appreciable copper. These studies are being conducted by the writer at Yale University.

Petrographic and mineralographic studies to date indicate that the Little Deer deposit was subjected to dynamic metamorphism subsequent to its formation.

Studies are continuing in order to establish the relationship between sulphide mineralization and volcanic rocks.

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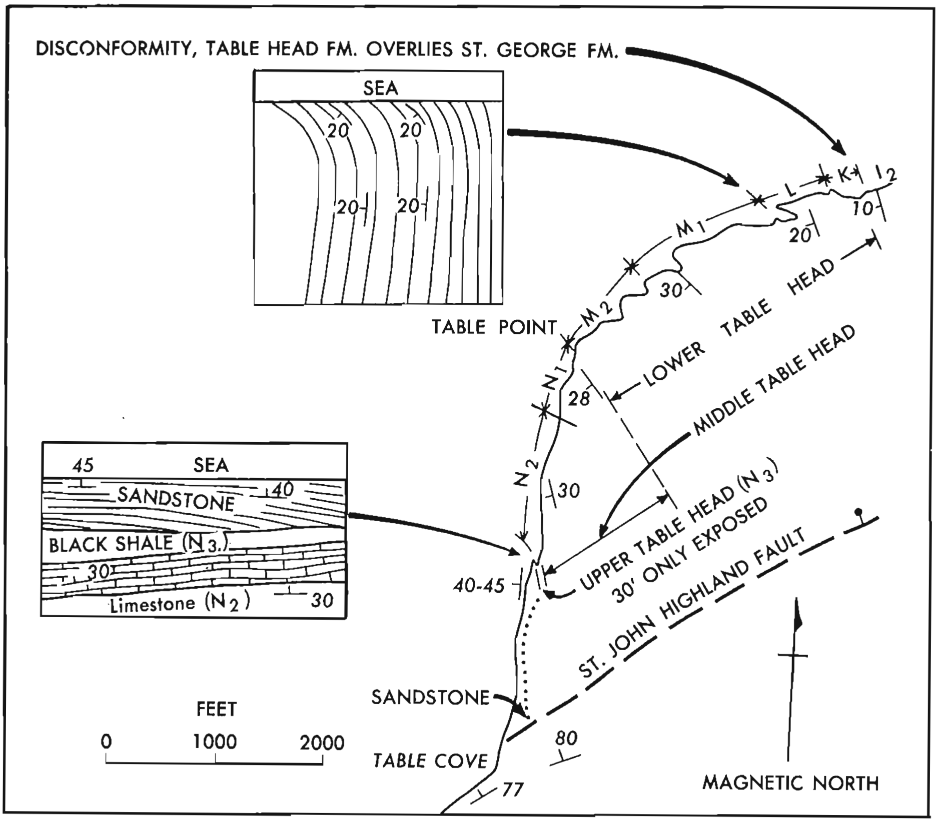

Figure 1. Table Head Formation type section, western Newfoundland - showing stratigraphic subdivisions of the formation (K to N_3) as described by James Richardson. Unit I_2 is the upper member of the St. George Formation (see Geology of Canada 1863, p. 870 for description). Lower, Middle and Upper Table Head faunal subdivisions are those of Whittington and Kindle[2].

110. TABLE HEAD AND ST. GEORGE FORMATIONS, WESTERN NEWFOUNDLAND

L.M. Cumming

Stratigraphy of the type section of the Table Head Formation was re-examined and subdivisions K, L, M_1, M_2, N_1, N_2, and N_3 were recognized (*see* Fig. 1). These aid in defining the stratigraphic position of previously described fossils from this area.

The disconformity between dolomite of the St. George Formation (Cambro-Ordovician) and limestone of the Table Head Formation (Middle Ordovician) was examined in the Port au Port, Table Point, and Port au Choix areas. A mottled grey and white dolomite pseudobreccia in the St. George Formation is formed: 1) in porous algal reefs or stromatolite beds; and 2) along vertical fractures. This rock type, which locally contains concentrations of zinc sulphide, was originally described as a stratigraphic unit (i.e. mottled magnesian limestone, Division I-1) by J. Richardson, as reported by Logan[1].

Lower Ordovician graptolites including *Clonograptus* cf. *C. flexilis* (Hall) were discovered in the St. George Formation along the west side of Port au Choix Peninsula, 2,000 feet south of Barbace Cove.

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111. STRUCTURAL STUDY OF THE FLEUR DE LYS GROUP, NEWFOUNDLAND

M.J. Kennedy

The first phase of a detailed study of the Fleur de Lys Group occupied approximately 3 months of the 1966 field season. The investigation concentrated on a coastal section extending from Partridge Point through Fleur de Lys to Coachman's Cove, which was first described by Fuller[1] and later included in a compilation map by Neale[2]. Short trips were made beyond this area to study relationships between the Fleur de Lys and other units on the Burlington Peninsula. The objectives of the present study were (i) to study the detailed structural and metamorphic history of the Fleur de Lys Group, (ii) to investigate the stratigraphy of the group and compare it with the Dalradian rocks of Scotland and Ireland, and (iii) to investigate the relationship between the Fleur de Lys and other units in contact with it on the Burlington Peninsula.

The Fleur de Lys Group is a thick metasedimentary sequence, with locally abundant amphibolites, of Early Palaeozoic or Late Precambrian age, which has been traced 60 miles south-southwestward of the present area[3] and is suspected from reconnaissance studies to extend much farther in that direction. The metasediments are chiefly semi-pelitic and psammitic schists, but minor marble, graphitic biotite schist, and conglomerate are also known. Distinctive actinolite-chlorite schist layers ("Birchy Schist" of Fuller[1]) occur close to and along the junction of this group with the Ordovician (?) Baie Verte Group to the southeast. Intrusions of serpentinized peridotite are exposed at Fleur de Lys village and farther south, close to the Baie Verte Group.

The Fleur de Lys Group can be divided into two stratigraphic successions, which are separated by a slide.* This slide was formed during the first period of deformation and was recognized by its close lithological similarity to early slides in the Dalradian rocks of the British Isles; further work will be required to prove that the slide facies cuts across the successions above and below it.

Grading in grit beds and crossbedding in other psammitic rocks are rare, but the nearby evidence available suggests that both successions are essentially overturned. However, further work on fold vergence and structural facing directions is required.

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* Following the definition of Fleuty[4] "a slide is a fault formed in close connection with folding which is broadly conformable with a major geometric feature (either fold limb or axial surface) of the structure, and which is accompanied by thinning and/or excision of the rock succession affected by the folding."

Five phases of deformation are recognized in the group. The first deformation, D_1, produced isoclinal folds and a penetrative schistosity, S_1. This schistosity was largely destroyed by translation during the second deformation, D_2, which produced S_2, the prominent schistosity of most Fleur de Lys rocks. The F_2 folds, to which S_2 is related, are tight to isoclinal and have essentially horizontal axial planes, except south of Fleur de Lys village, where the axial plane schistosity, S_2, is progressively steeper and finally vertical near the junction with the Baie Verte Group. The plunge of the F_2 folds varies greatly over short distances. The third deformation, D_3, produced a moderately dipping strain-slip schistosity, S_3, associated with tight to close, gently plunging folds north of Fleur de Lys village. South of the village, S_3 also becomes steep, but the F_3 folds retain their gentle plunge. A minor deformation, which produced open crenulations with flat axial planes was noted in the southern part of the coastal section studied, close to the junction with the Baie Verte Group. Tentatively, this is designated D_4, but lacking critical evidence, it could have been earlier than D_3. Finally, kink bands that were developed over a wide area, possibly associated with late fault movements, are referred to D_5.

In the area mapped, the Fleur de Lys Group represents the lower limb of a southward-facing recumbent F_2 anticline, which faces downward in the south.

In some metamorphic belts, especially those of intermediate metamorphic grade, although metamorphism has continued through considerable periods of time, the metamorphic climax, or climaxes are often relatively short lived. This is true of the Fleur de Lys rocks, which have undergone metamorphism from the first to the third phase of deformation. There are, in fact, no intense post-metamorphic deformations. However, from field evidence, the metamorphic climax is of MP_1 (post-tectonic with respect to D_1) or MS_2 (syntectonic with respect to D_2) age[5].

The climatic grade varied from garnet to staurolite, probably mainly within the amphibolite facies, but the pre- and post-climatic grade was probably of greenschist facies. Local retrogression shows that the grade dropped to chlorite in some parts of the area at a late stage of the metamorphic history.

The Fleur de Lys Group represents an early period of sedimentation, deformation, and metamorphism in the history of the Appalachian belt. Its structures are deformed by post D_3 downwarping close to the Baie Verte Group, from which it is probably separated by a major, fundamental fault. Further work may show that the Fleur de Lys rocks represent a complex phase of the orogenic history of the Appalachians, which is earlier and distinct from the well known Taconic movements. To date, the study has shown no obvious similarities between the stratigraphic successions of the Fleur de Lys Group and those of the Dalradian rocks, but it does occupy a comparable position in the mobile belt to the Dalradian of the British Isles.

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112. BURLINGTON (BAIE VERTE) PENINSULA, NEWFOUNDLAND

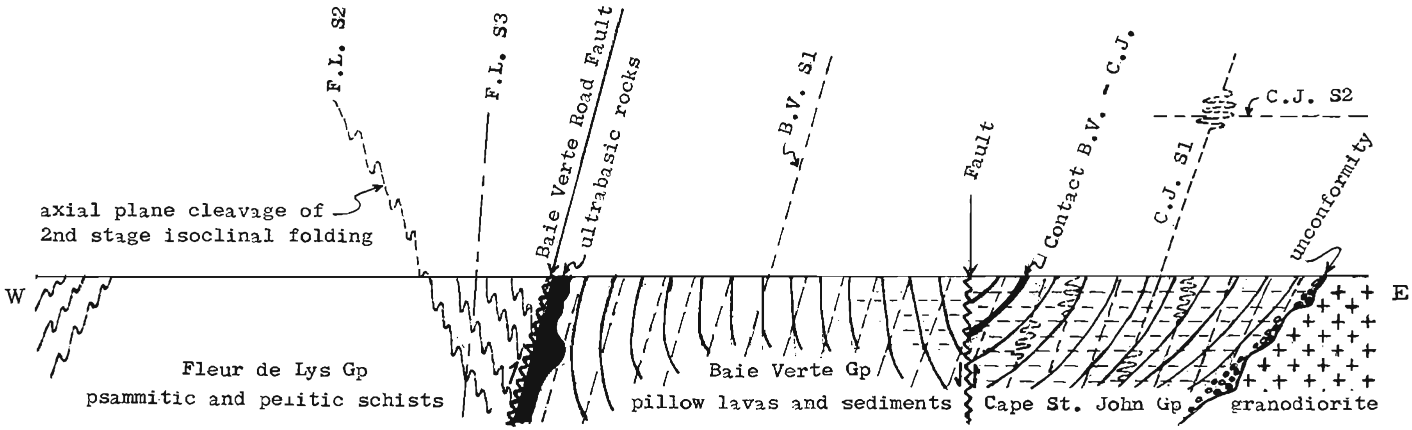
E.R.W. Neale

Approximately six weeks were spent on this Peninsula to study exposures in new road-cuts and also those produced by a 1959 forest fire, the pulpwood operations, and soil erosion, which followed it. An appraisal was made of studies by mining company and university scientists carried out since preliminary maps were published several years ago on this region[1,2] with a view to ascertaining what future work will be required to prepare final maps and reports. Two short field conferences were held in the area, chiefly near Mic Mac Lake and Flatwater Pond, and the writer benefited greatly from the advice of John Dewey, John Rodgers, Stuart McKerrow, Marshal Kay, Dan Bradley, R. Munro, W.R. Church, and other participants including his colleagues, M.J. Kennedy, R.K. Stevens, H. Williams, and W.H. Poole.

The oldest rocks of the area, the Fleur de Lys Group of Precambrian and/or Palaeozoic age, have undergone five phases of deformation, the first two of which involved tight isoclinal folding, as described by Kennedy elsewhere in this publication. It seems probable that an earlier suggestion[2] that the Fleur de Lys Group occupies a major anticlinorium was premature and a full appreciation of the structure of this group will require detailed study such as that now underway in the type area. A conglomerate unit within the Fleur de Lys Group[2] is now well exposed in cuts along the recently constructed Bear Cove and Westport roads. Three early phases of folding (F1 – F3) and kink bands similar to the 5th phase of Fleur de Lys folding are clearly displayed in this unit and, although traces of original bedding remain, it is unlikely that any evidence is preserved to support the recent proposal[3] that these rocks are tilloids. Clasts in the conglomerate unit are chiefly psammitic and pelitic rocks with lesser amounts of amphibolite (i.e. the dominant Fleur de Lys lithologies), although a few clasts with a pre-Fleur de Lys (Grenville?) metamorphic fabric were also observed.

A reconnaissance tour of the coast of the Horse Islands (2 L/4), which lie about 12 miles north of Burlington Peninsula, confirmed previous conjectures that these islands are entirely underlain by rocks of the Fleur de Lys Group.

Basic volcanic rocks, partly metamorphosed in the amphibolite facies, that outcrop between Rambler Brook and Woodstock village and elsewhere on the Peninsula were originally mapped as Ordovician (?) Baie Verte Group[4,5] and later interpreted as conformable on the Fleur de Lys Group at Pacquet Harbour[1,2]. These rocks have been subjected to a similar deformational history as the Fleur de Lys Group and W.R. Church's suggestion (pers. comm.) that they constitute a distinct and separate group from



DIAGRAMMATIC E-W PROFILE ACROSS MIC MAC LAKE - FLATWATER POND REGION

SHOWING POSSIBLE STRUCTURAL RELATIONSHIPS OF MAJOR SEQUENCES

not to scale

the Baie Verte is probably valid. Detailed studies will be required to trace the extent of these rocks and to separate them from the Baie Verte and possibly from altered facies of the Cape St. John Group with which they have been previously[1,2] mapped.

The Baie Verte Group - basic pillow lavas and lesser amounts of sedimentary rocks in which no fossils are known - outcrops chiefly in a linear belt that extends southward from Baie Verte to Mic Mac Lake and beyond and is separated from the Fleur de Lys Group throughout this distance by a major, high angle fault as first inferred by Watson[4]. There is no evidence of an unconformable contact between the two groups near Mic Mac Lake, as recently reported[3]. The Baie Verte rocks certainly post-date both the first two phases of deformation and the amphibolite facies metamorphism of the Fleur de Lys Group; however, it is not known which if any of the later phases of Fleur de Lys deformation are related to the folding and kink bands in the Baie Verte Group.

The generally steeply dipping, east-facing Baie Verte Group is bounded eastward by a generally west-dipping, west-facing sequence of clastic sediments, basic lavas, and acid ignimbrites, flows, and sills, which rest unconformably on a large pluton of granodiorite. This sequence, best developed between Mic Mac Lake and Flatwater Pond, is correlated with the Silurian (?) Cape St. John Group, which outcrops chiefly in the northeastern part of Burlington Peninsula. These west-dipping Cape St. John rocks were originally interpreted as faulted against the Baie Verte Group and the fault zone was considered to be cut by rhyolitic sills and dykes. However, re-interpretation of some of the 'sills' as pyroclastic rocks, the fact that the Baie Verte Group contains pebbles of granodiorite, which resembles the granodiorite underlying the Cape St. John Group, and evidence from minor structures combine to suggest the possibility that the Baie Verte Group is younger than the Cape St. John Group instead of older as always previously assumed. According to this hypothesis, these groups now occupy opposing limbs of a syncline and the Baie Verte has been brought into juxtaposition with the underlying Cape St. John rocks by faults within the axial zone of this structure as shown in the accompanying sketch. Further field work and, hopefully, the discovery of some fossils will be required to test this hypothesis.

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[1]Neale, E.R.W.: Nipper's Harbour, Newfoundland; Geol. Surv. Can., Map 22-1958 (1958).

[2]Neale, E.R.W. and Nash, W.A.: Sandy Lake (East Half), Newfoundland; Geol. Surv. Can., Paper 62-28, p. 40 (1963).

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[4] Watson, K de P.: Geology and mineral deposits of Baie Verte - Ming's Bight area; Newfoundland Geol. Surv., Bull. 21, 48 p. (1947).

[5] Baird, D.M.: The geology of Burlington Peninsula, Newfoundland; Geol. Surv. Can., Paper 51-21, p. 70 (1951).

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113. GREAT NORTHERN PENINSULA (PARTS OF 2L, M, 12I, P)

R.K. Stevens

Geological study of the Great Northern Peninsula for publication at 1 inch to 4 miles occupied 6 weeks of the 1966 season. This represented a continuation of a 1965 study initiated by J.W. Gillis, who has published a small scale map of the region[1]. The present study concentrated on the region between Hare Bay and Canada Bay, but also included a short visit to Belle Isle, which had not received previous geological investigation.

In the Hare Bay - Canada Bay region, four Palaeozoic stratigraphic sequences were recognized: a pre-Upper Ordovician platform sequence; a Middle Ordovician flysch sequence; a pre-Upper Ordovician geosynclinal sequence; and a Carboniferous molasse sequence.

The platform sequence consists of fossiliferous Lower Cambrian shales and oolitic limestones of the Forteau Formation[2], overlain by a succession of massive carbonates of Middle Cambrian to Middle Ordovician age. The sequence and facies of the platform rocks resemble the standard section along the west coast of Newfoundland[2] except that massive carbonate deposition may have started slightly earlier in the Canada Bay region.

Massive carbonate deposition ceased during Middle Ordovician (Wilderness) time and was followed by an influx of calcareous shale, greywacke, and conglomerate, interpreted as flysch derived from an advancing gravity slide mass. The contact between the slide mass and the flysch sequence is marked by zones of chaotic structure made up of blocks, derived from both the allochthone and autochthone, in a shaly matrix.

The gravity slide mass[3] constitutes a geosynclinal sequence of greywacke, slate, volcanic rocks, greenschist, and amphibolite, which have been mapped as the Maiden Point Sandstone[4,5], Goose Cove Schist[4,5] and the Canada Head Formation[6]. The stratigraphic succession within the slide mass is not yet well understood.

A recent description[7] has been published of the Carboniferous conglomerate, sandstone, and shale sequence.

All known structures in the region trend northeasterly and decrease in intensity from east to west. The autochthonous rocks along the east side of the Peninsula have undergone at least one pervasive and two minor phases of deformation. The allochthonous rocks show the effects of at least two penetrative isoclinal and two non-penetrative deformations. Major structures associated with the isoclinal events have not been recognized. Correlation of the deformational phases in the autochthone and in the allochthone has not yet been made.

The zones of chaotic structure are deformed by all phases of folding that affect the autochthonous rocks. It is concluded, therefore, that the region was not subjected to Palaeozoic folding prior to the emplacement of the slide mass.

Belle Isle is chiefly underlain by a Grenville-like basement complex of acidic gneiss cut by abundant Lower Cambrian or Eocambrian basic dykes and sills. Small exposures of basic volcanic flows are intimately associated with the basic intrusions and are conformably overlain by arenites and shales of the Lower Cambrian Bradore and Forteau Formations. A small fault block contains massive carbonates of probable Middle Cambrian age. A northeasterly trending cleavage cuts the basic intrusions and sediments. High-angle faults with similar northeasterly trends are abundant.

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[2] Schuchert, C., and Dunbar, O.: The stratigraphy of western Newfoundland; Geol. Soc. America Mem. I (1934).

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

[4]Cooper, J.R.: Geology and mineral deposits of the Hare Bay area, northern Newfoundland; Newfoundland Dept. Nat. Res., Geol. Sec. Bull. 9 (1937).

[5]Tuke, M.F.: The significance of sudden facies changes in the Pistolet Bay area, northern Newfoundland; unpub. Ph.D. Thesis, Univ. of Ottawa.

[6]Betz, F.: Geology and mineral deposits of the Canada Bay area, northern Newfoundland; Newfoundland Geol. Surv., Bull. 16 (1939).

[7]Baird, D.M.: Carboniferous rocks of the Conche-Groais Islands area, Newfoundland; Can. J. Earth Sci., vol. 3, pp. 247-257 (1966).

114. RED INDIAN LAKE (EAST HALF) (12 A E 1/2) MAP-AREA

H. Williams

Geological mapping of the Red Indian Lake (east half) map-area was completed suitable for publication on a scale of 1 inch to 4 miles. A sketch map of the geology is shown in the accompanying figure. Much of the general geology was summarized earlier[1] and the following are supplementary comments.

Volcanic (1) and sedimentary (2) rocks of the Cold Spring Pond-Round Pond area are undated, but are lithologically similar to dated Ordovician sedimentary rocks, and associated volcanic rocks, in the Exploits River belt. The rocks are interpreted to be gradational with metamorphic rocks (10) where in contact.

Conglomerates and sandstones of map-unit 3 are undated, but are assigned to the Silurian because of their lithological similarity to Silurian rocks of northeastern Newfoundland[3].

Rocks of map-units 6 and 7 appear to form a continuous southeast-facing succession that overlies Silurian rocks (5). However, basic pillow lavas (6) and green argillites (7) indicate a different depositional environment than that which prevailed during deposition of conglomerates and micaceous sandstones of map-unit 5. The nature of the contact between map-units 5 and 6 is not known, but if conformable with the beds facing southeast, then map-units 6 and 7 represent atypical upper units of the Silurian succession that are absent in the Silurian Botwood Group toward the northeast[2,3].

Metamorphic rocks (10) are almost entirely of sedimentary derivation and where contacts have been observed grade into known Ordovician (2) and Silurian rocks (3,7).

Volcanic rocks (9) that form the host rocks for the Buchans ores have been reassigned from the Ordovician[4] to the Silurian. Most of these rocks are lithologically similar to volcanic rocks that have been assigned to the Silurian elsewhere in northeast Newfoundland[3,5], although others are atypical and may be of Ordovician age.

The Buchans orebodies have yielded more than 12,000,000 tons of ore since production started in 1928. The average grade was 1.45 per cent copper, 7.85 per cent lead, 15.5 per cent zinc, 0.05 oz. of gold per ton, and 3.52 ozs. of silver per ton[4]. The highest grade orebodies are localized along volcanic breccia zones, and granite-boulder conglomerate zones that grade downward into volcanic breccias[4]. The deposition of the breccia and

LEGEND

CARBONIFEROUS

14 Poorly indurated conglomerate, sandstone, and mudstone.

DEVONIAN AND EARLIER

13 Granitic rocks: 13a, mainly coarse-grained equigranular to coarsely porphyritic pink biotite granite; 13b, mainly hornblende granite, granodiorite, hornblende syenite, syenite, and monzonite.

12 Diorite, gabbro, quartz diorite; minor granodiorite.

11 Ultrabasic intrusive rocks and gabbro.

10 Metamorphic rocks and unseparated granitic intrusions. Mainly muscovite biotite schist, porphyroblastic granite gneiss, garnet staurolite biotite schist, albite biotite schist, spotted slate and phyllite.

SILURIAN (Probably equivalent to 4 and 5 below; may include Ordovician rocks)

9 Green to purple and red amygdaloidal lava, silicic pyroclastic rocks and porphyry, altered green intermediate to basic lava and pyroclastic rocks, tuffaceous greywacke, siliceous siltstone and chert.

8 Quartzose siltstone and greywacke, red argillite and siltstone, red micaceous sandstone.

SILURIAN

7 Finely laminated grey argillite and slate with sandstone and quartzite interbeds; 7a, silicic volcanic rocks.

6 Altered green lava, basic pillow lava, tuff, and agglomerate; minor interlayered finely laminated limestone and argillite.

5 Purple to grey volcanic pebble conglomerate and sandstone, buff to red micaceous sandstone and siltstone, minor grey argillite and phyllite.

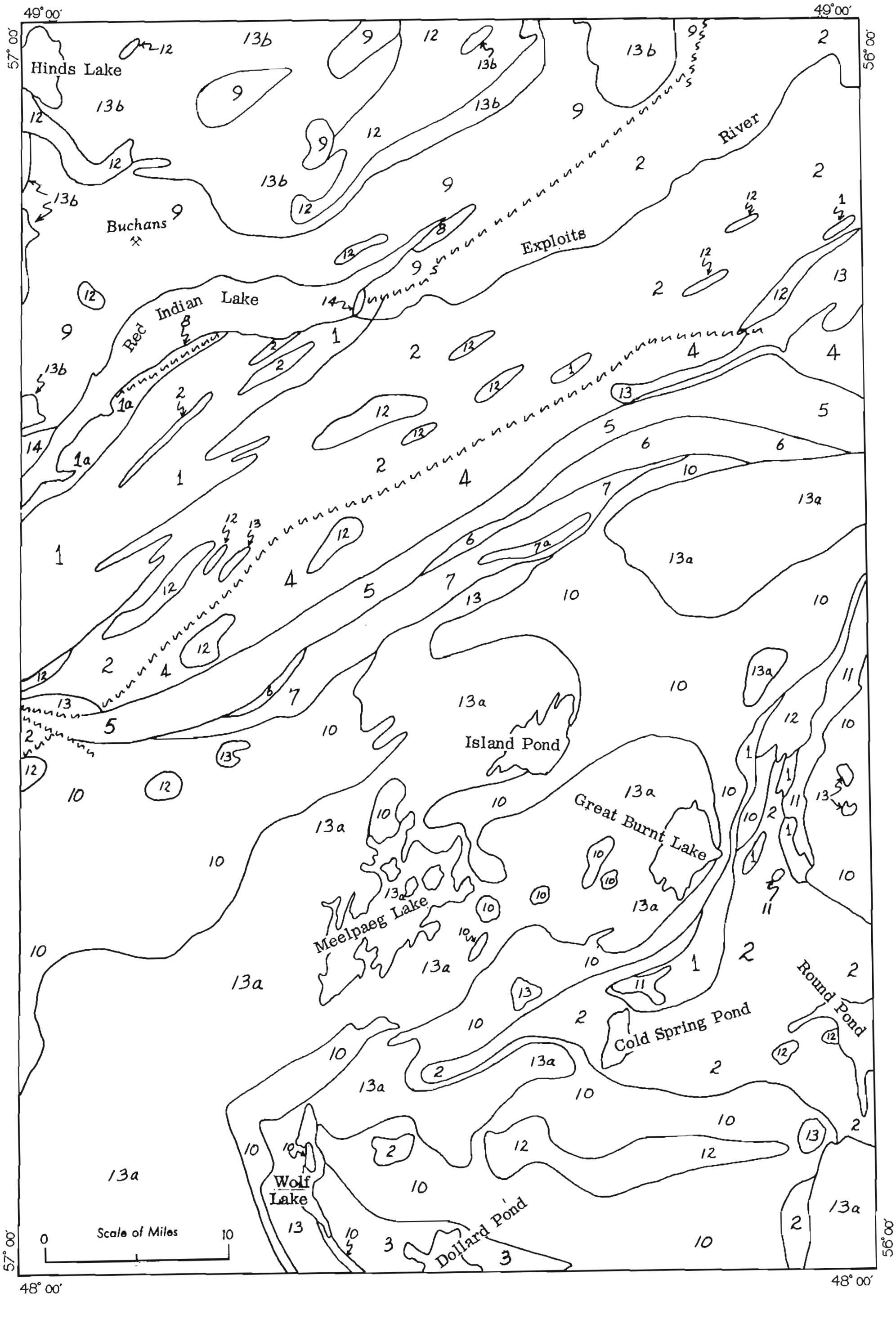
4 Green to purple and red amygdaloidal lava and agglomerate, porphyritic silicic lava, silicic pyroclastic rocks.

3 Grey shaly conglomerate with limestone, black shale, and plutonic pebbles, micaceous grey sandstone, siltstone, and argillite.

ORDOVICIAN

2 Grey to black slate, siltstone, greywacke, and pebble conglomerate; probably includes Silurian beds in upper parts.

1 Altered green lava, intermediate to silicic volcanic rocks, minor greywacke, siliceous siltstone, slate, chert, and unseparated dioritic intrusions; la, sandstone, slate, siltstone, conglomerate, and purple to green amygdaloidal lava and agglomerate (la possibly Silurian).



Geological map of the Red Indian Lake (east half) map-area.

conglomerate zones, along with associated underlying sandstones and siltstones, has been interpreted to have been controlled by a series of palaeotopographic troughs and basins[4]. Swanson and Brown[4] felt that the ores were of epigenetic hydrothermal replacement origin. In contrast, Anger[6] has suggested that the ores are syngenetic and has drawn attention to the similarities between the Buchans deposits and those of the Rammelsberg-type in Germany.

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[1]Williams, H.: Red Indian Lake (east half) (12 A E 1/2) map-area; in Report of Activities, May to Oct., 1965; Geol. Surv. Can., Paper 66-1, pp. 183-185 (1966).

[2]Anderson, F.D. and Williams, H.: Gander Lake (west half) map-area, Nfld.; Geol. Surv. Can., final map (in preparation).

[3]Williams, H.: Botwood map-area, Newfoundland; Geol. Surv. Can., Map 60-1963 (1964).

[4]Swanson, E.A. and Brown, R.L.: Geology of the Buchans orebodies; Bull. Can. Inst. Mining Met., vol. 55, pp. 618-626 (1962).

[5]Neale, E.R.W. and Nash, W.A.: Sandy Lake (east half) map-area, Newfoundland; Geol. Surv. Can., Paper 62-28 (1965).

[6]Anger, Clausthal: The lead-zinc-copper-deposits of Buchans, Middle Newfoundland; Neues Jahrbuch für Mineralogie, Manatshefte, pp. 126-136 (1963).

COAST OF LABRADOR

115. MICHIKAMAU INTRUSION

R.F. Emslie

A section across the layered series of the Michikamau intrusion was mapped and sampled in detail by R. Wares, a master's candidate at Queen's University. The area mapped was selected as the most complete single section of layered rocks showing least structural complication.

Mapping and sampling elsewhere were directed toward clarifying relationships between units and in closer examination of the contacts of the intrusion. A small, portable diamond drill was used to advantage in obtaining fresh specimens in many parts of the intrusion.

The geological interpretation of the Michikamau intrusion based on previous reconnaissance mapping[1] has been largely confirmed and much detail obtained in areas of complex geology. The main rock units of the intrusion, from older to younger, comprise: an olivine gabbro marginal zone; a thick series of layered troctolitic and anorthositic rocks; an anorthosite and gabbroic anorthosite unit; and late-crystallized ferrous-rich differentiates. Titanium- and vanadium-bearing oxides occur heavily disseminated in lenses and bands, chiefly in the marginal olivine gabbro within a few thousand feet of the contact.

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

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116. NORTHWEST RIVER (13D,E; 23A) MAP-AREA, LABRADOR AND QUEBEC

I.M. Stevenson

During the 1966 field season, approximately 18,500 square miles of Labrador and Quebec, lying between 52°00'N – 54°00'N latitudes and 62°00'W – 66°00'W longitudes were geologically mapped on a scale of 1 inch to 4 miles. A Bell 47G2A helicopter was used to assist in traversing, supplemented by casual charter of Otter and Beaver float-equipped aircraft from Goose Bay as required. Personnel, equipment, and aviation gasoline were transported into the field by Canso amphibian based in Seven Islands, P.Q.

The mapped area, which forms part of the peneplaned Laurentian plateau, has a general elevation about 1,500 feet above sea-level. Locally, as in the southwest corner of N.T.S. 23A, the relief may exceed 3,000 feet above sea-level. The major river in the area, the southeast-flowing Hamilton River that drains such a vast watershed, has incised a channel several hundreds of feet below the general surface of the plateau. Though lakes are numerous, many are too shallow for use by float-equipped aircraft. Areas with slight local relief are in general poorly drained, resulting in extensive areas of bog and swamp with little exposed bedrock. Relatively few of the rivers and streams are navigable by canoe.

Abundant evidence of glaciation appears throughout the area in the form of drumlins, eskers, roches moutonnées, chatter-marks, striae, and glacial grooves. The summits of the resistant hills are generally smoothed and polished by the ice, particularly those areas underlain by anorthosite and related rock types. Many of the flat, poorly drained, swampy and muskeg-covered areas are underlain by thick deposits of glacial till, sand, and clay. Black spruce, larch, and birch grow profusely in the better-drained areas and along river valleys.

The entire area mapped lies well within the Grenville Province, and the rocks are predominantly metamorphosed sediments, paragneisses, and granitoid gneisses derived from pre-Grenville rocks. Only in areas of marked relief are the rocks well exposed, and hence separation of the gneisses into distinct units is difficult. Some of the darker gneisses grade into amphibolites whose relationship to the other rocks is unknown. Although most of the gneisses are of undoubted sedimentary origin, and show such criteria as relict bedding, a few areas of massive, pink biotite granite and granite gneiss of probable intrusive origin were recognized. Granite dykes cut the paragneisses indiscriminately.

Anorthosite, gabbro, diorite, and related rocks, which occur in the southeastern part of N.T.S. 23A and the Red Wine Mountains are intrusive into the gneisses. The entire assemblage is cut by granite and diabase dykes.

Conglomerates, arkoses, and quartzite of probable Proterozoic age outcrop near Lake Michikamau.

Although no mineralization of economic importance was recognized in the area, the structure and metamorphism of the area is such that future detailed investigations, particularly if aided by aeromagnetic maps, might be of value. Vast areas are covered by shallow drift and muskeg, which effectively obscure the bedrock from view. Magnetite-ilmenite occurs abundantly in the anorthositic-gabbroic rocks, and the detrital mineral forms conspicuous layers in the sandy beaches of many lakes. Pod-shaped lenses of magnetite-ilmenite occur in a zone some 10 miles long by 2 miles wide immediately north of Wilson Lake.

Minor pyrite-pyrrhotite-chalcopyrite mineralization was noted at numerous localities throughout the area, mainly in those regions underlain by contorted gneiss. Many of the basic dykes and gabbro bodies contain pyrite that weathers a rusty brown. Numerous rust zones in the gneisses are due to the oxidation of pyrite in amphibolitic bands.

117. GEOLOGICAL RECONNAISSANCE, NORTHERN QUEBEC AND LABRADOR

F.C. Taylor

A brief reconnaissance of northern Quebec and Labrador was undertaken in preparation for Operation Torngat in 1967.

Flat-lying strata at several widely separated places in Labrador and northern Newfoundland were examined. Data gathered will constitute part of a study embracing flat-lying strata of the easternmost part of Quebec and Labrador and the post-Precambrian history of this part of the Canadian Shield.

118. SNEGAMOOK (13 K E 1/2) MAP-AREA, LABRADOR

F.M.G. Williams

During the 1966 field season, a preliminary examination of the bedrock geology of parts of NTS area 13 K E 1/2 was carried out by the writer and one assistant. Navigable lakes and rivers were traversed by canoe and interstream areas on foot. The party was serviced by float-equipped Beaver aircraft operating out of Goose Bay.

Particular emphasis was placed on an investigation of the structure and metamorphism in that part of the map-area between Seal Lake and the Labrador coast through which the so-called "Grenville front" passes. Approximately half of the field season was spent in an examination of the Croteau Group, a sequence of pink quartzite, massive conglomerate, and thick volcanic flows with minor dolomite, argillite, greywacke, and tuff. The rocks of the Croteau Group, which have been folded into a series of broad, open, synclinal folds plunging gently southwest, are cut by two distinct sets of faults that strike east and northeast respectively.

In the eastern part of the area, the Croteau Group is underlain by a northeast-trending belt of more complexly folded and faulted amphibolite, granite gneiss, minor quartzite, and garnet-bearing biotite schist, all intruded by granite. This assemblage, which has probably experienced more than one major orogeny, appears to grade northward into an area of massive granite.

The relation of granitic rocks and granulite occurring north of the Croteau Group and west of the previously mentioned massive granite to rocks of the Croteau Group is not yet clear. Radiometric age dates[1] show that they were involved in the Kenoran orogeny, but the extent to which they have been modified by the later Hudsonian and Grenville orogenies is not certain. Field work during 1967 is expected to clarify the relation of the adjacent areas to the Croteau Group and establish the nature and position of the Grenville front in the region.

Although no mineralization of economic importance was recognized, the structure, composition, and metamorphism of the bedrock in Snegamook map-area are such as to render the region worthy of further investigation.

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[1] Lowdon, J.A. et al.: Age determinations by the Geological Survey of Canada, Paper 62-17, p. 115 (1963).

GENERAL

119. FIELD TESTS OF 8 C/S TELLURIC CURRENT EQUIPMENT

A. Becker

This study was primarily devoted to an evaluation of the magnitudes of magneto-telluric anomalies due to elongated, essentially two-dimensional structures. For such bodies the horizontal component of the ambient magnetic field parallel to the strike of the anomalous feature is uniform along any traverse across strike. The presence of the disturbing mass is completely indicated by variations in the relative field strength of the orthogonal telluric vector.

The measuring equipment consisted of two matched, portable, averaging micro-voltmeters constructed at the Geological Survey of Canada. These were broadly tuned to 8 c/s in order to benefit from the advantageous natural atmospheric signal strength at this frequency.

The first test of the method was a traverse across the Gloucester Fault near Leitrim, Ontario. The fault is characterized by a strong positive anomaly indicative of the near-surface presence of resistive basement material. Because the skin depth at 8 c/s is large in comparison with the thickness of the youngest formations, the change in lithology as the fault is traversed is not demonstrated.

In Bartouille Township, Quebec, a near-surface massive sulphide conductor was associated with a telluric field strength variation by a factor of 20. The shape of the anomaly, however, is more complex than can be accounted for by the available drill hole data.

The last survey carried out consisted of a series of traverses across an aquifer near Winkler, Manitoba, which had previously been mapped with airborne E.M. and ground resistivity[1]. Although the telluric results here were but mildly correlated with the resistivity data, they did nevertheless indicate the presence of the resistive sand formation.

In all three cases the average telluric field magnitude reflected the country rock resistivity. The field strengths in Quebec were about three times higher than at Leitrim, while those in Manitoba were much lower.

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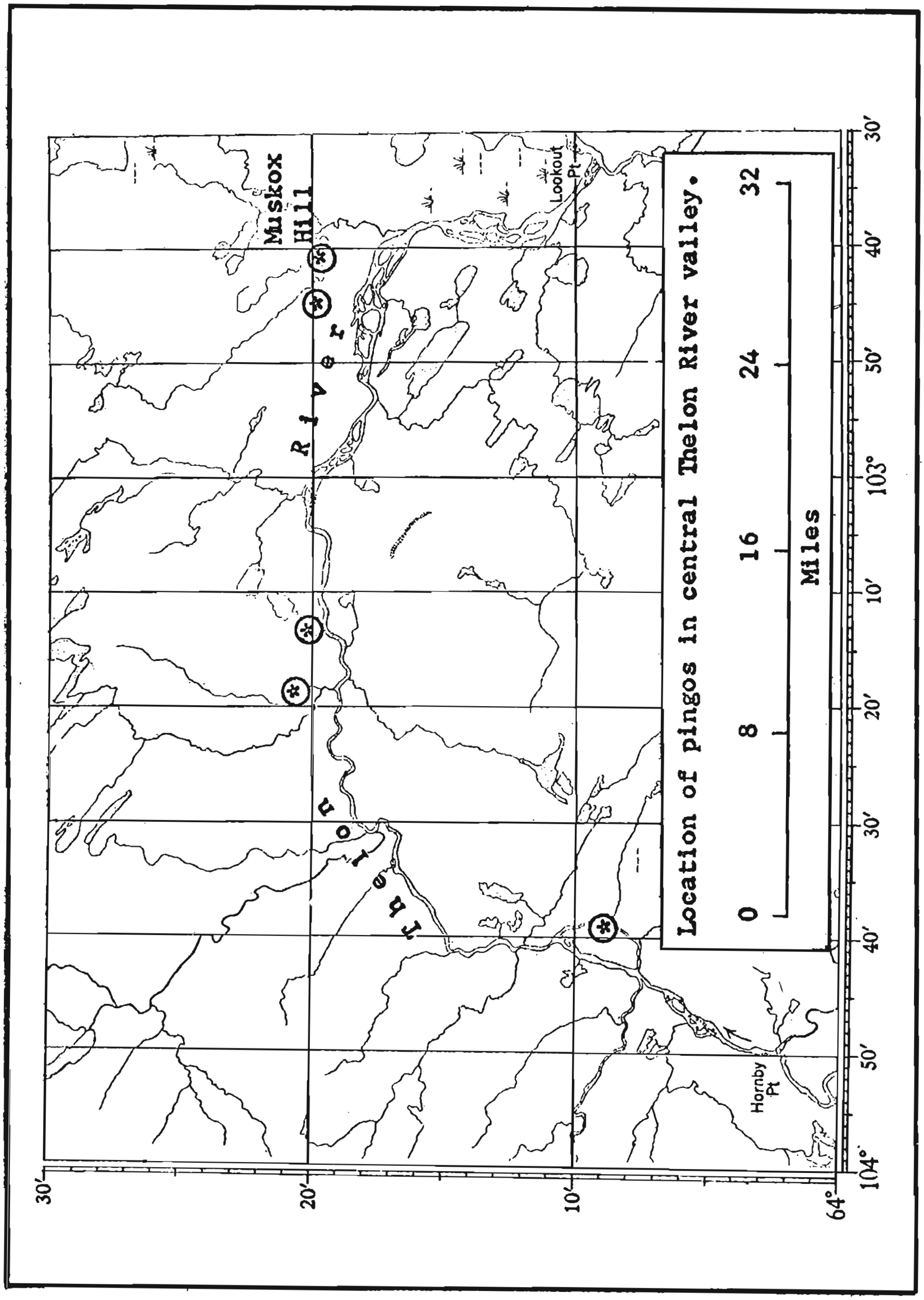
[1] Collett, L.S.: The measurement of the resistivity of surficial deposits by airborne pulsed electromagnetic equipment; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 137-138 (1966).



Location of pingos in central Thelon River valley.

120. RECONNAISSANCE GLACIAL INVESTIGATIONS, THELON RIVER BASIN, CHURCHILL AREA, AND HUDSON BAY LOWLAND

B.G. Craig

Field work consisted of three phases; nine days were spent with J.G. Fyles in the Thelon River basin conducting a preliminary reconnaissance of the area with a view to initiating a study of eskers; five days were spent in the Churchill area investigating late Quaternary uplift in the southern Hudson Bay area; and three days were spent on aerial reconnaissance of the Hudson Bay Lowland with A.W. Norris, W.L. Davison, and B.V. Sanford in preparation for Operation Winisk in 1967.

In the course of the esker reconnaissance sediments containing marine shells were examined along the Back River, which confirmed that an arm of the sea extended up that valley at least as far as Mount Meadowbank, as suggested earlier[1]. About 30 miles to the west along the valley near Lower Macdougall Lake an exposure of fine-grained sand containing no shells was examined. This deposit is presumed to be of lacustrine origin. Similar unfossiliferous deposits have been noted by J.G. Fyles (personal communication) in the general area of the Macdougall Lakes, and westward to Pelly and Upper Garry Lake[2].

Also during the esker reconnaissance four more pingos were observed along Thelon River between Hornby Point and the pingo described previously by the author[3], and now officially named Muskox Hill. J.A. Donaldson (personal communication) reports that other pingos and pingo-like forms occur in that general area. These newly discovered pingos are smaller and less conspicuous than Muskox Hill, and some are completely covered with vegetation.

Late Quaternary Uplift, Southern Hudson Bay

In the Churchill area field work was directed toward detailed collecting of marine shells and other organic material for radiocarbon dating in order to provide data on the rate of isostatic uplift during late Quaternary time. Seventeen collections were made from beaches ranging in elevation from 15 to 128 feet above sea-level. It is hoped that these will provide the data necessary to draw a detailed time-uplift curve for the period represented by the fall in sea-level from ca. 130 feet to ca. 15 feet.

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[1]Craig, B.G.: Surficial geology of northern District of Keewatin, Northwest Territories; Geol. Surv. Can., Paper 61-5, p. 3 (1961).

[2]Craig, B.G.: Surficial geology of east-central District of Mackenzie; Geol. Surv. Can., Bull. 99, p. 26 (1964).

[3]Craig, B.G.: Pingo in the Thelon Valley, Northwest Territories; radiocarbon age and historical significance of the contained organic material; Bull. Geol. Soc. Amer., vol. 70, pp. 509-510 (1959).

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121. PROGRESS REPORT OF THE PLANT PROSPECTING METHODS RESEARCH GROUP

J.A.C. Fortescue and E.H. Hornbrook

At the end of May J.A.C. Fortescue attended a field trip, led by Dr. V.J. Krajina, through a number of bioclimatic zones in British Columbia. In June he made a visit to the Terra Nova copper deposit in Gaspé in order to plan a quick biogeochemical project (see also report # 126 by G.D. Hobson), which was then carried out by E.H. Hornbrook and a party of two students. In July and early August Fortescue paid visits to six drilled, but undisturbed mineral deposits, three in British Columbia and three in the Yukon, in order to select areas for next summer's field work by the group. At the end of August he organized a three week field trip to the Forest Experimental Station at Petawawa and planned the collection of tree and soil samples from a plot adjacent to the site selected by foresters for inclusion in the International Biological Programme. This site is at Perch Lake near Chalk River.

Hornbrook and a crew of two students carried out a pilot biogeochemical project at a lead deposit near Silvermine on Cape Breton Island. All the vegetable samples collected at Terra Nova and Silvermine were dried and subsampled in the trailer laboratory of the Plant Prospecting Methods group. In addition scan spectrographic analyses were completed for thirteen elements in each of 540 samples collected during the Silvermine and Perch Lake projects. All these results were plotted out by a computor in 47.1 minutes, which represents at least a man year of plotting by manual methods.

122. THE PLIENSBACHIAN BEDS IN THE ROCKY MOUNTAINS AND FOOTHILLS

H. Frebold

After the recent establishment of the presence of upper Pliensbachian beds in the Limestone Mountain area of the Rocky Mountains[1] the distribution of these rocks in other areas was studied. They are now known to be present at various localities south of Clearwater River, extending southward to south of Panther River. Farther south, they seem to be primarily absent. The connection of these occurrences with the Lower Jurassic seas to the west and north is still under study. The ammonite faunas found indicate the presence of several subzones of the Amalthens margaritatus zone, which is overlain directly by the Toarcian. Uppermost Pliensbachian, characterized elsewhere by Pleuroceras spinatum, seems to be absent. Parts of these studies were made in cooperation with N.C. Ollerenshaw of the Geological Survey of Canada.

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[1]Frebold H.: Upper Pliensbachian beds in the Fernie Group of Alberta; Geol. Surv. Can., Paper 66-27 (1966).

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123. JURASSIC FAUNAS FROM THE MANNING PARK AREA, BRITISH COLUMBIA

H. Frebold

Fossil collections made by J.A. Coates of the Geological Survey of Canada in the Manning Park area, British Columbia, and identified by the author, establish the presence of the Sinemurian, lower and middle Bajocian, and probably some of the Upper Jurassic stages in this area of British Columbia. Some of Coates' sections were studied in detail by the author in close cooperation with J.A. Coates.

124. GEOLOGY OF IRON ORE DEPOSITS AND IRON-FORMATIONS IN CANADA

G.A. Gross

Field work during 1966 season included examination of iron-formations and the geology around iron mines in Labrador, Newfoundland, Quebec, and Ontario. Geological structures and ore zones previously examined at or near surface were studied in the deeper parts of the mines. Geological data from new mine exposures were studied as a part of the survey of the geology of iron ores in Canada.

Study of the sedimentary facies of iron-formations in the Knob Lake-Schefferville area of Quebec and Labrador was completed in the course of supervision of field work being done by I.S. Zajac.

125. LOWER CAMBRIAN BIOSTRATIGRAPHIC STUDIES, MACKENZIE MOUNTAINS

R.C. Handfield

Field work for biostratigraphic studies of the Lower Cambrian in the Mackenzie Mountains, N.W.T. was completed in the 1966 field season. Six Lower Cambrian sections were measured; two in Sekwi Mountain (105 P) map-area; one in Nahanni (105 I) map-area; one in Coal River (95 D) map-area; and two in McDame (104 P) map-area, British Columbia.

Fossiliferous early to late Lower Cambrian strata in Sekwi and Nahanni areas consist mainly of predominantly orange-and grey-weathering well-bedded limestones and dolostones with sandy carbonates and sandstones in the middle part of the section. These rocks range in thickness from 1,200 feet in northern Nahanni area to 3,200 feet in west-central and northern Sekwi Mountain area. The variation in thickness is primarily due to an unconformity beneath Middle Cambrian strata. Lower Cambrian carbonates appear to change facies easterly to white and purple hematitic sandstones in Wrigley Lake area described by Gabrielse et al.[1].

Fossiliferous early and late Lower Cambrian strata, 2,300 feet thick in northwest Coal River area, consist mainly of brown-weathering silty limestone, brown-weathering siltstone, and reddish weathering, fine-grained sandstone. The section contains many species in common with the Sekwi area fossils. White to light grey weathering, medium-grained dolostones of unknown age overlie the Lower Cambrian, apparently conformably.

The McDame Lower Cambrian has been described elsewhere[2].

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[1]Gabrielse, H., Roddick, J.A., and Blusson, S.L.: Flat River, Glacier Lake, and Wrigley Lake, District of Mackenzie and Yukon Territory; Geol. Surv. Can., Paper 64-52 (1965).

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

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126. HAMMER SEISMIC INVESTIGATIONS, CENTRAL GASPÉ AND CAPE BRETON ISLAND

G.D. Hobson

Shallow seismic profiles were made in conjunction with the pilot biogeochemical project at Silvermine on the Salmon River in southeastern Cape Breton Island, and the quick biogeochemical project on the Pékan copper property of Terra Nova Explorations Ltd., Lesseps Township, Gaspé (see biochemical report by Fortescue in this paper).

Forty-five locations, 100-foot spacing, were investigated by hammer refraction seismograph at the Silvermine property to determine thickness of overburden and to identify drift material. The seismic data reveal a thin layer of topsoil overlying a gravel deposit of varying thickness overlying bedrock. The bedrock does not exhibit a consistent seismic velocity, indicating either a variable bedrock with respect to lithology, or considerable relief on the bedrock surface.

Forty locations, 200 foot spacing, were investigated by hammer refraction seismograph on the Pékan copper property, about 11 miles east-southeast of Mount Albert, Gaspé. Approximately 1000 feet of relief prevails over the surveyed line.

Depths to bedrock never in excess of 25 feet were determined. Gravel and sandy gravel constitute the overburden material. Bedrock is variable in nature, as evidenced by two main groupings of seismic velocities associated with the bedrock surface.

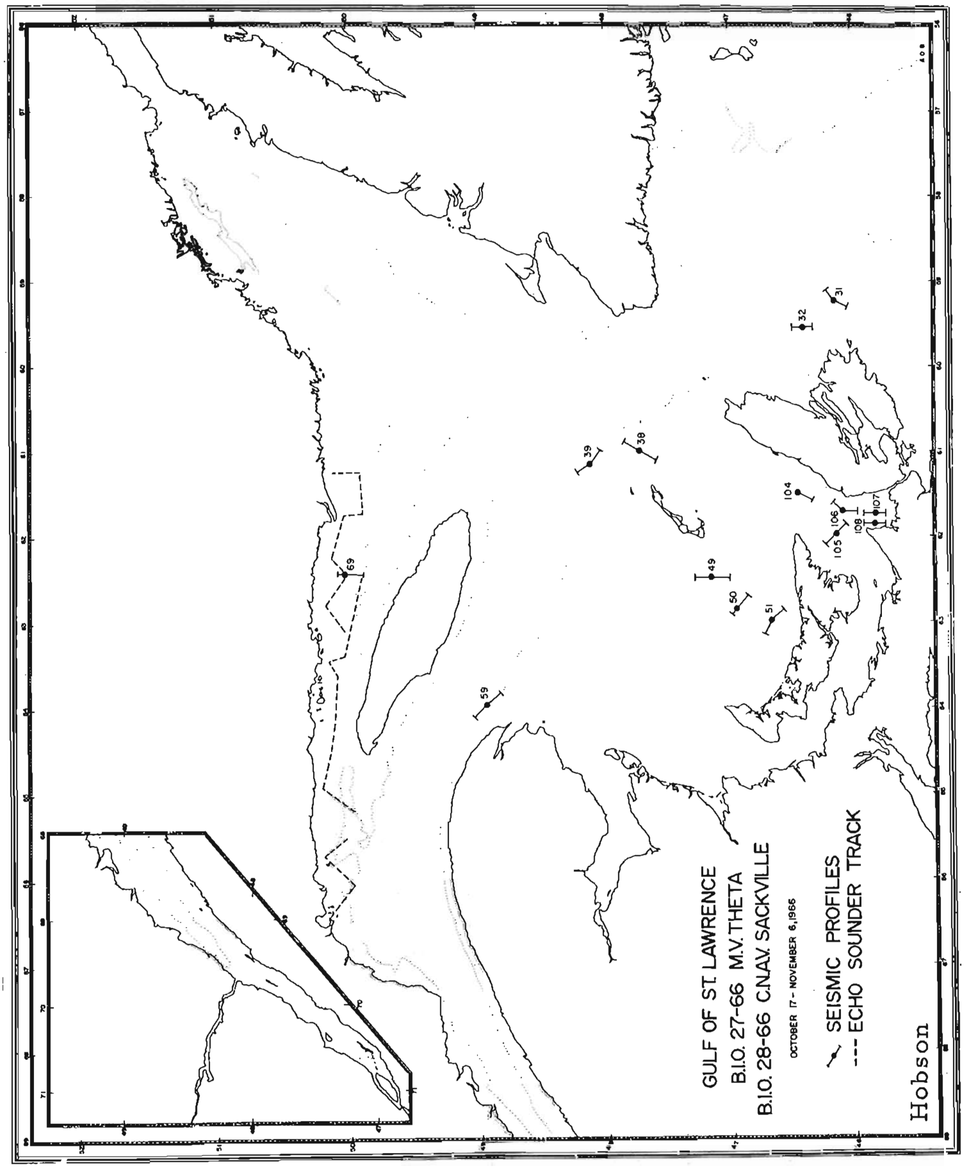
127. MARINE SEISMIC INVESTIGATIONS, GULF OF ST. LAWRENCE

G.D. Hobson

A marine seismic program was carried out in the Gulf of St. Lawrence during October-November 1966 as a continuation of a program begun in 1964. Two ships were used to investigate the thickness, nature, and attitude of the sedimentary rocks underlying the Gulf.

C.N.A.V. Sackville was used as the recording platform while M.V. Theta participated as the shooting vessel. Refraction techniques were employed throughout. An EDO depth recorder-indicator was used to record water-sediment topography in an attempt to define the contact between Precambrian and later sedimentary rocks immediately south of the north shore of the Gulf. Five profiles were shot in George Bay and the adjacent Northumberland Strait to complement geological and shallow "sparker" investigations in the area (Fig. 1).

A cursory examination of the records indicates that generally good to excellent quality data have been obtained. No interpretation of the data has been undertaken to date of writing. In general, there is very little if any unconsolidated materials overlying bedrock at the locations investigated. Bedrock in all cases exhibits a high velocity for seismic waves; this velocity is not less than 9000 feet per second.


GULF OF ST. LAWRENCE
B.I.O. 27-66 M.V. THETA
B.I.O. 28-66 C.NAV. SACKVILLE
OCTOBER 17 - NOVEMBER 6, 1966
SEISMIC PROFILES
--- ECHO SOUNDER TRACK
Hobson

The profiles obtained on the EDO echo-sounder indicate both Precambrian and sedimentary types of topography permitting an interpretation of the contact and the northern extent of the sedimentary basin.

Nitrone SM Super X was used during this program as an explosive in water depths less than 50 fathoms. This type of explosive is excellent for marine seismic programs; it is a canned product, it is comparatively cheap, and the energy output is relatively high in comparison with other canned products and gelatins.

128. PRECAMBRIAN BIOSTRATIGRAPHY

H.J. Hofmann

A program of systematic study of Precambrian fossils was initiated. The project is directed towards the search, collection, description, and interpretation of Precambrian organic structures, in an attempt at eventual zonations and biostratigraphic correlations in Precambrian sedimentary rocks of Canada.

In August, ten localities in the Point Lake - Takiyuak Lake — Contwoyto Lake area (District of Mackenzie) were visited to examine and collect stromatolites from Proterozoic rocks assigned to the Epworth and Goulburn Formations. In addition, stromatolites from formations of the Proterozoic Great Slave Group were examined and collected at twelve localities on Great Slave Lake.

In September a visit was made to the Elliot Lake area, Ontario, to view the locality of an extraordinarily well preserved structure (megafossil or trace fossil) in quartzites assigned to the Huronian Cobalt Group. This structure had been discovered by Victor Lahti of Elliot Lake, and subsequently submitted for study by F.R. Joubin. Additional samples were obtained from the same locality. Two basic dykes cut the fossiliferous sedimentary units; these dykes were sampled for radiometric dating. The fossil resembles that described by Frarey and McLaren[1] from the Huronian Lorrain Formation near Desbarats, Ontario. The Desbarats locality was revisited and additional specimens obtained.

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[1] Frarey, M.J. and McLaren, D.J.: Possible metazoans from Early Proterozoic of the Canadian Shield; Nature, vol. 200, No. 4905, pp. 461-462 (1963).

129. LOW-LEVEL AEROMAGNETIC PROFILES OVER THE LABRADOR SEA, BAFFIN BAY, AND ACROSS THE NORTH ATLANTIC OCEAN

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

In cooperation with the National Aeronautical Establishment the Geological Survey carried out aeromagnetic surveys over the Labrador Sea, in Baffin Bay, and across the North Atlantic Ocean. Ten aeromagnetic profiles were obtained in the Labrador Sea, running northeastward from between latitudes 56°30' and 59°30' on the Coast of Labrador. Preliminary examination of these profiles establishes the continuity of a previously partly known, northwesterly trending magnetic zone off the Labrador coast. A similar number of aeromagnetic profiles were obtained between Baffin Island and Greenland in the southern part of Baffin Bay and Davis Strait. Preliminary examination of these profiles shows them to be sharper and more complicated than those obtained to the south in the Labrador Sea and there is no indication of the continuation into Baffin Bay of the northwesterly trending magnetic zone off the Labrador coast.

Two profiles were obtained across the North Atlantic Ocean from Gander, Newfoundland, to southern Greenland, Iceland, and northern Scotland. These two profiles indicated that the sedimentary section underlying the continental shelf northeast of Newfoundland is at least 20,000 feet thick. Magnetic anomalies occur in line with the southward continuation of the two zones of magnetic anomalies recorded in the Labrador Sea. Several distinct anomalies occur between Iceland and the southern tip of Greenland. A distinct magnetic anomaly was recorded immediately south of the new volcanic island of Surtsey (about 20 miles south of Iceland).

A more detailed account of these activities will be published in Geological Survey of Canada Paper 66-58.

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

R. Mulligan

About three weeks work was done in late July-August in the western part of the project area, in conjunction with regional mapping of the Jennings River area by H. Gabrielse (see paper # 23 by Gabrielse earlier in this report).

The area contains numerous and diverse types of mineral deposits, and occurrences in part related to particular bodies and varieties of igneous intrusion.

Localities examined and sampled included: garnet-epidote-pyroxene-vesuvianite-axinite skarns, such as locally contain extraordinary tin-rich silicates[1,2]; similar skarns with lead-zinc minerals; fluoritic quartz veins; berylliferous pegmatites; bismuth-bearing quartz veins; and zirconium-rich rhyolite dykes[1].

Composite samples of granitic bodies associated with some of the mineral deposits were obtained. A number of creeks were panned to supplement and check previous work, which showed wide variations in heavy-mineral assemblage and tin content.

At the lead-zinc-silver property of Logjam Silver Mines (Lat. 60°01', Long. 131°36') a crosscut was being driven to intersect mineralized sections indicated by previous diamond drilling. At the Silvertip lead-zinc-silver property (Lat. 59°55', Long. 130°20') preparations for a proposed diamond-drilling program were under way.

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[1] Watson, K. deP. and Mathews, W.H.: The Tuya-Teslin area, northern British Columbia; B.C. Dept. Mines, Bull. No. 19 (1944).

[2] Mulligan, R. and Jambor, J.L.: Tin-bearing silicates from skarn in the Cassiar district, northern British Columbia (abst.); Geol. and Mineral. Assoc. Can., Tech. Program, 1966 Ann. Meetings, Halifax, N.S., pp. 32-33 (1966).

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131. 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 vicinity of the northern Cassiar Batholith (see previous report by Mulligan).

Investigations in the tin province of the southwestern Cordillera included the examination and sampling of:

1) The Akokli mine, Lat. 49°26', Long. 116°44'. This is a wolframite-sulphide deposit, unique in that district, which should be especially favourable for concentration of tin.

2) The J. and L. property, north of Revelstoke, Lat. 51°13', Long. 117°45', recently reopened by Westairs, Ltd. Tin has been reported in spectrographic analyses of ore from this property, which is about 10 miles northwest of the Snowflake-Regal Silver property along the trend-line of several minor tin occurrences.

In the Mount Pleasant-St. Stephen area of New Brunswick where A. Ruitenberg has been conducting a structural-stratigraphic study (see paper by Ruitenberg, elsewhere in this report), some recently stripped areas of the Mount Pleasant Mines property were examined and material for analysis was collected from granitic plugs along the north side of the main granite batholith.

132. STRATIGRAPHIC AND STRUCTURAL STUDIES IN THE SOUTHEASTERN CANADIAN CORDILLERA

D.K. Norris

Investigations included the continuation of lithostratigraphic studies of the non-marine Lower Cretaceous Blairmore Group, the continuation of investigations of the structural fabric of the Jurassic and (?) Lower Cretaceous Kootenay Formation and a comparison of this fabric with that in Pennsylvanian coal measures of the northern Appalachians.

Additional studies of the Blairmore Group at the headwaters of Nez-Percé Creek and on the east flank of Ma Butte revealed the presence of Kootenay Formation at the base of the section; the Cadomin Formation is therefore complete. A careful examination of a pebble-conglomerate near the base of the upper part of the Blairmore Group resulted in the discovery of volcanic and metavolcanic pebbles forming less than one per cent of the rock. This dominantly chert and quartzite pebble bed is highly lenticular, is up to 10 feet thick and grades laterally into the resistant ribs of coarse-grained sandstone toward the base of Unit 24 of the described section[1]. The conglomerate is therefore probably the stratigraphic equivalent of the McDougall – Segur horizon noted at several locations in the southeastern Canadian Cordillera[2].

The investigation of the tectonic fabric of the rock mass in and about coal mines of the southeastern Cordillera was extended to the Upper Marsh seam in the Lac des Arcs thrust sheet at Canmore, Alberta, and to the A-North mine in the Lewis thrust sheet at Michel, British Columbia. Data from these and other mines of the region[3] are of vital importance in the interpretation of the Crowsnest deflection, the change in tectonic trend in the Crowsnest area. As part of a comparative study, the structural fabric of coal measure rocks was sampled in three mines in the northern Appalachians - two in the Northern Anthracite Field, and one in the Southern Anthracite Field. Kinematic patterns established from slickenside striae at the coal rock interfaces in these mines do not appear to differ from those in mines in the eastern Cordillera; the frequency distribution of azimuths of striae are Gaussian to slightly asymmetrical in all cases, whether or not the coal measures are associated with a major change in tectonic trend of the megascopic fabric elements.

In conjunction with H. Bielenstein, the writer critically examined prospects and outcrops in the Kootenay Formation beneath Mount Rundle and beyond the northwestern limit of active underground mining in the Cascade coal area. There it was established that prospecting of low-ash coals with favourable coking properties was being carried out in a deformed, largely overturned succession on the structural continuation of the southwest flank of the Mount Allan syncline. It is highly probable that more than three coal seams of considerable economic importance have been exposed in the prospects and that they will occur in upright succession and in a less deformed condition in the southwest-dipping homocline on the lower slopes of Mount Rundle.

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[1]Norris, D.K.: The Lower Cretaceous of the southeastern Canadian Cordillera; Bull. Can. Petrol. Geol., Field Conference Guide Book, August 1964, pp. 512-535 (1964).

[2]Norris, D.K., Stevens, R.D., and Wanless, R.K.: K-Ar age of igneous pebbles in the McDougall-Segur Conglomerate, southeastern Canadian Cordillera; Geol. Surv. Can., Paper 65-26 (1965).

[3]Norris, D.K.: Interbed slip in some Cordilleran coal mines; in Report of Activities, May to October, 1965; Geol. Surv. Can., Paper 66-1, pp. 114-115 (1966).

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133. PLEISTOCENE FIELD RECONNAISSANCE, MARITIME PROVINCES

V.K. Prest

A few days were spent examining evidence of marine overlap and rate of tilting on the north shore of Minas Basin, and in a search for evidence of radial glacier movements from the Cobequids. Ice-flow features and the northward transport of Cobequid-type rocks clearly reveal northward glacier transport from the eastern end of Cobequid Mountains toward Pictou, New

Glasgow, and Merigomish. End moraines were recognized in the Pictou area, which, though built by eastward ice-movements, contain an abundance of Cobequid-type rocks. Very complex glacier movements are indicated during recession of the Wisconsin glacier complex.

A hurried visit was made to the Magdalen Islands, in order to obtain further information regarding Wisconsin events there. Many recent road cuts provided an opportunity to examine the till-like material on Amherst Island. This is clearly a marine deposit; it occurs interstratified with Demoiselle (local) gravel and sand, and does not occur above the marine limit. Stones foreign to the island appear to be exceptionally rare if not entirely absent. No evidence was seen that a glacier flowed across Amherst Island. The northern islands also lack ice-flow features of any sort. The bedrock there is mantled by ice-contact stratified drift from a nearby northern (?) glacier that did not reach the islands. Both bedrock and stratified sands are mantled by a very bouldery gravel of northern derivation, which appears to have been emplaced by an ice-rafting process.

A short time was spent on Prince Edward Island collecting till samples for mechanical analyses.

Samples were collected for heavy mineral studies from all areas visited in order to see if any of them contain any of the diagnostic 'suites' of minerals from Labrador, New Brunswick, Cape Breton Island etc. If present such mineral suites would provide clues to directions of glacier movements.

134. METALLOGENIC STUDY, LAKE SUPERIOR - CHIBOUGAMAU REGION, ONTARIO AND QUEBEC

S.M. Roscoe

Field trips were made to Lake Superior, Sault Ste. Marie, Elliott Lake, Chibougamau, Lake Mistassini, and Otish Mountains area during the period, May - September 1966.

Manitouwadge zinc- and copper-bearing massive sulphide deposits appear to have been metamorphosed along with enclosing Archaean strata and intruded by Kenoran pegmatites. The zinc spinel, gahnite, was recognized in sulphide-bearing gneisses adjacent to massive ore. Quartzose, sulphide-bearing bands, locally termed iron-formation, resemble similar bands in metamorphosed Archaean strata north of Sudbury and elsewhere in the region. West of the Wilroy Mine, the host gneisses dip gently to the north beneath granite. This has given rise to the unusual exploration procedure of drilling in granite far from the contact in search of the depth projection of the favourable zone.

A study of deposits in Proterozoic rocks in the Nipigon-Lakehead area was begun by J.M. Franklin, the writer's summer assistant. These deposits include: silver deposits in the Rove Formation, native silver-arsenide deposits of the Silver Islet type; non-argentiferous lead-zinc deposits near the base of the Sibley Formation; copper occurrences in the Osler (Keweenawan) volcanics; copper-nickel deposits at the base of a gabbro sill; and recently discovered occurrences of copper (digenite) in pink, stromatolitic (algal) dolomite near the base of the Sibley Formation.

Newly-discovered copper deposits 35 miles northeast of Chibougamau, Quebec, at the southern end of the basin underlain by strata of the Mistassini Group represent a most unusual type of mineral deposit. Extensive lenses of coarse-grained quartz, carbonate, and chalcopyrite, resembling material found in veins in many areas, are concordant with bedding in unmetamorphosed, gently-dipping strata. Individual lenses have an east-west trend. They have been found only at a single, well-defined stratigraphic position within black shale overlying grey stromatolitic (algal) dolomite near the base of the Mistassini Group. Mineralization of this type has been found north of the area containing known ore bodies and the favourable stratigraphic horizon apparently extends continuously along the northwest and north edges of the basin. Black shale near the base of the Mistassini Group and much higher beneath the Albanel iron-formation is faintly radioactive, due either to an abnormally high potassium content, a slight concentration of uranium, or both.

Proterozoic rocks occur south, north, and northwest of the Mistassini basin - respectively, the Chibougamau Group, the Papaskwasati Formation, and the Otish Mountain Group - and resemble the Huronian rocks 300 to 600 miles to the southwest. The resemblance of the Chibougamau Group to the Gowganda Formation is remarkable. The Papaskwasati Formation resembles Mississagi quartzite. Very slightly radioactive layers of very small quartz pebbles were noted along green sericitic partings between beds of coarse-grained, cross-bedded, feldspathic quartzite. Slight radioactivity and traces of pyrite were also noted at the base of the formation in one place where it rests on an ancient weathered surface in quartz-feldspar porphyry, which may also be of Proterozoic age. Monazite-rich beach sand was noted along the shore of a small lake within the area underlain by the Papaskwasati Formation. The Otish Mountain Group closely resembles the Lorrain Formation. Basal sericitic arkose along the north and west side of the Otish Mountain belt contains abundant pebbles of quartz and chert and is very slightly radioactive; thin beds of thorium-bearing hematitic quartz-pebble conglomerate are also present in this unit and in pebbly arkose at the southeast side of the Otish Mountain belt. The Lorrain Formation north of Elliot Lake contains a similar arkosic lower unit with monazite-rich hematitic quartz pebble beds.

Routine collections of geological data and samples for laboratory study were made at gold and other deposits in the Beardmore, Long Lac, and Schrieber areas; copper deposits in the Coldwell alkalic syenite complex at Marathon; lead-zinc, copper, and uranium deposits in the Sault Ste. Marie-Sudbury area; and copper and gold deposits in the Chibougamau area.

135. MINERAL COLLECTING AREAS BETWEEN KINGSTON, ONTARIO AND TADOUSSAC, QUEBEC

Ann P. Sabina

The field work consisted of an examination of about 160 mineral and rock localities on the north side of the St. Lawrence River between Kingston, Ontario and Tadoussac-Lac St. Jean area, Quebec. 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.

Mineral, rock, and fossil specimens can be found at numerous localities, but lapidary material is limited. The Kingston-Perth-Gananoque area is the most prolific collecting area; it includes apatite-mica, feldspar, base-metal mines, and limestone and granite quarries. In the Montreal area, quarries on both sides of the St. Lawrence River yield uncommon mineral specimens and fossils. Between Montreal and the Saguenay River there are quarries supplying building stone, fossiliferous limestone, marble, and silica. Old mines include feldspar-mica, titanium, iron, and base-metals.

136. GEOCHEMISTRY OF LEAD AND ZINC DEPOSITS IN CARBONATE ROCKS

D.F. Sangster

Field studies of lead-zinc deposits of the "Mississippi Valley type" were carried out in southwestern Ontario, the Gaspé and Lake Mistassini areas of Quebec, and Pine Point, District of Keewatin. All occurrences are of simple ore mineralogy and are found in essentially non-metamorphosed, gently-dipping rocks remote from any known igneous intrusions. Although they have much in common, there is sufficient variation, in the Canadian deposits examined, to allow recognition of four main sub-types based on host rock lithology and metal ratios. The characteristics of these sub-types are summarized below:

	1	2	3	4
Host rock	Widespread, reefal dolomite not restricted to area of mineral deposit.	Dolomite, restricted to immediate vicinity of mineral deposit. Outside of mineralized area, rock is limestone.	Highly fossiliferous dolomite or limestone.	Coarse-grained calcite veins in fine-grained dolomite. Veining is frequently sufficiently intense to produce a calcite-dolomite breccia.
Metal ratios	Deposits are either entirely sphalerite or the Zn/Pb atomic ratio is high e.g. 10:1 at Pine Point.	Zn predominates over Pb but the Zn/Pb ratio is lower than in Type 1 e.g. 4:1 at the Monarch-Kicking Horse Mines.	Metal is predominantly or entirely Pb.	Metal is predominantly or entirely Pb.
Character of mineralization	Disseminations, cavity fillings, veins, or replacement.	Replacement and veins.	Disseminated, cavity filling, minor veining.	Grains or clusters of grains restricted to the calcite veins.

For comparison, several small lead-zinc showings in the Grenville Province of the Shield were also examined. These all occur in coarse-grained marble and their ores are compositionally simple. Two main contrasting types of mineralization were noted: (1) predominantly or entirely galena in cross-cutting, generally vertical, barite or calcite veins; (2) predominantly or entirely sphalerite, occurring in bands or lenses conformable with the surrounding marble.

Determinations of the trace-element contents of sphalerite and galena in all these occurrences are being carried out to study intra- and inter-deposit variations.

137. FIELD TEST OF TRANSDUCER PIEZOMETER

J.S. Scott

A comparison was made between the responsitivity of a mechanical water-level recorder equipped with an electric probe and a closed-system transducer piezometer to changes in water levels in 1 1/2" diameter well-point type piezometers. The piezometers are located in overconsolidated shales of low permeability adjacent to the South Saskatchewan Reservoir in central Saskatchewan and in fractured arenaceous rocks on the south shore of Prince Edward Island.

A preliminary assessment of the results obtained indicates that a greatly increased responsitivity to changes in piezometric level is obtained with the transducer piezometer in shales of low permeability. Measurements obtained from both instruments installed on piezometers in the fractured rock showed a similar degree of responsitivity to changes in water level caused by tidal influence. The closed system transducer piezometer, however, detected the influence of barometric pressure changes in addition to tidal effects.

Instrumental errors occasioned by thermal influence in the 24 v battery power supply for the amplifier and recorder system of the transducer piezometer were experienced after 36 hours of continuous operation of the equipment. It is probable that these errors can be eliminated by the use of a stable power source.

138. STRATIGRAPHY OF SUPERIOR-TYPE IRON-FORMATION IN THE SCHEFFERVILLE-KNOB LAKE AREA OF QUEBEC AND LABRADOR

I.S. Zajac

The detailed study started in 1965[1] of the stratigraphy and depositional environment of this iron-formation was continued in 1966. Sampling and description of the sedimentary facies in the iron-formation was completed on a large number of rock exposures.

At least four distinctive beds of red cherty iron-formation (jasper members) have been recognized and their usefulness for stratigraphic markers was demonstrated. Revision of the detailed stratigraphy of the iron-formation is proposed on the basis of the work, which is of special scientific interest as well as having important significance in exploration for iron ore and further mine development in the area.

Results from this project will be used by the writer for a Ph.D. dissertation at the University of Michigan, Ann Arbor, Michigan.

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[1]Kajac, I.S.: Stratigraphy of Superior-type iron-formation in the Schefferville-Knob Lake area, Quebec and Labrador; in Report of Activities, May to October 1965; Geol. Surv. Can., Paper 66-1, p. 205 (1966).

GEOLOGICAL COLLECTING

The collection of rocks, minerals, fossils, and other geological data is an important phase of many of the Survey's field investigations. Some field activities, however, consist entirely or almost entirely of making collections for specific research projects being carried out at Geological Survey headquarters. Consequently only the collecting phase of such activities can be recorded at this time. Further results are expected to appear from time to time in other Geological Survey publications or in assorted scientific periodicals.

Sixteen collecting projects are recorded below.

F. Aumento spent four weeks on the CSS Hudson during the Bedford Institute of Oceanography 1966 geophysical cruise dredging a selected area of the Mid-Atlantic Ridge (45°N). Two sampling areas were selected. 1) A series of dredges from the centre of the Median Valley (1700 fms) up the slope to the top of a flanking sea mountain (490 fms). A number of basalts were collected, including two complete fresh lava pillows from the bottom of the Median Valley. 2) A deeper mountain (900 fms) to the west of the Median Valley where bottom photography had shown granitic bedrock rather than basic lava flows. Out of 100 specimens collected in three dredge hauls on different sides of the peak, more than 50 per cent were plutonic acid rocks (granites/granodiorites); other specimens included numerous metamorphic rocks, two basalts, and rounded sedimentary boulders.

T.E. Bolton and M.J. Copeland collected samples for macro- and micropalaeontological examinations from all formations exposed on the western and central parts of Anticosti Island. These augment previous collections, which did not contain adequate samples from the lower Becscie, upper Jupiter, and Chicotte Formations, and give additional stratigraphic and palaeontologic information of the Vauréal, Ellis Bay, Gun River, and Jupiter Formations from localities farther east than had previously been accessible.

J.A. Chamberlain collected samples from ultramafic intrusions in the Timmins area, and nickel-copper sulphide samples from the Timmins, Belleterre, and Sudbury areas. The mineralogy and chemistry of the samples are being studied in the laboratory. Problems include the partitioning of nickel in coexisting sulphide and silicate rock fractions, and the behaviour of nickel and other elements during serpentinization in different environments.

R.L. Cox sampled thirty-two Cretaceous type and reference sections in southwestern Manitoba for palaeontological studies.

W.F. Fahrig completed the sampling and examination of field relations of the major diabase dyke swarms of the Western Shield during the 1966 field season. He also collected material from gabbro sheets and sills over a large part of the Western Shield, it is expected that completion of laboratory work will result in significant advances in our knowledge of the correlation of the widespread unmetamorphosed basic rocks of the Shield.

Oriented samples for palaeomagnetic study should be useful in determining correlation and structural deformation of the various bodies of basic rock.

G.N. Freda collected 86 oriented samples from 15 sites in Lake Panache (41 I/3) and Lake Matinenda (41 J/2) map-areas, Ontario. Twelve of these sites were from diabase sills and the other three sites at Lake Panache were from diabase dykes. The purpose of this collection was to investigate the age of the folding in the diabase relative to the general structure of the area. This work was done under the supervision of M.J. Frarey and A. Larochelle.

C.H.R. Gauthier and M. Larose, from 24 May to 28 September, collected more than 20 tons of minerals, rocks, and ores used in the preparation of various educational and other collections. These were from about 50 localities in the provinces of Nova Scotia, New Brunswick, Ontario, and Quebec. In addition he shipped to Notre Dame Island in Montreal for Expo 67 more than 38 specimens of various rocks and ores from Nova Scotia, New Brunswick, Ontario, and Quebec. The overall weight of the specimens amounted to 52,500 lbs.

P.A. Hacquebard collected two additional column samples of the Minto coal seam in New Brunswick, and one column sample of the No. 5 seam at St. Rose, Cape Breton Island, N.S. These samples were obtained for a study on regional variations in the petrography and palynology of coal seams.

R.D. Howie collected oil and gas well data from the Mines Department in Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland; logged the Nova Scotia Department of Mines Maligash No. 1 well; examined the Ordovician sections in the Port au Port and Parsons Pond area of Newfoundland; and visited an offshore drill rig on the Grand Banks. Two days were spent in the Moncton area with Mr. H.W. van de Poll of the New Brunswick Department of Lands and Mines, checking palaeocurrent directions in the Albert Formation. Sands in the Albert section originated south of the Stony Creek Field. Outcrops in the Indian Mountain area of the Kingston uplift indicate that the stream that deposited sands in the Stony Creek area continued to flow north towards the Miramichi Bay area.

J.L. Jambor collected mineral samples as a basis for a mineralogical study of the vein carbonates of the Cobalt area.

A. Larochelle directed the drilling of an average of 5 oriented samples for palaeomagnetic studies at each of 26 sites disseminated throughout the Yukon Territories, Northwest Territories, and northern British Columbia. The samples were collected from diabase dykes and sills for the purpose of studying the structural history of the Cordillera. This project was carried out jointly with D.K. Norris.

J.E. Reesor spent six weeks re-examining problem areas and sampling the Thor-Odin gneiss dome in southeastern British Columbia with Dr. E. Froese for a continuing petrochemical study of the gneiss complex.

H.R. Steacy collected specimens of rare minerals at five localities in Ontario and Quebec for the National Mineral Collection's Systematic Reference Series, for which the Geological Survey is responsible. Some minerals were collected in sufficient quantity to be used for exchanges in Canada and abroad for minerals lacking from the Series. Specimens of rose quartz were also collected for use in the exhibits in the Centennial Caravans and some assistance was rendered in the provision of specimens for the Geological Court at the Canadian Pavilion, Expo '67, Montreal, Quebec.

H. Miriam Steele collected samples containing silicified fossils from Middle Ordovician rocks at Paquette Rapids, Ontario.

T.T. Uyeno collected samples for conodont analysis from Lower and Middle Devonian rocks of southwestern Ontario and adjacent regions of Ohio and Michigan.

R.K. Wanless and R.D. Stevens collected samples from the Dauversière stock and associated rocks both north and south of the Grenville-Superior boundary south of Chibougamau, Quebec. The materials will be used to extend age determination studies based on the K/Ar, Rb/Sr, and U/Pb systems.

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