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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 65-1

REPORT OF ACTIVITIES: FIELD, 1964

Compiled by S. E. Jenness

Price, 75 cents

1965

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OF CANADA

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Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1964

CONTENTS

ABSTRACT

This publication presents 133 reports of field work undertaken in 1964 by members of the Geological Survey of Canada, and six additional statements on mineralogical and palaeontological collecting projects.

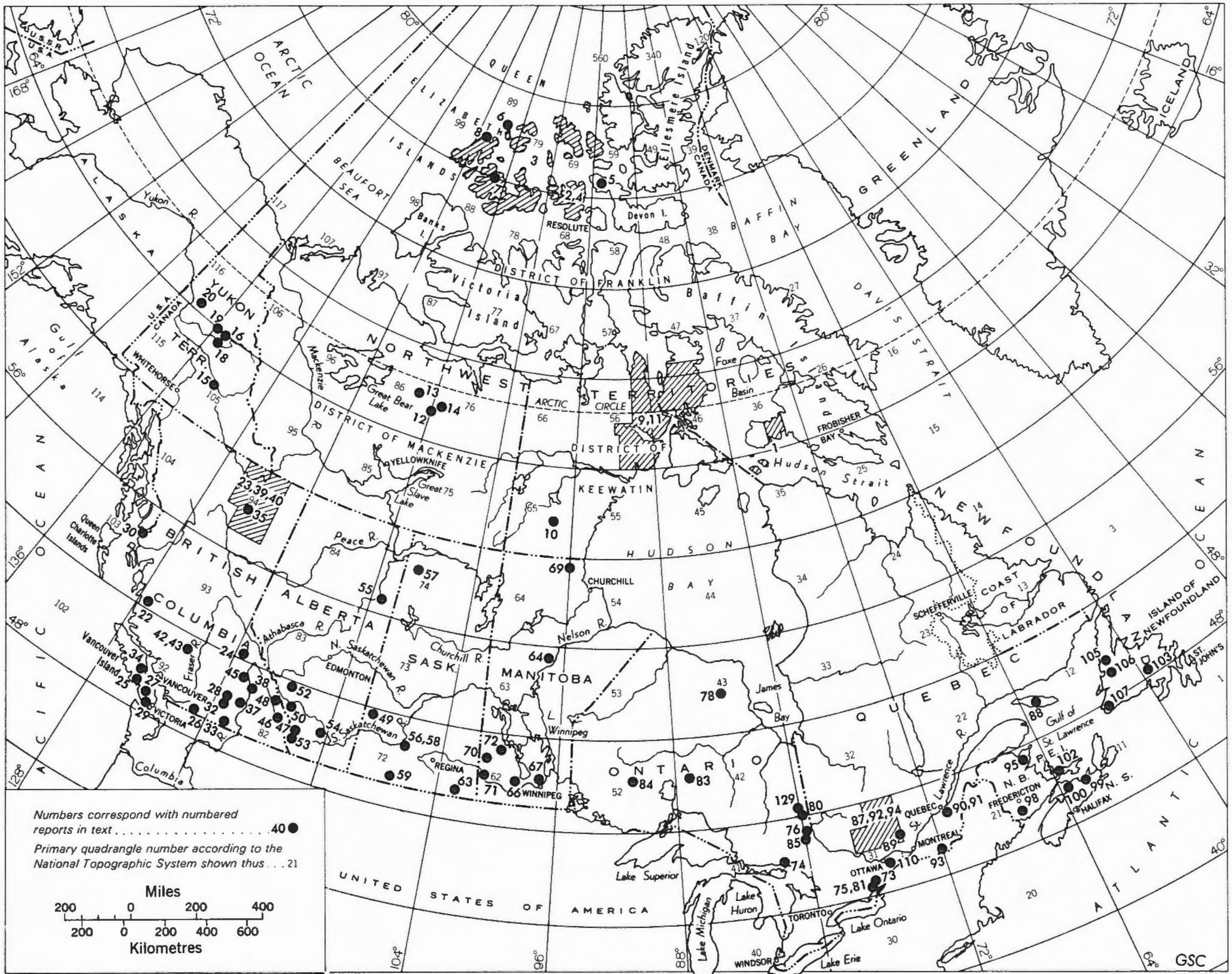

Figure 1. Distribution of most of the 1964 Geological Survey field parties.

REPORTS OF ACTIVITIES: FIELD, 1964

INTRODUCTION

For the past several years the Geological Survey has issued annual brief accounts of the results of its geological field program. The data on each project were collected from the geologists upon their return from the field in the autumn, and released to the public shortly after the New Year. The first five such accounts were issued between 1958 and 1962 as Information Circulars, and are now out of print. Since then, the data have appeared in Papers 63-1 (Summary of Research: Field, 1962) and 64-1 (Summary of Activities: Field, 1963). Papers 63-2 and 64-2 were issued as companion volumes to cover the 1962 and 1963 activities in the Geological Survey's laboratories and offices.

The main purpose of most Geological Survey field work is to obtain basic data on the geology of Canada. When assembled, interpreted, and published as appropriate maps and reports, this information may help to guide those engaged in the search for and development of metallic and non-metallic mineral deposits, fuels, water supplies, and construction materials.

The release dates of such reports and maps, and all other Geological Survey publications 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 Mines and Technical Surveys, Ottawa.

Reports presented on the following pages were received up to October 30, 1964, and were given only cursory editing in order to permit early publication. They 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 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.

An author index and a general subject index are included at the end of the report for easy reference. The locations of most of the field parties are shown on the figure facing page 1.

DISTRICT OF FRANKLIN

1. RECONNAISSANCE MAPPING, SOUTHWESTERN BAFFIN ISLAND

R.G. Blackadar

Reconnaissance mapping of Andrew Gordon Bay - Cory Bay map-area (36 B and G) initiated in 1961 was completed with the exception of a small area in northern Cory Bay map-area. Gneissic rocks predominate, although in the vicinity of Andrew Gordon Bay crystalline limestone and rusty schists outcrop extensively. These rocks are similar to the Grenville-type lithology characteristic of southern Baffin Island and appear to be a westward extension of similar rocks described on Geological Survey of Canada preliminary maps 55-1959 (Hobart Island) and 43-1960 (Mingo Lake). Metavolcanic rocks outcrop on West Foxe Islands in the extreme southwestern part of Andrew Gordon Bay map-area. Economic mineral deposits within the area are confined to low-grade magnetite deposits noted previously[1] and to altered amphibolites used by the Eskimo for carving and thus of considerable economic importance to the district.

Nottingham, Salisbury, and Hill Islands are composed primarily of quartz-feldspar granular gneiss commonly veined with pinkish granite or aplite. Here and there mafic-rich bands give rise to lit-par-lit gneiss. No occurrences of economic interest were observed. Available evidence indicates that ice movement on these islands during glaciation was from the southwest. Sand and silt deposits are widespread on the southwestern half of Nottingham Island and float of presumed Lower Palaeozoic age is more common in drift and gravel deposits on these islands than in Andrew Gordon Bay - Cory Bay map-areas.

A short reconnaissance of southern Baffin Island was made in August to assist in planning for "Operation Amadjuak", a helicopter-supported project planned for 1965.

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[1] Blackadar, R.G.: Andrew Gordon Bay - Cory Bay map-areas; Geol. Surv. Can., Map 5-1962 (1962).

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2. SURFICIAL GEOLOGY, BATHURST ISLAND

W. Blake, Jr.

Field work was devoted primarily to the western part of Bathurst Island (68 G, H; 69 A, B), but certain localities in the eastern part of the island that had not been visited in 1963 were examined also. Brief visits were made to Alexander and Massey Islands to the northwest of Bathurst Island.

Emphasis was placed on determining the elevation of the limit of marine submergence, and a number of shell samples near the marine limit were collected for radiocarbon dating. In addition a second boring was made in frozen peat, and a 3 metre-long core was recovered. Finally, a number of new localities with erratic boulders or glacially transported shell fragments were found, attesting further to the glaciated nature of Bathurst Island despite the lack of prominent glacial landforms. Contrary to ideas expressed after the 1963 field season[1], it now appears that all the high-level shells can have been transported to their present positions by local ice flowing outward from Bathurst Island; Laurentide ice, which may have flowed northward in the straits need not have impinged upon the island.

The limit of marine submergence in western and southwestern Bathurst Island is close to 105 metres (350 feet), i.e., lower than in the northern part of the island, where postglacial shells have been found up to 140 metres (450 feet) above sea-level, but higher than in east-central Bathurst Island, where beaches or postglacial shells have not been found above 90 metres (300 feet).

Radiocarbon age determinations on shells and peat indicate that much of the island was ice-free by 9,000 years ago[1].

---

[1] Blake, W., Jr.: The glacial history of Bathurst Island, Arctic Canada; Abstracts of Papers, 20th Internat. Geographical Congress, London, England, p. 79 (1964).

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3. SURFICIAL GEOLOGY, WESTERN QUEEN ELIZABETH ISLANDS

J.G. Fyles

During July and August, the writer made a brief reconnaissance of some aspects of Quaternary geology on the following Islands: Prince Patrick, Eglington, Melville, Byam Martin, Lougheed, Emerald, Brock, Borden, and Ellef Ringnes. With the aid of a Piper Super Cub aircraft on balloon tires observations were made at some 250 localities. Fuel, food, and base-camp facilities were provided by the Polar Continental Shelf Project.

The fluvial sands, gravels, and silts comprising the Beaufort Formation were investigated on Prince Patrick, Brock, Borden, and Ellef Ringnes Islands. On Ellef Ringnes and Borden Islands, these late Tertiary or early Quaternary coastal-plain sediments comprise two units; the lower consisting largely of brown silt with peaty (lignitic?) layers, the upper of sand, pebble gravel, minor silt, and driftwood. The organic matter in the lower unit gives the impression of being distinctly older (i.e. is more altered) than that in the upper unit. The widespread Beaufort deposits on Prince Patrick Island are similar to the upper sandy unit and apparently include no equivalent of the lower silty unit. Throughout much of its extent, the Beaufort strata dip northwestward and northward, respectively, steeper than the present seaward slope of the Beaufort plain. Extensive terraces and plains within the areas mapped as Beaufort Formation consist of gravel and sand reworked from the original deposits. On Prince Patrick Island, most if not all of these terraces are younger than the northward-trending fault scarps cutting across the Beaufort Formation.

Erosional remnants of far-travelled gravels and sands locally containing wood are widely scattered in the eastern half of Melville Island and one outlier (without wood) has been found on the summit upland of Byam Martin Island. Some or all of these deposits may be equivalent to the Beaufort Formation.

Deposits or landforms inferred to be of glacial origin were found on all of the major islands. On Prince Patrick Island, the following manifestations of glacial activity were found on the Beaufort Formation: (1) morainal? hilly topography both in the south and the north; (2) kame-like hills; (3) two small gravel ridges that appear to be eskers; and (4) a few abandoned or misfit river channels that require a 'glacial' explanation. The presence of numerous erratic boulders apparently derived from distant sources to the southeast has been noted by earlier workers. The distribution of these boulders relative to ridge and valley topography in the eastern part of the island suggests that they date from a glaciation prior to the last. Striae on sandstone surfaces within valleys in the Mould Bay region probably relate to a later locally centred glacier system.

An arcuate belt of ridges on northeastern Brock Island appears to be a thrust moraine formed by a glacier flowing westward through Wilkins Strait. Some of the ridges within the moraine consist of tilted layers of Beaufort gravel and Cretaceous sandstone in reverse stratigraphic position. No other glacial landforms were recognized on Brock or Borden Island although a few erratic boulders are scattered on the surface of the Beaufort and older formations.

In northwestern Ellef Ringnes Island, large blocks of diabase and sandstone are locally abundant on the surface of the Beaufort Formation; both lithologies are represented in the bedrock exposed in adjoining parts of the island to the east and southeast. The presence of these erratics — some of which are striated — at altitudes well above any evidence of marine submergence is taken as evidence that Ellef Ringnes Island has undergone some form of glaciation (see however St. Onge[1]).

Brief ground observations on Lougheed Island have lead to the tentative conclusion that a north-trending esker-like feature at the south end of the island is of glacial origin, and that ridges trending north to north-northwest in the central part of the island are drumlinoid features. Erratic boulders occur at all altitudes, and in several places they were seen to consist predominantly of rock types common on Bathurst Island. It is tentatively suggested that Lougheed Island has been overridden by a northward-flowing glacier of regional extent.

Prior to this field season, from a synthesis of fragmentary information, it appeared that Melville Island had been glaciated as follows: (1) The North American, Laurentide, ice-sheet overrode part (and perhaps all) of the island during one or more "old" glaciations and impinged on the southern part of the island during the last (Wisconsin) glaciation. (2) During the last glaciation and perhaps earlier, locally centred glaciers covered much (and perhaps all) of the island. In general, data collected this season have confirmed this picture. Evidences of glaciation are more abundant and varied than had formerly been thought, and isolated glacial landforms have been found in terrain that otherwise appears unglaciated. Outstanding examples are an esker several miles long in northwestern Melville Island between Ibbett Bay and Hecla and Griper Bay, and a group of drumlinoid ridges on the northwestern part of Babine Peninsula.

Raised marine features of late Quaternary age were found throughout the region except in some areas adjoining the Beaufort Sea. The data at hand suggest that the marine limit varies markedly in altitude from place to place on individual islands and in passing from one island to the next.

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[1]St. Onge, D.: La geomorphologie de l'ile Ellef Ringnes, Territores du Nord-Ouest, Canada; Cahiers de Geogs d. Que., No. 14, p. 224 (1963).

Three Canadian geomorphological maps; 20th Internat. Geogr. Congress, London, Abstracts of Papers, p. 35 (1964).

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4. STRATIGRAPHY AND STRUCTURE OF BATHURST ISLAND

J.W. Kerr and P.G. Temple*

Field work for a two-year study of the stratigraphy and structural geology of Bathurst Island (68 G, H; 69 A, B) was completed in 1964.

The oldest rock exposed on the island is the Cornwallis Formation of Lower and Middle Ordovician age[1]. It consists mainly of fine-grained limestone with minor petroliferous sugary dolomite. It is succeeded conformably by the Cape Phillips Formation, which comprises predominantly dark grey to black, non-calcareous to slightly calcareous graptolitic shale and siltstone. North of Bracebridge Inlet the Cape Phillips beds are widely exposed and have a fairly constant thickness in the order of 1,400 feet.

In the vicinity of Sherard Osborn Island on the northeast coast the Cape Phillips Formation is characterized by quartzose siltstone. South of Bracebridge Inlet the thickness of the formation increases and the lower part contains considerable carbonate. The entire formation grades laterally into a thick carbonate succession similar to the Allen Bay and Read Bay Formations of southern Cornwallis Island.

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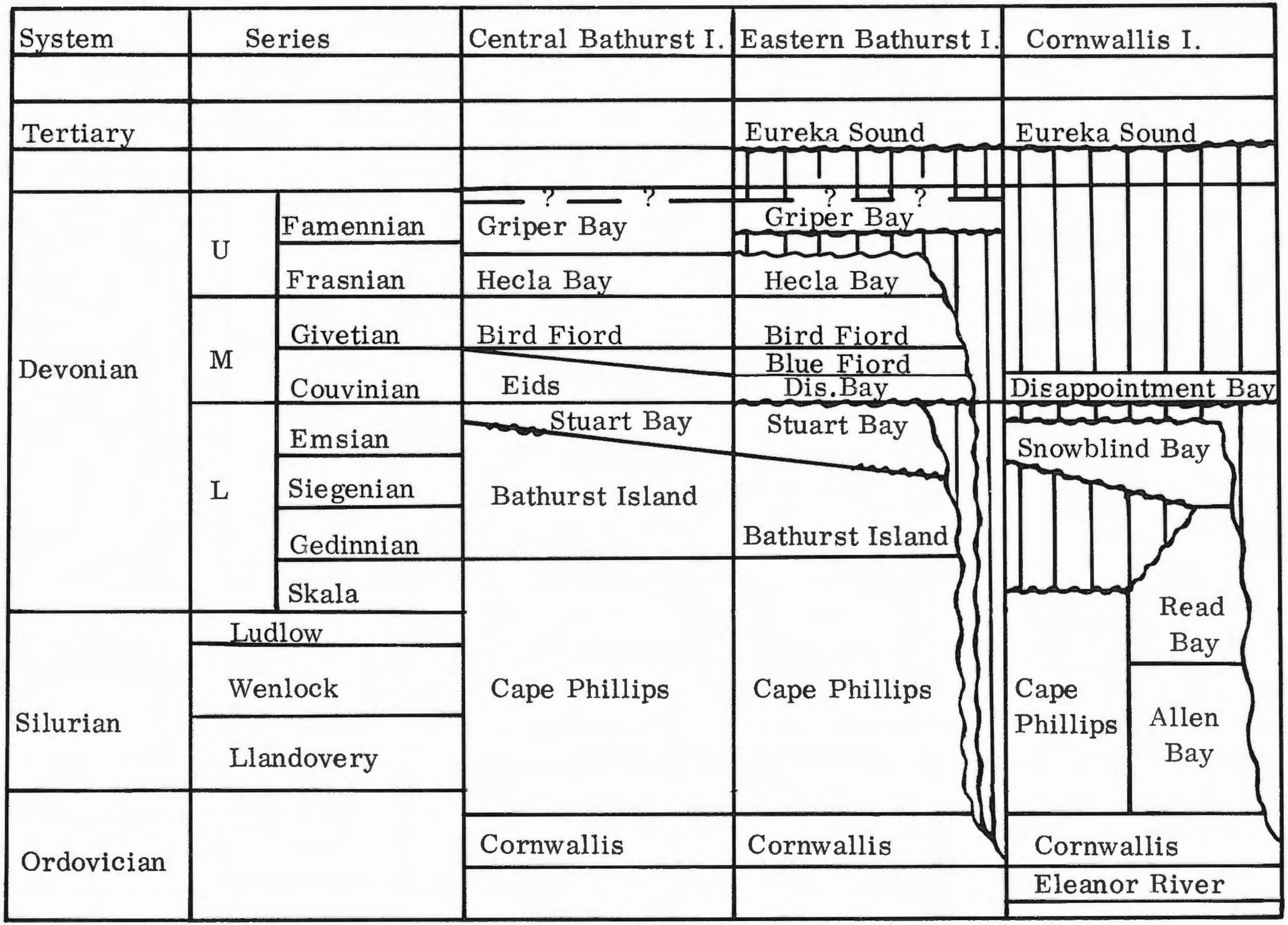
*Department of Geology, Princeton University, Princeton, N.J.


System
Series
Central Bathurst I.
Eastern Bathurst I.
Cornwallis I.
Tertiary
Eureka Sound
Eureka Sound
Devonian
U
M
L
Famennian
Frasnian
Givetian
Couvinian
Emsian
Siegenian
Gedinnian
Skala
Griper Bay
Hecla Bay
Bird Fiord
Eids
Stuart Bay
Bathurst Island
Griper Bay
Hecla Bay
Bird Fiord
Blue Fiord
Dis.Bay
Stuart Bay
Bathurst Island
Disappointment Bay
Snowblind Bay
Silurian
Ludlow
Wenlock
Llandovery
Cape Phillips
Cape Phillips
Cape Phillips
Read Bay
Allen Bay
Ordovician
Cornwallis
Cornwallis
Cornwallis
Eleanor River

The Cape Phillips Formation grades upward by increasing proportion of quartz siltstone, to calcareous quartz siltstone of the Bathurst Island Formation[1]. On the east coast of Bathurst Island small isolated reefs occur in the upper part of this formation and are interbedded with graptolite-bearing siltstones. The overlying Stuart Bay Formation comprises limestones and interbedded sandstones on eastern Bathurst Island, which grade to siltstones with basal pebble beds to the west. The Stuart Bay Formation represents a shallowing and incursion of clastic sediments associated with a major Lower Devonian unconformity to the east on Cornwallis Island. The Snowblind Bay Formation of Cornwallis Island rests upon this unconformity; red silty dolomite in the Stuart Bay Formation of eastern Bathurst Island is considered to represent an interbed of red beds correlative with the Snowblind Bay Formation. On eastern Bathurst Island, no angular breaks are associated with the Stuart Bay Formation; however, in central Bathurst Island a local angular unconformity occurs at the base. This local Lower Devonian unconformity developed over weak folding contemporaneous with the stronger folding of the Cornwallis Fold Belt. Recent revision of the Silurian and Devonian type sections in Europe[2,3], requires modification of the age assignment of the Cape Phillips, Bathurst Island, and Stuart Bay Formations.

The time of the second major deformation of the Cornwallis Fold Belt is bracketed between late Early Devonian (Stuart Bay Formation) and early Middle Devonian (Disappointment Bay Formation). The Disappointment Bay Formation grades westerly into the Eids Formation, which is dated as Couvinian (early Middle Devonian). The Disappointment Bay Formation comprises a basal pebbly sandstone and an overlying cream dolomite that occurs on northern Cornwallis Island and eastern Bathurst Island. In these regions the formation rests with marked angular unconformity upon folded rocks ranging in age from the Cornwallis to the Stuart Bay Formations. Angularity on this unconformity diminishes and disappears westward to central Bathurst Island. Most of Member A of the type Sherard Osborn Formation[4], represents the Stuart Bay Formation. The upper 100 feet of this member constitutes the Driftwood Bay Formation of Thorsteinsson and Glenister[4]. The upper beds of the type section of the Sherard Osborn Formation (Member B) and the upper 100 feet of Member A are considered correlative with the Disappointment Bay Formation of Cornwallis Island, on the basis of similarity of lithology and structural relationships to older rocks. For reasons of priority the name Sherard Osborn Formation should be rejected. It is proposed to refer Member B and the upper 100 feet of Member A of that formation to the Disappointment Bay Formation[5]. The Driftwood Bay Formation is considered to be equivalent to the basal clastic sediments of the typical Disappointment Bay Formation; these clastic sediments, however, have not proven to be a practical mapping unit and it is therefore, proposed that the name Driftwood Bay Formation should be abandoned.

The Middle Devonian Blue Fiord Formation has its greatest thickness on eastern Bathurst Island where it appears to represent a lagoonal limestone; westward it grades to biohermal rocks and still farther westward it gradually grades out into basinal siltstones of the Eids Formation.

An unconformity of Late Devonian age has been mapped in the Reindeer Bay area of northeastern Bathurst Island, where the Griper Bay Formation (Famennian) rests unconformably upon rocks ranging from the Hecla Bay (Frasnian) to the Cornwallis Formation.

Two exposures of intrusive gypsum occur in anticlines north and northeast of Purcell Bay. The intrusive nature of this gypsum appears to have been the result of folding rather than the cause of folding.

Tertiary rocks of the Eureka Sound Formation occur in downfaulted blocks on the southeastern part of Bathurst Island, and in one locality include interbedded basic volcanic rocks. The plexus of basic dykes cutting Middle Devonian and older rocks on southern Bathurst Island may also be of Tertiary age and related to these volcanic rocks.

Northwest of Freemans Cove in southern Bathurst Island, the Disappointment Bay Formation forms a prominent domal structure, the formation itself having been eroded from the apex, and older rocks exposed. On the east side the Disappointment Bay Formation rests with angular unconformity upon older beds; the angularity of this unconformity diminishes and disappears into a concordant sequence on the west side. The structure of formations beneath this unconformity bears little relation to that of the Disappointment Bay Formation. The crest of the structure beneath the unconformity is some distance to the east of the apex in the younger rocks, and is transected by steep north-trending faults.

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[1]McLaren, D.J.: Stuart River area, Bathurst Island; in Operation Franklin; Geol. Surv. Can., Mem. 320, pp. 596-620 (1963).

[2]Boucot, A.J., and Pankiwskyj, Kost: Llandoverian to Gedinnian stratigraphy of Podolia and adjacent Moldavia; in Internationalen Arbeitstagung über die Silur/Devon - Grenze und die Stratigraphie von Silur/Devon; Bonn-Bruxelles, 1960; Stuttgart, E. Schweizerbart'sche Verlagsbuchlandlung (1962).

[3]Jaeger, Hermann: Das Silur (Gotlandium) in Thüringen und am Ostrand des Rheinischen Scheifergebirges (Kellerwald, Marburg, Giessen); in Internationalen Arbeitstagung über die Silur/Devon - Grenze und die Stratigraphie von Silur und Devon; Bonn-Bruxelles, 1960; Stuttgart, E. Schweizerbart'sche Verlagsbuchlandlung (1962).

[4]Thorsteinsson, R., and Glenister, B.F.: Driftwood Bay, Bathurst Island; in Operation Franklin; Geol. Surv. Can., Mem. 320, pp. 585-596 (1963).

[5]Thorsteinsson, R.: Cornwallis and Little Cornwallis Islands, District of Franklin, Northwest Territories; Geol. Surv. Can., Mem. 294 (1958).

5. PENNSYLVANIAN AND PERMIAN ROCKS IN THE PARRY ISLANDS GROUP, CANADIAN ARCTIC ARCHIPELAGO

W.W. Nassichuk

During the field season of 1964, reconnaissance stratigraphic and mapping studies were carried out on Pennsylvanian and Permian outcrops that fringe on northern regions of the Parry Islands Group in the Canadian Arctic Archipelago. The oldest sediments of the Sverdrup Basin, according to Kerr and Trettin[1] are Mississippian (Viséan) in age. These occur on northern Axel Heiberg and northern Ellesmere Islands. In the Parry Islands, Pennsylvanian and Permian rocks comprise the oldest Sverdrup Basin sediments and these rest everywhere with profound angular unconformity on strata that range in age from Ordovician to Devonian.

Three late Palaeozoic formations are recognized on Devon Island, where they are confined to the northern extremity of Grinnel Peninsula. These formations are, from oldest to youngest:

1. Canyon Fiord Formation, consisting of red conglomerate, quartzose sandstone, and calcareous sandstone. This unit ranges in thickness from a feather-edge to 500 feet. It is separated from the overlying Belcher Channel Formation by a disconformity. In the Parry Islands the Canyon Fiord Formation is probably of Moscovian age, whereas in the Canyon Fiord region of Ellesmere Island, it ranges from Moscovian to Lower Permian. (R. Thorsteinsson, pers. comm.)

2. Belcher Channel Formation, which comprises limestone, dolomite, and minor interbeds of sandstone. Two measured sections show thicknesses of 600 and 650 feet. In some places the formation rests with structural conformity on Canyon Fiord strata; in other places Canyon Fiord beds lie with uniform unconformity on various early Palaeozoic systems. On the basis of fusulinids this formation is of Asselian, Sakmarian and early Artinskian age. A regional unconformity separates Belcher Channel rocks from the overlying Assistance Formation.

3. Assistance Formation is composed of dark grey, loosely consolidated sands interspersed with iron-rich concretionary siltstone bands. The maximum exposed thickness is 200 feet and the formation represents the youngest rocks in this area. Ammonoids collected from the Assistance Formation include *Metalegoceras*, *Spirolegoceras*, *Pseudogastrioceras*, *Popanoceras*, and a probable new genus. These genera suggest a late Artinskian age for the formation.

In the southern region of Sabine Peninsula on Melville Island, Pennsylvanian and Permian sedimentary rocks form a northeast-southwest striking belt. In this area six formations are recognized. From oldest to youngest these are:

1. Canyon Fiord Formation. This formation was not examined in critical detail in the area. According to Tozer and Thorsteinsson[2] the Canyon Fiord Formation on Sabine Peninsula comprises conglomerate, sandstone, shale, and minor limestone beds. These workers suggest (p. 96) that the total thickness approaches 2,000 feet and that the beds "... overlie with angular unconformity the folded rocks of the Parry Islands Fold Belt".

2. Belcher Channel Formation, which rests disconformably on Canyon Fiord rocks and consists of limestone, calcareous sandstone, and minor conglomerate. It has a thickness of approximately 200 feet on eastern Sabine Peninsula, but thins to 10 feet and eventually pinches out in western regions of the Peninsula. The Sabine Peninsula occurrence of the Belcher Channel Formation probably is correlative with only the uppermost part of the formation in the type locality on Grinnell Peninsula. This is suggested by the extreme thinness of the unit on Sabine Peninsula and by the occurrence of only one fusulinid zone, which indicates an early Artinskian age.

3. Sabine Bay Formation, which comprises mainly non-marine, light coloured sandstone and conglomerate, but includes minor marine beds near the base. This unit rests disconformably on the Belcher Channel Formation and thins from 400 to less than 20 feet between eastern and western Sabine Peninsula. On the basis of the occurrence of Spirolegoceras near the base of the formation, it is thought to be of late Artinskian age.

4. Assistance Formation, which was thought to be absent from Melville Island[2]. This formation and the two described below, were included by these authors in one map unit, which they regard as constituting a new, unnamed formation. The Assistance Formation consists of unconsolidated grey sands and ironstone concretionary bands, and varies in thickness from less than 85 to 100 feet. Seldom are contacts discernible because of the recessive nature of the beds. Assistance beds rest disconformably on the Sabine Bay Formation and have yielded typical Assistance fossils including the ammonoids Spirolegoceras and Pseudogastricoceras.

5. Unit A, consists principally of bioclastic limestone. It is a persistant unit on Sabine Peninsula and is approximately 300 feet thick.

It is suggested that the upper and lower contacts of this formation mark disconformities. This suggestion is based upon the following evidence: (1) The upper and lower contacts are sharp. (2) The relationship of Unit A interposed between the Assistance Formation and Unit B is unique. For instance, at East Cape in Canyon Fiord on Ellesmere Island, Unit B rests directly on the Assistance Formation (R. Thorsteinsson, pers. comm.). (3) On northwestern Melville Island, Cameron Island, and in Trold Fiord, Canyon Fiord, and Greely Fiord regions of Ellesmere Island, Unit B rests variously on virtually all older Palaeozoic systems.

Unit A has yielded abundant brachiopods and bryozoans, but they have not been studied critically. For the present time the age of Unit A can be indicated only as late Lower or early Upper Permian on the basis of its stratigraphic position between beds of the Assistance Formation and Unit B. Unit A represents the second occurrence in the Arctic Archipelago of a carbonate formation that rests on the Assistance Formation. In southern regions of Bjorne Peninsula on Ellesmere Island, a carbonate sequence that attains a thickness of 465 feet rests with conformable yet abrupt contact on the Assistance Formation (R. Thorsteinsson, pers. comm.). Fossils collected from this unit at Great Bear Cape were described by Tschernyschew and Stepanow[3], who assigned an Upper Carboniferous age to these rocks. Various other authors have assigned different ages to the Great Bear Cape limestone, e.g., Dunbar[4], L. Permian; Gobbett[5], L. Permian portion of the Svalbardian; and Minato[6], uppermost Lower or lowermost Upper Permian. The similar stratigraphic position of Unit A and the Great Bear Cape limestone, overlying the Assistance Formation, suggests that these units may eventually prove correlative.

6. Unit B consists of distinctive green glauconitic sandstone, black chert and minor limestone beds. It is overlain by the Lower Triassic Bjorne Formation. Unit B attains a maximum thickness of 800 feet in the eastern region of Sabine Peninsula and thins markedly to the west. This formation yields abundant and well-preserved faunas, consisting principally of brachiopods and including also bryozoans, pelecypods, gastropods, and rare cephalopods. The faunas have not been studied critically, but they differ perceptively from those of the Assistance and formational Unit B.

On northwestern Melville Island only two Upper Palaeozoic formations are present. The Canyon Fiord Formation was studied at McCormick Inlet, south of the Raglan Range, where it attains a thickness of 3,300 feet. There it consists mainly of unconsolidated sands, conglomerate, and thinly bedded sandy limestones. In this area also the Canyon Fiord beds are separated from older Palaeozoic rocks by a pronounced unconformity. No upper contact of Canyon Fiord beds exists in the McCormick Inlet area. Fusulinaceans collected from the base of this formation and identified by R. Thorsteinsson suggest a Moscovian age.

Formational Unit B, as discussed under the Sabine Peninsula occurrence, exists as a narrow belt between Hecla and Griper Bay and Marie Bay. In northwestern Melville Island this formation consists mainly of pale green glauconitic sandstone with minor limestone interbeds. An angular unconformity, indicating a period of orogeny that occurred sometime between Moscovian and late Permian time, marks the base of Unit B in northwestern Melville Island. In places Unit B rests unconformably on the Canyon Fiord Formation and in other places directly on Ordovician and Devonian strata. Formation B thins from about 200 feet at Hecla and Griper Bay to a featheredge, north of Marie Bay. In northwestern Melville Island it is invariably overlain disconformably by sandstones of the lower Triassic Bjorne Formation.

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[1]Kerr, J.W., and Trettin, H.P.: Mississippian rocks and the Mid-Palaeozoic earth movements in the Canadian Arctic Archipelago; J. Alta. Soc. Petrol. Geol., vol. 10, No. 5, pp. 247-256 (1962).

[2]Tozer, T., and Thorsteinsson, R.: Western Queen Elizabeth Islands, Arctic Archipelago; Geol. Surv. Can., Mem. 332 (1964).

[3]Tschernyschew, T., and Stepanow, P.: Obercarbonfauna Von König Oscars und Heibergs Land, Report of the Second Norwegian Arctic Expedition in the "Fram" 1898-1902; Oslo, No. 34, pp. 1-67; pls. 1-12 (1916).

[4]Dunbar, C.O.: Permian brachiopod faunas of Central East Greenlamd; Medd. om Grønland, bd. 110, No. 3, pp. 1-169, pls. 1-32 (1955).

[5]Gobbett, J.D.: Carboniferous and Permian brachiopods of Svalbard; Norsk Polarinstitutt Skrifter, Nr. 127, pp. 8-201, pls. 1-25 (1963).

[6]Minato, Masao: Eine Permische Koralle von König Oscarland im Nordwestlichen Ellesmereland; Stockholm, Univ., Stockholm Contr. Geology, vol. 6, pp. 25-36 (1960).

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6. BOTTOM STUDIES ON THE ARCTIC CONTINENTAL SHELF (POLAR CONTINENTAL SHELF PROJECT)

B.R. Pelletier

This is a continuing reconnaissance program of sampling bottom sediments of the Arctic Ocean in an area extending from the western coast of Borden, Brock, and Prince Patrick Islands, to the edge of the Continental Shelf and upper Continental Slope. Soundings were also made in order to obtain a map and profile of the submarine topography in this area.

On the basis of field observations the bottom sediments consist mostly of fine to coarse sand in the inner shelf area and fine sand, silt, and mud on the outer area of the Continental Shelf. The soundings show the occurrences of submarine valleys at 400 metres depth in the inner shelf area, and the merging of these valleys onto the floor of the outer part of the Continental Shelf.

The tentative interpretation based on these field observations is that the inner shelf is a drowned area of relief that was formed under conditions of subaerial erosion; that such erosion comprised normal fluvial action in pre-Pleistocene time followed by valley glaciation. Some of these glacially modified river valleys commence as drowned cirques 5-15 miles offshore. In areas off Prince Patrick Island the topography resembles drowned buttes and mesas, but this conclusion is based on sparce soundings. The fact that coarse sediments occur in the inner shelf area may be explained in terms of the occurrence of the underlying Beaufort Formation, which consists chiefly of sands and gravels in the upper part in the area outcrop adjoining the Arctic Ocean. These sediments are probably reworked Beaufort material and may in part be within a few feet or tens of feet of the underlying Beaufort Formation.

7. LOWER TRIASSIC ASPHALTIC SANDSTONES OF NORTHWESTERN MELVILLE ISLAND

H.P. Trettin and L.V. Hills*

Following the reconnaissance mapping by the Geological Survey,[1,2] asphaltic sandstones were discovered and explored in the Lower Triassic Bjorne Formation of northwestern Melville Island[3,4,5,6]. In 1964 Trettin and Hills mapped the Bjorne Formation west of Hecla and Griper Bay, a belt some 50 miles long, and up to 9 miles wide, which trends about N75°W and dips slightly NE. The work was done from six fly camps moved by a Piper Super Cub plane supplied by Bradley Air Services Ltd.

The distribution, and the structural and stratigraphic setting of the asphalt deposits were known[5,6], and only minor additions and modifications could be made. Detailed isopachous and palaeocurrent mapping, however, had led to new conclusions about their controls and origin.

Four major, and two minor deposits or groups of deposits are known. They consist of quartzose sandstone, conglomeratic sandstone, and minor conglomerate with interstitial, highly viscous petroleum. The deposits range in grade from saturated to lightly stained, and are generally less than 4 miles in their longest dimension, and less than 100 feet thick.

The Bjorne Formation in this area ranges in thickness from a few to about 400 feet, and grades from marine clay, silt, and fine sand up into fluviatile sandstones and conglomerates. Numerous extensive light grey clays, probably bentonites, occur at intervals throughout the section, and some have been used as stratigraphic markers. The Bjorne is unconformably overlain by clay and silt of the Lower Jurassic Wilkie Point Formation. The pre-Wilkie Point erosion surface has a relief of probably less than 100 feet, and seems to affect only the upper two of the five members now recognized in the Bjorne. Several minor disconformities are probably present within the formation.

Isopachs based on 137 sections show that the southwestern margin of the present outcrop belt lies generally within a few miles of the limits of deposition of the formation. During Early Triassic time intermittent, increasingly pronounced uplift took place southwest of the basin, mainly in the area just southeast of the head of Marie Bay. Current directions ranging from NW through N to SE radiate from this area. They have been inferred from 677 determinations of directional features, mainly dip-azimuths of planar to concave cross-beds, and scoop axes, made at 59 stations. Immediately to the NE of the inferred dispersal centre, coarse boulder conglomerate is present in the upper part of the formation, which grades laterally - to the NW and SE - through cobble conglomerate to pebbly sandstone. The composition of the clasts and a few fossils in them indicate that they were derived from Ordovician to Upper Palaeozoic strata.

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The following controls of the oil deposits seem to have been effective: (1) The oil occurs always in the upper part of the formation and decreases downwards. The clay and silt of the Wilkie Point Formation obviously formed a permeability barrier. (2) All oil deposits lie in strongly to weakly defined troughs where the formation is thickest as indicated by southwestward bulges in the isopachs, which probably represent embayments in the basin margin. (3) A major deposit near the head of Marie Bay lying in a weakly defined trough is very close to the dispersal centre mentioned above. (4) All deposits - except for the Kitson River showings - lens out or die out to the NE, that is towards the basin centre, and have an erosional southwesterly boundary towards the basin margins. (5) The Kitson River showings, which die out toward the basin margin, lie within but probably close to the depositional limits of the Wilkie Point Formation.

The asphalt deposits have no obvious relationship to facies changes within the Bjorne or to pre- and post-Triassic folds and faults, or to the age and lithology of the underlying rock units. In the western part of Marie Bay area, the Permo-Pennsylvanian strata are truncated by a pre-Triassic erosion surface and wedge out to the north so that locally petroliferous zones of the Bjorne locally directly overlie lower Palaeozoic strata. The lower Palaeozoic beds dip steeply, and anticlinal structures are deeply truncated by pre-Pennsylvanian erosion. Therefore the Palaeozoic sediments in this area were probably not the source of the oil in the Bjorne.

From the above observations the following mode of origin is suggested. The oil probably formed in the pre-Jurassic basinal facies of the Sverdrup Basin characterized by thick shale units with some carbonates in the Permian and Pennsylvanian. Migration to the basin margin occurred probably mainly in clastic troughs or tongues extending from centres of marginal uplift into the basin. The oil was trapped beneath the impermeable clays of the Wilkie Point Formation in embayments of the basin margin or within the troughs that served as avenues. Where the Wilkie Point was thin or less extensive than the Bjorne, the oil accumulated some distance from the basin margin. Migration took place in post-Lower Jurassic time, perhaps in the Middle and Late Jurassic, and in the Cretaceous when a considerable column of sediments accumulated in the central part of the Sverdrup Basin compacting the underlying Triassic and Upper Palaeozoic sediments.

The following conclusions are tentatively drawn. (1) The Lower Triassic asphaltic sandstones of northwestern Melville Island are significant as the first reported major showing of hydrocarbons in the Arctic Islands. (2) Because of their small size, scattered occurrences, partly low grade, and unfavourable geographic position the deposits are probably not economic at the present time. (3) The pre-Jurassic basinal facies of the Sverdrup Basin is a promising source of oil. (4) Oil from this source may be found mainly in stratigraphic traps and possibly also in structural traps connected with them. (5) Stratigraphic traps may be found at the basin margin (a) in embayments of the basin margin, and (b) adjacent to clastic dispersal centres.

[1] Thorsteinsson, R., and Tozer, E.T.: Western Queen Elizabeth Islands, District of Franklin, Northwest Territories; Geol. Surv. Can., Paper 59-4 (1959).

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

[3] Jenness, S.E. ed.: Summary of research; field, 1962; Geol. Surv. Can., Paper 63-1 (1963), p. 7.

[4] Sproule, J.C., and Lloyd, G.V.: A note on the comparison of McMurray and Melville Island oil sands; the K.A. Clarke Volume; Res. Counc., Alberta, M.A. Carrigy ed. (1963).

[5] Sproule, J.C., and Associates: Oil and gas prospects of Marie Bay area, northwestern Melville Island; Nickle's Daily Oil Bull., June 1 (1964).

[6] Sproule, J.C. and Associates: Reconnaissance report on the Triassic oil sands and related geology of northwestern Melville Island, 1963 field season; (auth. J. Stuart-Smith); confidential report prepared for the Department of Northern Affairs and National Resources (1964).

8. BOTTOM SEDIMENT AND FORAMINIFERAL STUDIES IN SATELLITE BAY, PRINCE PATRICK ISLAND, DISTRICT OF FRANKLIN

G. Vilks

During the 1964 field season sampling of bottom sediments was carried out in Satellite Bay, Prince Patrick Island, District of Franklin. The purpose of the sampling was to investigate the distribution of benthonic foraminifera in the nearshore regions exposed to the Arctic Ocean and to relate fauna to the bathymetry type of sediment, and distance from the shore of the bay. In the field logistics were provided by the Polar Continental Shelf Project based at Mould Bay, Prince Patrick Island.

One hundred and nineteen sampling stations were distributed in 17 2-or 3-mile traverses extending seaward from selected points on the shore. Samples were taken at depths ranging from 3 to 252 metres.

The soundings show irregular bottom topography with features typical of glaciated valleys, such as, steep submarine slopes, U-shaped cross-sections, and undulating longitudinal section. In the western head region of the bay there is a marked depression with a local topographic difference of about 50 metres.

The sediment consists chiefly of light brown mud. In the eastern head region of the bay, nearshore samples at shallow depths contain black mud characterized by a sour odour. Layers of black fine mud were also found on the platform along the east shore at depths less than 10 metres. A zone of sandy sediment extends along the shores in most areas, but pebbles were found at the mouth of a prominent river entering the bay from its western shore.

The foraminiferal content of the sediments is basically similar to the inshore regions of Prince Gustaf Adolf Sea. However, it appears to have a higher ratio of calcareous forms, represented mainly by Elphidiidae and Rotaliidae.

DISTRICT OF KEEWATIN

9. SURFICIAL GEOLOGY, OPERATION WAGER; NORTHEAST DISTRICT OF KEEWATIN AND MELVILLE PENINSULA, DISTRICT OF FRANKLIN

B.G. Craig

This summary report is based on a study of air photographs and on field data collected by the writer on helicopter-supported 'Operation Wager',* supplemented by additional observations made by other members of the party whose primary interest was the bedrock geology. The field area included all of Melville Peninsula except that part lying north of 68°30'N Lat., and it included the northern tip of Southampton Island (north of 65°30'N Lat.). On the mainland the southern boundary lay along the 64th parallel, the western boundary between 64° and 65°30'N Lat. lay along the 92nd meridian, and north of this along the 90th meridian. In addition, Melville Peninsula north of 68°30'N Lat. was traversed by fixed-wing aircraft and studied from air photographs.

Directions of Ice-flow

Throughout much of the map-area glacial landforms are abundant. Together with many hundreds of glacial striae that were measured they indicate clearly the direction of ice movement at the margin of the retreating Wisconsin Laurentide ice-sheet. The last ice flow was northward in northern Simpson Peninsula and northwestward in the northern part of Melville Peninsula, toward the Gulf of Boothia. As the ice-front receded southward, and the southern part of Committee Bay became ice-free, ice movement was eastward and northeastward south of Simpson Peninsula, northward in the Rae Isthmus and Repulse Bay areas, and northwestward on Melville Peninsula. Continued southward ice recession and the opening of Foxe Basin and Hudson Bay allowed the sea to flood Rae Isthmus. Thus a continuous water body extended from Committee Bay to Roes Welcome Sound, Repulse Bay, and Frozen Strait, and separated the remnant ice on Melville Peninsula from that on the mainland. West of Repulse Bay and the northern end of Roes Welcome Sound the direction of flow changed from northward to eastward; south and southwest of Wager Bay flow was southeastward as the ice margin shrunk back to the Keewatin ice divide that trends east-west near 65°30'N Lat.

Remnant Ice-caps

The east-central part of southern Melville Peninsula became the locus of an isolated ice-cap that produced a radial pattern of flow features. Farther north a second isolated ice-cap may have persisted in the central part of the peninsula at about 68°N Lat., where, although there is no distinctive pattern of flow features, the distribution of ice-marginal channels that formed along the edges of retreating ice tongues in the larger valleys suggests the former presence

*For additional information on "Operation Wager" see report No. 11 by Heywood, elsewhere in this publication.

of a small ice-cap. A third ice-cap may have existed still farther north in the Hall Lake region, southwest of Foster Bay. There is no clear evidence of ice movement in that area, but the esker pattern suggests a southeasterly flow of meltwater.

End Moraines

In the northwest corner of Melville Peninsula an end moraine ridge and an associated drumlin field indicate that in this region the ice retreated to the northeast, across Fury and Hecla Strait to Baffin Island.

Along the west side of Melville Peninsula segments of an end moraine ridge extend about 75 miles from near 69°30'N Lat. south to a point east of Sabine Island. From Garry Bay south the segments are almost continuous, with interruptions only at major river valleys. The segments are subparallel to the present coast, and appear to mark the position of a continuous ice front. The southern half of this moraine belt lies below the marine limit and has been reworked by the sea. The northern half is entirely above the marine limit; it rises to at least 1,450 feet above sea-level and consists of a single, bold, clearly defined ridge. East of Garry Bay there is a gap of some 30 miles where no moraine ridges were noted, but another 30 miles north of this gap short irregular segments occur. In many places these segments are poorly defined and irregularly oriented; they tend to be subparallel to the valley walls of streams flowing into Committee Bay rather than to the coast. West of the southern end of Committee Bay a zone 20 to 25 miles wide contains short segments of morainal ridges trending slightly south of west. These ridges may extend eastward beneath Committee Bay to join the moraine on the east side. The zone of ridges also extends west of the map-area, gradually diminishing in width, and can be traced as a single ridge at least as far as Chantrey Inlet. Taken together, these segments and zones of moraine may relate to a static position of the retreating ice margin which extended for nearly 400 miles, from northern Melville Peninsula to Chantrey Inlet.

Finally, south of Simpson Peninsula, but north of the moraine zone described above, is an isolated morainal ridge, arcuate in plan and convex to the northeast. It extends for about 25 miles west of the Ellice Hills and was formed earlier than the moraines west of the south end of Committee Bay.

Limit of Marine Submergence

Elevations of high-level marine features (beaches, deltas, sediments, shells, and the line marking the lower limit of unwashed till) were measured by altimeter throughout the map-area in order to determine the upper limit of the post-glacial marine invasion. This limit appears to be about 485 feet above sea-level along the Foxe Basin and Foxe Channel coasts of southern Melville Peninsula. It is apparently a few feet higher along the west coast of the peninsula east of Wales Island, and it possibly reaches 525 feet northeast of Repulse Bay. Through Rae Isthmus and east of the south end of Committee Bay the highest elevations of features marking this limit do not exceed 465 feet. Precise data were not obtained west of Committee Bay, but mollusc shells found at 625 feet and marine sediments at 650 feet suggest that the marine limit is at least 700 feet above sea-level in this region. Southward from Repulse Bay along Roes Welcome Sound the maximum elevation of the marine limit decreases from 475 feet to about 440 feet at the mouth of Wager Bay. In the inner part of Wager Bay it is close to 450 feet, and in the southern part of the map-area it varies between 450 and 500 feet.

10. RECONNAISSANCE MAPPING, KOGNAK RIVER AREA (65G E1/2, 65H W1/2)

K.E. Eade

Field work in the Kognak River area (65G E1/2, 65H W1/2) was completed in 1964. The past summer's work was concentrated in the west half of the area. A group of sedimentary rocks - quartzite, dolomite, argillite, and phyllite - have been mapped that are preserved in down-faulted blocks in the Archaean volcanic and sedimentary rocks. They are different from the Lower Proterozoic (?) Hurwitz Group rocks but may be correlated with the conglomerate, quartzite, siltstone group mapped last year[1] in the area to the east.

A number of small plutons, which are high-level intrusions, cut the Archaean sedimentary and volcanic rocks and related gneisses. Composition of these intrusive rocks is variable, from syenite or syenodiorite to quartz diorite, quartz monzonite, granodiorite, or granite. The largest of these bodies, a granite-granodiorite mass, is responsible for contact metamorphism of Hurwitz Group sedimentary rocks, with tremolite-bearing dolomite and garnetiferous metagreywacke resulting. This is the first indication anywhere in this map-area of post-Hurwitz igneous rocks, other than the late gabbro-diabase dykes. This same granite-granodiorite body contact metamorphosed Archaean greywacke and subgreywacke to knotted schists and hornfels containing garnet and cordierite porphyroblasts.

A number of narrow discontinuous bands or lenses of quartz-magnetite iron formation have been noted in the Archaean greywacke, subgreywacke, and tuff unit. Normally the iron formation is fine grained, but it is medium grained in some localities where metamorphism has resulted in recrystallization. Narrow bands of jasper-hematite iron formation are present in dolomite of the Hurwitz Group in a few places.

Faults and folds affect all the bedrock with the exception of the late diabase dykes. Folds have two prominent trends, north to northeast, and northwest. The numerous normal faults are a significant feature of the map-area.

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[1] Eade, K.E.: Kognak River area: (abst.) in Summary of Activities, Field, 1963, compiled by S.E. Jenness; G.S.C. Paper 64-1 (1964).

11. OPERATION WAGER, NORTHEAST DISTRICT OF KEEWATIN, AND MELVILLE PENINSULA, DISTRICT OF FRANKLIN

W.W. Heywood

Reconnaissance mapping of about 55,000 square miles of the northeastern District of Keewatin and of Melville Peninsula, District of Franklin, south of 68°30'N was completed during the 1964 field season. W.W. Heywood, J.A. Donaldson, W.R.A. Baragar, G.D. Jackson, and C.I. Godwin mapped the bedrock geology, and B.G. Craig examined the surficial deposits. Two Bell 47G 2A helicopters were used for geological traversing. A ski-wheel equipped Otter was used before breakup, and a float-equipped Otter and a Cessna 180 were used after breakup.

Metamorphosed volcanic and sedimentary rocks probably are the oldest in the area. Remnants of these rocks occur throughout most of the region, but the largest areas underlain by these rocks are in the northern half of the area. A discontinuous narrow belt of metasedimentary rocks, with minor iron-formation extends from the Committee Bay area at 67°35'N, 88°10'W southwest to 67°10'N, 90°00'W. Greenstone and amphibolite, derived largely from volcanic rocks, and associated metamorphosed sedimentary rocks, occur on both sides of Melville Peninsula. The western belt extends from Erlandson Bay to approximately 68°30'N, 84°50'W. The eastern belt, which is about 15 miles wide near the coast south of Hall Lake, narrows and ends about 30 miles to the southwest. Associated with these volcanic rocks are bands of iron-formation.

Gneiss, migmatite, and massive to foliated granitic rocks underlie most of the area west of Committee Bay, Rae Isthmus, and Roes Welcome Sound. Minor amounts of amphibolite and paragneiss occur with these rocks. Massive porphyritic granite forms much of the upland area southwest and north of Wager Bay. Gneiss and paragneiss are the common rock types in central and southwestern Melville Peninsula. Granulite and gneiss are the characteristic rocks east and west of Lyon Inlet.

One large and several small gabbro bodies outcrop near Armit Lake. Peridotite and serpentinite were observed in or near areas underlain by volcanic rocks. In the Daly Bay area a concentric pluton consists of a massive anorthosite core surrounded by moderate to steeply dipping interlayered anorthositic and mafic rocks.

Younger intensely folded Proterozoic crystalline limestone, quartzite, and paragneiss outcrop extensively on Melville Peninsula in an east to northeasterly trending belt. This belt is about 50 miles wide on the west side of Foxe Basin. Granitic intrusions are widespread in this area.

Early Palaeozoic sandstone, dolomite, and dolomite limestone occur on Simpson Peninsula, Wales Island, the east side of Melville Peninsula at Parry Bay, on Southampton Island and on the western side of White Island. Outliers are present in Hoppner Inlet and on the shores of the large lake in the middle of White Island.

Sulphide minerals were observed in many locations. Pyrite, pyrrhotite, and minor chalcopyrite are present in the volcanic rocks. Many zones of rusty weathering metasediments occur in the younger Proterozoic rocks of Melville Peninsula. Rusty zones are common in the gneisses of the southern and western parts of the area. A zone containing iron-formation in the Prince Albert Hills extends northeast from 68°10'N, 85°32'W. Fine-grained magnetite with some specular hematite forms as much as 70 per cent of the rock and averages about 50 per cent over a maximum observed width of 550 feet. Southwest of Hall Lake several iron-formations occur in a zone up to 4 miles wide and 30 miles long. Individual formations, as much as 500 feet thick, consist of banded iron-formation that ranges from 35 to 70 per cent of the rock and averages about 45 per cent.

Structural trends throughout most of the area are easterly to northeasterly. Several major faults of probable post-Silurian age strike north-northwest. Prominent lineaments and joints parallel these faults.

DISTRICT OF MACKENZIE

12. POINT LAKE EAST HALF (86 H E1/2) MAP-AREA

H. H. Bostock

In the area about Point Lake prominent glacial striae indicate two directions of ice movement, one west, the other southwest. South and east of Itchen Lake only one set is prominent, indicating ice movement slightly south of west. North of Itchen Lake prominent striae indicate ice movement to the west-northwest.

Basic volcanic rocks (map-unit 1 on the accompanying figure) are dark green and have in part been metamorphosed to amphibolites and amphibole schists. Pillows are well developed locally and show that the flows are steeply dipping. Where top determinations are possible, the volcanic rocks are thought to be overturned slightly to the east and therefore may, in part at least, underlie the schists and greywacke (2a). At the west edge of the area mapped near the south shore of Point Lake, however, part of the volcanic rocks may be younger than unit 3.

Schist and greywacke (2a) are fine to medium grained and typically light to dark grey or brownish. Ovoid porphyroblasts (cordierite ?) commonly 1/2 to 1 inch in diameter are widespread and andalusite crystals up to 6 inches in length are present in some beds. Graded bedding is common and well exposed along the shores of Point Lake and Itchen Lake, but is largely concealed by lichens elsewhere. Scour and fill structures and concretions occur locally in quartz rich beds. Dips are rarely less than 60 degrees except along the east shore of Itchen Lake. Meta-quartzite (?) of unit 2b is interbedded in migmatite (Aa) thought to be equivalent to rocks of unit 2a.

Rocks of unit 3a are in part similar to those of unit 2a, but include bands of amphibolite with associated gossans. In the belt (3a) that passes across the west end of Itchen Lake the rocks are typically of lower metamorphic grade than the schists to the east. Garnets are common in the border zones of the amphibolites. A roughly circular body of amphibolite to hornblende gabbro (3b) northwest of Itchen Lake is massive in the central parts, but includes local banded garnet-bearing amphibolite and gossan near its margins.

The rocks of map-unit 4 comprise well rounded boulders of granitic rocks up to several feet in diameter and boulders of quartzite in a softer typically dark green, commonly porous-weathering matrix. The best lichen-free exposures show that ovoids of dark and light green rock (the former thought to be volcanic bombs) are present at least locally in the matrix and that carbonate is responsible for part of all of the porous-weathering texture. It therefore seems likely that the rock is largely agglomerate. Locally, however, the matrix is sandy and the rock more closely resembles a conglomerate. The large lens-like exposure of agglomerate (4) at the west border of the map-area thins rapidly southeastward and interfingers with greenschist of composition similar to the agglomerate matrix. Basic volcanic rocks in the immediate vicinity appear less altered than similar

LEGEND

Proterozoic

- [7] Diabase.
- [6] Quartzite, slate, argillite, greywacke; minor conglomerate and carbonate rocks

Archaean

- [5] a:- Slate, argillite; some greywacke and greenschist; minor quartzite and interlamenated slate-carbonate rock.
  - b:- Acid volcanic rocks (?), phyllite, tuff (?), minor slate argillite, gneiss, schist, quartzite, and amphibolite.
  - c:- Amphibolite, basic volcanic rocks, bedded amphibole-feldspar rich rocks, gneiss schist, quartzite.
- [4] Agglomerate; some conglomerate, and greenschist.
- [3] a:- Schist, phyllite and greenschist with interbanded amphibolite accompanied by gossan
  - b:- Amphibolite, hornblende gabbro.
- [2] a:- Schist, greywacke.
  - b:- Metaquartzite (?), granite, minor amphibolite and calc-silicate rock.
- [1] Basic volcanic rocks; some greenschist greywacke; minor quartzite granite and acid volcanic rocks(?)

Plutonic Rocks

- [C] Massive granite to granodiorite; minor hybrid rocks
- [B] Massive diorite.
- [A] Hybrid Rocks
  - a:- Migmatite
  - b:- Schist and/or quartzite with granitic rocks
  - c:- Diorite with granitic rocks.
  - d:- Diorite gneiss, granite gneiss, greenstone, granite, diorite, acid metavolcanic rocks (?), metaquartzite, massive and banded amphibolite, greenschist.

POINT LAKE - ITCHEN LAKE

MILES 5 0 5 10 15 20 MILES

Symbols

Geological Contact ------- Limits of area mapped ········ Fault ~~~~

rocks to the south and southeast and it is therefore considered that both unit 4 and some of the surrounding volcanic rocks may be distinctly younger than the main part of unit 1. On an island in Point Lake immediately west of the map-area agglomerate-conglomerate (4) appears to be in conformable contact with slate (5a). It is possible therefore that unit 4 may be younger than units 2 and 3 also; however, no boulders of rocks similar to those of units 2 and 3 have been found in the agglomerate (4).

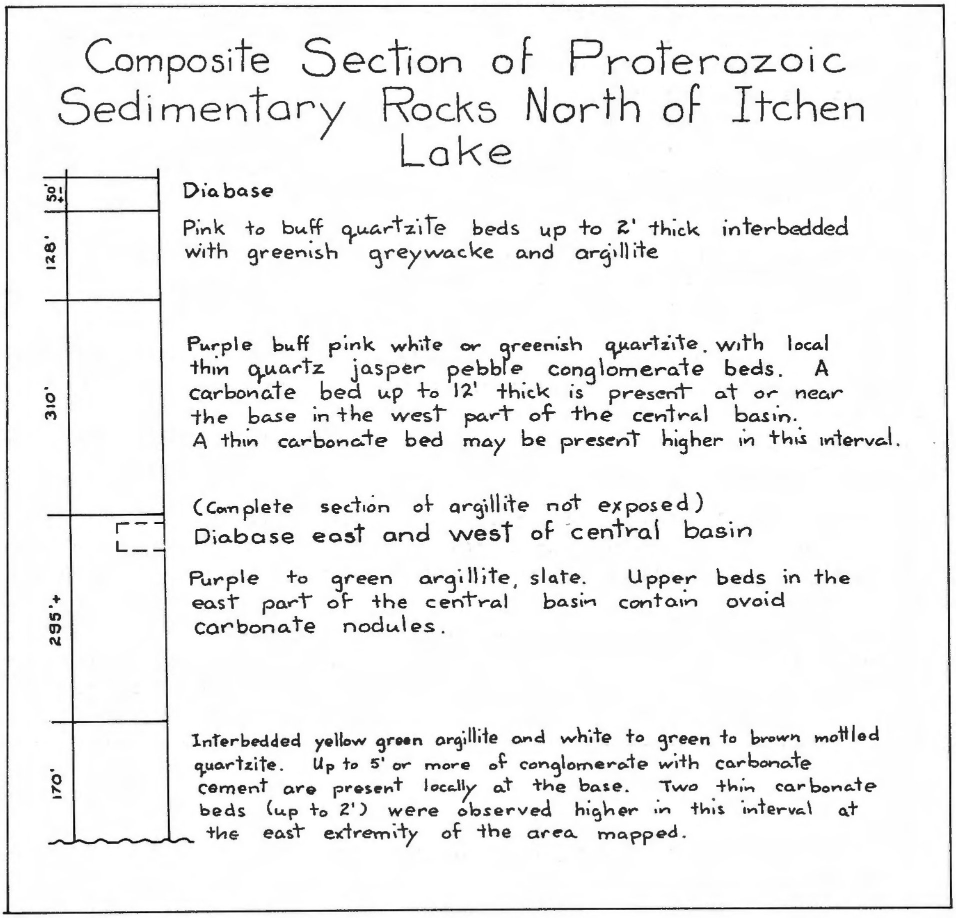
Slate and argillite (5a) are typically dark grey, but commonly contain lighter grey slate laminae. Greywacke and quartzite appear to be local and discontinuous. Laminae of carbonate are present in slate where unit 5a crosses the large bay in the southeast part of Point Lake. On the north shore greenschists are prominent at the east margin of this unit. Dips are typically 60 degrees or greater. Map-unit 5a is thought to be younger than units 1, 2, and 3 because of its distinctly lower grade of metamorphism. Unit 5a is thought to be younger than unit 4 because crossbedding in a 10-foot sandy lens in agglomerate west of the map-area indicates that the tops are to the northeast in the direction of the slate (5a).

Rocks of unit 5b comprise white-weathering very fine-grained buff to grey rocks commonly showing fine lenticular lamellar structures (acid volcanic rocks ?), slaty grey argillite, laminated green and white to green and buff-coloured fine-grained rocks, and minor quartzite, schist, and gneiss. The latter lithologies have been found only north of Itchen Lake. Dips are typically 60 degrees or greater. The age of these rocks relative to other map-units is unknown, and they are tentatively placed in unit 5 only because of their local lithologic similarity to the slates of unit 5a and their geographic position close to the projected strike of part of unit 5a.

Amphibole-rich rocks (5c) are distinct from those of unit 3a in having only minor associated gossan. Garnet is less common and the rocks appear less altered where they are remote from the hybrid and granitic rocks. Dips are typically greater than 60 degrees and suggest that these rocks occupy the centre of a synclinal structure within map-unit 2a.

Proterozoic sediments (6) within the area mapped are restricted to the vicinity of the large lake north of Itchen Lake (see map and section). The basal half of the section is exposed on the east and west shores of the lake. The upper half is exposed on the islands in the south-central part of the lake and at the southwest end of the prominent peninsula projecting from the southeast corner of the lake. On the northeast the upper and lower parts of the section are separated by a single major fault, whereas to the west there may be several faults accompanied by eastward downwarping. Dips are typically less than 10 degrees except locally along the west coast where eastward dips of 15 degrees have been measured, and along the northwest margin of Proterozoic outcrops where a narrow band at the base of the section dips southeast at 70 degrees.

Fine-grained to medium-grained grey to green, brown-weathering diabase (7) forms tabular bodies (probably sills) that are commonly up to 50 feet thick but locally are thicker. The present elevation of the top of the diabase



immediately northeast and southwest of the major fault is about the same though its stratigraphic position is 450 feet or more higher on the southwest. The diabase is therefore probably younger than the faulting. Diabase dykes mostly less than 200 feet thick may be found locally throughout the area mapped.

The rocks of map-units 1, 2, 3, and 5b have been deformed, altered, and penetrated by granitic magmas along their contacts with the larger bodies of granitic rocks to produce zones of hybrid rocks (A). In the far southeast schists and greywacke (2a) grade into migmatite (Aa) with increase in proportion of intimately associated granitic material, increase in degree of recrystallization, and locally with increase in deformation. The change is commonly oscillatory, rather than continuous, across a broad contact zone. Elsewhere within areas of metasediments and along the contacts between metasediments and granitic rocks, bodies of metasediments are separated by large dyke- or sill-like masses of granitic rocks (Ab). Any proportion of granitic rocks may be found. Northeast of Point Lake along the east boundary of the area mapped, massive dioritic rocks have been intruded in all proportions by granitic rocks (Ac). The borders of dioritic inclusions are commonly sharp and angular. Associated with the basic volcanic rocks along the west margin of the area mapped are hybrid rocks derived from the alteration and intrusion of volcanic rocks and some sedimentary rocks by granitic rocks (Ad).

Diorite (B) is found chiefly along the west margins of the area where it appears to be associated with remnants of basic volcanic rocks. Contacts between these rocks are commonly gradational.

Massive granitic rocks (C) vary from granite to granodiorite. Textures vary from fine to coarse grained. Biotite is the principal mafic mineral and hornblende is only locally prominent. Locally muscovite is present. Black tourmaline and locally garnet are present in small bodies intrusive into the schists and greywacke(2a).

Minerals of economic importance, chiefly pyrrhotite, magnetite, arsenopyrite, lollingite[1], pyrite, minor chalcopyrite, and associated gold, are concentrated along the amphibolite bands in unti 3a, and in areas of hybrid rocks (Ab) adjacent to unit 3a.

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[1]McConnel, G.W.: Notes on similarities between some Canadian gold deposits and the Homestake deposits of South Dakota; Econ. Geol., vol. 59, pp. 719-720 (1964).

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13. STUDY OF THE EPWORTH GROUP

J.A. Fraser

An examination of critical localities in Rocknest Lake area (86 G/NE, H/NW, I/SW, J/SE) was begun as part of a two-year study of the stratigraphy and structure of the sediments of the Epworth Group of Proterozoic age. These rocks had been mapped previously on a reconnaissance scale[1].

The Epworth Group comprises a conformable sequence of five mappable sedimentary units. Lying unconformably on the Archaean basement is a grey to pink quartzite interbedded with argillite, siltstone, and minor layers of carbonate and quartz-pebble conglomerate, which total, in all, about 2,000 feet in thickness. Overlying this unit is dolomite that ranges in thickness from 2,000 to more than 5,000 feet. The carbonate strata are of varied lithology but algal structures are common throughout much of the section as are laminae of white and black chert. The dolomite is overlain by argillite up to 4,000 feet thick, which is interlayered with siltstone and massive feldspathic greywacke. Beds from 3 to 40 feet or more in thickness containing abundant limy concretions are found throughout the argillite. Graded bedding is well developed in exposures west of Rocknest Lake. Above the argillite is about 4,000 feet of limestone with interlaminated argillite grading upwards into red argillite and siltstone, and at the top, into a dark red calcareous sandstone, which is at least 1,200 feet thick. Coarsely porphyritic andesite occurs as a concordant body, possibly a sill, in the quartzite near its contact with Archaean granite. West of Redrock Lake andesite is interlayered with argillite. Sills and dykes of diabase are younger than the sediments. At least two ages of intrusion are represented by the dykes.

The sediments have been folded around northerly trending axes and show some evidence also of folding across this direction. Faults younger than the folds strike northeasterly, displacing the sediments with right-hand horizontal separations. The most prominent of these faults extends almost 50 miles from Redrock Lake to Takiyuak Lake. Near it, and parallel with it, are smaller faults along which separations of 6,000 feet or more have been measured. Associated with it also are north-trending dip-slip faults.

The sediments are for the most part unmetamorphosed, but argillite in the Hepburn River - Scotstoun Lake region exhibits progressive metamorphism westwards through phyllite to knotted schist within a mile of the contact with the granite. This granite is known, from isotope studies, to be Hudsonian in age. The Epworth Group must therefore belong to the Lower Proterozoic.

Stringers of quartz and calcite are common in the sediments, particularly in the dolomite, but direct evidence of mineralization is rare. Northwest of Itchen Lake quartzite is brecciated and veined by quartz and hematite. Silicified granite nearby contains disseminated chalcopyrite. A mile south of Scotstoun Lake, amphibolite lenses in phyllite carry pyrrhotite and chalcopyrite in numerous pockets, most of which are only a few feet long and not more than 6 inches wide.

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[1]Craig, B.G., Davison, W.L., Fraser, A.L., Fulton, R.T., Heywood, W.W., and Irvine, T.N.: Geology, North-Central District of Mackenzie, scale 1 inch to 8 miles; Geol. Surv. Can., Map 18-1960 (1960).

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14. CONTWOYTO LAKE AREA

L. P. Tremblay

Contwoyto Lake (76 E/11) map-area is underlain almost entirely by metamorphosed sedimentary rocks. In the northeast quarter these are black to grey argillite, slates, and siltstone of Yellowknife Group type and include a few narrow beds and lenses of amphibole-garnet-quartz-sulphide rock. They are the top unit of the stratigraphic succession. Due to more intense metamorphism this unit grades to the south and west into a wide belt of nodular (cordierite and andalusite) schists and of some augen gneiss and coarse biotite schists.

The nodular schists are underlain by a narrow layer of sugary, well-layered, quartz-feldspar-biotite gneiss. Due to facies changes and higher metamorphism this gneiss is probably represented in the southwest corner by a layered mixture of feathery amphibole-garnet-quartz rock, of granitoid garnetiferous gneiss, and of slightly coarser granular gneisses. These rocks occur in small basins in the lowest unit.

The lowest unit covers the southwest quarter of the map-area. It is a massive, red sugary, quartz-feldspar-gneiss, low in biotite, that grades locally into red granite.

A white extensively pegmatitic granite covers a large area in the northwest quarter of the map-area. It is surrounded by a narrow aureole of nodular schists and encloses many remnants of these schists. The pegmatites carry black tourmaline.

Northwesterly to rarely easterly trending gabbro dykes cut all other rocks.

Gold has been reported from many showings, the Inco showing on Contwoyto Lake being the most important to date. Gold is found in the amphibole-garnet-quartz-sulphide rock, closely associated with pyrite or pyrrhotite and arsenopyrite.

YUKON TERRITORY AND DISTRICT OF MACKENZIE

15. ENGINEERING GEOLOGY INVESTIGATIONS OF DAM SITES IN THE YUKON AND NORTHWEST TERRITORIES

E. B. Owen

In cooperation with a Water Resources Branch party the topography and geology at five potential hydro-electric power dam sites on Caribou and Flat Rivers were mapped. These rivers form part of the Mackenzie River drainage system. The sites were all located within the Northwest Territories. The maps prepared are all in the scale of 1 inch to 100 feet with a 10-foot contour interval.

Due to recent mining activity along Pelly River near the community of Ross River in Yukon Territory one potential power dam site was examined on Pelly River and another on Lapie River. Both these rivers are in the Yukon River drainage basin. In June the writer discovered asbestos-bearing ultrabasic rocks, previously unknown, at the site on Pelly River, which is approximately 21 miles up-river from the community of Ross River. The area has since been staked.

YUKON TERRITORY

16. ### OPERATION KENO

C. F. Gleeson

A reconnaissance geochemical and heavy mineral survey was completed in the Keno Hill area, Yukon Territory (106 D/1, 2, 3, 4; 105 M/13, 14, 15). The project area covered approximately 1,900 square miles. Fifty-eight hundred stream sediments, 5,700 stream waters, 150 spring sediments, 150 spring waters, and 550 heavy mineral samples were taken along the creeks and rivers of the area. The sediment and water samples were tested for easily extractable heavy metals at the sample sites. Gold pans were used to obtain the heavy mineral concentrates.

The stream waters were sent to the laboratories in Ottawa for SO_4 and Cl analysis and the spring waters were submitted for complete anion and cation analyses.

The stream sediments were dried and sieved to minus 80 mesh in the field and submitted to Ottawa for Cu, Pb, Zn, As, Sb, W, Mo, Bi, Sn, Ni, Co, B, Mn, Au, and Ag analyses. The heavy mineral concentrates were sent to the laboratories for heavy liquid separations; trace element analyses will be done on the heavy fractions from these separations.

Presently laboratory work is continuing on the sediment, water, and heavy mineral samples. Preliminary maps showing the results of the field tests are in preparation and will be published shortly.

A preliminary examination of the data collected so far indicates the following:

1. Geochemical water and stream sediment surveys are a practical and helpful prospecting tool in this area.

2. These surveys can be carried out anytime after the middle of June.

3. Many creeks are anomalous in easily extractable heavy metal.

4. Generally the water and sediment field analyses gave coincident anomalies. However, there were exceptions and these seemed to occur in the vicinity of metal-rich acid springs. In some creeks the cut-off of the stream sediment anomaly was displaced several thousand feet below the cut-off of the water anomaly. Usually the latter pinpointed the location of the metal-rich spring.

5. The field tests gave anomalous trains that varied in length from a mile to over 10 miles.

6. Dilution from heavy rains and high water was not an interferring factor.

7. The pH of the creek waters varies from 3.7 to 8 and temperatures from 0 to 10 degrees centigrade.

8. Most of the anomalies picked up by the field tests are due to zinc.

9. Tungsten is present in anomalous amounts in the stream sediments from creeks draining areas underlain by granite intrusions.

10. High arsenic values are common in the vicinity of granite intrusions and porphyry dykes.

11. Anomalous copper, nickel, and cobalt values occur in the vicinity of greenstone bodies.

12. High zinc, lead, manganese, and silver values occur in the sediments from areas occupied by quartzites and phyllites and in the contact aureoles of the granite intrusions.

13. A small amount of molybdenite was found in a large granite block on Olive Pup, a tributary of Dublin Gulch (106 D/4).

14. Several specks of gold were observed in pan concentrates from the creek gravels in upper parts of Granite Creek (105 M/15).

17. FURTHER STUDIES IN THE OPERATION PELLY AREA

L.H. Green, J.A. Roddick, and J.O. Wheeler

In late July the Department of Northern Affairs very kindly placed a helicopter at the disposal of the Geological Survey at Whitehorse. The writers took this opportunity to spend ten days checking parts of the Pelly River area (105 F, G, J, and K). The information obtained will be included in the final report on Operation Pelly now in preparation.

18. SURFICIAL GEOLOGY STUDIES IN CENTRAL YUKON

O. L. Hughes

Deeply weathered glacial gravels of early or middle Pleistocene age were studied in Tintina Trench and in Stewart River valley west of Tintina Trench. A new occurrence of fossil mammal bones was found on Stewart River about 7 miles above the north of Valley Creek.

Karl Ricker, under the writer's supervision, prepared maps at the scale of 1 inch = 1 mile of deposits related to three stages of glaciation in North Klondike and East Blackstone valleys. Detailed observations were made of the morphology of moraines of the respective glaciations, and of soil development and vegetation cover on the moraines. Results have not been analyzed.

Glacial deposits of Mayo north half (105 M N1/2) map-area are the product of at least three glaciations. Well-marked lateral moraines and associated ice-marginal deposits, of late Wisconsinan age, lie at elevations of 5,000 feet or above in the eastern part of the area, and decline westward and northward along the sides of the major valleys toward terminal moraines, which lie within or just beyond the map-areas. Locally thick drift accumulations, with subdued glacial topography, at elevations 500 to 800 feet above the late Wisconsinan moraines, represent glaciation of possible early Wisconsinan age. Thin scattered deposits, particularly erratic pebbles and boulders, give evidence of still earlier glaciation levels to 5,300 feet in the east, and 5,000 feet in the west. Provenance of erratics indicates ice movements mainly from southeast and south in early and pre-Wisconsin glaciations, and from southeast and east-northeast in late Wisconsin glaciation.

Floors of the main valleys are typically occupied by pitted or terraced outwash, but locally, as along Keno Ladue River and Haldane Creek, are occupied by glaciolacustrine silt with thermokarst topography. Lower and intermediate valley slopes have relatively thick drift cover, with widespread organic deposits on the lower slopes and valley floor. Higher slopes have relatively thin glacial deposits, but have extensive cover of frost-river detritus.

Permafrost prevails throughout the area except locally in areas of glaciofluvial sand and gravel, and on south- and southwest-facing slopes.

19. MOUNT HALDANE (105 M/13) AND DUBLIN GULCH (106 D/4) MAP-AREAS

W.H. Poole

The geology of Mount Haldane (105 M/13) and Dublin Gulch (106 D/4) map-areas was studied and mapped for publication at a scale of 1 inch to 1 mile. The two map-areas total 1,055 square miles and lie west and northwest of the nearby silver-lead mining camp of Galena Hill-Keno Hill (Fig. 1).

The three formations of Galena Hill—Lower Schist, Central Quartzite, and Upper Schist—were traced throughout the area. The Central Quartzite Formation was followed by L.H. Green and the writer through an area of little and no outcrop from the headwaters of Lynx Creek northward to connect with the Steamboat Mountain belt. The formation can now be traced from Tombstone River map-area, 75 miles to the west (see report by Tempelman-Kluit, elsewhere in this publication) into, through, and beyond the Galena Hill-Keno Hill mining camp[1,2].

Rocks of the three formations have been described many times[3,4,5]. The lower part of the Upper Schist Formation contains discontinuous limestone beds; the contact with the upper part is located only approximately. In places, the lower part contains one or two units, a few tens of feet or more thick, of medium to dark grey quartzite and graphitic phyllite characteristic of the Central Quartzite Formation. The upper part contains quartzite and grit with coarse sand and granules of quartz and feldspar.

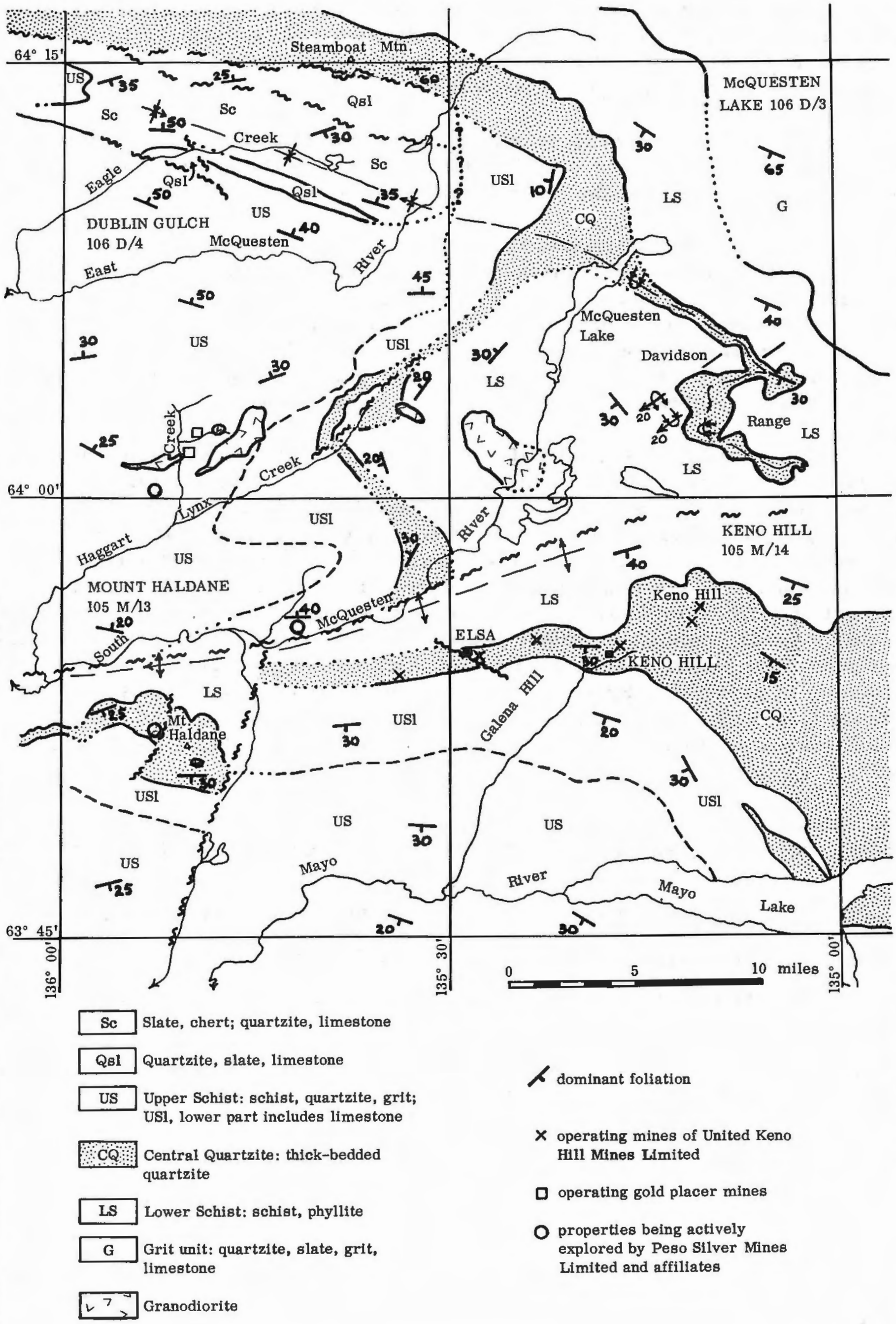

Figure Geology of upper McQuesten River area, northern Yukon

North of East McQuesten River, the quartzite-slate-limestone unit, apparently overlying the Upper Schist Formation, contains minor varicoloured slate, dark chert and slate, and quartzite with dark grey quartz grains. The inner part of the Eagle Creek syncline consists mostly of grey and green slate, and chert slightly recrystallized to a quartzitic texture.

Granitic stocks, quartz porphyry-rhyolite sills, and biotite lamprophyre dykes occur sparsely in a belt comprising the southern one-third of Dublin Gulch map-area and the northern two-thirds of Mount Haldane map-area.

The Central Quartzite Formation traces out a broad syncline (Eagle Creek) and anticline (Mt. Haldane), and a partly developed fold in Lynx Creek area. Each fold is cut by longitudinal faults. The Eagle Creek syncline, if projected into Davidson Range, may form an isoclinal syncline, the keel of which is Central Quartzite Formation flanked on both sides by Lower Schist Formation. Later, this fold must have been crumbled on southwest-plunging axes, and still later arched on south-southeast axes of the Mayo Lake anticline[6].

The age of the formations is in doubt. The succession north of McQuesten Lake appears to be normal and is confirmed by recent mapping to the west (see report by Tempelman-Kluit,elsewhere in this publication). Stratigraphically upwards, the succession is Precambrian grit unit, Carboniferous (?) and Permian limestone, and Permian-Triassic Lower Schist and Central Quartzite. Schist of the Upper Schist conformably overlies Central Quartzite northwest of McQuesten Lake and appears to do so elsewhere along the contact to the south; hence, some of the Upper Schist is Permian-Triassic. However, in the upper part of the Upper Schist, schistose quartzite and grit seem to be metamorphic equivalents of part of the Precambrian grit unit. Furthermore, slate and chert of the Eagle Creek syncline are probably Ordovician-Silurian. Nevertheless, the Upper Schist is not thrust upon the Central Quartzite in the upper McQuesten River area.

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

[2]Bostock, H.S.: Mayo, Yukon Territory; Geol. Surv. Can., Map 890A (1947).

[3]Kindle, E.D.: Keno Hill, Yukon Territory; Geol. Surv. Can., Map 1105A (1962).

[4]Green, L.H.: McQuesten Lake and Scougale Creek map-areas, Yukon Territory; Geol. Surv. Can., Paper 58-4 (1958).

[5]Boyle, R.W.: The geology and geochemistry of the silver-lead-zinc deposits of Galena Hill, Yukon Territory; Geol. Surv. Can., Paper 57-1 (1957).

[6]Green, L.H., and McTaggart, K.C.: Structural studies in the Mayo District, Yukon Territory; Proc. Geol. Assoc. Can., vol. 12, pp. 119-134 (1960).

Within the area mapped, all known occurrences of base metal sulphides, including those of mineralogical interest only, lie in the southern half of Dublin Gulch map-area and northern two-thirds of Mount Haldane map-area. The belt containing sulphide ore minerals corresponds more or less with the belt containing granite, porphyry-rhyolite, and lamprophyre. Scheelite occurs sparsely in quartz veins in the granites along Dublin Gulch and elsewhere, and in diopsidic skarns on Ray Gulch and nearby creeks. Arsenopyrite is common in quartz veins in the belt containing granites through Haggart and Lynx Creeks and as disseminations in some granitic rocks, particularly those on Mt. Haldane (especially Fortune Creek). Jamesonite ($Pb_4 Fe Sb_6 S_{14}$) and arsenopyrite are common ore minerals in vein-faults north of Haggart and Lynx Creeks (Peso, Rex, tributaries of Dublin Gulch, Lynx Dome); sphalerite is the common ore mineral at the Shanghai property on South McQuesten River, and galena south of the South McQuesten River (Mt. Haldane, Silver King).

20. TOMBSTONE RIVER (116 B/7) MAP-AREA

D. Tempelman-Kluit

Tombstone River (116 B/7) map-area is underlain by a sequence of unmetamorphosed and variably deformed sedimentary rocks that have been intruded by two syenite stocks. The rocks have the appearance of being a homoclinal sequence that dips almost invariably to the southeast at angles of from 10 to 70 degrees.

The oldest rocks, which are exposed in the northwest corner of the map-area, are considered to be of Precambrian or Cambrian age and consist largely of maroon and green shale and slate with minor interbedded quartz pebble conglomerate and dark green basalt. These rocks have been folded very complexly along north-trending axes. The base of this unit is not exposed in the map-area and its thickness is unknown.

About 1,000 feet of interbedded black shale and lesser black chert of Ordovician and Silurian age overlie the maroon and green shale sequence unconformably. The top of the shale-chert unit is marked by a continuous bed of fossiliferous chert-pebble limestone about 100 feet thick, which contains Permian fossils. Open folds trending east-southeast that are considered to be related to Tintina Trench have deformed this unit in the southern part of the map-area.

Graphitic black shale and argillite with very minor interbedded grey quartzite overlie the shale-chert sequence conformably. The thickness of this unit is uncertain as it is poorly exposed and complexly deformed. Intense deformation by shearing along bedding with related folding has occurred.

Massive grey quartzite with minor interbedded black slate and very minor red and green phyllitic slate overlies the black shale unit and occupies the largest part of the southeastern half of the map-area. The contact between these units is considered to be a gently southeast-dipping thrust surface upon which the quartzite has moved to the northwest. Remarkably continuous diorite sills (generally about 300 feet thick) have intruded the quartzite. Concentric folds along northeast-trending axes have deformed the quartzite and diorite sills. Such folds are prominent above the black shale contact and become tighter to the southeast. In the southeastern corner of the map-area no folds are recognizable and an apparently homoclinal sequence of quartzite is found. Considerable internal shearing along slaty beds within quartzite has occurred in this apparently homoclinal sequence. It is considered that the thickness of the quartzite is about 5,000 feet, although its outcrop width suggests a thickness of the order of 50,000 feet.

Two large stocks of hornblende syenite occupy the north-central part of the map-area. These consist of several mappable, concentrically zoned phases of which the central phase is very coarse grained, porphyritic, and leucocratic. The leucocratic phase grades outward into medium-grained hornblende-rich porphyritic syenite, which makes up about three quarters of the stocks and which shows a concentric trachytoid texture by virtue of alignment of tabular orthoclase phenocrysts. Within a hundred feet of the margins of the stocks equigranular fine-grained to medium-grained biotite syenite occurs.

No economic metalliferous deposits were discovered although evidence of mineralization was noted at a number of localities. Coarse-grained molybdenite on a joint surface within and near the margin of a syenite stock occurs as float at one place. Disseminated chalcopyrite occurs in diorite at two localities. Five localities of massive and disseminated pyrrhotite, pyrite, arsenopyrite, and chalcopyrite were discovered in quartzite close to syenite contacts; these appear to be small and lenticular and controlled by bedding in quartzite. Disseminated fluorite and galena occur at a locality in coarse-grained syenite. Small pieces of float of coarsely crystalline manganiferous siderite were found on a ridge near a syenite contact and similar float in a nearby cirque contained pyrite, sphalerite, and pyrrhotite. The long-known showing on Spotted Fawn Gulch was not found although chalcopyrite in bedrock was noted here.

YUKON TERRITORY AND BRITISH COLUMBIA

21. STUDIES OF COPPER DEPOSITS, YUKON TERRITORY AND NORTHERN BRITISH COLUMBIA

E. D. Kindle

Geological mapping along the Whitehorse Copper belt was concluded with the preparation of a geological plan of the Pueblo Mine. Selected copper occurrences were visited in the coastal region of northern British Columbia between Telegraph Creek and Kitimat. Mineral specimens were collected near Hazelton for use of the Mineral Sets Section of the Geological Survey. The Endako Molybdenum Mine, 10 miles southwest of Endako was visited. Ore samples suited for exhibit purposes and others for study were collected at 2 producing copper mines, the Bethlehem Copper Mine 24 miles southeast of Ashcroft, and the Craigmont Copper Mine near Merritt.

The Granduc orebodies are mostly replacement deposits of siliceous sedimentary rocks along a great fault and wide shear zone. The lode deposits contain magnetite, pyrrhotite, pyrite, chalcopyrite, and arsenopyrite, both as massive veins and as thin stringers, the latter being most prevalent. Both altered sedimentary and volcanic rocks of Jurassic and younger age are prevalent in the Granduc area and a large mass of granite and granodiorite lies 2 miles south of the mine. Three bands of limestone rest against the N. N. W. -striking Granduc Fault on its west side and one thin limestone bed occurs on the east side. Dr. G. W. H. Norman, mine geologist, reports that in some places tourmaline is found interbanded with magnetite and both are penetrated by younger sulphide and biotite veinlets.

The main Galore Creek orebody, which has been outlined by Stikine Copper Limited, occurs in a shattered feldspar porphyry stock along its contact with altered volcanic and sedimentary rocks. The feldspar porphyry is very fissile, splitting readily along closely spaced parallel planes as a result of a strong fracture cleavage development within the ore zone. In surface outcrops the laminae dip 20° to 30° at low angles in varying directions along the strike and are intersected by steeply dipping joints. The fractured and cracked host rock is replaced by pyrite, chalcopyrite, and bornite, with chalcopyrite being the dominant copper mineral. Some deep drill cores show brecciation and replacement by gypsum, but sulphide replacement is in most places accompanied by development of finely crystalline biotite.

The North Junction orebody lies along the contact of feldspar porphyry with younger coarsely crystalline feldspar porphyry. Other ore occurrences within the Galore Creek basin include contact metamorphic skarn deposits.

BRITISH COLUMBIA

22. BELLA COOLA (93 D) MAP-AREA

A. J. Baer

The east half of Bella Boola (93 D) map-area is crossed by a good motor road that connects Bella Coola on the Pacific Coast with Williams Lake, 20C miles to the east. Good logging roads reach into the lower parts of most valleys tributary to Bella Coola valley. Numerous small lakes are accessible to fixed-wing aircraft in the northeast part of the area, but heavy bush and deep river canyons slow progress in that area. Most of the area, however, is accessible only by helicopter, and to a limited extent only.

Bedrock is commonly well exposed, except in creek bottoms and in the northeast part of the area where glacial drift is widespread.

A greenish granodiorite (map-unit 1) is the oldest plutonic rock in the area. The green colour is due to intense chloritization of mafic constituents, and to crystallization of epidote along numerous small fractures.

Black argillites and slates (2) form discontinuous rusty-weathering bands interlayered with rocks of map-unit 3. Their stratigraphic position within that unit has not been determined.

The granodiorite (1) is cut by green andesitic dykes that form locally 50 per cent of the outcrop. Twelve miles south of Mount Mackenzie these dykes feed lava flows of unit 3. Four miles northwest of peak elevation 6,138 feet, a 50-foot thick conglomerate bed marks the non-conformable contact of unit 3 on the greenish granodiorite. Some poorly preserved fossils have been found in a greywacke on top of the conglomerate.

The part of unit 3 that is younger than (1) appears identical to series containing Middle Bajocian fossils (determined by H. Frebold of the Geological Survey) in the northeast corner of the map-area. Fresh-looking lava flows and reddish rocks (3a) belong probably also to the younger part of unit 3.

The greenish granodiorite (1) contains locally numerous blocks of greenstone, and some contacts between (1) and (3) show a progressive granitization of the greenstone. A part of unit 3 is therefore older than the intrusion of the granodiorite (1), but no stratigraphic criterion was found that would separate the two parts.

West of a line running southeast from the mouth of Dean River to peak elevation 9,500 feet, greenstone and associated rocks (3b) are locally dioritized in irregular zones and patches. These metamorphosed rocks contain abundant, but irregularly distributed quartzo-feldspathic veins, bands, and stringers.

LEGEND

TERTIARY

MIOCENE AND (?) PLIOCENE

[7] Vesicular and amygdaloidal basalt, olivine basalt and related tuff

EOCENE AND/OR PALEOCENE

[6] Massive, medium-grained to coarse-grained biotite granodiorite, quartz monzonite and granite

CRETACEOUS OR TERTIARY

CRETACEOUS OR LOWER TERTIARY

[5] Pink, medium-grained to fine-grained quartz monzonite and granodiorite

CRETACEOUS (?)

UPPER CRETACEOUS(?)

[4] White or light grey, foliated, medium-grained granodiorite

JURASSIC AND OLDER

MIDDLE JURASSIC AND OLDER

[3] Mainly greenstone and green lava, tuff and agglomerate of andesitic composition, interbedded minor slate and greywacke, subordinate rhyolite; 3a, purple, chocolate-brown and reddish flows and tuffs; 3b, metamorphosed and granitized equivalents, recrystallized greenstone, diorite and quartz diorite, with veins and stringers of granodiorite

JURASSIC OR OLDER

MIDDLE JURASSIC (?) OR OLDER

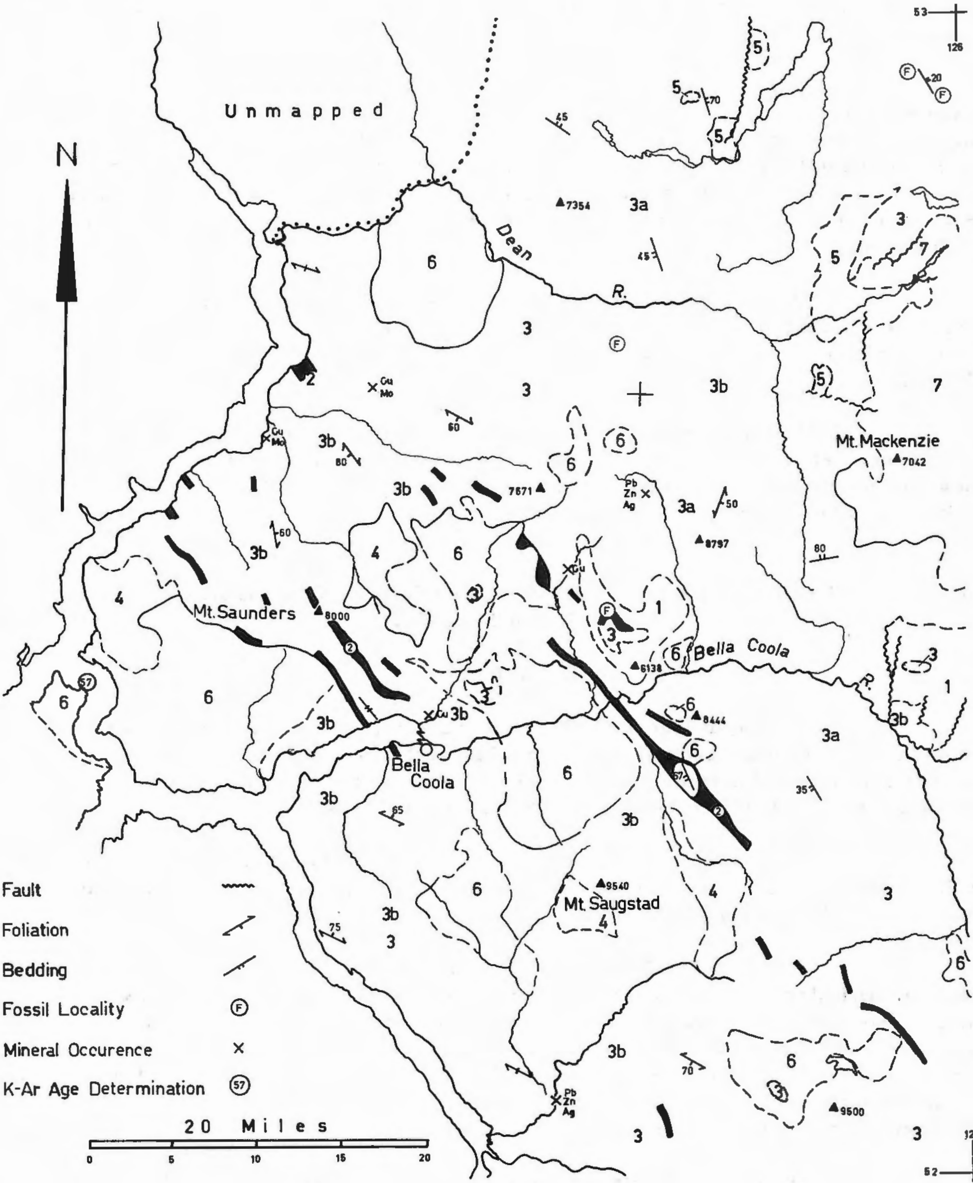
[2] Black slates and argillites interbedded with 3

PRE-MIDDLE JURASSIC

[1] Greenish, foliated granodiorite, cut by andesitic green dykes

Mineral Symbols

Silver. . . . . Ag	Lead. . . . . Pb
Copper. . . . . Cu	Zinc . . . . Zn
Molybdenum . . . . Mo	


Unmapped
N
Dean R.
Bella Coola R.
Bella Coola
Mt. Saunders
Mt. Mackenzie
Mt. Saugstad
3a
3b
Fault
Foliation
Bedding
Fossil Locality
Mineral Occurence
K-Ar Age Determination
20 Miles
0
5
10
15
20

Deformation of volcanic and sedimentary rocks (2) and (3) increases from northeast to southwest. It is particularly intense around plutons of units 4 and 6, where the older rocks appear to have been pushed aside and up during the intrusion.

Units 4, 5, and 6 have sharp contacts with other rocks and are clearly intrusive. They appear to represent different stages of intrusion of the Coast Mountain plutons. The foliated granodiorite (4) is cut by the massive quartz monzonite (6). The pink quartz monzonite (5) cuts rocks of Middle Jurassic age, and is overlain by Miocene plateau lavas (7). The age of a sample from unit 6 has been determined by the K-Ar method on biotite as 57 million years (Palaeocene).

Plateau lavas (7) occur along the eastern margin of the map-area. They are attributed to the Miocene Epoch by comparison with similar rocks in map-areas to the east and southeast. Later faulting has affected them north of Mount Mackenzie.

Though prospecting has been intermittent and unrewarding, mineral occurrences have been known for many years in the area. Reports on most of these properties may be found in the Annual Reports of the Minister of Mines of British Columbia for the last sixty years.

23. STRATIGRAPHY OF PERMO-CARBONIFEROUS ROCKS, OPERATION LIARD

E. W. Bamber

In conjunction with Operation Liard (see report by G. C. Taylor, elsewhere in this publication), stratigraphic sections were measured through Carboniferous and Permian rocks in the eastern part of the outcrop belt of the Rocky Mountains between latitudes 56°20'N and 58°51'N.

The basal unit, the Besa River Formation, ranges from Devonian to Early Mississippian in age and consists mainly of shale and mudstone. Its contact with the overlying Prophet Formation is gradational.

The Prophet Formation, which is mainly limestone and chert, is Osagean and Meramecian in age. In the more easterly sections its thickness ranges from approximately 3,600 feet near the Peace River to less than 1,300 feet near the Muskwa River, and decreases rapidly from east to west. The formation is mainly cherty limestone in the east, but toward the west it becomes predominantly chert with interbedded shale. The northern limit of outcrop for the Prophet Formation is in the Tetsa River area.

Overlying the Prophet Formation is a sequence of shale, sandstone, and minor limestone, which varies greatly in thickness and is of Late Mississippian age in part. Its upper age limit has not been determined. This unit is overlain by a thin, fairly consistent siltstone and shale unit, which is probably Permian in age.

The Fantasque Formation, at the top of the Palaeozoic section, is Permian in age and consists mainly of dark grey bedded chert with minor shale partings in its lower beds. The lower and upper contacts are sharp and the thickness ranges from approximately 120 feet in the north to less than 50 feet in the south.

24. CANOE RIVER WEST HALF (83 D W1/2) MAP-AREA

R.B. Campbell

Field work in the area southwest of the Rocky Mountain Trench was conducted by Campbell and that to the northeast by E.W. Mountjoy.

Structural data on the accompanying sketch map is generalized and is intended to show the broad structural patterns.

The rocks of the Shuswap Metamorphic Complex (map-unit 1) generally display a marked mineral lineation, tend to be gneissic though schist is common, and are intensely deformed. Folds characteristically are recumbent or nearly so; in some small folds the ratio of amplitude to wave length is 10:1.

The Miette Group (map-unit 2)[1] is restricted to the Rocky Mountains. Both the degree of metamorphism and the intensity of folding within the group decrease toward the northeast, that is, with increasing distance from the Rocky Mountain Trench. Near the Trench phyllite contains some fine biotite and scattered small (manganiferous ?) garnets, minerals which were not observed farther to the northeast. Folds near the Trench are isoclinal, but to the northeast are broad and open.

The Kaza Group (map-unit 3)[2, 3] is equivalent to the Miette Group and both are correlated with the Horsethief Creek Group of the Selkirk Mountains to the south. The degree of metamorphism changes gradually across the line separating map-units 3a and 3c. The carbonate unit (map-unit 3b) is probably not part of the Kaza Group, but at present its relationships to other units is not known. On the north boundary of the map-area just west of the Trench, rocks have been included with the Kaza Group that may, with further study, be shown to be part of the Isaac Formation.

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[1] Mountjoy, E.W.: Mount Robson (SE) map-area, Rocky Mountains of Alberta and British Columbia; Geol. Surv. Can., Paper 61-31 (1961).

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

[3] Campbell, R.B.: Quesnel Lake (East Half), British Columbia; Geol. Surv. Can., Map 1-1963 (1963).

LEGEND

MESOZOIC CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

9 Glacial deposits; alluvium

TERTIARY, PLEISTOCENE, AND RECENT

8 Basaltic flows, cinder cones, and fragmental deposits

CRETACEOUS OR EARLIER

7 7a, biotite quartz monzonite; 7b muscovite-biotite granite

PALAEOZOIC

CAMBRIAN OR LATER

LOWER CAMBRIAN OR LATER

CARIBOO GROUP (4 to 6)

6 YANKEE BELLE FORMATION: slate, phyllite, and quartzite

LOWER CAMBRIAN

5 CUNNINGHAM LIMESTONE: grey and buff marble; may include some carbonate units of Isaac Formation

LOWER CAMBRIAN OR EARLIER

4 ISAAC FORMATION: 4a, phyllite, schist, marble, quartzite, slate, and limestone; 4b, garnet, staurolite, and kyanite mica schist, quartzite, and marble; may include undifferentiated Yankee Belle Formation

PRECAMBRIAN

WINDERMERE

KAZA GROUP (equivalent to Miette Group)

3 3a, quartzite, micaceous and garnetiferous quartzite, garnet, staurolite, and kyanite mica schist; minor marble and metaconglomerate; 3b, micaceous marble, minor schist (may be equivalent to units 4 or 5); 3c, quartzite, commonly feldspathic and gritty, phyllite, schist, and minor conglomerate

MIETTE GROUP (equivalent to Kaza Group)

2 Phyllite (locally garnetiferous), slate, quartzite, grit, conglomerate, and limestone

AGE UNKNOWN

SHUSWAP METAMORPHIC COMPLEX

1 1a, quartz-feldspar-biotite gneiss, quartzite, amphibolite, mica schist (locally garnetiferous) marble, lime-silicate gneiss; includes much pegmatite; 1b, grey and buff marble; 1c, quartz-hornblende gneiss, amphibolite, quartzite; minor staurolite and garnet mica schist

Geological contact (defined, approximate or assumed)

Foliation (approximates axial planes of folds) (inclined, vertical)

Lineation (approximates fold axes) (plunging, horizontal)

Fault (approximate or inferred)

Thrust fault, approximate

Anticline (upright, overturned)

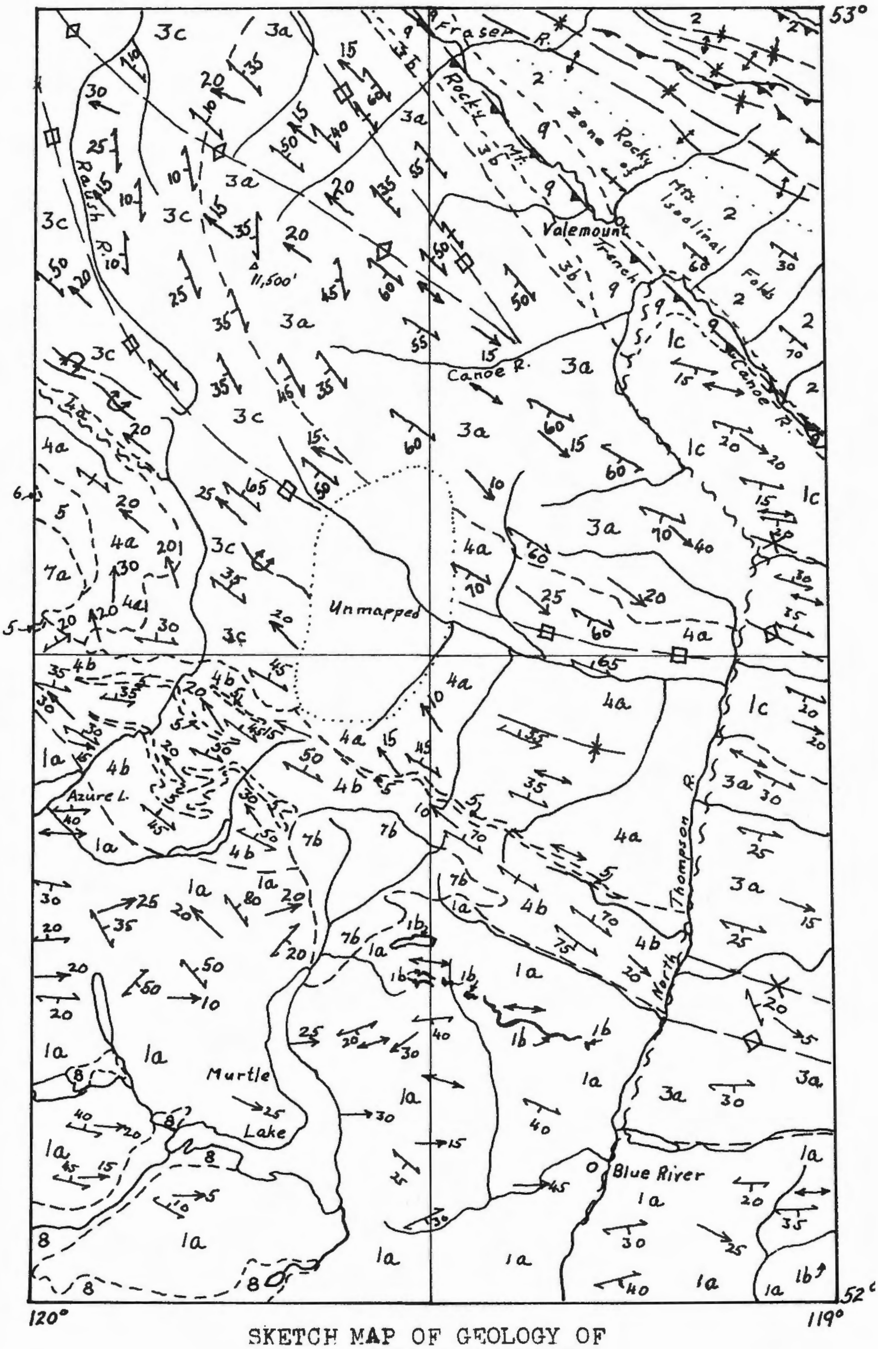
Syncline (upright, overturned)

Antiform (fold in foliation and axial planes of older folds)

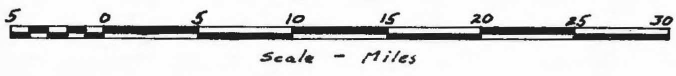
Synform (fold in foliation and axial planes of older folds)

Fan axis

Geology by R.B. Campbell, 1963
and R.B. Campbell and E.W. Mountjoy, 1964



SKETCH MAP OF GEOLOGY OF
CANOE RIVER WEST HALF
BRITISH COLUMBIA
83D W½



The Isaac Formation (map-unit 4)[1] consists of limy slate, phyllite, and limestone (map-unit 4a) southwest of the head of Raush River near the west boundary of the map-area, and of phyllite, mica schist, quartzite, marble, and locally garnetiferous schist (map-unit 4a) near North Thompson River. These low- to moderate-grade metamorphic rocks change rapidly but gradationally southward to high-grade schists (map-unit 4b) where, together with the Cunningham Limestone (map-unit 5)[2,3] they are deformed into isoclinal folds.

Granitic rocks (map-unit 7) seem definitely to be post-tectonic and the westernmost body, particularly, appears to have warped pre-existing folds during its intrusion.

The basaltic rocks of map-unit 8 include late Tertiary flows along Murtle Valley, Tertiary or Pleistocene flows, fragmental deposits, and a volcanic cone south of the valley, and a fresh Recent cone and series of flows north of the valley.

In terms of structural geology the region may be divided into two broad systems. The Shuswap Metamorphic Complex, irrespective of the age of the rocks involved within it, displays a unique structural style featuring recumbent folds with axial trends generally east-west, though variations from this up to 30 degrees are not uncommon. The second system includes the folded Kaza and Cariboo Groups in which folds vary from isoclinal to relatively open structures mainly with distinct northwesterly axial trends.

The contacts between the two structural systems where they have been studied are not clear cut. Near Azure Lake the contact lies in a zone a mile or more in width in which the rocks are not clearly relatable structurally or lithologically to either system. West of North Thompson River the contact seems to be structurally complex, but is poorly exposed. The contact extending easterly from Azure Lake appears to be a fault, but if this is the case the fault has evidently been subjected to deformation and possible metamorphism. The contacts east of North Thompson River have not been adequately studied. The northernmost contact extending easterly from North Thompson River may be a south-dipping thrust fault, whereas that extending easterly from near Blue River is evidently the faulted extension of the contact extending west of North Thompson River. It appears to be a steep fault.

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

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

[3] Campbell, R.B.: Quesnel Lake (East Half), British Columbia; Geol. Surv. Can., Map 1-1963 (1963).

25. METALLOGENIC STUDY, VANCOUVER ISLAND

D.J.T. Carson

The writer commenced a metallogenic study of known metal-bearing deposits on Vancouver Island. Samples of mineralized rocks, host rocks, gangue, and related intrusions from approximately eighty representative deposits occurring throughout the island were collected for laboratory study, and specimens relating to the absolute ages of certain deposits were taken for radioactive age determinations.

In addition to sampling each deposit, the writer gathered data concerning the type, age, and extent of mineralized rocks, host rocks, and intrusive rocks. Mining companies supplied much of this data as well as some structural information.

Systematic, but necessarily widely spaced sampling and traversing of certain intrusions were carried out with the aim of determining if any relationships exist between the petrography of these intrusions and metallic mineralization.

The metal-bearing deposits of Vancouver Island occur in host rocks ranging in ages from Late Palaeozoic to Middle Tertiary, and can be classified in a general manner using the Russian metallogenic scheme as a basis. It may be possible to demonstrate qualitatively the influence which the various types of host rocks have had on the mineralogy and physical forms of the deposits.

Both Early Permian and Late Triassic limestones are exposed in quantity on Vancouver Island, but only the latter appear to have been favourable for the formation of relatively sulphide-free commercial contact metamorphic or pyrometasomatic magnetite orebodies.

Three groups of deposits may be shown to be genetically related to intrusions of distinctive petrography and ages. These are copper deposits related to Early Oligocene gabbros, copper-gold deposits related to Tertiary dacite porphyries, and gold-quartz veins, many of which appear to be related to the latest siliceous phases of the Coast Intrusions.

26. STRUCTURAL STUDIES IN THE MANNING PART (92 H/2) AND ADJACENT AREAS OF THE CASCADES MOUNTAINS

J. Coates

Initial work has been mainly confined to examining the Pasayten and Dewdney Creek Groups, with brief attention to the Ladner and Jackass Mountain Groups. Northwesterly trending chevron folds have been recognized in the Pasayten and Dewdney Creek Groups, with overturn to the east in the eastern part of this Cretaceous belt. Nearly isoclinal folds occur in the Ladner Group slates and in parts of the Dewdney Creek Group. Additional complexities, including cross-folding, occur near plutons intruding these rocks. Search for the Gibson and

Chuwanten faults has so far yielded only negative evidence. An unconformity was noted at the base of the Pasayten Group and evidence of another unconformity within the Dewdney Creek Group has also been noted. Correlation of the Jackass Mountain Group with the Dewdney Creek Group is tentatively confirmed. Plant fossils have been collected in the Pasayten Group, and the Dewdney Creek Group has yielded an abundant marine fauna.

27. BIOSTRATIGRAPHY OF THE SOOKE AND CARMANAH FORMATIONS

Raymond Cox

Clastic sediments of middle Tertiary age fringe the southwest coast of Vancouver Island from Sooke to Barkley Sound. The sediments are subdivided into the Sooke (early Miocene) and Carmanah (middle? Oligocene) Formations on palaeontological evidence. They lie unconformably on older rocks and are unconformably overlain by Pleistocene strata. The Tertiary beds strike parallel to the coastline and dip 7°- 20° seaward.

Sooke sediments are poorly sorted calcareous sandstones and conglomerates, typically lenticular and crossbedded. The sediments were apparently rapidly deposited on a rugged coastline of Metchosin basalt from Becher Bay to Sombrio Point and of Leech River schists and slates from Sombrio Point to Port Renfrew. Fossils include a large intertidal invertebrate fauna, a few vertebrate remains, and an extensive microfossil flora.

From Port Renfrew to Barkley Sound, interbeds of calcareous sandstones, argillaceous concretionary siltstones, and minor conglomerates lie disconformably on volcanic rocks of the Vancouver Group. The siltstone beds are moderately contorted and have a well developed fracture pattern along which normal faulting has occurred. Many fractures are filled by sandstone dykes 1"- 18" thick. Fossils include invertebrates, a few leaf impressions, foraminifera, and vertebrate remains. Whale bones are exposed at Carmanah Point, and the skull of a marine mammal (possibly Desmostylus) was found in a concretion at Bonilla Point. The relationship of these sediments to the Sooke and Carmanah Formations must await palaeontological studies.

Loss Creek follows a fault line nearly to the coast. The fault brings the Palaeozoic or lower Mesozoic Leech River Formation into contact with Eocene Metchosin volcanic rocks, but apparently does not cut the Sooke Formation. East-west faulting there, and a possibly related fault parallel to the San Juan River, are probably therefore of late Eocene or Oligocene age.

28. SURFICIAL GEOLOGY STUDIES, VERNON (WEST HALF) MAP-AREA

R.J. Fulton

Mapping of the northern half of Vernon west half map-area (82 L W1/2) on a scale of 1 inch = 2 miles was completed. The southern half of the area will be completed next summer.

Areas of thick sediments deposited prior to the last glaciation may form important groundwater reservoirs. The materials occupy several side valleys and occur in portions of the main valleys protected from vigorous glacial erosion.

Near Monte Creek silt structurally and texturally similar to the South Thompson Silt[1] lies below and carries to a higher level than the late glacial South Thompson Silt. This early silt may have been deposited in a glacial lake associated with an ice advance prior to the last. Volcanic ash, located near the middle of the silt, may correlate with ash collected from dateable subtill deposits.

A deposit of sand near Squilax and sand and gravel west of Notch Hill may correlate with subtill sand and silt on the opposite (north) side of Shuswap Lake. This material, located near Celista, was dated at 20,230 ± 270 B.P. (GSC No. 194). No organic material was found in the Squilax or Notch Hill materials.

The distribution of high-level lacustrine deposits and the pattern of meltwater channels indicate the last ice-sheet receeded by down-wasting with stagnant ice tongues remaining in the major valleys after the uplands were free of ice. An east-to-west component of recession existed in addition to the general south-to-north retreat.

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[1] Fulton, R.J.: Kamloops Lake map-area; Geol. Surv. Can., Map 9-1963 (1963).

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29. SURFICIAL GEOLOGY, S.E. VANCOUVER ISLAND

E.C. Halstead

Three tills exposed in cliff sections indicate repeated glaciation of the Saanich-Victoria-Sooke areas. The surficial deposits as mapped throughout much of the area represent those deposited directly by the last major ice advance or its meltwaters. The ice advanced in a general southerly direction and deglaciation was accomplished with advancing seas into which ice-contact deltas and stony clays were deposited upon the till, up to elevations of approximately 275 feet above present sea-level. On Galiano Island former Pleistocene sea-levels reached elevations of more than 580 feet above sea-level.

One thousand twelve hundred and fifty six feet of drilling were completed with a minute-man power auger. These holes were drilled for stratigraphic purposes and were from 10 to 57 feet deep.

Groundwater is obtained from subtill sands and gravels throughout much of the area. Observation wells were established at Sidney and Cowichan Station and four piezometers as well as a stream-gauge station were installed as the initial instrumentation for a hydrogeological study of the Dougan Lake area.

30. PRINCE RUPERT EAST HALF (103 J E1/2) AND TERRACE WEST HALF (103 I W1/2) MAP-AREAS

W.W. Hutchison

Most of the metasedimentary rocks (1) and the metavolcanic rocks (2) of the Tsimpsean Peninsula, Khutzeymateen Inlet and the outer islands, are part of what was previously called the Prince Rupert Formation. Although no diagnostic fossils have been found, Dolmage[1] tentatively assigned these rocks to the Triassic or Upper Palaeozoic on the basis of correlation with similar rocks of probable Triassic age in Alaska. There is insufficient evidence to preclude the possibility that some of these rocks are also, in part, of Jurassic age.

On Tsimpsean Peninsula, there is a progressive change in metamorphism from lower greenschist facies in the west to middle almandine amphibolite facies in the east, which is accompanied by changes in the style of folding. In addition, the metasediments show evidence of at least two periods or phases of deformation, the younger being related to the emplacement of the Ecstall pluton.

The gneiss complex (3) composed of paragneiss, gneiss (of unknown origin), migmatite, and intimately related quartz diorite and granodiorite, forms a broad north-south zone in the middle of the area. Part of the gneiss is derived from the metasediments (1) and metavolcanic rocks (2). The structure is complex, but in the few localities where marker horizons are present, large scale recumbent structures are, in places, apparent (see Figure 1). Those parts of the gneiss complex that are mainly composed of gneissic quartz diorite, and granodiorite (3b) appear to have been mobilized and moved in a more plastic manner than the surrounding gneiss.

The greywacke and argillite (4) are part of the Bowser Group, which underlies a large area to the east of the map boundary, where Duffell and Souther[2] attribute an Upper Jurassic and Lower Cretaceous age on the basis of diagnostic fossil evidence.

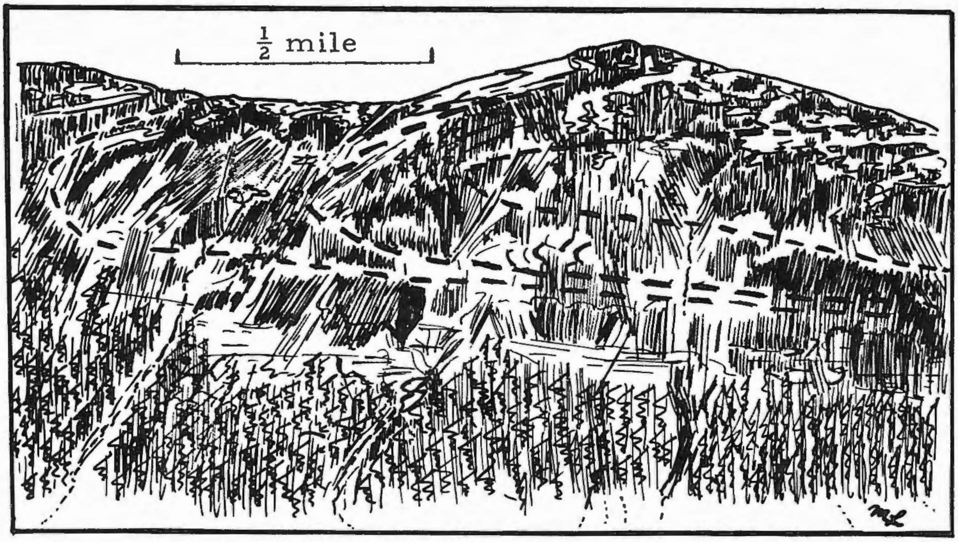


Figure 1. Looking east at recumbent fold in gneiss, 2 miles south-east of Kwinitsa, British Columbia.

Norite and pyroxene diorite (5) form the plug-like core of a quartz diorite mass on Smith Island. Diorite, gneissic diorite, and intimately related amphibolite and metavolcanic rocks (6) are probably the metamorphic equivalent of Hazelton volcanic rocks that lie to the east. A similar group of rocks (6) forms a marginal zone along the western contact of the Quotoon pluton and, farther south, along the eastern contact of the Ecstall pluton.

Diorite and quartz diorite (7) form the greater part of the Quotoon and the Ecstall plutons. The rock near the margin of these plutons is moderately to well foliated, but inwards the rock becomes poorly foliated or massive. The Ecstall pluton appears to have been forcibly emplaced causing the buckling of the adjacent metasediments to the north.

Granodiorite and minor quartz monzonite (8) form the bulk of the Exstew and Alastair Lake pluton and the central area of the Ecstall pluton. Both the Exstew and Alastair Lake plutons have sharp eastern contacts, but each grades into the gneisses to the west. Some evidence suggests that the Alastair Lake pluton tended to thrust over the gneisses to the west.

Massive quartz monzonite (9) with very sharp, intrusive contacts, forms a small body on Melville Island. Apart from the Exstew pluton, which intrudes Upper Jurassic and Lower Cretaceous sediments, the age of emplacement of the mobile crystalline plutonic rocks is unknown, but is probably Jurassic and/or younger.

LEGEND

TERTIARY

10 Volcanic breccia

JURASSIC AND/OR YOUNGER

9 Quartz monzonite

8 Granodiorite and minor quartz monzonite

7 Diorite and quartz diorite

6 Diorite, gneissic diorite and hornblende gneiss

5 Norite and diorite

UPPER JURASSIC AND (?) LOWER CRETACEOUS

4 BOWSER GROUP
Greywacke and argillite

JURASSIC OR OLDER (?)

3 Gneiss complex. Hornblende and biotite gneiss, migmatite gneiss and intimately intermixed phases of quartz diorite and granodiorite.
3a, Over 50% outcrop composed of paragneiss
3b, Over 50% outcrop composed of gneissic quartz diorite and granodiorite

2 Metavolcanic rocks. Greenstone, tuff, agglomerate; minor rhyolite and greywacke

1 Metasedimentary rocks. Phyllites, meta-argillites, mica$\pm$ chloritoid$\pm$ staurolite$\pm$ garnet$\pm$ kyanite$\pm$cordierite schists, hornblende-biotite $\pm$ garnet schists; minor quartzites, conglomerate, limestone and metavolcanic rocks.
1a, Greenschist facies
1b, Almandine amphibolite facies
1c, Conglomerate
1d, Limestone

Geological boundary (defined, and gradational or assumed) ....

Limit of geological mapping ....

Bedding inclined, top unknown ....

Trend of foliation ....

Fault (defined and approximate or assumed) ....

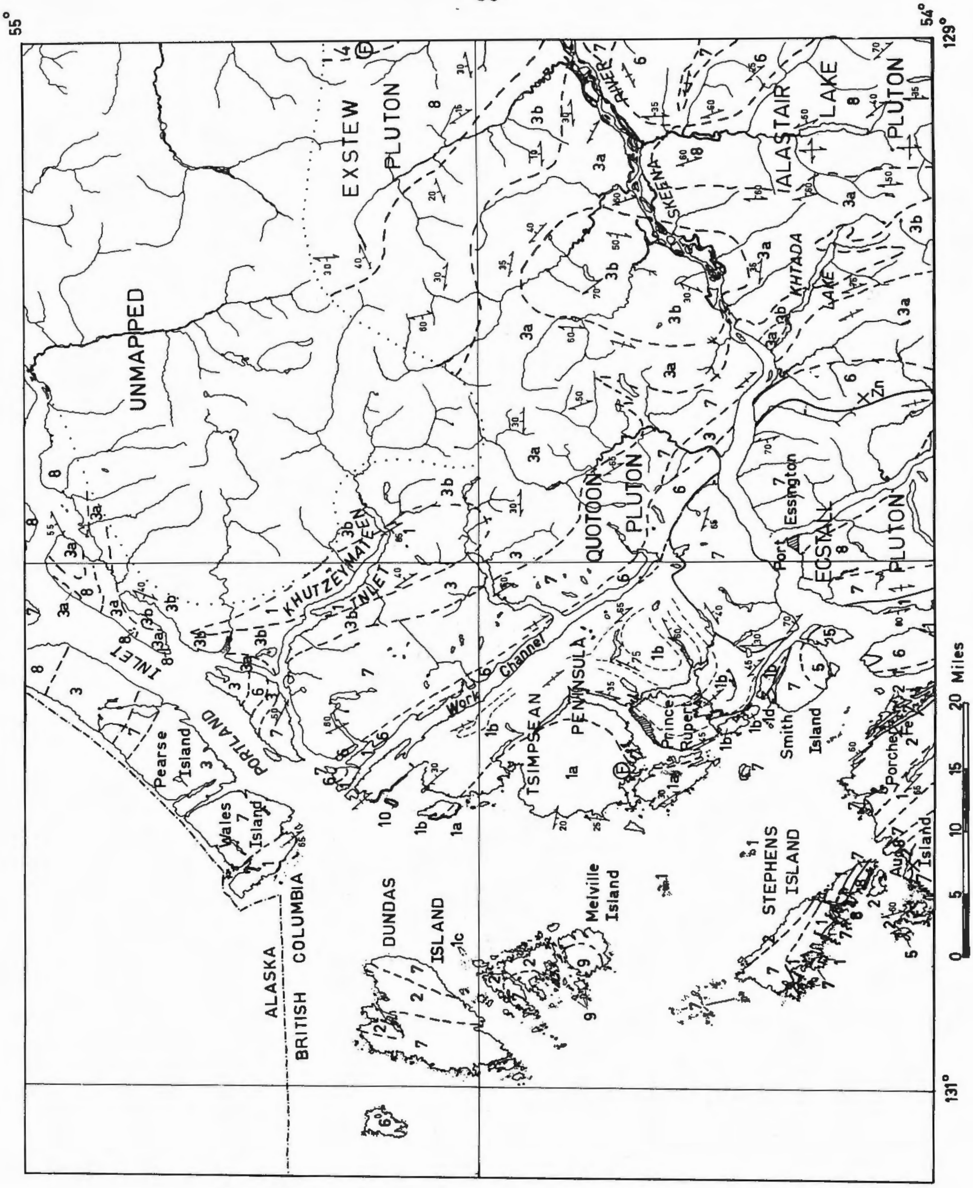
Fossil locality .... (F)

Mineral occurrence .... Au

Mineral Symbols

Gold .... Au Iron .... Fe Zinc .... Zn

Geology by W. W. Hutchison, 1962, 1963 and 1964, A. J. Baer, 1963 and 1964 and J. G. Souther, 1963


55°
54°
129°
131°
UNMAPPED
EXSTEW PLUTON
ALASKA
BRITISH COLUMBIA
PORTLAND
INLET
Pearse Island
Wales Island
KHUTZEYMATEEN
INLET
DUNDAS ISLAND
Melville Island
TSIMPSEAN PENINSULA
Work Channel
Prince Rupert
QUOTOON PLUTON
SKEENA RIVER
ALASTAIR LAKE PLUTON
KHTADA LAKE
Port Essington
ECSTALL PLUTON
Smith Island
STEPHENS ISLAND
Porcher Island
0 5 10 15 20 Miles

Some of the channels parallel to the regional (NNW - SSE) trend are the loci of faults, and others possibly follow fault zones that are no longer exposed. Portland Inlet, which crosses the regional trend, is possibly a major fault, but the continuity of some of the map units across this inlet suggests that there has not been any major lateral movement.

Gold and copper prospects have been known for many years on Porcher Island, and during the 1930's gold was mined at two localities. Magnetite, in iron formation, forms a distinct zone along the eastern shore of Porcher Island. Minor zinc occurs near the eastern margin of the Ecstall pluton.

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[1] Dolmage, V.: Coast and islands of British Columbia between Douglas Channel and the Alaskan boundary; Geol. Surv. Can., Sum. Rept. 1922, pt. A, pp. 9-34 (1923).

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

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31. PALAEONTOLOGICAL AND STRATIGRAPHIC STUDIES OF UPPER JURASSIC AND LOWER CRETACEOUS ROCKS IN TASEKO LAKES (92 O) MAP-AREA

J.A. Jeletzky

Further work in Taseko Lakes area[1] revealed the presence of some 600 feet of fossiliferous marine uppermost Jurassic (Upper Tithonian) and basal Cretaceous (basal Berriasian) shales and siltstones between Buchia cf. blanfordiana and typical Buchia okensis zones. These rocks carry Buchia fischeriana fauna below and Buchia subinflata - early Buchia okensis fauna above. The latter is correlative with the youngest Buchia fauna of the Knoxville Formation of California and occurs immediately below the typical B. okensis fauna of British Columbia[2]. The Jurassic-Cretaceous boundary was tentatively drawn between the B. subinflata - early B. okensis and typical B. okensis beds within an apparently uninterrupted shale sequence.

The Lower to ? Middle Hauterivian Inoceramus colonicus zone begins only some 200 to 300 feet above the top of the Upper Valanginian Buchia crassicollis zone. Dichotomites oregonensis and Speetoniceras cf. agnessense-Simbirskites spp. faunas occur within Inoceramus colonicus zone, but their time relationships are uncertain. Beds with Craspedodiscus ex gr. discofalcatus? and Simbirskites ex gr. progredicus occur some 1,000 feet above the highest known occurrence of I. colonicus. These beds are Upper Nauterivian in age, Several hundred feet of shales and limy siltstones with Crioceras (Hoplocrioceras?) sp. ind., Inoceramus nov. sp. aff. quatsinoensis and Acroteuthis ex aff. impressa overlie the Craspedodiscus-Simbirskites beds; they may possibly be of Barremian age, although no exact dating is now possible. The Aptian is probably either represented by coarse, non-marine(?) clastic rocks or by a regional hiatus (an orogenic phase).

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[1] Jeletzky, J.A.: Stratigraphy and correlation of Late Upper Jurassic and Lower Cretaceous Rocks of Taseko Lakes area; in Jenness, S.E.: Summary of activities; Field, 1963; Geol. Surv. Can., Paper 64-1, p. 20-21.

[2] Jeletzky, J.A.: Late Upper Jurassic and early Lower Cretaceous fossil zones of the Canadian Western Cordillera; Geol. Surv. Can., Bull. 103 (in press).

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32. STUDIES OF SAND AND GRAVEL DEPOSITS IN SOUTH-CENTRAL BRITISH COLUMBIA

S.F. Leaming

A study of the sand and gravel deposits in south-central British Columbia begun in 1963 was completed in 1964. The area covered includes the main centres of population in a block between the 49th and 51st parallels from 115° 30' to 121°30'. The relatively low population density is reflected in the figures for production of sand and gravel, which amounted in 1962 to about 12 per cent of the provincial total.

Sand and gravel deposits are abundant in this area but owing to urban expansion, the convenient deposits are being alienated for other purposes. Practically all the deposits are located in the valley bottom and lower slopes and therefore must compete with other land-use requirements.

Most of the deposits are associated with the wasting of the last continental glacier and are glacial-fluvial recessional outwash deposits. Some deposits, notably along Columbia River are mainly post-glacial fluvial deposits. Pre-glacial deposits are rare.

The composition of the gravels depend on the local bedrock. Generally, they are largely composed of granitic and metamorphic rocks; weak or absorbent Tertiary sediments and vesicular basalts are minor. High-quality aggregate is made from some deposits without any processing save rejection of oversize. A white coating of calcium carbonate is a notable feature in many interior pits. A large part of the production goes into provincial and municipal roads as fill, base course, and asphalt surfacing. Most towns support one or more ready-mix concrete plants.

33. GREENWOOD (82 E/2) MAP-AREA

H.W. Little and R.I. Thorpe

Geological mapping of Greenwood (82 E/2) map-area was completed in 1964 for final publication on the scale of 1 inch to 1 mile. Thorpe was responsible in 1963 for most of the area bounded by July, Eholt, Boundary, and McCarren Creeks. Little mapped most of the remainder of the area, and was ably assisted by V.A. Preto in 1964. The cooperation and assistance of many residents in the area is gratefully acknowledged. Geological data have been supplied by geologists of the Granby Mining and Smelting Company, especially George Addie on Greenwood area, and by R.C. Pearson, R.L. Parker, J.A. Calkins, and others of the U.S. Geological Survey on areas to the south that have a bearing on the local geology.

Fossils were identified by E.T. Tozer, E.W. Bamber, and Peter Harker of the Geological Survey, and by Donald F. Squires of the American Museum of Natural History.

The generalized sketch map and the following comments are based solely upon field work; revision of some map-units, particularly parts of Units 13, 18, and 19 may follow thin section examination.

Map-unit 1 is believed to comprise the oldest rocks in the map-area. Its relationship to Unit 2 is not known; the contact was not seen, being either covered by drift and, for much of its length, marked by a zone of sheared serpentinite.

Unit 2a is tentatively correlated with Unit 2 because the most abundant component of each is a distinctive bedded chert with thin, black argillaceous partings along the bedding. In Unit 2a, which is generally more metamorphosed than Unit 2, these argillaceous partings are now biotite or hornblende.

Map-unit 2 is succeeded northward progressively by Units 3, 4, and 6, the last being probably the youngest and least metamorphosed. Fossils from one of two localities in Unit 3 are Palaeozoic; the other collection is not yet identified. The relationship of Unit 5 to others is puzzling. It seems to occupy the same stratigraphic position as Unit 3, but if so, it marks an abrupt lateral gradation from argillaceous rocks to limestone. Fossils from Unit 5 are tentatively classified as probably Palaeozoic. No fossils have yet been found in Unit 6.

Unit 7 rests unconformably on chert of Unit 6 and, near McCarren Creek, apparently also on chert of Unit 2. Where the contact is exposed, the succession stratigraphically upwards is massive chert, fractured chert, chert breccia, and bedded chert sharpstone conglomerate. North of Providence Creek chert beds of Unit 6 are truncated at the unconformity. Contacts between greenstone of Unit 6 and sharpstone conglomerate of Unit 7 were not seen. The writer agrees with Seraphim[1] that Unit 7 comprises clastic rocks and not jasperoid. The clastic material is clearly bedded and in several places tops can be determined from graded beds. The matrix of the upper part of the unit is chloritic and many of the fragments are of volcanic rocks, but both chlorite and volcanic fragments are commonly lacking in the lower part.

The Rawhide Formation (8), as Seraphim has shown, lies within Unit 7 and is of limited lateral extent. Map-unit 9 overlies Unit 7 with apparent conformity, and is locally silicified or altered to skarn. The age of Unit 9 is Middle Triassic, as it contains Daonella, and shells found in the Rawhide Formation (8) by Thorpe are Middle or Upper Triassic. Map-units 8 and 9 are therefore Middle Triassic, as is the upper part of Unit 7, but the lower part may be Lower Triassic.

Map-unit 10 comprises limestone conglomerate, believed to be basal, and agglomerate, both members containing limestone boulders resembling that of Unit 9. The limestone conglomerate, which may be basal, can be traced intermittently southward toward Fisherman Creek, just north of which it is well exposed in highway cuts. South of Fisherman Creek is limestone-bearing agglomerate that may represent a lateral gradation of the conglomerate. Massive limestone associated with these rocks contains Upper Triassic (Norian) corals. In lower July Creek grey shales interbedded with limestone are identical to Halobia-bearing beds some 5 miles to the south near Danville, Washington, and so are also placed in Unit 10.

Unit 11, consisting mainly of flow-breccia, massive greenstone, and, in the southeast corner of the map-area, interbedded limestone (11a), rests upon Units 2, 7, 9, and 10, apparently unconformably. Megascopically the lavas resemble those of the Rossland Group to the east, of Lower and Middle Jurassic age. Massive basalt (11b), mapped by Seraphim[1], is tentatively correlated with Unit 11, as is massive greenstone (11c) in Hypolite Creek, which seems to truncate bedding of Unit 1 but is neither schistose nor lineated like Unit 1. Unit 11c does not, however, show any volcanic structures, but on the other hand is very fine grained for an intrusive body.

Map-unit 12 consists mostly of serpentinite, but coarse-grained pyroxenite forms part of the body near the head of July Creek. South of May Creek rocks associated with ultrabasic rocks of Unit 12 are differentiated into layers of gabbro and anorthosite.

Unit 21 comprises rocks that occur mainly in Unit 2, and all are more or less fractured and brecciated. It represents the northern extension of a zone of breccias tentatively mapped by R.C. Pearson of the U.S. Geological Survey (personal communication) as a large slide mass that rests upon Daly's Midway Group, and the writer concurs that this is the most likely explanation to account for its origin.

The complexity of the geology is such that there is insufficient space to show structure other than faults on the sketch map.

L E G E N D

QUATERNARY AND RECENT

22	Till, sand, and gravel; areas of little or no outcrop

TERTIARY

21	Bedded chert, greenstone, syenitic, dioritic, and gabbroic rocks, all more or less brecciated; some serpentine
20	CORYELL INTRUSIONS: Syenite, quartz monzonite, pulaskite
19	Rhyodacite
18	Diorite, medium-grained, and some gabbro
	EOCENE OR OLIGOCENE
17	DALY'S MIDWAY GROUP: latite, andesite; minor tuff
	EOCENE
16	KETTLE RIVER FORMATION: Dacitic tuff and arkose, locally conglomerate and shale

CRETACEOUS OR TERTIARY

15	Quartz porphyry and quartz-feldspar porphyry

CRETACEOUS (?)

14	VALHALLA INTRUSIONS: Granite and quartz monzonite, mainly porphyritic
13	NELSON INTRUSIONS: Granodiorite and quartz diorite
12	Serpentinite and pyroxenite; 12a, pyroxenite; 12b, anorthosite-gabbro complex

JURASSIC (?)

11	Flow breccia and massive greenstone; 11a, interbedded limestone; 11b, massive basalt; 11c, massive greenstone in Hypolite Creek

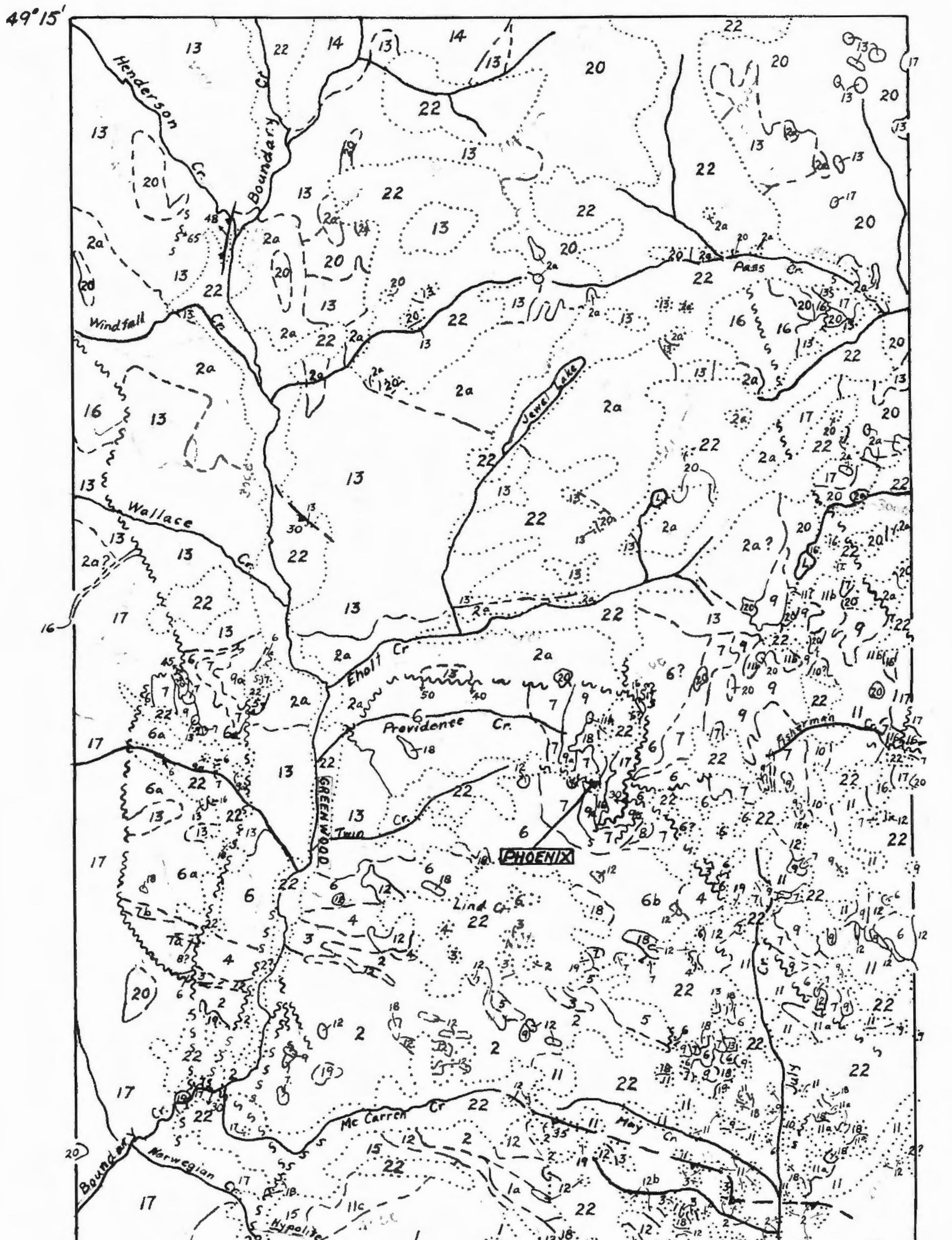
TRIASSIC

	UPPER TRIASSIC
10	Limestone conglomerate, limestone, grey and buff shale, red agglomerate and conglomerate, commonly limestone-bearing
	MIDDLE TRIASSIC
9	Limestone; some skarn; minor sharpstone conglomerate, siltstone, and shale; 9a, mainly skarn
8	RAWHIDE FORMATION: Black siltstone; minor black argillite and chert sharpstone conglomerate
	MIDDLE AND (?) LOWER TRIASSIC
7	Sharpstone conglomerate with mainly chert fragments; minor chert sandstone and siltstone, and green argillite; 7a, mainly chert sandstone; 7b, green argillite

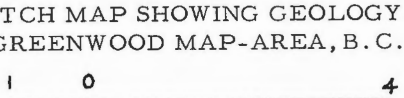
PERMIAN AND/OR EARLIER

6	KNOB HILL FORMATION: Massive chert and greenstone; locally minor limestone and tan argillite; 6a, mainly chert; 6b, mainly greenstone
5	Limestone; some limestone with thin chert interbeds
4	Amphibolite; minor greenstone and bedded chert
3	Black to grey bedded argillite; locally some grey chert and cherty siltstone, and minor chert sharpstone conglomerate
2	Bedded chert, commonly with argillaceous partings; chlorite schist, mica schist, and minor limestone; 2a, bedded chert, hornfels, mica schist, chlorite schist, and minor limestone. May not be equivalent to 2
1	Black phyllite; minor argillaceous quartzite and greywacke; 1a, includes interbedded chlorite schist

Geology by H.W. Little, 1963 and 1964, and R.I. Thorpe, 1963



SKETCH MAP SHOWING GEOLOGY OF GREENWOOD MAP-AREA, B.C.



Relatively few bedding tops have been determined so no major folds have been outlined. Minor folds with amplitudes up to about 100 feet are seen in Unit 9. A major overturned syncline is inferred about 3 miles southwest of Greenwood because chert of Unit 6 occurs both north and south of chert sandstone (7a), which strikes east and dips 40 degrees north, and Unit 9 is missing. However, the thick argillite unit (7b) that occurs along the north contact is missing to the south.

In general, bedding in Units 1 to 6 trends northwesterly, but that in Unit 2a north of Eholt Creek for the most part trends northeasterly. Unit 1 has strong wrinkle lineation that plunges 10° to 25°, S 70° to 80°E. In Units 2 to 6 lineation is commonly faint or indeterminate. In Units 7 to 10, bedding generally trends northerly. Because of the unconformity between Unit 7 and older units, it is evident that the northwesterly trend of those units was established before Units 7 to 9 were deposited, but no evidence that the northerly trend of the latter was superimposed on the former has been seen. It is possible, therefore, that a decollement exists between the major parts of Units 7 to 9 and older units. More detailed structural studies would be required to resolve this problem.

A pre-Tertiary fault strikes east through Phoenix and apparently has a vertical displacement of not more than a few hundred feet, though the horizontal displacement may be greater. Between Providence and Eholt Creeks a reverse fault dipping south, which is possibly a thrust, has been traced from the Providence mine, near Greenwood, some 4 miles eastward. It is presumed to be cut off by a north-trending, gently dipping fault that bounds on the east the Tertiary sediments and volcanic rocks (16 and 17) near the Phoenix mine. The age of the north-northwesterly trending fault in the northeast part of the area is not known. Another major fault has been traced from near Phoenix, where it marks the north boundary of the Snowshoe orebody, southeastward to the eastern border of the map-area. This fault, and the north-trending ones south of Greenwood in Boundary Creek, are pre-Tertiary and are partly occupied by dykes of Tertiary diorite, which is unsheared, or nearly so. Where the above major faults are bounded on one or both sides by massive chert, chert breccia that does not resemble the bedded sharpstone conglomerate locally forms zones up to several hundred feet wide.

South of May Creek, Palaeozoic rocks are thrust northward over rocks of Unit 11. West- and southwest-dipping faults in upper Boundary Creek are believed to be thrusts.

In 1964, the only large mining operation was that at Phoenix, and the only other production was from the Skomac mine. Active exploration by geophysical methods and drilling was being done at some other properties and prospects, in a search for copper and molybdenum ores.

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[1] Seraphim, R.H.: Geology and copper deposits of Boundary District, B.C.; Trans. Can. Inst. Mining Met., vol. LIX, pp. 384-394 (1956).

34. ALBERNI (92 F) MAP-AREA

J.E. Muller

Mapping of the northwest quarter and the Comox coal-area in the northeast quarter of the map-area was completed in 1964. Within this area detailed mapping by W.G. Jeffery of the British Columbia Department of Mines of the Permian rocks west and south of Buttle Lake was also in progress.

Formations encountered are, with minor variations, like those reported in the preliminary map of the southeast quarter of the area[1].

A structural uplift, in some respects similar to that of the Nitinat-Horne Lake uplift, exposes Sicker Group volcanic tuffs and breccias west and south of Buttle Lake. Here overlying Permian limestone, recently studied in detail by R.W. Yole, attains its greatest thickness and continuity on Vancouver Island.

The uplift plunges northward at 10 to 20 degrees, exhibiting an impressive homoclinal sequence of Triassic basaltic rocks. It is estimated that between 12,000 and 15,000 feet of pillow basalts overlie the Permian limestone disconformably on both sides of Buttle Lake. In the west, north of Elk River, they are succeeded by a few hundred feet of pillow breccias and between 7,000 and 10,000 feet of massive flows with amygdaloidal tops, mainly 1 foot to 20 feet thick. To the east, in Forbidden Plateau and Comox Lake areas, several thousand feet of pillow breccia and minor tuff overlie pillow basalt, forming the top of the incomplete sequence.

Thick-bedded limestone and shaly limestone, up to 1,500 feet thick, and with Upper Triassic fauna overlie the volcanic rocks in the Iron River area and have recently been studied in detail by D. Carlisle and co-workers.

Andesitic to rhyolitic tuffs and breccias, mainly massive and structureless, succeed the Triassic rocks in the Quinsam Lakes area and are probably Jurassic in age.

The Permian to Jurassic rocks are intruded by granitic rocks, ranging from biotite quartz monzonite to hornblende diorite. The body in the Quinsam Lakes area is variable in composition and broken by many faults, smaller stocks occur at the head of Cruikshank Creek and Henshaw Creek. From the island watershed westward the area is underlain by a large batholith, consisting mainly of coarse-grained biotite quartz monzonite. There roof pendants of contact metamorphic volcanic rocks, containing many granitic dykes, form most of the rugged peaks.

Conglomerate, sandstone, shale, and coal of the Upper Cretaceous Nanaimo Group overlie the older formations disconformably and occur in the coastal area, the Quinsam Lakes area, and on Mt. Washington and several adjacent outliers on Forbidden Plateau. A very coarse conglomerate containing mainly pebbles and boulders of volcanic rocks forms the base in a narrow belt on both sides of Oyster River and may represent an ancient major drainage channel. Special attention was given to formations of the Nanaimo Group in the Comox and Nanaimo areas. Detailed sections of the shale formations were measured and sampled for microfossils by K. Roy of the writer's party. It is expected that this study of the Upper Cretaceous basin of deposition will continue next year.

Mt. Washington and adjacent Cretaceous rocks are invaded by a laccolith of porphyritic hornblende dacite, similar to sills mapped in the Nanaimo Lakes area[1]. The sills, and especially the root of hornblende quartz diorite, have converted the Cretaceous rocks into quartzite and hornfels.

The structure is characterized by block faulting and tilting, and folding is virtually absent. Main directions of faults are about due north and north 40° west. Since Cretaceous beds are considerably affected, the main displacements may have occurred in Tertiary time. Horizontal slickensides suggest that some strike-slip faulting may have occurred together with normal faulting.

Various types of economic mineral deposits are present. Copper-zinc-lead-sulphides with silver and gold values occur in a northwest-trending shear zone in Sicker volcanic rocks (Western Mines). Magnetite and chalcopyrite are emplaced in contact-metamorphic Triassic limestone (Argonaut Mine). Copper sulphides, magnetite, minor molybdenite, and realgar occur at the contact of dacite porphyry and related breccia with Cretaceous sediments (Mt. Washington). Apart from these known types of mineral occurrences Triassic volcanic rocks at granitic contacts and the Jurassic tuffs commonly contain disseminated sulphides that locally could be of economic significance.

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[1] Muller, J.E.: Geology, Alberni area, British Columbia; Geol. Surv. Can., Map 49-1963 (1964).

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35. ORDOVICIAN AND SILURIAN BIOSTRATIGRAPHY IN THE ROCKY MOUNTAINS OF BRITISH COLUMBIA

B.S. Norford

Field work in the southern Rocky Mountains included detailed study of a critical stratigraphic section that was discovered by G.B. Leech in 1963. The section is near the North White River and shows interfingering of the Middle Ordovician easterly (carbonate) and westerly (graptolitic) facies.

Work with Operation Liard in the northern Rocky Mountains (see report by G.C. Taylor, elsewhere in this publication) traced a distinctive Silurian dark dolomite unit from the Peace River north to the Liard River. Vuggy porosity is locally important and the unit may prove to be a significant oil and gas reservoir in its subsurface development in the La Biche River (95 C), Toad River (94 N), Tuchodi Lakes (94 K), Fort Nelson (94 J), Trutch (94 G), and Halfway River (94 B) map-areas.

36. A STUDY OF THE ENVIRONS OF THE EAST CONTACT OF THE KUSKANAX BATHOLITH

Peter B. Read

The eastern part of Poplar Creek (82 K/6) map-area is underlain by rocks of the Lardeau Group. Correlation by physical continuity with the stratigraphic sequence of the Ferguson area[1] shows that the Lardeau Group within the map-area consists of grey phyllite and metavolcanic rocks of the Index Formation and meta-grit and mica schist of the Broadview Formation. The Triune, Ajax, Sharon Creek, and Jowett Formations of the Ferguson area are absent. The Lardeau Group has undergone multiphase deformation with at least three phases affecting the distribution of formations. Of the two coaxial phases of folding about predominantly northwesterly trending and plunging axes, the first phase is represented by folded isoclinal folds and related thrust faults and the second phase by N-shaped folds (looking northwesterly in cross-section) with a northeasterly dipping axial plane. Second phase structures are large compared to first phase folds and most of the Lardeau Group in the map-area lies on the southwestern limb of the second phase Silvercup Antiform[1].

The central part of the map-area is underlain by Milford Group with Broadview Formation outcropping in cores of northwesterly and southeasterly plunging second phase antiforms formed prior to the intrusion of leucocratic quartz monzonite stocks. The northeastern contact of the Milford Group, though locally infolded with the Broadview, is modified by faults developed subsequent to second phase folding but prior to intrusion of the stocks.

To the west, the leucocratic aegirine-augite gneiss of the Kuskanax batholith appears to have been involved in first phase deformation, and Kuskanax dykes and sills in the Milford Group are folded by second phase folds.

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

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37. THE THOR-ODIN GNEISS DOME, SOUTHERN BRITISH COLUMBIA (PARTS OF 82 L/8 AND 82 L/9)

J.E. Reesor

The study of Thor-Odin gneiss dome, the southern part of a large domal complex within the Shuswap Metamorphic Complex, was continued for two months during 1964. The complex consists of four structurally and petrologically distinct units: a gneissic inner core; an envelope of metasedimentary gneiss; an outer zone of predominant pegmatite and leucogranite with minor metasedimentary gneiss; and a fringing zone of low-grade metasediments and volcanic rocks. The contact between the core and the enveloping gneisses is well defined and sharp, other contacts are less well defined and the outer fringe zone is marked either by a wide zone of crushing and mylonitization or by a rapid gradation in metamorphic grade from sillimanite-almandine-orthoclase through a sillimanite-almandine-muscovite to a staurolite-bearing zone, to greenschist facies. Kyanite is sporadically present at some localities. The metamorphic zones show a rude concentric arrangement about the central core.

Superimposition of structural elements shows a complex structural evolution consisting of at least two important episodes that can be identified in all rock types and in all zones. The earliest consists of large-scale folding with a northeast to eastward trend. These folds are considerably modified by a later penetrative folding, trending northwest within the core zone, but east-west south of the core. Local trends conform to the overall oval shape of the core zone. Thus it appears from the study so far completed, that early northeast folds were formed independent of the domal structures, but that the principal late structures are closely related to the formation of the dome. Metamorphism may have reached a culmination during the second principal phase of structural evolution.

Local structural complexities show superimposition of up to four structural episodes. In the interpretation of such local complexities it is necessary to evaluate their regional importance over a large area. On this basis such complexities are tentatively interpreted as testifying to complex subepisodes and local irregularities within the two principal structural events recognized over the entire area.

38. STRUCTURAL STUDIES, MOUNT REVELSTOKE AREA (PARTS OF 82 M/1, 82 N/4)

J.V. Ross

The map-area embraces the easternmost or marginal part of the Shuswap metamorphic complex where it is in contact with the less metamorphosed rocks lying to the east.

Present field work suggests that gneisses within the map-area, belonging to the Shuswap complex are equivalent to the less metamorphosed Hamill and Lardeau sediments to the east. The contact between these two large groups of rocks appears to be contained within a narrow transitional zone, along which later dislocation has occurred.

Structures within these groups of variable metamorphosed rocks indicate a common structural history and origin. Recumbent folds plunging northerly appear to be first structures that were developed during an episode of dynamothermal metamorphism wherein the Shuswap gneisses were formed, the metamorphic grade decreasing to the east. Towards the end of the movement dioritic material was emplaced into the metamorphosed sediments in the form of flat-lying tabular bodies almost parallel to the axial-surfaces of the recumbent folds.

Further movement caused dislocation at the upper margin of the dioritic zone of intrusions and gave rise to a new set of structures having variable plunges contained within steeply dipping axial-surfaces that trend easterly and southeasterly.

39. CRETACEOUS STRATIGRAPHY OF NORTHEASTERN BRITISH COLUMBIA

D.F. Stott

Cretaceous and Jurassic rocks were examined in the Foothills between Graham River at latitude 56°30' and Fort Nelson River at latitude 59°30' and eastward on the Plains to longitude 122°. In addition, the distribution of Cretaceous rocks was mapped in parts of the map-areas of Fort Nelson (94 J), Maxhamish (94 O), and Toad River (94 N).

Several new sections and other critical exposures of the Jurassic Fernie and Lower Cretaceous Monteith and Beattie Peaks Formations were examined in the map-areas of Halfway River (94 B) and Trutch (94 G). Obtained data confirm and improve correlations presented in a final report[1] submitted for publication.

Numerous sections of the Gething Formation reveal that its well sorted nearshore sandstones grade laterally northward from Halfway River and eastward from the Foothills into marine shales. The Gething is a mappable unit as far north as Tuchodi River, but beyond there, only a very thin sandstone occurs at the base of the Fort St. John Group and, for mapping purposes, is included with the latter. The pre-Gething unconformity bevels successively older rocks from south to north. At Halfway River, the rocks immediately below the unconformity are the Lower Cretaceous (Valanginian) Beattie Peaks Formation. In the eastern Foothills along the Alaska Highway, the underlying beds are the Middle Triassic (Ladinian) Liard Formation.

The Lower Cretaceous Fort St. John Group contains a variable succession of marine rocks in this region. In the Trutch area, it comprises, in ascending order, thick Buckinghorse shales, Sikanni sandstones, and Sully shales. A sandstone, present within Buckinghorse equivalents between Muskwa and Tetsa Rivers, represents some part of the Scatter Formation of the Liard River basin. Father east, both that sandstone and the Sikanni sandstones grade laterally into shales and argillaceous siltstones. The Sikanni sandstones also thin rapidly northwestward in the vicinity of Dunedin River.

The Upper Cretaceous Fort Nelson Formation, equivalent to much of the Dunvegan Formation of the Peace River Plains, maintains a relatively uniform thickness of approximately 500 feet throughout the region. It comprises several units of massive conglomerate separated by fine-grained sandstone and mudstone. North of the Alaska Highway, the Fort Nelson is disconformably overlain by the Kotaneelee Formation. As no equivalents of Upper Cretaceous Turonian beds (Kaskapau and Blackstone Formations) are known to occur between the Fort Nelson and Kotaneelee in this region, the disconformity represents a major hiatus.

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[1] Stott, D.F.: The Fernie and Minnes strata north of Peace River, Foothills of northeastern British Columbia; Geol. Surv. Can., Bull. (in press).

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40. OPERATION LIARD

G.C. Taylor

G.C. Taylor, E.W. Bamber, R.T. Bell, B.S. Norford, and D.F. Stott continued the study of the surface rocks within the project area of Operation Liard, an air-supported reconnaissance geological survey in northeastern British Columbia.

Strata from all systems except the Tertiary are exposed within the area. For details of the Mesozoic strata see account by Stott elsewhere in this publication; for Permo-Carboniferous strata, see Bamber, and for Silurian strata, see Norford,both elsewhere in this publication. The studies of R.T. Bell on the Proterozoic and some of the lower Palaeozoic strata are included in this report.

Not less than 25,000 feet of Proterozoic sedimentary rocks underlie the south-central region of Tuochodi Lakes map-area. Only the lower 14,500 feet of these rocks has been studied in detail. The sequence is one of normal marine miogeosynclinal sediments with an increasing clastic content in the progressively younger rocks. Conspicuous and persistent basic dykes cut this succession. To the west the units are conformably overlain by a weakly metamorphosed formation. This unit is interpreted to be metavolcanic rocks, and is probably associated with the dykes.

Unconformably overlying the Proterozoic rocks is an extremely variable succession of lower Cambrian sediments. Active faulting at the time of deposition of these sediments can be demonstrated. Thick (+5,000') conglomerates and conglomeratic clastic rocks were deposited near these faults and interfinger rapidly with normal marine deposits of the same age.

Thick (7,000') Lower and Middle Ordovician limestones unconformably overlie the older rocks. Westwards these carbonates grade into a graptolitic shale facies along a front immediately west of the main drainage divide. In the western part of the graptolitic basin thin flows and volcanic sediments are interbedded in the Lower Ordovician succession.

Unconformably overlying the older rocks is a blanket of carbonates ranging in age from low Middle Silurian to Middle Devonian. Only minor facies changes within this blanket are noted from the British Columbia - Yukon border in the north to the southern boundary of the project area. The most significant such change is noted at the top of the Middle Devonian unit south from Kiely Creek.

South from Kiely Creek a massive, commonly dolomitized reef caps the succession. A well developed reentrant in this reef front occurs south of Redfern Lake, so that the reef is not present on Mount Helen or Mount McCusker, though it is present in surface exposures to the east of these localities.

The dominant structural habit of the area is the fold. Within the mountains significant reverse faults are observed with stratigraphic displacements of several thousand feet. Only one low-angle thrust fault of significant displacement was observed. While the bulk of the deformation within the area can be ascribed to the Laramide orogeny, large Proterozoic, Lower Cambrian, Upper Ordovician, and lesser younger deformations can be demonstrated to predate the Laramide.

41. BONAPARTE RIVER EAST HALF (92 P E1/2) MAP-AREA

H.W. Tipper and R.B. Campbell

The area is readily accessible by means of the North Thompson Highway and a network of secondary and logging roads radiating from it. For the most part, the area is heavily drift-covered and densely forested. Most of the drift areas have been omitted from the accompanying map for simplification.

Glaciation was intense and ice moved into the area from the north and crossed the area in a southerly direction. Conflicting information suggests that the direction of ice movement changed during deglaciation.

Strata of the Snowshoe Formation (map-unit 2 on the accompanying figure) are on trend with rocks believed to belong to that formation to the north in Quesnel Lake map-area[1].

Rocks of the Cache Creek Group (3a, 3b) can be traced continuously from areas of palaeontologically dated rocks in Nicola[2] and Vernon map-areas[3] to the south and southeast. They can also be followed continuously through Adams Lake map-area[4] into the Vernon map-area, where they are mapped as the Mount Ida Group of possible Precambrian age[3]. In the North Thompson Valley these rocks (3a, 3b) were mapped as probably Precambrian by Uglow[5] and as partly Carboniferous and partly Cambrian by Dawson[6]. The rocks of the Cache Creek Group in the northern part of the map-area (3c) are entirely separated from those to the south and may be of different age.

The rocks of map-unit 4a are thought to be mainly Upper Triassic, but proof of this awaits the identification of fossils in several collections. The volcanic rocks of map-unit 4b may be of the same age or younger. Some limestone beds (4c) are Permian in part and relation to units 4a and 4b is not known.

The shale and argillite of map-unit 5a is believed to be equivalent to the phyllite of map-unit 5b because of the close association of the two units to the Fennell Greenstone (6). The argillaceous rocks (5a) appear to underlie the greenstone. Their age is not known.

LEGEND

QUATERNARY
PLEISTOCENE AND RECENT

14 Glacial deposits; alluvium

TERTIARY(?) AND QUATERNARY
PLIOCENE(?), PLEISTOCENE, AND RECENT

13 Basaltic fragmental deposits, cinder cones, lava cones, and flows

TERTIARY
MIOCENE AND/OR PLIOCENE

12 Basaltic and andesitic flows; minor volcanic fragmental deposits and gravel

11 Shale, sandstone, conglomerate, and diatomite

EOCENE OR LATER

10 Andesitic and basaltic breccias, tuffs, and flows; minor dacite and rhyolite

EOCENE

9 Conglomerate, sandstone, and shale

CRETACEOUS OR EARLIER

8 8a, biotite granodiorite and quartz monzonite; 8b, syenite and monzonite; 8c, hornblende quartz diorite, diorite, and hornblendite; 8d, hornblende diorite

7 Serpentinite

JURASSIC OR OLDER

6 FENNELL GREENSTONE: andesitic and dacitic pillow lavas and massive flows; argillite and chert; greenstone dykes

5 5a, shale and argillite; minor tuff; 5b, black and dark grey phyllite (may not be equivalent to 5a)

4 4a, argillite, greenstone, amphibolite, metadiorite, chert, limestone, augite porphyry (may be all or partly intrusive); 4b, augite andesite breccia and agglomerate; 4c, limestone (Permian in part)

PERMIAN AND OLDER

3 CACHE CREEK GROUP
3a, argillite, phyllite, greenstone, limestone (includes small granitic bodies); augite porphy. (may be all or partly intrusive); 3b, phyllite, slate, and quartzite; 3c, phyllite, green schist, and greenstone (may be older than Cache Creek Group)

2 CARIBOO GROUP
SNOWSHOE FORMATION(?): quartzite, quartz-mica schist and phyllite

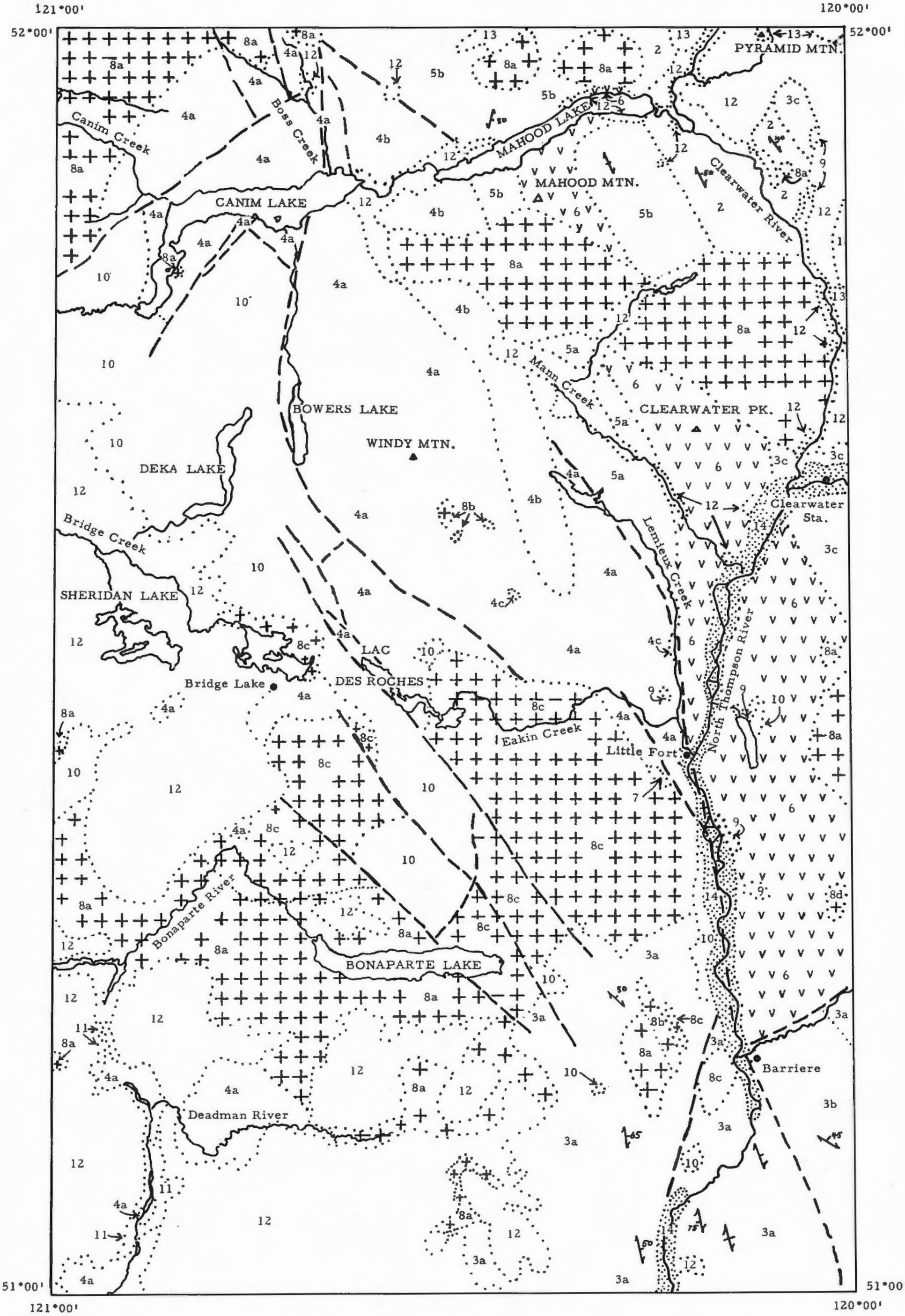
AGE UNKNOWN

1 SHUSWAP METAMORPHIC COMPLEX
Quartz-feldspar-biotite and hornblende gneiss, amphibolite, quartz-mica schist, and pegmatite

Geological contacts (assumed) . . . .

Faults (assumed) . . . . — — —

Foliation (inclined, vertical) . . . .



BONAPARTE RIVER EAST HALF, BRITISH COLUMBIA

5 MILES 0 5 10 15

The Fennell Greenstone (6) was first mapped and named by Uglow[5], who believed it to be a volcanic assemblage. Walker[7] thought the greenstone was an intrusive mass. Pillow structure is common though not universal throughout the unit and the rocks are amygdaloidal in many places. The writers concur with Uglow's opinion. The age of the greenstone is not known, but it would seem unlikely it is older than Carboniferous and might possibly be Triassic or Jurassic.

The quartz diorite mass (8c) northeast of Bonaparte Lake has a complex contact with the rocks of map-unit 4a. Intruded andesitic volcanic rocks are converted to amphibolite, metadiorite, and greenstone. The contact phase of the batholith is dioritic and locally contains bodies of hornblendite. The syenite (8b) west of the mouth of Barriere River locally contains a high percentage of closely packed potash feldspar crystals, which range to more than 1 inch in diameter and to 1/4 inch in thickness. The quartz monzonite (8a) west of Bonaparte Lake is coarse grained and low in mafic minerals.

Sedimentary rocks (9) of Eocene age are confined to the valleys of North Thompson and Clearwater Rivers. These rocks contain fragments of the older rocks that are exposed nearby. As suggested by Uglow[5] the sediments were evidently deposited in a valley that has persisted to the present.

Early Tertiary volcanic rocks (10) are believed to overlie the Eocene sediments (9), possibly conformably. In places these rocks (10) are mainly fragmental, in others mainly flows. The unit has been dissected by late block faulting into many isolated segments down-faulted into older rocks.

Late Miocene(?) buff-coloured shales, sandstones, and conglomerate (11) over 500 feet thick underlie the plateau basalt (12) along Deadman River. These are soft, poorly consolidated, and flat-lying. A few beds of diatomite up to 10 feet thick are interbedded.

The central interior of British Columbia is underlain in part by a widespread basalt lava plateau. These lavas (12) extend into the western part of the area around Bridge Lake and Deadman River. These rocks are flat-lying lavas, mainly basaltic, with well-formed columnar jointing in many places. The basaltic flows in the valleys of Clearwater River, Mahood Lake, and Mann Creek are believed to be equivalent to the plateau basalts. The surfaces of these flows are glaciated and no recognizable glacial deposits have been found beneath them. They evidently formed from local sources beyond the eastern margin of the plateau where they were confined to existing valleys.

Late Tertiary or Quaternary volcanic rocks (13) commonly form or are related to distinct cones. Some have been glaciated and some have not. Where they are in contact these rocks overlie the flows of map-unit 12.

Mineral occurrences are known at several places in the area. Copper and gold occurrences are known or reported in the Triassic rocks (4a) near Deadman River. Mineral occurrences are known in the northern part, particularly in and near unit 8a. No new occurrences were noted during the field work.

[1] Campbell, R.B.: Quesnel Lake, East Half, British Columbia; Geol. Surv. Can., Map 1-1963 (1963).

[2] Cockfield, W.E.: Geology and mineral deposits of the Nicola map-area, British Columbia; Geol. Surv. Can., Mem. 249 (1948).

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

[4] Campbell, R.B.: Adams Lake, British Columbia; Geol. Surv. Can., Map 48-1963 (1964).

[5] Uglow, W.L.: Geology of the North Thompson Valley map-area, British Columbia; Geol. Surv. Can., Summ. Rept. 1921, Part A, pp. 72-106 (1922).

[6] Dawson, G.M.: Shuswap sheet, British Columbia; Geol. Surv. Can., Map 604 (1898).

[7] Walker, J.F.: Clearwater River and Foghorn Creek map-area, Kamloops district; Geol. Surv. Can., Summ. Rept. 1930, Part A, pp. 125-153 (1931).

42. BONAPARTE RIVER WEST HALF (92 P W1/2) MAP-AREA

H.W. Tipper

The area is readily accessible to motor vehicles by means of the Cariboo Highway and many secondary, logging, and ranch roads.

Bedrock is, in general, poorly exposed. In the southwest and northeast quarters fair exposure occurs but elsewhere outcrops are limited to creeks, rivers, road cuts, and isolated hills. No drift areas are shown on the accompanying map although such areas are extensive.

The area was intensely glaciated and ice moved into the area from the northeast and east and from the southwest and west. Ice moved out of the area to the northwest and north and to the southeast and south. The glacial features provide a confused picture of glaciation and deglaciation and the area is interpreted as the location of a shifting ice divide that marked the division between northward- and southward-flowing ice.

The part of the area along Fraser River and around Mt. Bowman was mapped by H.P. Trettin for the British Columbia Department of Mines and Petroleum Resources. The geology as shown on the accompanying map and the following accounts of the Cache Creek and Pavilion Groups are taken from Trettin's work and a full account of the geology can be obtained from his bulletin[1].

LEGEND

CENOZOIC

TERTIARY

UPPER MIOCENE AND PLIOCENE

7	Olivine basalt, andesite; minor breccias and tuffs
6	Sandstone, shale, conglomerate

EOCENE TO MIOCENE

5	Basalt, andesite, related breccias; minor dacitic and rhyolitic flows and pyroclastic rocks

MESOZOIC

JURASSIC OR LATER

4	Biotite granite, granodiorite, quartz diorite; minor diorite

TRIASSIC

3	NICOLA GROUP Argillite, greywacke, andesite, volcanic breccia, limestone

PERMIAN AND/OR TRIASSIC

2	PAVILION GROUP Chert, argillite, limestone, sandstone, volcanic flows and tuffs

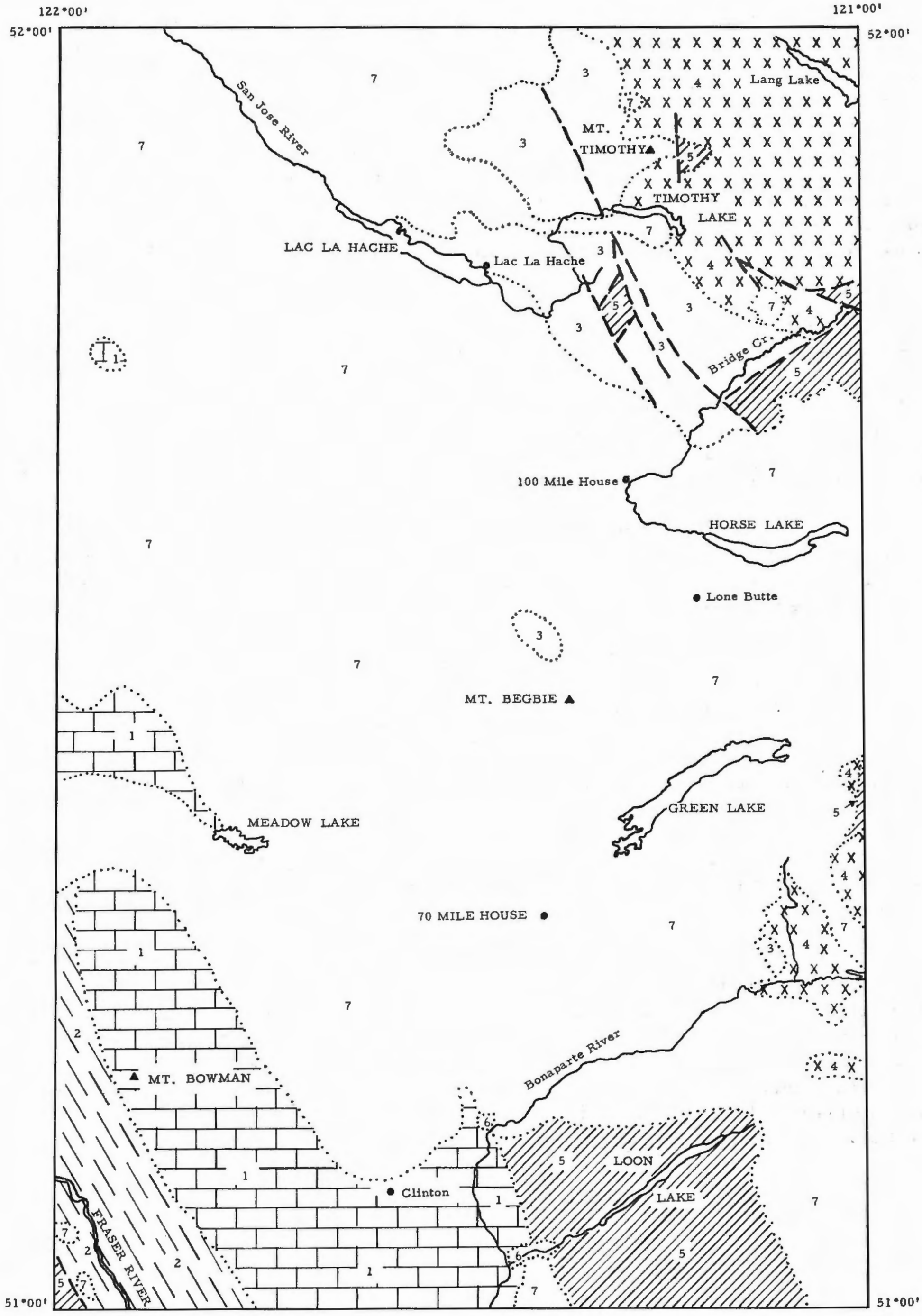
PALAEOZOIC

PERMIAN AND (?) OLDER

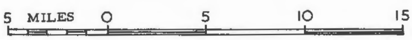
1	CACHE CREEK GROUP Limestone, chert, argillite, greywacke, volcanic flows

Geological boundary (assumed).. .·˙·.,.·

Fault (assumed).. — — —



BONAPARTE RIVER (WEST HALF), BRITISH COLUMBIA



The Cache Creek Group (1) is approximately 7,500 feet thick, the upper 6,000 feet of which is known as the Marble Canyon Formation consisting mainly of massive grey limestone with interbedded chert, argillite, and volcanic rocks. The age of the group is Late Permian but may in part be older.

The Pavilion Group (2) may be conformable with and gradational into the Cache Creek Group. The lower part of the Pavilion Group is mainly chert and argillite and the upper part is mainly volcanic rocks and sandstone. This group was formerly part of the Permian Cache Creek Group, but on the basis of poorly preserved corals is thought to extend, in part, into the Triassic.

The Nicola Group (3) as exposed in this area is mainly indurated sedimentary rocks that trend northerly and northwesterly. Limy argillites and limestone predominate. The volcanic breccias are mainly coarse green, mauve, and red-brown andesitic and basaltic fragments in a tuffaceous matrix of similar composition. Volcanic flows are uncommon. Dark green pyroxene andesite porphyries occur as sills, dykes, and flows, and in places fragments from these porphyries are predominant in volcanic breccias. These porphyries may be partly or entirely younger than the Nicola Group.

Granitic rocks (4) intrude the Nicola Group and in most places have sharp contacts and narrow contact zones. For the most part the rocks are coarse grained, usually non-foliated, have few inclusions, particularly east of Green Lake, and are generally low in mafic minerals.

The Eocene to Miocene volcanic rocks (5) are in fault contact with older rocks, but in the area to the east overlie Eocene sedimentary rocks. These rocks are mainly coarse volcanic breccias, tuffs, and flows, but the proportion of one to the other varies from place to place. The composition likewise is varied but is generally andesitic to basaltic, in places dacitic, and rarely rhyolitic. They are essentially flat-lying or have low dips and in places are difficult to distinguish from younger lavas (7).

Small areas of shale, sandstone, and conglomerate (6), usually of volcanic derivation, occur in old stream courses below the late Tertiary plateau lavas.

Nearly flat topography, abundance of basalt erratics, and scattered outcrops suggest that plateau lavas (7) underlie much of the central part of the map-area, but exposure is poor. Massive, vesicular, and amygdaloidal basalt flows, many of them olivine-bearing, predominate. Mt. Begbie and hills near Lone Butte are necks composed of feldspathic rocks, and flows of similar composition form the highest flows stratigraphically. Andesites are common but nowhere predominant. Breccias and tuffs are locally important but are of minor importance in the unit as a whole.

Structurally the units differ greatly. The Cache Creek (1) and Pavilion (2) Groups are folded with moderate to steep dips, in places overturned to the northeast. The Nicola Group may be folded but this group (3) together with the granitic rocks (4) and the Eocene volcanic rocks (5) is block faulted and results in a complex fault pattern, particularly around Timothy Mountain. Around Loon Lake the Eocene volcanic rocks possess a gentle dip. The late Tertiary rocks (6 and 7) are essentially undisturbed.

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[1] Trettin, H.P.: Geology of the Fraser River Valley between Lillooet and Big Bar Creek; B.C. Dept. Mines and Petroleum Resources, Bull. 44 (1961).

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43. TASEKO LAKES (92 O) MAP-AREA

H.W. Tipper

The southeast quarter of Taseko Lakes (92 O) map-area was studied to obtain further stratigraphic and structural information and to complete the reconnaissance mapping of the area.

The rocks from Upper Triassic to late Lower Cretaceous (Albian) are almost entirely marine sedimentary in the area near Tyaughton Creek, but the units that extend westward (mainly Cretaceous) grade very quickly into sedimentary rocks and pyroclastic rocks with interlayered volcanic flows. In the area around Spruce Lake and Tyaughton and Relay Creeks the best exposures of the marine Mesozoic sedimentary rocks occur and record the sedimentary history of much of Mesozoic time. Three important periods of non-deposition or erosion are recorded: 1) late Lower Jurassic (Pliensbachian and Toarcian) strata have not been recognized; 2) a period of erosion, non-deposition, and probable deformation in Middle Jurassic time (upper Bojocian and Bathonian) has produced a widespread unconformity; and 3) a late Lower Cretaceous unconformity (pre-Albian) is represented by coarse conglomerate and greywacke. The marine history of the area was apparently ended by late Albian and early Upper Cretaceous uplift, which was followed by widespread early Upper Cretaceous volcanism. Early Tertiary (Palaeocene?) volcanic rocks rest unconformably on the early Upper Cretaceous rocks.

The area is structurally complex as a result of repeated thrust faulting from the southwest and from the northeast and east. This thrusting may have been active as early as Middle Jurassic time, but the greatest deformation has occurred in post-Albian time. Tertiary normal faulting, intrusion, and volcanism have further complicated the structure.

Several mineral occurrences are known in Tyaughton and Relay Creek valleys, particularly mercury, tungsten, and gold occurrences. These deposits occur in rocks at least as young as Albian, and possibly Upper Cretaceous. They appear to be spatially related to mid-Tertiary feldspar porphyry dykes and stocks and to major fault zones. If this be the case they are then of Tertiary age (Eocene ?) and were deposited after the major period of thrust faulting.

44. STRATIGRAPHIC AND PALAEONTOLOGICAL STUDIES IN THE MARBLE RANGE (92 P/4)

H.P. Trettin

The writer spent 5 days in the Marble Range, between Clinton and Jesmond, revising earlier reconnaissance work[1] on the limestones of the Marble Canyon Formation. It was found that not only relatively thin limestone units but also thick, massive members are tightly, and, in part, isoclinally folded. The stratigraphic thickness of the limestones is therefore less than previously estimated. Only two extensive units are now recognized. In the southwestern part of the Mt. Bowman - Mt. Soues range, member I[1] is about 100 feet thick, and member III roughly 700 feet. The large limestone lens within member IV seems to be a structural repetition of member III. Four stratigraphic sections were measured and sampled for further laboratory studies. Most of the carbonate rock is very poorly bedded, microcrystalline limestone, locally mottled with dolomite. Some stromatolitic beds and calcarenites are present. Fossils, mainly fusulinids and echinoderms, are sparse. Only one coralline patch reef (loc. F 7[1]) has so far been recognized.

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[1] Trettin, H.P.: Geology of the Fraser River Valley between Lillooet and Big Bar Creek; B.C. Dept. Mines and Petroleum Resources, Bull. 44 (1961).

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45. BIG BEND (82 M E1/2) MAP-AREA

J.O. Wheeler

About three weeks was spent in the field completing the mapping of Big Bend map-area and in examining several mineral properties. A preliminary account of the geology of this area has just been published[1].

Two days were spent in a helicopter reconnaissance of Lardeau West Half (82 K W1/2) map-area as preparation for mapping in 1965.

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[1] Wheeler, J.O.: Big Bend map-area, B.C.; Geol. Surv. Can., Paper 64-32 (1964).

BRITISH COLUMBIA AND ALBERTA

46. KANANASKIS LAKES (WEST HALF) (82 J W1/2) MAP-AREA

G.B. Leech

This map-area spans the Rocky Mountains and Rocky Mountain Trench.

Gypsum, poorly exposed, occurs 2 1/4 miles southwesterly from Pocaterra Dam at Lower Kananaskis Lake. Larger outcrops of this Devonian (pre-Maligne) gypsum occur in at least two localities on the east side of Joffre Creek, just west of the Interprovincial Boundary.

Coarsely crystalline dolomite, in part pyritiferous, occurs extensively as a metamorphic facies of the Middle Cambrian Cathedral Formation at the western and southern base of Mt. Brussilof in the forks of the Cross and Mitchell Rivers. This occurrence is at the east edge of the zone in which Cambrian carbonate rocks give way westward to an argillaceous facies and the zone is relatively favourable for prospecting. The Monarch-Kicking Horse and Hawk Ridge Pb-Zn deposits are near its east and west sides respectively farther north.

Additional examples of diatreme breccias[1] were observed southeast of Palliser River. Chromite and pyroxenite, indicative of a deep-seated relationship, occur in a diatreme at the head of Blackfoot Creek, 1 3/4 miles south of latitude 50°.

The Mississippian section at Connor Lake is of the order of 7,500 feet thick, of which the Rundle Group comprises some 5,500 feet.

Devonian strata are much more abundant in the Stanford Range and the mountains northwest of Whiteswan Lake than has previously been supposed, and they are tectonically significant. Extensive breccias associated with faults are now interpreted in many instances as being fundamentally solution breccias, which, with associated gypsum, have localized faults. The Stanford fault is within or bounded on the east by Devonian strata for most of its length, as are the Mary-Anne and Redwall faults and major parts of faults in Fairmont Ridge. These faults are believed to have originated as low-angle easterly-directed thrust faults.

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[1] Leech, G.B.: Kananaskis (West Half) (82 J W1/2) map-area; in Jenness, S.E., Summary of Activities: Field, 1963; Geol. Surv. Can., Paper 64-1, p. 30 (1964).

47. LITHOSTRATIGRAPHIC STUDIES IN THE SOUTHEASTERN CANADIAN CORDILLERA

D.K. Norris

During the 1964 field season stratigraphic sections in southwestern Alberta and southeastern British Columbia were examined with a view to effecting a lithostratigraphic correlation between the Cambrian succession in the southeastern Canadian Cordillera and the northeastern American Cordillera, to locating the fossil plant-bearing beds in the Fairholme Group on Windsor Mountain, and to defining the nature, stratigraphic position, mode of origin, and source of the conglomerate in the upper part of the Blairmore Group that contains igneous pebbles.

An examination of the completely exposed lower part of the Cambrian succession on the west flank of Wood Creek Canyon[1], Montana, confirmed the obvious lithic correlation of the Flathead Formation between the Canadian and American Cordilleras and the fact that the Middle Cambrian shale and limestone succession lying between the Flathead and Elko Formations in Canada very probably contains strata in addition to the Gordon Formation of northwestern Montana. Yellowish grey weathering, nodular limestones in the upper part of the shale succession would appear to represent all or part of the Damnation Limestone, and dolomites and dolomitized limestones of the Elko all or part of the remainder of the Middle and Upper Cambrian succession of the northern American Cordillera. Upper Cambrian strata may therefore be present on Windsor Mountain.

The occurrence of fossil vascular plant axes on Windsor Mountain in Beaver Mines (82 G/8 E1/2) map-area[2] was examined and established to occur in a shale and siltstone succession resting unconformably on the Cambrian Elko Formation and with possible disconformity beneath the Upper Devonian Hollebeke Formation of the Fairholme Group. It may be equivalent to the "Devonian clastic unit" of Aitken[3] in the Bow Valley area. On the west face of Windsor Mountain the sub-Devonian unconformity is highly irregular. It has an observable relief of the order of 50 feet and the shale succession containing fossil plants fills the depressions. Yellowish grey weathering quartzose dolomite and pebble-conglomerate forming the base of the Hollebeke overlies the plant-bearing beds and locally rests on Elko Formation.

Igneous pebbles were collected from a conglomerate in the upper part of the Blairmore Group at several widely separated localities south of Bow Valley. With the possible exception of the occurrence on the ridge between Loomis and McPhail Creeks, the data support the contention[4] that in any given section of the Blairmore Group there is only one conglomerate containing igneous pebbles. In contrast to the Cadomin conglomerate, which is a widespread and continuous sedimentary body, this conglomerate is highly lenticular and grades rapidly laterally into feldspathic sandstone. It is observed to range in stratigraphic position from within Crowsnest facies on Slacker Creek in Beehive Mountain (82 J/2 E1/2) map-area and on the divide between Vicary and Blairmore Creeks in Blairmore (82 G/9 W1/2) map-area to approximately 900 feet below the top of the Blairmore Group on York Creek, 3 miles south of Coleman, Alberta.

[1] Deiss, C.: Cambrian stratigraphy and trilobites of northwestern Montana; Geol. Soc. Amer., Special Paper No. 18, pp. 28-31 (1939).

[2] Hage, C.O.: Beaver Mines; Geol. Surv. Can., Map 739A (1940).

[3] Aitken, J.D.: Ghost River type section; Bull. Can. Petr. Geol., vol. 11, No. 3, pp. 267-287 (1963).

[4] Norris, D.K.: The Lower Cretaceous of the Southeastern Canadian Cordillera; Bull. Can. Petr. Geol., vol. 12, Field Conference Guide Book Issue (Aug. 1964), pp. 512-535 (1964).

48. TECTONIC FABRICS, SOUTHERN ROCKY MOUNTAINS AND FOOTHILLS, ALBERTA AND BRITISH COLUMBIA

R.A. Price

Mesoscopic subfabrics were studied on a reconnaissance scale at a number of easily accessible localities in the Rocky Mountains between Yellowhead Pass and Crowsnest Pass. The localities were selected with the objective of relating the mesoscopic subfabrics to gross features of geologic structure, and of establishing some of the details of changes in tectonic style that occur among the various structural subdivisions and stratigraphic units in the region. These reconnaissance fabric data will serve as a basis for planning a more comprehensive study of the nature and variation of tectonic fabrics in the region and of the kinematics and mechanical basis of various structural features.

Preliminary results of analyses of some of the fabric data are available. A distinctive subfabric defined in terms of slickensided fractures characterizes most or all of the series of northeast-trending transverse "tear" faults that occurs in the McConnell, Misty, Mount Rundle, and Lewis thrust plates in Highwood, Misty, and Opal Ranges. On the basis of this subfabric it can be shown that movements have occurred along these faults in a direction approximately perpendicular to the thrust faults, which mark the limits of the individual thrust plates. Many of the transverse faults abut the thrust faults. Accordingly, the transverse faults may be old 'normal' faults, but they do not appear to be simple "tear faults" that developed during the thrusting. Moreover, it appears that the distinctive mesoscopic subfabric may not be restricted to the immediate vicinity of the transverse faults, but instead may be pervasive within this local area.

ALBERTA

49. STRATIGRAPHY AND STRUCTURE, UPPER CRETACEOUS FORMATIONS OF THE ALBERTA PLAINS

E.J.W. Irish

A detailed stratigraphic and structural study of the Upper Cretaceous formations of the Alberta Plains was started during the field season of 1964. Work during this field season was confined, largely, to the valley of Red Deer River from the town of Red Deer east to the Saskatchewan border and the region south of this river to, and including part of the valley of Bow River.

The exposed rocks include those belonging to the Edmonton, Bearpaw, and Belly River Formations. Forty-six stratigraphic sections of parts of these formations were measured. Lithologic samples were collected from the measured sections for laboratory study and analysis. All shale samples have been submitted for disintegration and examination for possible microfossils.

50. MISSISSIPPIAN SEDIMENTOLOGY, BOW AND HIGHWOOD RIVERS AREA

R.W. Macqueen

Field work has been completed for a detailed study of the Rundle Group, with over 40 sections measured.

The Livingstone Formation shows no readily observable field subdivisions from the type Mount Head map-area to the Panther River area; northward from the Panther River in the first, second, and third ranges a 3-fold subdivision (customarily termed "Pekisko-Shunda-Turner Valley") is easily recognizable at least to Red Deer River.

Mount Head Formation lithologies are similar to those of the type area in Front Range sections as far north as Exshaw Creek head; northward the formation thins, and the characteristic members of the type area are no longer easily recognizable, although alternations between a) spar-cemented calcarenites, and b) fine limestones and dolomites do occur. In ranges west of the Front Range, the lower part of the Mount Head Formation is difficult to separate from the Livingstone Formation, owing to the disappearance of sandy Mount Head members. At the level of investigation here undertaken the lower Mount Head can be separated from the Livingstone by the presence of a distinctive zone about 100-200 feet thick of fine limestones, brown-weathering dolomites, and minor dolomitic, crinoidal limestones. This zone and the overlying Livingstone-like limestones make up the lower Mount Head. The upper Mount Head thickens in more westerly sections, and changes facies from easterly cyclic limestones and dolomites to westerly dark shaly limestones with very abundant corals and brachiopods. North of Banff, the Mount Head Formation thins.

51. STRUCTURAL PROTOTYPES IN THE EASTERN CANADIAN CORDILLERA

D.K. Norris

A field study of the mesoscopic geometry, fracture fabric, and kinematics of the fold-fault system in rocks of the Lower Cretaceous Blairmore Group on Castle River just above its confluence with Carbondale River has been completed. A preliminary analysis of the field data would suggest that the sedimentary layering played a fundamental role in the mechanics of deformation of the rock mass. Planar and curviplanar surfaces coincident with and parallel and subparallel to the layering were kinematically active during the deformation and limited the degree of strain penetration largely to these surfaces and to systematic fracture arrays between them. The folds are concentric and a consequence of flexural slip. Many of the fracture arrays can be kinematically and dynamically related to the local compressive stresses, which produced the deformation. All of the tectonic fabric elements studied in the Castle River prototype have been previously recognized in the Jurassic Kootenay Formation and three-dimensional structural analysis of some of them is being carried out in coal mines at Canmore, Alberta.

A few days were spent with scientists of the Shell Research and Development Company in a review of their studies of fracture arrays on Teton anticline[1] in northwestern Montana. It was a consequence of this review that the dynamic significance of fracture patterns in the Castle River prototype were recognized.

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[1] Stearns, D.W.: Macrofracture patterns on Teton anticline, Northwestern Montana; American Geophysical Union, Trans., vol. 45, No. 1, pp. 107-108 (1964).

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52. LIMESTONE MOUNTAIN (82 O/14, WEST HALF) MAP-AREA

N.C. Ollerenshaw

The geological mapping of Limestone Mountain map-area, in the Central Foothills, has been completed on a scale of 1 inch to 1 mile.

Northwest of James River, a series of anticlinal Palaeozoic inliers occur in the Foothills, and two of these cut across the Limestone Mountain area. The Limestone Mountain anticline runs from the northwest to southeast corners of the map-area and forms the major structural feature. The Corkscrew-Marble Mountain anticline cuts across the northeast corner. These inliers are basically anticlines, with local faults and probable more extensive fault continuation at depth. They commonly include subsidiary folds, some of which are overturned to the northeast. The areas between these carbonate inliers are occupied by broad synclinal areas of Mesozoic (predominantly Cretaceous) sandstones and shales.

On the southwest side of the Limestone Mountain anticline, the Mesozoic rocks are repeated by a major west-dipping thrust. A few miles farther southwest, the McConnell thrust places Palaeozoic rocks over the Mesozoic in the southwest corner of the map-area, and marks the boundary between Mountains and Foothills.

Several stratigraphic changes occur in this map-area, including: the thinning of the Kootenay Formation to about 150 feet; the virtual elimination of the Rocky Mountain Group east of the McConnell fault; and pronounced change in the Rundle Group, to predominantly dolomites above the Pekisko Formation, with only very minor crinoidal limestone at the probable level of the Turner Valley Formation.

53. THE CROWSNEST FORMATION IN SOUTHWEST ALBERTA (82 G NE, 82 G SE)

T.H. Pearce

Three months were spent in the field, and 38 localities were described, sampled for petrographic and chemical studies, and measured where appropriate. Eleven of these were plane tabled to clarify relationships and measure sections accurately. One fossil flora was collected from an outcrop on Highway 3 west of Coleman, Alberta.

The Crowsnest Formation consists mainly of interbedded pyroclastic and epiclastic rocks of alkalic volcanic origin. Scattered flows of trachyte and analcite trachyte have been found, the most northerly of which is on South Racehorse Creek in Lsd. 10 of Sec. 12, Tp. 10, Rg. 5 W5M, and the most southerly, west of George Creek in Lsd. 7 of Sec. 14, Tp. 6, Rg. 4 W5M.

The Crowsnest volcanism was mainly explosive with minor effusive activity resulting in flows. Rittmann's "explosive index" is probably $E > 95\%$. Pisoliths have been found in 4 localities, indicating that at least some of the eruptions were subaerial. Fossil plant fragments, graded bedding, and cross-bedding, found in widespread localities substantiate the non-marine character of the sedimentation.

There is a general tendency for the size of the ejecta to decrease away from the Coleman area, and for the amount of analcite to be greater in the southern part of the area than in the northern. Analcite trachyte flows appear to be confined to the area south of Coleman, while trachyte predominates to the north. In the Coleman area, analcite-rich rocks occur near the top of the formation, while trachytic material is prevalent in the lower 590' and rare in the upper part. The lower contact is gradational both by mixing of lithologies, and by interfingering with the underlying Blairmore Group. The same relationship obtains at the extremities of the formation.

No volcanoes have been exposed by erosion at the present surface. However, several source areas are indicated by one or more of: size of ejecta, lateral rock and mineral variations, and the presence of dykes. They are, Ma Butte (approximate source of red trachyte), Star Creek near Coleman (green felsite), Coleman area (green trachyte), and George Creek (analcite trachyte).

54. GLACIAL GEOLOGY STUDIES IN SOUTHERN AND CENTRAL ALBERTA

A.M. Stalker

The writer completed mapping of the surficial geology of the Bassano (82 I E1/2) map-area on a scale of 1 inch to 4 miles. The area is well supplied with high quality gravel, most of which is readily accessible. Preglacial gravel is abundant in the western part of the area, and glacial and postglacial deposits are well distributed throughout the eastern two thirds of the area. Many buried valleys are present and some of these were traced; these valleys include both preglacial and interglacial channels. Though most of these valleys do not appear to have much potential as groundwater aquifers, an exception is a valley that strikes eastward, to the south of Lomond. This latter valley may be a good source of groundwater in an area where other water supplies are scarce.

The surficial deposits are surprisingly thick for southern Alberta, and have an average thickness of about 50 feet. Till is their chief constituent. Strongly developed hummocky moraine forms about one third of the surface, ground moraine another third, with outwash, lake deposits, and alluvium covering the remainder of the area.

The writer also commenced mapping the surficial geology of the Kananaskis Lakes (82 J) map-area (east of the Continental Divide) on a similar scale, starting in the northwestern part of the area. The work was slowed by extremely poor weather. In addition investigation was continued of the important Pleistocene sections exposed along South Saskatchewan River north of Medicine Hat and of the Foothills Erratics Train. Study was also given to potential Pleistocene vertebrate fossil localities. Information on surficial geology was supplied to forestry officers of the Alberta Department of Lands and Forests.

55. CONODONT BIOSTRATIGRAPHIC STUDY OF THE (DEVONIAN) WATERWAYS AND BEAVERHILL LAKE FORMATIONS OF NORTHERN ALBERTA

T.T. Uyeno

Selected outcrops of the Waterways Formation along the Athabasca and Clearwater Rivers and tributary streams were sampled in detail for conodont biostratigraphic study. Four of the five members of the Waterways Formation are exposed in the area. These are, in the ascending order, Firebag, Calumet, Christina, and Moberly Members; the uppermost Mildred Member is covered. Some 550 samples of rocks were collected from outcrops.

Two weeks were spent in Calgary, sampling intervals of Beaverhill Lake Formation, as well as units above and below it, from nine well cores stored at the Alberta Oil and Gas Conservation Board. Stratigraphic problems of the Waterways-Beaverhill Lake Formations were also discussed with Dr. H.R. Belyea at that time.

SASKATCHEWAN AND ALBERTA

56. LANDSLIDE INVESTIGATIONS, SASKATCHEWAN AND ALBERTA

J.S. Scott

Six nests of piezometers, each containing 3 piezometers, were installed in an area of landslides along a small stream tributary to south Saskatchewan River near Riverhurst, Saskatchewan (Fig. 1).

The upland surface has an elevation of approximately 1,930 feet ASL and is underlain by 30 feet of alluvial sand and gravel and 80 feet of till, which overlie the overconsolidated clay shales of the Upper Cretaceous Bearpaw Formation. Stress relief of the overconsolidated shales by stream erosion has resulted in extensive sliding of the valley walls (Fig. 2).

The piezometers were installed to determine the configuration of the groundwater flow pattern in an area of landslides and, in particular, to determine changes in the groundwater regimen and their effect upon slope stability as future filling of South Saskatchewan Reservoir inundates the toe of the slide area.

Each piezometer consists of a 3 foot 1 1/4-inch diameter No. 10 slot well point that is sand-packed and cement-sealed and connected to the surface by a 1 1/2-inch diameter galvanized pipe. All of the piezometer tips are within the Bearpaw Formation. The tip elevation of the deepest piezometers in each nest is at 1,700 feet ASL and the tips of the two shallower piezometers in each nest are located at intervals of 50 feet or less above that elevation depending upon geological and topographic conditions. Piezometer nests Nos. 2 and 5 were offset to the north of the section line in an attempt to determine the magnitude of the component of groundwater flow toward the South Saskatchewan River.

Stabilization of the piezometers following development required approximately 4 weeks. Water samples were obtained from the top of the well point in each piezometer for chemical analysis to assist in the determination of the proper chemistry of water to be used in the laboratory testing of shale samples.

The probable location of the zone of failure can be obtained by a comparison of electrical logs from bore-holes in the slide mass with electrical logs obtained from bore-holes in the stable upland surface.

An attempt to obtain undisturbed samples of the Bearpaw Formation by use of thin-wall sampling tubes was unsuccessful. The consistency of the shale is such that the energy required to cause penetration of the sample tube also causes failure of the tube. It is proposed to obtain undisturbed samples of the formation in the future by the use of a double-walled core barrel.

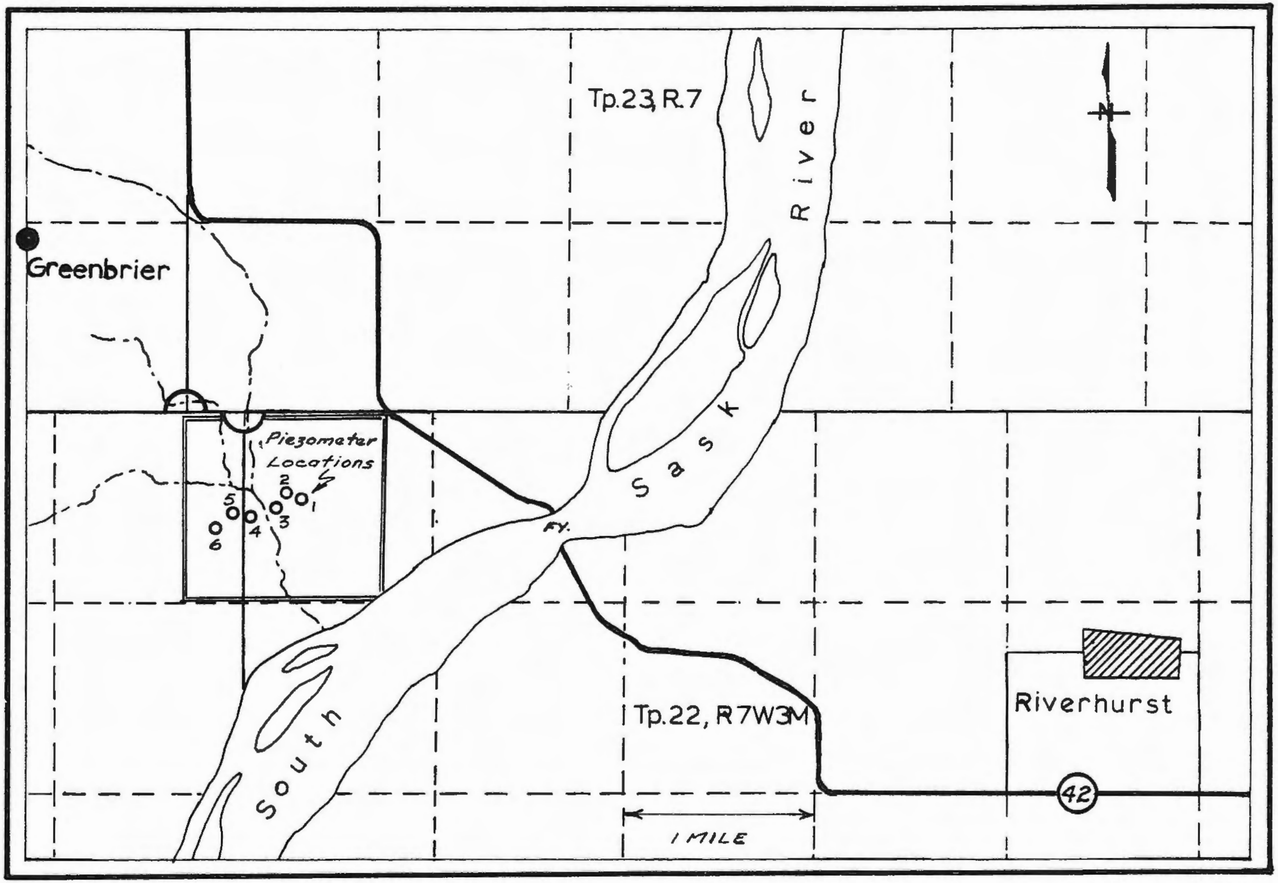

Figure 1. Location of piezometers for landslide study near Riverhurst, Saskatchewan.

Figure 2. Installation of piezometers in landslide area along stream valley tributary to South Saskatchewan River.

Slopes composed of the Bearpaw Formation along St. Mary and Red Deer Rivers in Alberta were examined by the writer in company with Prof. E.W. Brooker and Mr. G.W. Hollingshead, Department of Civil Engineering, University of Alberta as a part of the cooperative project on landslides being undertaken by the Geological Survey and the University of Alberta.

It is concluded from a comparison of slopes composed of the Bearpaw Formation in central Saskatchewan with those in Alberta that the following factors must be assessed in any study of the stability of these slopes.

1. Geological history and morphology of the river valley.
2. Lithology of the formation as a function of depositional environment with particular emphasis on the presence of minor geological details such as the presence of bentonite seams.
3. Hydrogeology with reference to the geological factors affecting groundwater discharge.
4. Chemistry of groundwater as related to the development of osmotic and rehydration pressures within the soil mass.
5. The stress history of the soil mass in which the slope has developed. The overconsolidation ratio (O.C.R., i.e. the maximum effective stress to which a soil has ever been subjected divided by the effective stress under which it presently exists) of the Bearpaw Formation in central Saskatchewan is probably higher than that of the formation in Alberta because of the greater amount of removal by erosion of superincumbent load. The development of fractures in the soil mass is also related to the stress history of the material.

SASKATCHEWAN

57. GEOLOGY OF THE CARSWELL CIRCULAR STRUCTURE

K.L. Currie

The Carswell structure in northern Saskatchewan (74 K) is outlined by outcrop of the Carswell dolomite 24 miles in outside diameter. Six hundred feet of Carswell strata are exposed, comprising 400 feet of thin bedded slaty dolomite with algal structures, and 200 feet of thick bedded to massive dolomite, the top of which was not seen. Toward the centre of the structure, lower stratigraphic formations are poorly exposed, namely a granitoid basement complex, and the Athabaska sandstone. Two members of the Athabaska sandstone were recognized, an upper, fine-grained, creamy sandstone, and a lower, reddish, pebbly sandstone. The Athabaska Formation rests with great unconformity on generally granitoid gneisses.

Structurally, the Carswell Formation is intricately folded, forming a complex synclinorium overturned from the centre of the structure. This ring syncline occupies a marked depression in the Athabaska Formation. The latter appears to be gently folded, and horizontal to moderate dips are the rule. The basement complex is likewise little deformed in most exposures. All three units are cut by faults oblique to the rim. In all cases where movement can be defined it appears to be essentially lateral. A characteristic red, allochthonous breccia ('crater breccia') fills these zones, occasionally weakly mineralized with epidote and sulphides. In one zone poorly defined, striated, curved fracture surfaces may represent shatter cones. No other evidence of possible impact cratering (large scale brecciation, tear faulting, quaqua-versal dips on the rim) was recognized.

Structurally, topographically, and petrographically the structure is unlike any known impact crater. An autonomous origin analagous to salt doming is considered possible but implausible. There is no geological or geophysical evidence of igneous activity of any normal type. The theory of cratering by deep-seated gas eruption (Currie, 1964) seems to best explain the observed facts. The evidence is insufficient for a clearcut decision.

Currie, K.L.: Analogues of lunar craters on the Canadian Shield; in Geologic problems in lunar research; Annals, N.Y. Acad. Sciences, vol. 117 (1964).

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58. GROUNDWATER STUDIES, SOUTH SASKATCHEWAN RIVER RESERVOIR (72 J, 72 O)

R.O. van Everdingen

Sixteen new piezometers were installed in the section near Riverhurst, Saskatchewan, on the South Saskatchewan River, during June and July of 1964, bringing the total for the section to 28 piezometers.

Recorders equipped with electric probes, for operation in small-diameter cased holes, were installed to obtain a first approximation of the barometric efficiency of the aquifers in the Bearpaw and Belly River Formations.

A small-diameter sampler was used to obtain representative water samples from the various aquifers. The installation is now ready to register the influence of the South Saskatchewan River Reservoir, filling of which will probably start early in 1965.

59. HYDROGEOLOGY OF THE OLD WIVES LAKE DRAINAGE BASIN

R.A. Freeze

During the summer of 1964, a detailed study was carried out of groundwater flow patterns in several "type areas" within the Old Wives Lake basin. Each "type area" represents a unique geologic and topographic model with its own consequent hydrogeological regime. The hydrogeology of the entire basin can best be understood by reference to these type models, which recur throughout the basin.

The methods employed to trace the flow patterns include:

1. Piezometric analyses of well records:
   a) the utilization of the relation between well depth and depth to static water level to detect discharge and recharge areas;
   b) the construction of piezometric surfaces for aquifers transmitting horizontal flow.
2. The interpretation of results obtained from piezometer nests installed in 1962, 1963.
3. The mapping of groundwater discharge and recharge by surficial evidence:
   a) topography
   b) salinity of surface waters
   c) occurrence of alkali soils
   d) presence of phreatophytic vegetation.
4. The correlation of hydrogeochemistry with flow pattern and geological formation.
5. The determination of the nature of the geological model in one of the "type areas" by means of a drilling program designed to clarify the lithology and extent of several bedrock formations.

In addition, a proposed Ph.D. program to be carried out at the University of California at Berkeley will deal with theoretical regional groundwater flow patterns based on situations encountered in the Old Wives Lake basin. The mathematical model approach using computer solutions will be used.

60. THE GROUNDWATER BALANCE OF THE ARM RIVER DRAINAGE BASIN

Peter Meyboom

During the summer of 1964 final piezometer installations were constructed to define the groundwater flow in the Arm River basin, Saskatchewan. The results of the study are threefold:

1. It is possible to calculate the groundwater balance from the constructed flow patterns by means of agricultural drainage equations.

2. Consumption use by phreatophytes is an important factor in the groundwater budget of a prairie basin and the consumptive use of the most common phreatophytes was determined at some 40 locations.

3. Groundwater flow-patterns in hummocky moraine change throughout the seasons, depending on precipitation and evapotranspiration. So-called "willow rings" are effective recharge ponds in the beginning of the summer but become areas of groundwater discharge later during the growing period when the willows draw their moisture supply from the water table. There may be a critical size for a willow ring to be an effective recharge pond, for the amount of consumptive use in the smaller willow rings exceeds the amount of surface infiltration during the early summer.

61. OSMOTIC SPECTRA AS A MEANS TO DEFINE PHREATOPHYTES IN SOUTH-CENTRAL SASKATCHEWAN

Peter Meyboom

The osmotic spectrum of a plant is the entire range of its osmotic values during the growing season. It yields important information regarding the seasonal changes in the moisture balance between plant and environment. Phreatophytes, which are those plants that habitually obtain their water supply from the zone of saturation (groundwater) can be distinguished from other prairie vegetation by their narrow osmotic spectrum.

Osmotic spectra of plants growing in or near areas where fresh groundwater is being discharged indicate that the following species are phreatophytic: Cornus stolonifera, Salix interior, S. discolor, S. pseudomonticola, Shepherdia argentea, and Acer negundo. Elaeagnus commutata is a phreatophyte whenever it grows in valley bottoms or near springs.

The common shrubs Symphoricarpos occidentalis, Rosa woddsii, Crataegus columbiana, and Amelanchier alrifolia are not phreatophytic, but the osmotic spectra of S. occidentalis and A. alnifolia do indicate that these species favour habitats with stable soil-moisture conditions.

The osmotic spectra of plants in saline discharge areas show that contrary to findings in the Western United States Distichlis stricta Suaeda depressa and Atriplex hastata are in general not phreatophytic in South-central Saskatchewan.

62. STREAMFLOW DEPLETION BY PHREATOPHYTES

Peter Meyboom

Phreatophytes cause streamflow losses under natural and regulated flow-conditions, regardless whether the stream is influent or effluent.

Indirect losses are said to occur whenever groundwater is intercepted by the vegetation before it reaches the stream. This type of depletion is common under conditions of natural drainage in valleys with a transverse water table gradient greater than 0.01.

Direct losses from a river occur in a zone of induced infiltration, the width of which depends on the relation between the phreatophytic fluctuations and the transverse water-table gradient in the valley. Direct losses can result also from bank storage effects brought about by water releases from a reservoir.

Extreme streamflow depletion takes place when the river dries up during the summer. This condition is characteristic for places where the consumptive use of the vegetation temporarily exceeds the combined supply of stream discharge and groundwater inflow.

SASKATCHEWAN AND MANITOBA

63. GROUNDWATER GEOPHYSICS SURVEYS, SASKATCHEWAN AND MANITOBA

J.E. Wyder

An integrated program of gravity and surface resistivity surveys and stratigraphic drilling was conducted near Steelman, Saskatchewan. The purpose of the program was to determine if gravity and surface resistivity techniques could be used to delineate the buried preglacial Missouri River system.

The gravity results indicate that there is not a significant gravity anomaly associated with the buried Missouri except possibly where thick deposits of sand and gravel occur; in which case it appears that a negative anomaly of the order of 0.2 milligals is detectable. These results are in disagreement with results published by Robinson[1], who reported a positive anomaly associated with the buried Missouri. Stratigraphic drilling has, in part, verified the association of a negative gravity anomaly with thick sand and gravel deposits.

The surface resistivity survey was conducted on a grid pattern with stations every 1/2 mile on north-south grid lines and every mile on east-west grid lines. A very noticeable resistivity high was delineated. The resistivity anomaly is attributed to sand and gravel deposits associated with, but not necessarily in the centre of the channels of the buried Missouri River system. These gravels and sands were not necessarily deposited by the preglacial rivers and streams.

The stratigraphic drill holes locations were selected with the aid of an equi-resistivity map prepared from values for a Wenner span of a = 500 feet. The drilling results substantiated the resistivity interpretations, including the prediction of the presence of a sand and gravel deposit, which had not been previously reported. It has thus been demonstrated that surface resistivity surveys can be used, in the Steelman area, to detect and delineate large subsurface sand and gravel deposits, which can yield large quantities of water.

The drilling results also show that in the Steelman area, the depths to bedrock as estimated from water wells, oil well reports, and shallow test wells by Meneley _et al_.[2] can be as much as 50 per cent in error.

Two gravity profiles with a station every 250 feet and a combined length of 11 miles were completed near Outram. The results indicate that as in the Steelman area, there is a slight negative anomaly associated with the buried Missouri.

A cooperative program with Mr. A. Lissey of the Geological Survey's Groundwater Section was conducted during late August near Shoal Lake, Manitoba. The purpose of the program was to determine if the surface resistivity method could be successfully used to detect a saline-water-bearing gravel in an environment of saline-water-bearing shales and till. The program was successful and Mr. Lissey used the surface resistivity results to locate a piezometer nest.

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[1] Robinson, W.J.: The gravity method and its application to groundwater studies in southern Saskatchewan; Sask. Res. Council, Report P-63-1 (1963).

[2] Meneley, W.A. et al.: Preglacial Missouri River in Saskatchewan; Jour. Geol., vol. 65, No. 4 (1957).

MANITOBA

64. RECONNAISSANCE MAPPING IN UPPER NELSON RIVER AREA (63 NE)

C.K. Bell

The upper Nelson River (63 NE) area is bisected by the boundary between the Churchill and Superior structural provinces. Reconnaissance mapping was completed in Sipiwesk (63 P) map-area as part of a regional study along the front.

The Thompson - Setting Lake nickel-bearing peridotite belt occurs within a Bouguer gravity low along the northwest (Churchill) side of the contact zone[1]. These 'alpine' peridotites intrude the metasedimentary and volcanic rocks, gneisses, and schists in the area and are in turn intruded by apophyses from Churchillian (± 1,750 m.y.) granite[2]. The Moak, Mystery, Thompson, and Birch Tree nickel deposits of the International Nickel Company, Limited, occur within this area.

The boundary zone is a 25-mile wide complex of highly folded gneisses that are intruded by late biotite-granite stocks. Evidence suggests that the gneisses were originally in part, granulite facies rocks of Superior age. These have been retrogressively metamorphosed to amphibolite facies rocks by transgressive effects of the Hudsonian orogeny.

Southeast of these retrogressive gneisses is a wide belt of granulite facies gneisses of Superior age (2,400 m.y.). These granulites coincide with a Bouguer gravity high[1]. They widen from 25 miles between Thicket Portage and Sipiwesk Lake to 50 miles in the northeast part of the area. The granulite-amphibolite facies contact on the northwest is vague and sinuous while the southeast contact is sharp and extends from Bulger Lake northeast to the Cauchon Lake area. South of the contact the rocks are Superior-type monzonite and granodiorite gneisses.

Cross Lake-type metavolcanic rocks outcrop as narrow belts in the Bear Lake area[3,4,5]. Swarms of late diabase dykes strike in a northerly and northeasterly direction in the centre of the map-area, cutting the granulites and retrogressive gneisses[6]. A number of northwest-striking diabase dykes intrude Churchillian rocks in the Thompson area[2].

In addition to the peridotite-nickel association in the Thompson area, nickel-bearing sulphides occur as small pockets in the old gabbro sills and dykes that intrude the retrogressive gneiss on Wintering Lake. The sills are narrow, highly contorted, and boudinaged, and the gabbro has been partly altered to amphibolite. To date, none of these occurrences has proved of economic importance. Gold has been reported associated with volcanic rocks in the Bear-Cotton Lake area[3,4,5].

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[1] Wilson, H.D.B. and Brisbin, W.C.: Tectonics of the Canadian Shield in Northern Manitoba; Roy. Soc. Canada, Spec. Pub. No. 4, pp. 60-75 (1962).

[2] Zurbrigg, H.F.: Thompson Mine geology; Trans. C.I.M.M., vol. LXVI, pp. 227-236 (1963).

[3] Allen, C.M.: Geology of the Western Bear Lake area; Man. Mines Br., Pub. 52-4 (1953).

[4] Allen, C.M.: Geology of the Cotton Lake area; Man. Mines Br., Pub. 53-2 (1954).

[5] Milligan, G.C.: Geology of the Utic Lake - Bear Lake area; Man. Mines Br., Pub. 51-4 (1952).

[6] Patterson, J.M.: Geology of the Thompson - Moak Lake area; Man. Mines Br., Pub. 60-4 (1963).

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65. HYDROGEOLOGICAL RECONNAISSANCE OF THE CARBERRY SAND PLAINS (PART OF 62 G)

P.A. Carr

Values of coefficient of permeability were obtained from horizontally and vertically oriented sand samples with a falling head permeameter. An average permeability of about 460 gallons per day per square foot was determined. Generally the sand varies in thickness from 50 to 200 feet, thus coefficients of transmissibility between 23,000 and 92,000 gallons per day per foot are to be expected.

Water samples were collected for chemical analyses, on a grid pattern throughout the area, in order to establish the suitability of the groundwater for irrigation.

66. GEOLOGICAL AND HYDROGEOLOGICAL STUDY OF WILSON CREEK BASIN (PART OF 62 J/12 E)

P.A. Carr

The Riding Mountain Formation underlies this basin and comprises hard shale with numerous ironstone concretions and a few bentonite beds. Numerous slides have occurred and have concealed the lower part of the section.

Two lithologically distinct tills overlie this formation. The lower till is grey and is composed of numerous grey shale fragments and a few small igneous pebbles in a matrix of silt and clay. Overlying this is a light brown stony till containing igneous and metamorphic pebbles, cobbles, and boulders.

Four shallow wells were drilled to determine the position of the water table and two recorders were set on these wells to ascertain the seasonal fluctuations of the water table. A specific capacity of 11 gallons per minute per foot of drawdown was obtained from a pump test of one of these wells.

67. HYDROGEOLOGY, PINE FALLS AREA (62 I E1/2)

J.E. Charron

The area covered by this hydrogeological study is bounded by ranges 6 E and 12 E and by townships 13 and 23. From this study the direction of groundwater movement throughout the area will have been established. It is hoped that the well-inventory data accumulated during the field season and the geochemical interpretation of the water analyses will help to clarify or pinpoint to a more accurate degree the western plains sedimentary rock contact with the Precambrian rocks south of Lake Winnipeg.

Many sand and gravel deposits exist in the area as well as large volume springs (over 100 gpm).

68. FIELD TESTS ON LOW FREQUENCY RESISTIVITY EQUIPMENT

L.S. Collett

Low frequency (10, 3, 1, 0.3, 0.1 cps) resistivity equipment capable of measuring phase angle was field tested in three areas in Manitoba. Expanding Wenner arrays were done over six drill holes in the aquifer near Winkler, Manitoba, one near Morris, Manitoba, and at four locations in the Oak River basin near Rivers, Manitoba. In all cases the response from the ground appeared as an inductive reactance above 1 cps and the reactance increased with increasing frequency. Below 1 cps, the reactance is small and because of instability in the equipment, the results are inconclusive as to whether the reactance is inductive or capacitive. The high ion content, approximately 10,000 ppm, in the Oak River basin gave abnormally large reactive values compared to those in the other two areas. The conclusion from these results has yet to be interpreted in relation to the geology.

It is now known that when the ground is subjected to a fast risetime pulse of current, a spike is produced in the ground. The decay of this spike is longer from clay and till than from sands and gravel, with the exception of the Oak River basin area. It would appear that this technique may be useful to differentiate between clay and till and sands and gravel. The conclusion from this phenomena is that the ion content of the water in the soils bears a definite relationship to the electrical properties of soils.

69. NEJANILINI LAKE (64 P) AND CARIBOU RIVER (54 M) MAP-AREAS

W.L. Davison

The Nejanilini Lake area was mapped by normal reconnaissance methods until late in August, when two helicopters became available from Operation "Wager". Eighteen traverses were made by helicopter; the Caribou River area was mapped entirely by this means, as was much of the east half of Nejanilini Lake area. Some work had been done previously along the major waterways[1,2].

The most characteristic rocks of both map-areas are paragneiss, granulite, and gneissic granite. Scattered among these are narrow belts of metasedimentary schist, quartzite, and allied rocks; a broader, discontinuous belt extends from southwest of Nejanilini Lake to the north and northeast. Near the southern boundary of Nejanilini Lake area, basalt occurs associated with sedimentary rocks of the Great Island Group[3]. Sedimentary rocks, possibly equivalent to the Great Island sequence, occupy the south side of Seal River where it loops across the boundary of the Caribou River area; included are fine-grained sandstone, siltstone, quartzite, and shale. Basic volcanic rocks, including pillowed flows, are found on either side of the Seal River about 12 miles from its outlet. Porphyritic biotite granite and quartz diorite occur locally in the east.

No features of definite economic interest were found, although small amounts of sulphides are present in many places. A high magnetic anomaly, near the southeast corner of Nejanilini Lake area[4] is centered over swampy terrain; the nearest outcrops are of basalt, with minor gabbro, to the east and north, and of sedimentary rocks to the west.

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[1] Johnston, A.W.: A geological reconnaissance of Seal River, Northern Manitoba; Geol. Surv. Can., Paper 35-2 (1935).

[2] Russell, G.A.: A geological reconnaissance of the Wolverine and Caribou Rivers, Northern Manitoba; Dept. Mines and Nat. Res., Manitoba, Pub. 52-2 (1953).

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

[4] Geological Survey of Canada: Magnetic anomaly north of Seal River, Manitoba; Map 550G (1957).

70. SURFICIAL GEOLOGY STUDIES IN SOUTHWESTERN MANITOBA AND SOUTHEASTERN SASKATCHEWAN

R.W. Klassen

Field work involved the completion of the Riding Mountain area (62 K) mapping project, and the detailed study of sections near the map-area, in the Duck Mountain area (62 N), and in the Winnipeg Floodway.

A section near the map-area (NE 1/4 section 20, Tp. 15, R. 18 WPM[1]), in which four till units are exposed, includes a silt unit containing peat and rodent bones between the two lower till units. Another section in the Duck Mountain area (NE 1/4 section 30, Tp. 33, R. 26 WPM) includes a highly fossiliferous silt unit overlain by two till units. Carbonaceous material was collected from the bottom of the silt unit. Further study of the material collected may indicate whether the silt units are interstadial or interglacial deposits.

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[1] West of the Principal Meridian

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71. GEOHYDROLOGY OF THE OAK RIVER DRAINAGE BASIN, MANITOBA

A. Lissey

Twenty seven piezometers were installed to augment those installed in 1963. The total 56 piezometers comprise 25 nests and will serve as the basic framework in determining groundwater conditions throughout the 1,100 square mile basin. Water from 37 of these piezometers was sampled for analysis to establish the hydrochemical part of this framework. Ten test-holes were drilled to supplement the geologic part, and head readings in all piezometers were carried out to establish the hydrologic part of this framework. Head measurements in 32 piezometers were recorded weekly to evaluate the range and magnitude of seasonal head fluctuations. A study of the surface manifestations of groundwater flow patterns, exhibited by natural plant growth and occurrence of sloughs, was started. By establishing a systematic relation between these surface features and the piezometer framework it is hoped that the hydrologic data provided by this framework can be extended laterally to define more accurately the different flow systems present.

The piezometers indicate a slight upward component of the longitudinal flow down the basin for over 2/3 of its 60 mile length, but the major component of this flow is essentially lateral. Surface features indicate that this upward flow is concentrated in broad discharge belts running transversely across the basin. These discharge belts are separated by similar broad transverse belts of recharge and transition. At least one of these discharge belts is believed to be due to a lateral decrease in the permeability of the Riding Mountain shales, which constitute the bedrock underlying the basin. It is also believed that at least one of the recharge and transition belts is indicative of a more local flow system depressing the discharge effects of the large longitudinal flow system and that this local flow system is established because of higher local relief.

Part of the framework of piezometers was used to investigate the possibility of flow across basin divides via highly permeable gravels confined to a buried meltwater channel. Preliminary work suggests that such a cross-connection flow may exist between the closed-drainage Salt Lake basin and the Oak River basin.

72. DEVONIAN BIOSTRATIGRAPHY OF LAKE MANITOBA - LAKE WINNIPEGOSIS AREA

A.W. Norris

During the field season of 1964 the writer began a study of the Devonian formations outcropping in Manitoba in a northwest-trending belt some 240 miles long and from 25 to 45 miles wide. Parts of the Ashern, Elm Point, Winnipegosis, Dawson Bay, and Souris River Formations outcrop in the belt. Fossils found in the upper part of the red and orange dolomite of the Ashern Formation indicate that at least the uppermost part of the formation is Middle Devonian in age. A good exposure in a recently opened quarry about 5 miles west of Highway No. 6 on the road to Vogar and Manitoba Lake Narrows Ferry shows that part of the Ashern Formation is brecciated. An unique molluscan fauna occurs in the Elm Point, Winnipegosis, and Dawson Bay Formations, some elements of which are present also in the Rogers City Limestone of Michigan and in an unnamed limestone formation of Indiana associated with a recently discovered *Stringocephalus* sp. The lithology and some of the fossils of the Winnipegosis Formation, particularly *Sphaerospongia* sp., *Mastigospira* sp., *Atrypa* sp. cf. *A. arctica* Warren, and *Stringocephalus* sp. indicate very close similarity to the Methy Formation outcropping near the edge of the Precambrian Shield on Clearwater River in northwestern Saskatchewan and northeastern Alberta. The combined Elm Point, Winnipegosis, and Dawson Bay Formations are tentatively correlated with the Pine Point Formation of the Great Slave Lake area. *Athyris* sp. and *Eleutherokomma* sp. in the Souris River Formation suggest correlation with the Moberly Member of the Waterways Formation of northeastern Alberta. In terms of the Great Slave Lake and northeastern Alberta Devonian sequences, a para-unconformity of considerable magnitude probably separates the top of the Middle Devonian Dawson Bay Formation from the base of the Upper Devonian Souris River Formation of the Manitoba outcrop succession.

ONTARIO

73. ORIGIN OF THE LOUGHBOROUGH SYENITE, NORTH OF KINGSTON

I.F. Ermanovics

In plan the Loughborough syenite is a lensoid body with its long northeast axis 5 miles and its great short axis 1 1/2 miles long. The present work, recorded on a scale of 1 inch to 1/4 mile, defines more closely the syenite and contiguous gneisses (see Fig. 1).

The syenite is a coarse, reddish-brown, weakly foliated, two-feldspar rock containing green chlorite, traces of pyroxene, and up to 10 per cent quartz in peripheral and sheared portions. The northeast nose truncates gneisses (units 6, 7, and 9), and is itself sheared and faulted. The southwest portion, hitherto unmapped, interfingers with pyroxene gneisses (8) and minor pyroxene granulite (9), finally disappearing under Palaeozoic cover. The syenite - gneiss contact (10 to 20 degree discontinuity of foliation) is gradational adjacent to acid gneisses and abrupt, with xenoliths, adjacent to basic gneisses. The syenite appears to be emplaced in a tightly overturned anticline (?) at the expense of units 8 and 9, leaving the more basic pyroxene gneisses (8) as relict structures.

Of particular interest is a pink, fine-grained, leucocratic pyroxene granulite (9), which occurs as a lenticular sinuous mass adjacent not only to the Loughborough syenite but also to the other two syenite bodies in Gananoque map-area[1]. Mixed with the pyroxene granulite are fine-grained biotite gneisses with porphyroblastic alkali feldspar and minor feldspar-quartz-pyroxene granitoid gneisses.

A possible stratigraphic succession in the area from southeast to northwest is represented by the now crystalline gneisses, involving: 1) crystalline limestone; 2) garnetiferous calc-silicates; 3) quartzite; and 4) stratiform biotite-quartz feldspar gneiss.

Garnets for piezometers, feldspars, calc-silicates, and biotites for geothermometers, and line-samples for composition were collected to establish pressure, temperature, and composition gradients. Regular sampling on a 1,500-foot grid may provide additional petrographic controls. In addition, several thousand structural data were collected for statistical analyses.

Probable evidence of material transfer is afforded by: 1) coarse quartz, feldspar, diopside, and biotite crystals within crystalline limestone; 2) small granitoid bodies; 3) numerous monomineralic and granitoid pegmatites; 4) porphyroblastic alkali feldspars in units 7 and 9; 5) the probable chemical similarity of the pyroxene granulite (granitoid) and syenite body; 6) the inseparable combination of coarse quartz amphibole and granite lenses in unit 6, and 7) continuity of contiguous gneisses into the syenite body.

Probable evidence of a liquid phase during emplacement of the syenite is afforded by: 1) homogeneity of the two-feldspar syenite; 2) prolific, large, pyroxene gneiss (8) xenoliths throughout the syenite; 3) rotated xenoliths

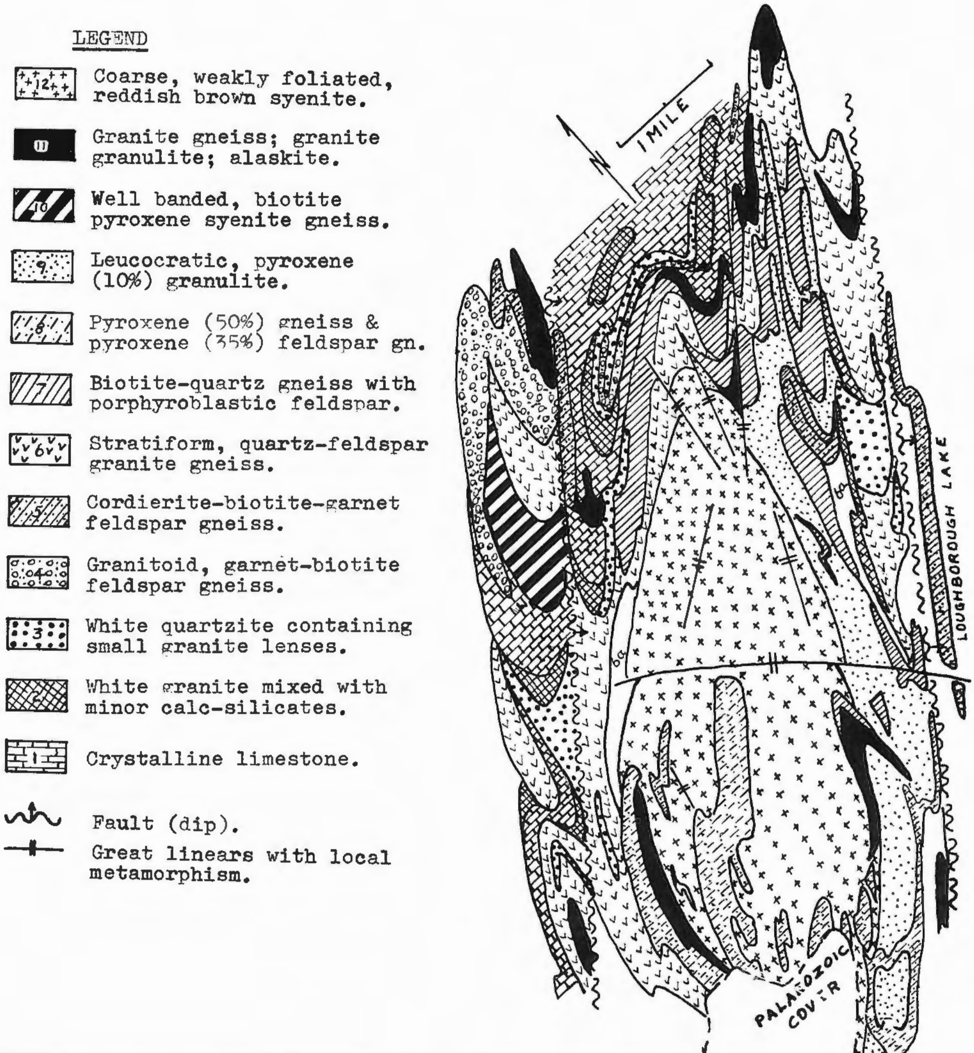

FIGURE 1. Loughborough Syenite; a tentative, diagrammatic interpretation.

of pyroxene gneiss (8) at the contacts with the syenite; 4) a leucocratic one-feldspar quartz-rich phase 50 to 150 feet thick, peripheral to the syenite.

Hopefully, the integration of all evidence will elucidate the origin of the Loughborough syenite and may suggest a partial solution for certain small granitic bodies of the Grenville province.

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[1] Wynne-Edwards, H.R.: Geology, Gananoque, Ontario; Geol. Surv. Can., Map 27-1962 (1962).

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74. LAKE PANACHE (41 I/3) MAP-AREA

M.J. Frarey

About 70 square miles in the west half of the map-area were examined. Collins'[1] Huronian succession was confirmed up to the Lorrain Formation. This sequence is cut by numerous diabase intrusions, of two or more ages. In the area examined, the Huronian rocks have undergone moderate to severe deformation, whereas the degree of metamorphism is generally low. Sedimentary structures are commonly well preserved, particularly in the north-west corner of the map-area. The transport direction of the quartzites of the Bruce Group was southward and southwestward. Tectonic breccias are common; on earlier maps, some breccia masses are erroneously shown as conglomerate.

For several miles along a line extending northeastward from the southwest corner of the map-area, the Huronian rocks are in fault contact with granitic rocks (Killarney Granite). Granitic dykes cut the Lorrain Formation in places just northwest of this line, and, as noted earlier by Quirke[2], Lorrain remnants occur southeast of it.

Little economic activity was evident in 1964. A few base-metal occurrences, previously prospected, were seen near Lake Panache. A number of large quartz veins near the same lake may be potential sources of quartz. Large amounts of high-silica quartzite occur along Killarney Bay, Lake Huron.

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

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

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75. SURFICIAL DEPOSITS IN THE KINGSTON-GANANOQUE (31 C SE1/4) AREA OF EASTERN ONTARIO

E.P. Henderson

Glacial deposits are sparse and discontinuous, deep till having formed only on the flanks of hills or in the lee of some escarpments. Where present as the dominant surface deposit till is generally up to 3 feet thick and of a sandy or gravelly texture. Rock outcrops, though prevalent everywhere, are more common in areas of uneven Precambrian than flat Palaeozoic rocks. Total amounts of till over both types of terrain, however, are about the same.

The character of most surficial deposits other than till was affected by the presence of glacial lake waters that gradually spread over the entire area as damming ice withdrew towards the east and northeast.

Glaciofluvial sediments are present as eskers, kames, kame moraine, and outwash. Though not widespread they nevertheless make up valuable sand and gravel deposits at several places throughout the area. The largest reserves of granular materials are in the kame moraine east of Brewers Mills. The kame moraine's western extension is a shield-shaped mass with an average depth of more than 30 feet over an area of nearly 2 square miles. An unusual feature of the moraine is the largely flat or only gently undulating surface rather than one rough and hummocky, as is common on these formations. The flat surface has been ascribed to formation under a limiting ice surface, probably the bottom of a floating edge raised slightly above the floor of the bounding deep glacial lake.

About half of the area has a thin to moderately thick cover of lake clays and silts that in depressions may attain considerable depths, a maximum of over 100 feet having been recorded just east of Gananoque. Varved clays have been found throughout the area and most lake sediments are thought to be of this nature. Rock exposures, generally topographic highs, are common in many clay areas, particularly when underlain by Precambrian rocks. Areal distribution of clays and their internal structure suggest they were carried to present locations by cold, dense bottom currents controlled by the configuration of the lake bottom and that only minor erosion has taken place subsequent to deposition. Some deep clay deposits have been modified by ice-pressing and exhibit an oriented ridge topography. Locally the surface of other wise relatively stone-free clays may be thickly studded with ice-rafted Precambrian erratics released near the close of lacustrine sedimentation.

There are fairly extensive marsh deposits, particularly in the northwest quadrant of the map-area, and a little marl, most of the latter in Leland and Cedar Lakes, near Battersea.

When the ice-margin was far to the south and the map-areas entirely submerged under deep ice the regional ice-flow, as recorded by striae and glacial fluting, was in a south-southwest direction. Later, as the ice retreated, flow shifted to a more westerly direction and ice moved southwest or west of southwest directly into the Ontario basin. This shift may largely demonstrate increased lobation of thinner ice as topographic control became increasingly effective. No deposits were observed that could be assigned stratigraphically to glaciations older than the last to affect the area. Marine invasion of the St. Lawrence Lowlands, contrary to some earlier reports, apparently did not progress as far west as the Gananoque area, and may have reached little past Brockville.

76. A HAMMER SEISMIC SURVEY IN THE COBALT AREA

G.H. Gale and G.D. Hobson

A hammer seismograph instrument was used in the Cobalt silver camp area, applying both refraction and reflection seismic techniques principally to determine whether the seismic method would be a useful tool in delineating structure associated with silver deposition. Broadly, it can be said that the contact between the Cobalt sediments and the Nipissing diabase can be observed by both reflection and refraction techniques except where the diabase overlies the sediments, in which case only the reflection technique is applicable. Seismic velocities in the Keewatin rocks show a marked separation coinciding with the broad division of these rocks into basic and acidic volcanic rocks. In specific situations the seismic method is definitely applicable to the partial solution of structural problems in the Cobalt camp. It cannot however detail such small features as a depression 100 feet vertical and 300 feet horizontal at depth. A critical review of the reflection records may lead to further conclusions.

77. A HAMMER REFRACTION SEISMIC SURVEY OF THE MER BLEUE, NEAR OTTAWA

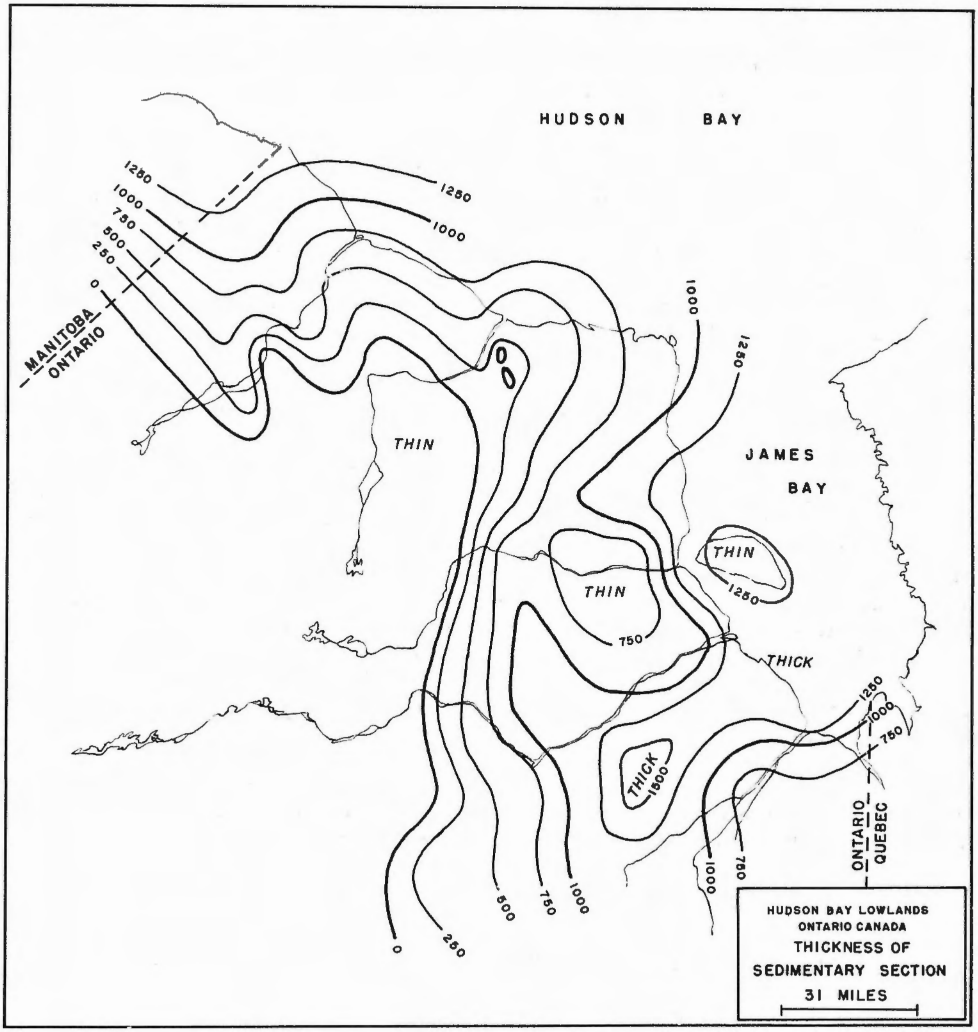
G.D. Hobson

A hammer refraction seismic survey has been conducted in the Mer Bleue area, 10 miles east of Ottawa, to determine thickness and, if possible, the type of overburden. Overburden thickness in some locations is in excess of 100 feet. Bedrock is limestone and therefore presents an appreciable contrast in seismic velocity with the overburden. Peat thicknesses are very well known over the bog and it should be possible to correlate seismic velocities with Pleistocene materials to indicate the type of drift material. Bedrock surface elevation increases generally from west to east.

78. SEISMIC REFRACTION SURVEY, HUDSON BAY LOWLANDS

G.D. Hobson

Forty-one seismic refraction profiles were shot by contract in the Hudson Bay Lowland area of Ontario, continuing a project commenced the previous season in Manitoba. Almost all profiles are reversed. The objectives of the


HUDSON BAY
JAMES BAY
MANITOBA
ONTARIO
QUEBEC
THIN
THICK
0
250
500
750
1000
1250
1500
HUDSON BAY LOWLANDS
ONTARIO CANADA
THICKNESS OF
SEDIMENTARY SECTION
31 MILES

project were to determine the thickness of the various geologic formations down to the Precambrian surface, to correlate seismic velocities with lithologic units, and to test the possibility of using reflection methods in this area. All objectives have been partly or completely achieved.

This project was a joint venture between the Ontario Department of Mines and the Geological Survey of Canada.

All field work was conducted from an Otter aircraft. Recording instruments were mounted in the cabin and a motorized snow vehicle permitted cable laying and shooting operations to be carried out quickly and efficiently at each location. The aircraft landed at locations on lakes and rivers and vertical elevations were carried on the aircraft altimeter. Snow depth was extreme during March and April, 1964, and directly influenced the thickness of the ice on the lakes and rivers. Average ice thickness was only about 3 feet. Seismic profiles were shot at 3 diamond drill-hole locations drilled in 1951 by the Ontario Department of Mines.

Glacial drift thickness in excess of 700 feet was encountered in the northwestern parts of the lowland area. Cross-sections, a map of the Precambrian surface, and an isopach Palaeozoic-Cretaceous map have been prepared in the preliminary interpretation. The thickest sedimentary section appears to be located in the southern part of the area, with the Ontario Department of Mines Jaab Lake hole within this area. Precambrian rocks appear to be about 55 feet below the bottom of this hole. The Precambrian surface also dips northward at the Ontario-Manitoba boundary suggesting a thicker section offshore in Manitoba. In both these areas the sedimentary section is in excess of 1,500 feet. Akimiski Island appears to be a basement high with the control attained. The windows of Precambrian rocks south and southeast of Winisk have been considered in the interpretation and the Cape Henrietta-Maria area appears to be covered with a relatively thin sedimentary layer.

The accompanying map is the result of a preliminary interpretation of the data to indicate the thickness of sediments overlying the Lowland area. This map has been published as preliminary map P243 by the Ontario Department of Mines.

79. HAMMER REFRACTION SEISMIC SURVEY, NIAGARA RIVER

P.G. Killeen and G.D. Hobson

A hammer refraction seismograph instrument was used to determine overburden thickness and thus directly the bedrock topography in an area north from the Whirlpool rapids on the Niagara River to Lake Ontario. The purpose of the survey was to test the theory put forth by Spencer in 1905 that a buried channel exists in the area. A channel has been found extending from the Whirlpool Rapids northwestward to the St. David's Gorge, and northward below the Niagara escarpment to a point east of Virgil, where the channel appears to bifurcate with one branch proceeding northward to Lake Ontario and the other northeasterly to the Niagara River. It is not known as yet whether this channel was the predominant or tributary course of the river or whether it was carved in preglacial or interglacial time.

80. MINERAL EXPLORATION USING SURFICIAL GEOLOGY, KIRKLAND LAKE - LARDER LAKE AREA

H. A. Lee

During the 1964 field season investigations of surficial deposits and geomorphology as an aid to mineral exploration were continued in the area between Kirkland Lake and Larder Lake. The work dealt principally with mineral distributions in an esker and an analysis of bedrock topography beneath overburden (i.e. submask geomorphology). An account of this work is being prepared for early publication in the Survey's Paper Series.

81. PALAEOZOIC MAPPING IN THE KINGSTON DISTRICT

B.A. Liberty

Detailed stratigraphic studies of Middle Ordovician strata were continued eastwards from Tweed[1] and Belleville[2] map-areas. Four 30 x 15 minute map-sheets were almost completed: Sydenham 31 C/7, Bath 31 C/2, Gananoque 31 C/8, and Wolfe Island 31 C/1.

The carbonate rocks all belong to the Simcoe Group of Middle Ordovician age. The Verulam Formation is exposed widely near Bath and again on Wolfe Island. Both upper and lower members of the Bobcaygeon Formation are exposed on Wolfe Island. The Gull River Formation is about 300 feet thick and is widespread. The Shadow Lake (Middle Ordovician) and Potsdam (Cambrian) Formations are both present in Gananoque map-area.

Most of the stratigraphic units have been traced into the Kingston area from the Tweed and Belleville areas. The Potsdam is the lone exception for it does not extend west of the Kingston area. Facies changes were noted; some minor units have wedged out, others have achieved greater stratigraphic importance, and most units thicken in an easterly direction. Most of the units can be traced into New York State. Stratigraphic evidence suggests basinal conditions at the eastern end of Lake Ontario and progressive overlap of Gull River sediments into New York State.

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[1] Liberty, B.A.: Geology of Tweed, Kaladar and Bannockburn map-areas, Ontario, with special emphasis on Middle Ordovician Stratigraphy; Geol. Surv. Can., Paper 63-14 (1963).

[2] Liberty, B.A.: Geology of Belleville and Wellington map-areas, Ontario; Geol. Surv. Can., Paper 60-31 (1960).

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82. ENGINEERING GEOLOGY INVESTIGATIONS, WELLAND CANAL AREA

E.B. Owen

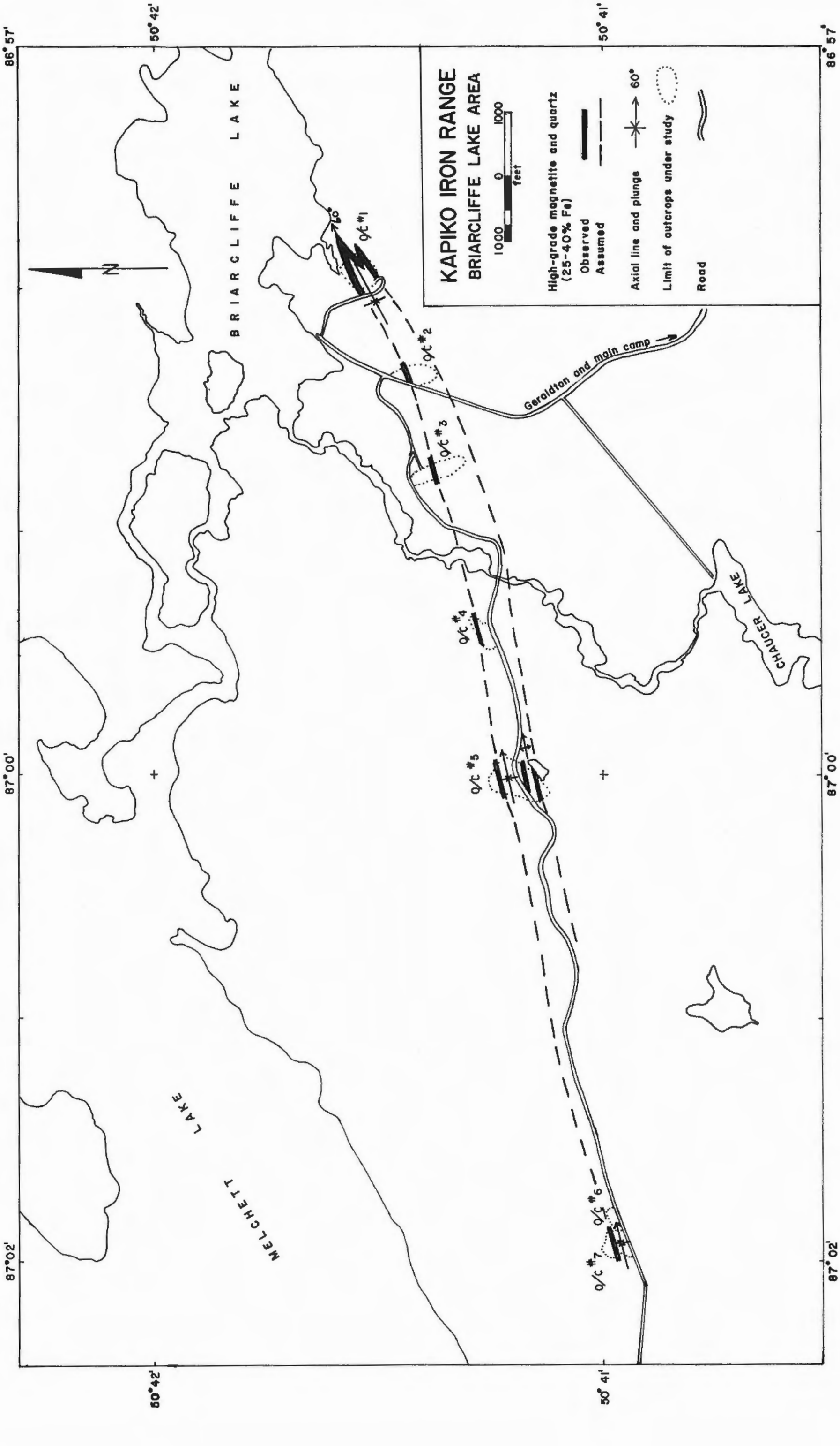
The writer spent the latter part of the field season in the Welland Canal area, Ontario, examining many soil and bedrock samples and preparing descriptions of the materials to be included in contract specifications by the St. Lawrence Seaway Authority. Some time was also spent examining potential aggregate materials in the Welland area.

83. GEOLOGICAL AND GEOPHYSICAL STUDY OF THE BRIARCLIFFE IRON FORMATION, NORTH OF NAKINA, NORTHERN ONTARIO

D.F. Sangster, P.J. Hood, and G.A. Gross

This was the second and final year of the investigation of the Briarcliffe orebody in the Kapiko Iron Range, which has been partly developed by Anaconda Iron Ore Company (Ontario) Ltd. The property is located approximately 44 miles north of Nakina on the Canadian National Railways line and about 70 miles north of Geraldton on the Trans-Canada highway. The Briarcliffe ore deposit is a steep to vertically dipping body some 500 feet wide of 25 to 30 per cent iron (see figure).

During the 1963 field season work was confined to outcrops 5 and 7 (see figure), where the structure is relatively straightforward. After the experience gained in 1963 it was decided to tackle outcrop 1, where the structure is much more complicated. A magnetometer traverse was also made right across the structure immediately to the east of outcrop 3, and finally a steeply dipping isolated magnetite band was studied, which was located some distance to the south of outcrop 1 and which crossed the road between the main camp and the Briarcliffe ore zone. In addition to other types of geophysical surveys, in-situ susceptibility measurements were obtained using an instrument based on the Carey-Foster mutual-inductance bridge principle built by Sharpe Instruments of Canada Limited. It appears to be reasonably possible that a reliable estimate of the percentage of magnetite present can be obtained directly from the susceptibility measurements, thus enabling a map to be produced showing per cent Fe of the topmost layer of the outcrop. One of the conclusions of the 1963 field season was that the highest vertical intensity magnetic values do not necessarily occur over the more massive iron formation because of the effect of remanent magnetization. The in-situ susceptibility meter whose readings are unaffected by the presence of remanent magnetism should therefore be preferred to the magnetometer for surveys over


KAPIKO IRON RANGE
BRIARCLIFFE LAKE AREA
1000 0 1000
feet
High-grade magnetite and quartz (25-40% Fe)
Observed
Assumed
Axial line and plunge
60°
Limit of outcrops under study
Road
BRIARCLIFFE LAKE
MELCHETT LAKE
CHAUCER LAKE
Geraldton and main camp
N
O/C #1
O/C #2
O/C #3
O/C #4
O/C #5
O/C #6
O/C #7
60
86° 57'
87° 00'
87° 02'
50° 42'
50° 41'

iron formation when the results are to be used to delineate zones having the highest tenor of magnetite.

The results from outcrop 5 are currently the basis of a M.Sc. thesis to be presented to the Geophysics Department of the University of Western Ontario by J.A. Slankis. He has measured the remanent magnetism of the 177 cores collected from outcrop 5 during the 1963 and 1964 field seasons using the astatic magnetometer built by Professor C.M. Carmichael. He has found that the remanent magnetism directions generally lie in the plane of the foliation of the iron formation.

Gravity surveys of outcrops 1 and 5 and the traverse to the east of outcrop 3 were carried out using a Worden gravimeter by Cheng Yung-Yu, who is also a Masters candidate at the University of Western Ontario. It is hoped that an estimate of tonnage for the outcrops studied can be made using Gauss's theorem.

Very detailed geological mapping and description of the iron-formation were completed so that results from the various geophysical studies could be oriented in their geological environment. Data from the geophysical measurements were correlated directly with specific geological features such as different lithological facies of iron-formation, fold structures, and metamorphic effects of diabase and pegmatite intrusions on iron-formation. Since the data show that the direction of magnetic polarization coincides with prominent mineral lineation and foliation in the banded rocks the study of direction of magnetic polarization would appear to have a very useful application in the interpretation of petrofabric and structural data.

Detailed mapping confirmed that mineral gradations across the gneissic bands, consisting of transitions from quartz and feldspar to feldspar, biotite, and garnet-rich layers, could be used to determine the stratigraphic tops of metamorphosed beds. The gneiss was derived from sediments that originally had graded bedding and the finer-grained parts of the graded beds were transformed to biotite and garnet-rich gneiss during metamorphism while the quartz-rich coarse-grained parts of the original beds were recrystallized. The internal structure of some of the ore zones and local structures have been interpreted with the benefit of these top determinations, detailed geological maps, and geophysical data.

84. SIOUX LOOKOUT (52 J) MAP-AREA

R. Skinner

Reconnaissance geological mapping was confined to the eastern half of the map-area where earlier mapping was checked and extended with the aid of aeromagnetic maps.

An excellent section was observed along the new road north and south of Savant Lake station. The conglomerate in the Savant Lake area was found to be an intraformational conglomerate in some places containing mainly rhyolitic clasts and matrix and in others mainly greenstone clasts and matrix. The coarse-grained rhyolitic material was most likely derived from contemporaneous or slightly older volcanic rocks, some of which are now visible in the immediate area (no typical granite clasts were seen). There is little or no evidence for an unconformity between the conglomerate and underlying greenstones.

A large westerly trending belt of rhyolite was outlined between Hough Lake and a point 1 mile north of Savant Lake station. A large greenstone area containing a high concentration of magnetite iron formation occurs north of Kashaweogama Lake. Greenstone areas were extended westward and eastward from Savant Lake.

Magnetite iron formation is concentrated and relatively extensive on Doran Lake, in the greenstone body southwest of Hill Lake, and south of Kashaweogama Lake. These occurrences have been known for several years. Mining companies and prospectors were active in the Sturgeon Lake area during the summer. One of the prospectors discovered a gossan zone about 1,000 feet long on the east shore of the west arm of Seseganaga Lake 2 miles north of latitude 50°. The writer's party found a small copper-bearing pyrrhotite zone on the south side of the most southerly arm of Fitchie Lake, and molybdenite along fractures in greenstone on a small island in Sturgeon Lake 1 3/4 miles west-northwest of the old Hudson Bay post.

85. SEDIMENTARY FACIES AND VOLCANIC ASSOCIATION OF EARLY PRECAMBRIAN IRON-FORMATIONS NEAR TIMAGAMI

H.P. Wilton

Field work has been completed on a study of the stratigraphy and geological setting of some Early Precambrian banded iron-formations near Timagami, Ontario. The area examined contains two distinct and roughly parallel ranges of iron-formation striking approximately ENE and lying immediately north of the Northeast Arm of Lake Timagami.

With the exception of younger intrusive rocks, all of the rocks associated with these iron-formations appear to be of volcanic origin and are highly variable in composition and distribution. Along the south range, chloritic, tuffaceous material and grey, water-laid pyroclastic rocks are intimately interbanded with the iron-formation. Volcanic rocks in the vicinity of the iron-formations, particularly within and immediately south of each range, contain a considerable amount of carbonate. These features strongly suggest deposition of the iron-beds in an environment of active volcanism.

The detailed stratigraphy of the iron-formation is extremely variable. Individual bands are traceable only for short distances along strike, either pinching out or grading sharply into material of different composition. Only large-scale facies units can be correlated between sections. The most abundant facies present is the magnetite oxide facies with thin bands of magnetite, chert, and jasper. An iron silicate-rich facies and a sulphide facies are widely distributed in the north range and a continuous belt of iron carbonate-rich chert is present along the entire north edge of the south range. In general, therefore, these iron-formations are seen as isolated sedimentary bodies in a volcanic setting, built up of irregularly distributed and lenticular facies units representing differing environmental conditions of deposition, and are in turn comprised of discontinuous bands of differing mineralogy.

86. GAMMA-RAY SPECTROMETER SURVEY, CARLOW TOWNSHIP

J.M. Woodside

During the month of June, a gamma-ray spectrometer survey was completed in Carlow township. Three observations were made at each of 190 stations spaced about 1,000 feet apart on a crude rectangular grid. From these observations, U, Th, and K contents were calculated for the underlying rocks, which comprised granites, granitic gneisses, and gabbro, with lesser metasedimentary rocks, syenite, and glacial till.

This experimental survey was made to test procedures for the spectrometric mapping of a relatively large area and to provide further field trials for the instrument, which was first tested in 1963. Samples of the rocks and soils were collected for subsequent analysis and correlation.

Distinct contrasts in radioelement content were observed between several granites as well as between different rock types. Preliminary interpretation suggests that the distribution of U and Th in any one of these rocks is quite irregular while the potassium content varies more regularly. A more complete study of the field observations and procedures is in progress.

QUEBEC

87. AEROMAGNETIC-PHOTOGEOLOGIC STUDY OF THE COULONGE RIVER (31 K E1/2) AREA

D.T. Anderson

The writer's field work in the summer of 1964 consisted of geological mapping by four-wheel drive vehicle, canoe, Cessna 180, and Piper Cub, of the readily accessible parts of the Grenville Project area between 74°45' and 77°00' longitude and between 46°00' and 47°00' latitude.

The mapping was carried out to test the efficiency and accuracy of interpretations made as a result of continuing studies of small scale panchromatic film, large scale colour, colour infrared, infrared, and panchromatic film, as well as aeromagnetic maps.

The as-yet incomplete evaluation of the field observations with respect to these studies suggests that there is a reasonably good correlation between both the aeromagnetic linear and photolinear analysis and the geological attitudes.

The evaluation of the special colour and infrared studies is in progress.

88. STRATIGRAPHY OF ANTICOSTI ISLAND

T.E. Bolton

The Ordovician and Silurian rocks of the western half of Anticosti Island, through a detailed study of new sections exposed since the writer's 1958 investigations, are divisible into six formations and several distinct and persistent members. The Ordovician Vaureal Formation has been examined in detail along the north shore of the island as far east as the MacDonald River. Two members may be recognized, with the upper member containing the type English Head strata. Suppression of the term English Head is recommended. The contact between the Vaureal and overlying Ellis Bay Formation and the six members of the Ellis Bay have been traced from the Junction Cliff - Port Menier area east some 50 miles.

A north-south section including the entire Ellis Bay and Silurian Becscie sequence, as well as much of the Gun River Formation, has been compiled in the La Loutre River area, supplementing composite sections defined to the east and west in previous seasons[1]. In addition, studies were undertaken of the Becscie Formation in the Becscie River area and the Mile 24 section of the Jupiter River; of the upper members of the Gun River Formation along the Middle Jupiter River; and of the Jupiter Formation in the type area around the mouth of the Jupiter River.

Large faunas from each of the formations have been collected. It is intended to monograph the coral and trilobite faunas, in conjunction with the microfaunal studies underway by M.J. Copeland.

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[1] Bolton, T.E.: Ordovician and Silurian formations of Anticosti Island, Quebec; Geol. Surv. Can., Paper 61-26 (1961).

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89. PETROLOGICAL STUDIES OF THE MORIN ANORTHOSITE

R.F. Emslie

Examination of approximately the western half of the Morin Anorthosite has verified the existence of a continuous series of rocks from anorthosite through diorite, mangerite, syenite, quartz syenite, and charnockitic rocks (the Morin series[1]). Extensive sampling of rocks of the series was undertaken so that mineralogical and chemical studies can provide information on details of crystallization of the series.

Primary structures such as compositional layering and igneous lamination have been found sporadically throughout the anorthositic rocks, but attempts to obtain a unified structural picture from them have been largely unsuccessful. Deformation, either during crystallization or post-crystallization, is considered to be responsible for the inconsistency of these structural data.

Inclusions of Grenville paragneisses are found in all members of the anorthosite-charnockite series indicating the emplacement of these rocks at some time after the period of Grenville sedimentation. Metamorphism of the anorthosite-charnockite series and the Grenville rocks to a similar grade indicates that both units were present during the last regional metamorphism in this part of the Grenville Province.

Distribution of oxide-bearing dioritic rocks, syenites, and Grenville paragneiss within the boundaries of the Morin massif suggest that the anorthosite has been unroofed without being deeply eroded.

Large areas of highly crushed anorthosite in the southeastern part of the Morin massif have associated with them highly crushed diorites and syenites. The crushing is therefore regarded as cataclastic and hypotheses requiring emplacement of the anorthosite as a protoclastic, largely crystalline plagioclase mass are rejected.

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[1] Osborne, F.F.: Ste. Agathe - Ste. Jovite map-area; Que. Bur. Mines, Ann. Rept. 1935, Part C, pp. 53-91 (1936).

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90. SURFICIAL GEOLOGY, CHAUDIÈRE RIVER VALLEY

N.R. Gadd

Major morainic systems projected across the Chaudière valley region by reconnaissance carried out during the 1963 field season[1] were studied in detail mainly within St. Joseph (21 L/7) map-area in the course of mapping that area during the 1964 season. This study revealed that although the regional trend of moraines is northeasterly there exist morainic features with southerly trends that outline elongate lobations south of the main ice front primarily in the valleys of the major rivers such as the Chaudière and the Etchemin. Meltwater phenomena of minor moraines, kame moraines, individual kames, and outwash deposits were produced in many places across the region. However, glacial lakes related to retreat of the ice front seem to have been narrow and confined in the main river valleys where pondings of relatively short duration occurred. The major sedimentary deposits of ice recession in places along the valleys were accumulations of sand and gravel in what may be called kame deltas. Such deposits combine ice-contact stratified sediments and inwash brought to the main valley by meltwater streams that flowed southward along the ice tongue into a glacial lake ponded in the central valley upstream from the ice lobe. One such kame delta of sand and gravel occupies both sides of the Chaudière valley at Vallee Jonction; although large parts of the deposit have been removed by river erosion since the glacial period, the existing remnants attain a height of about 200 feet above present river level. Similar, but lesser, ice-front features occur in the Chaudière valley at or near each of the communities along Highway 23 between St. Côme and Scott Jonction; most of these mark minor recessional halts of the ice front related to the valley lobe. Relationships of these valley moraines to the major regional morainic systems are still being studied.

Although glacial lake sediments in the central valleys (Chaudière and Etchemin) seem mainly to post-date the final glacial advance into the region, glacio-lacustrine sediments in some tributary valleys, such as the Gilbert valley, seem mainly to be overlain by glacial till; some varves are contorted beneath overlying till. Hence, it would appear that the overridden lakes pre-date the last ice advance. Since varved sediments have not been found in the same stratigraphic position in trunk valleys, it is possible to suggest either that they were removed by selective glacial erosion in the main valleys during ice advance, or that no directly correlative varves were deposited there. The writer favours the latter interpretation and the hypothesis outlined below.

Bearing in mind the lobate configuration of the ice front during recession of the ice sheet, the author has found it convenient to think in terms of 'valley glaciation in reverse' and to postulate a sequence of events during ice advance that could explain the phenomena observed. It is probable that narrow ice lobes, similar to those outlined by recessional moraines, extended up the Chaudière and Etchemin valleys several miles in advance of the main mass of the continental glacier. Such tongues, as they advanced up-valley, would successively block off tributaries to the trunk valleys, thus forming small glacial lakes in these tributaries from normal drainage waters augmented by glacial meltwaters. Thus, before the tributary valley was subject to glacial erosion by the last ice advance, there would be opportunity for deposition of glacio-lacustrine silt over the alluvial sand and gravel that may have existed there prior to glaciation. The blanket of glacio-lacustrine sediment in Gilbert River attained a thickness of 30 feet. As glaciation continued and the main ice sheet advanced southward across the country, these small lakes, tributary to the trunk valleys and thus lying transverse to the main direction of ice flow, might be overridden by the ice sheet with very little effect on the sediments other than minor contortion of varves, as till was laid on them by the overriding ice sheet.

Such a sequence of events would explain the presence in tributary valleys of stratigraphic successions not duplicated in the trunk valleys. It would also serve to explain the preservation of gold-bearing pre-last-glacial gravels in valleys that without their protective cover of glacio-lacustrine silt might have been scoured out more or less cleanly by glacial erosion, as probably was the case in most parts of the Chaudière and Etchemin valleys. This latter phenomenon, i.e. scouring of the main valleys, might explain, in part, the presence of some gold nuggets in glacial till and in some ice-contact sediments in parts of the area.

The results of previous reconnaissance and their value in interpretation of local phenomena stimulated further reconnaissance outside the area late in the field season of 1964. For this purpose an Eastern Airlines Cessna 170 from the airport at St. Georges de Beauce, was hired for flights over hilly areas between the St. Lawrence Lowland and the international boundary in the region from about Sherbrooke to the vicinity of Rivière du Loup. As this phase of the writer's surficial geology studies is not yet complete, only a few preliminary observations can be presented at this time.

Reconnaissance in 1963[1] established the existence, along the highland front, of a morainic system which attained elevations near 700 feet, and a second morainic system, farther south and presumably older, which attained elevations near 1,200 feet and was known as far east as St. Philémon (Dorchester). This latter morainic system may now be extended from St. Philémon eastward more or less along the Canadian National Railway line through Rosaire, St. Appolinaire Station, Ste. Perpètue, to the railway sidings of East Lake, which are about 16 miles east of Ste. Anne de la Pocatière and inland about the same distance from the south shore of the St. Lawrence River. The eastward extent from this point of this major morainic system is not known.

Another significant morainic system has been traced from the north side of Megantic Mountain eastward to Lake Megantic, where it swings southward in a broad lobe (Lake Megantic lobe), which extends southward to Woburn. Thus the southern two-thirds of Lake Megantic basin is flanked by gravelly moraine deposits. The morainic system continues northeast of the town of Megantic, between the Chaudière River and the high hills to the southeast, to a point near St. Gédeon de Beauce. Near St. Gédeon the system swings eastward away from the Chaudière, passing north of the village of Armstrong, along the north side of Wilson River valley and thence northeasterly more or less parallel to, but some 10 miles east of the international boundary to the vicinity of Ste. Aurélie (some 30 miles east of St. Georges de Beauce). Organic deposits from a bog south of this morainic system near St. Zacharie are under study by J. Terasmae in the Geological Survey's palynology laboratory. It is hoped that this study will shed light on the age of this southernmost Quebec moraine.

It is too early to define all the moraines of the Appalachian region of Quebec, but reconnaissance suggests that the area between the marine plain of the Champlain Sea (or, the St. Lawrence Lowland) and the international boundary near Lake Megantic may contain from four to six major morainic systems trending northeasterly and numerous minor recessional moraines, which are variously oriented and may have only local significance.

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[1] Gadd, N.R.: New morainic systems in the St. Lawrence Lowlands; in Jenness, S.E.: Summary of activities: Field, 1963; Geol. Surv. Can., Paper 64-1, pp. 54-55 (1964).

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91. BURIED VALLEYS AND GOLD PLACERS, BEAUCE COUNTY

N.R. Gadd

Placer gold deposits known in Beauce county, Quebec, for several generations, are currently exploited by a single company, Beauce Placer Mining Co., Ltd., reported by Canadian Mines Handbook, 1964, to have holdings of approximately 50,890 acres in the Seigniory of Rigaud-Vaudreuil, Beauce county, P.Q. and reserves of nearly 17 million cubic yards of gravel averaging 22.24 cents in gold. The reserves are proven by drilling in holdings, mainly along the Gilbert River. An 800-ton electrically powered floating dredge operates in an artificial basin or trench across the slope on the south side of Gilbert River about 1 mile northeast of the village of St. Simon-les-Mines; the equipment was in operation when visited in mid-September, 1964. The workings are as much as 60 feet below the surface in gravel-bearing channels of a river valley that was partly filled by glaciolacustrine and glacial sediments during the last glacial episode of the region. At the point of operations drillings have located the main channel of the buried valley several hundred feet south of the present stream.

Previous experience in the region indicates that placer gold is found in a variety of sediments (including the modern river gravels) over a wide area in Beauce county, but that the richest deposits exist in glacially buried valleys. Thus the interest of Pleistocene geology explorations in the area has been, at least in part, focused on the problem of locating such buried valleys. Much of the area is underlain by friable bedrock thinly veneered by glacial sediments. Thicker deposits of glacial sediment occur in moraines superposed on the bedrock surface and in fairly broad valleys set into the bedrock. In general, the broad, inset valleys contain sediments representing the burial of a pre-glacial river valley in the form of pre-last-glacial fluvial gravel, glacio-lacustrine sediments, and glacial till, commonly in that order; the writer has discussed briefly the significance of such deposits to the regional glacial history in the report immediately preceding this one. For present purposes it is perhaps sufficient to note that the current activity in gold exploitation of the Beauce region is concerned with removal of glacial and glacio-lacustrine sediments in order to expose to dredging the pre-glacial gravel and underlying bedrock; the bedrock is also a source of gold because its fractured surface acts as a natural riffle.

Detailed examination of the site of Beauce Placer operations showed that the lateral limits of the buried valley containing gold-bearing gravel are readily recognizable on the ground and also, commonly, on air photographs of the region. There, the surface of the region and on both sides of the buried valley is irregular and bedrock outcrops are numerous and readily recognized on air photographs; the area of the buried channel is characterized by relatively smooth flat terrain, flanked by steep bedrock slopes. Where the steeply dipping plane of the bedrock surface in the old valley wall intersects the plane of the surface of the glacial fill, there is a sharp break in slope, generally noticeable on the ground surface, but also commonly noticeable as a lineament on air photographs. With the aid of a stereascope, which greatly exaggerates relief, it is often possible to recognize breaks in slope that are barely perceptible on the ground, or are masked by vegetation.

Working from these simple criteria the writer located what appeared to be local extensions of the known buried channels currently being mined. These extensions on the Gilbert and Famine River valleys and in an intervening area near St. Simon-les-Mines and Cumberland station (Beauceville map-area) were examined during the 1963 and 1964 field seasons in hammer seismic surveys carried out by G.D. Hobson of the Geological Survey of Canada and his assistants. Their work has proved the usefulness of hammer seismic equipment in outlining bedrock topography and hence for delimiting the buried valleys and their principal channels. The data from such seismic work may be interpreted to indicate depths to bedrock within relatively few feet. The results in the test area, later verified in part by drilling subsequent to seismic surveying (Mr. J.K. Crowdy, oral communication), proved the existence of channels in the places chosen by airphoto and ground observations. The tests also indicated that the criteria for recognizing buried valleys could also be employed gainfully in other parts of the area.

During the latter part of the 1964 field season, it has been possible to examine on the ground and in air photographs, much of the area included in the Beauceville map-area and eastward from it to the international boundary.

Such examination of the region, indicates that buried valleys occupy parts of the main Chaudière valley (some parts have been re-excavated completely by various means) in much of its length through Beauceville (21 L/2) and St. Joseph (21 L/7) map-areas and the part of the Linière (formerly known as R. du Loup) that occurs within Beauceville map-area. Also within the Beauceville area, the valleys of the St. Victor River and its eastward and southeastward flowing tributaries, of Meule Creek, of Rivière du Moulin, and probably also of Pozer River, have in part re-occupied deep buried valleys. Some of these buried valleys have yielded gold in the past. In addition, the valleys of R. des Plantes, and tributaries of Gilbert and Famine Rivers, are the principal areas of current interest and activity and are known for their past and potential production of placer gold. Airphoto studies suggest that known buried valleys of the Famine-Gilbert area may extend from the Beauceville area eastward to the vicinity of St. Aurélie, near the international boundary, following branches of the Abenakis River that are tributary to the Famine.

The author would emphasize that most of these valleys containing channels buried during the last glacial ice advance trend northeasterly and are therefore transverse to the southeast regional direction of glaciation. Burial of the channels is almost certainly related to the last glaciation whose sediments still overlie and prevent the erosion and redistribution of large amounts of pre-glacial gravels and what may be important concentrations of gold.

Certain problems such as the ultimate origin of the gold and trends of its distribution will require further study. It is possible for an experienced person to obtain gold from a wide variety of source materials in the area, including modern alluvium. Knowledge of such distribution may lead to means of tracing back to rich placers. Very recently gold in sizeable nuggets has been extracted from stream gravels of the Chaudière, the Linière, and of some of the smaller streams. In at least one case, gold was extracted from gravel and sand accumulated behind a dam built and destroyed since the settlement of the region; this could represent either redistribution of pre-last-glacial concentrations, or recent deposition from primary sources.

92. PRELIMINARY INVESTIGATIONS OF AEROMAGNETIC ANOMALIES IN MONT LAURIER (31 J) AND KEMPT LAKE (31 O) MAP-AREAS

E. Gaucher and A.F. Gregory

Twelve aeromagnetic anomalies were investigated in the Mont Laurier (31 J) and Kempt Lake (31 O) areas. The work was done as part of the Grenville Project, a geological reconnaissance mapping project at a scale of 1 inch to 4 miles, as reported by Wynne-Edwards elsewhere in this publication.

The investigation of eleven positive and one negative aeromagnetic anomalies was undertaken to measure both the remanent and the induced magnetizations of the rocks underlying an anomaly. Additional geological mapping was done when necessary to define the shape of the bodies. Using these data we expect to explain quantitatively the aeromagnetic anomaly on the basis of the physical properties of the underlying rocks and thus aid geological interpretation of aeromagnetic maps.

Some 300 oriented core samples at 150 sites were collected to study the remanent magnetization, and several thousand determinations of the magnetic susceptibility were made on rocks in situ. In addition some 5,000 magnetometer readings were made to help locate and understand the cause of the aeromagnetic anomalies, especially the narrow linear features encountered in amphibolite gneisses.

A new direct-reading susceptibility meter was tested in the field to speed up measurements of in situ susceptibility (induced magnetization). It performed most satisfactorily and is being miniaturized at the present time.

While most measurements and calculations remain to be completed one observation already seems of interest: linear aeromagnetic anomalies in the gneisses in NTS areas 31-0-12, 13, 14 are caused by narrow magnetite-rich layers of amphibole or granite gneiss some 5 to 80 feet thick. These magnetite-rich layers often contain accessory sulphides, among which occur local small concentrations of chalcopyrite. The layers cause aeromagnetic anomalies when the geomagnetic vector is included in the plane of the layers. However, preliminary interpretation suggests that when such a thin layer is at a significant angle to the earth's field the induced magnetization is greatly reduced and sometimes negligible because of a large scale demagnetizing effect. This result is predictable from theory of magnetization, but the observed contrasts are surprisingly strong. As a result, a sequence of amphibole gneisses may or may not show anomalies depending on its attitude.

93. SURFICIAL GEOLOGY STUDIES, RICHMOND-SHERBROOKE AREA

B.C. McDonald

The writer commenced Pleistocene geology studies in the Richmond-Sherbrooke area, with field work concentrated on the west half of Sherbrooke (21 E/5) map-area. Additional reconnaissance was done in the remainder of the area (Richmond 31 H/9, and the east half of Orford 31 H/8) and south toward Coaticook (21 E/4). Field work will continue in 1965 and the project will form the basis of a doctoral dissertation at Yale University.

Stratigraphic investigations have revealed the presence of two and possibly three till sheets separated by stratified sediments. Evidence exists for ice advance from both northwest and northeast. The last ice to occupy the region advanced from the northwest, as confirmed from stoss-and-lee features, indicator lithologies, and three-dimensional till fabrics. This ice constructed a moraine, previously undescribed, extending southerly from the vicinity of Stoke Center to Martinville, a distance of about 20 miles. The moraine is composed entirely of ice-contact stratified drift and is an important source of sand and gravel as well as groundwater for communities in the area. Extensive deposits of ice-contact stratified drift on both sides of the St. Francois River valley, below Sherbrooke, are also being exploited for sand and gravel.

94. THE GRENVILLE PROJECT

H.R. Wynne-Edwards and A.F. Gregory

Thirteen thousand square miles of the Grenville structural province of southwestern Quebec between latitudes 46° and 48° and longitudes 74° and 76° (31 J and O) were mapped between May and September for publication at a scale of 1 inch to 4 miles. As the first phase of a larger program, the project was intended to devise and test reconnaissance mapping methods in the Grenville province, as well as to provide geological maps of Mont Laurier (31 J) and Kempt Lake (31 O) map-areas.

In this district, there are three broad geological divisions that include good examples of all the main rock units known to be present in the Grenville province. These geological divisions are:

1. the northern third of the map-area, comprising quartzo-feldspathic and hornblende-plagioclase gneisses with local, steeply-dipping metasedimentary zones;

2. a central metasedimentary complex, dominated to the west by marble and to the east by quartzite, that contains large, discrete masses of granite, syenite, gabbro, and charnockitic and granulitic rocks; and

3. a southeastern complex of anorthosite, charnockite, and porphyritic granite and syenite.

Each of these assemblages is distinctive, although rock types especially characteristic of one division may also occur within another. The regional divisions are further distinguished by their magnetic anomaly patterns ("magnetic texture"), and their structural style. They appear to have had somewhat different tectonic histories. Apart from distinctive suites of charnockite and granulite (the "Green rocks") in granulite facies, the rocks are uniformly metamorphosed to upper amphibolite facies.

Mapping was carried out by E.W. Reinhardt, P.W. Hay, C.A. Giovanella, A.C. Brown, V.H. Becker, and C.M. Nixon, in addition to the writers. As reported elsewhere in this publication, D.T. Anderson and E. Gaucher conducted special studies related to the project.

Six 2-man crews traversed the extensive network of lumber and other roads, largely with 4-wheel drive vehicles. Two light aircraft were used to make landings on all lakes where there was outcrop, and a helicopter was chartered for 45 hours to reach otherwise inaccessible areas. Aeromagnetic maps were used to interpolate the continuity of rocks between points of observation.

Preliminary estimates suggest that this type of mapping is approximately 1/10 as costly (per square mile) and 20 times as fast (per observer-year) as conventional one-mile mapping in the same terrain. These statistics can only be measured against the scientific return and the value of the maps themselves. At present, it appears that the results will exceed our expectations, and that they will compare favourably with more detailed mapping except in areas of great structural and stratigraphic complexity. The delimiting of such areas can, however, be legitimately claimed as a valuable by-product of the study.

NEW BRUNSWICK

95. GEOCHEMICAL STUDIES, BATHURST-NEWCASTLE MINERAL BELT

R.W. Boyle

During the field season the area containing the New Larder U deposit was mapped at a scale of 1 inch to 500 feet and samples were collected for geochemical work.

The New Larder U deposit is a massive sulphide deposit containing lead, zinc, and copper sulphides. The deposit is localized in a shear zone that cuts through the nose and axis of a steeply pitching syncline. The country rocks are iron formation, chlorite schists, altered lavas, and graphitic schists. The ore shoots are largely restricted to the iron formation, chlorite schists, and altered lavas. A characteristic wall-rock alteration consisting of sericitization, silicification, and chloritization surrounds the ore shoots.

96. SULPHIDES OF THE ST. STEPHEN AREA

J.A. Chamberlain

A study of the sulphides of the St. Stephen area was initiated in 1964 as part of a broad study of the geology of Canadian nickel deposits. The St. Stephen sulphides occur in a small, mafic pluton that intrudes metasediments of the Charlotte Group (pre-Silurian). The intrusive rocks range in composition from peridotite to anorthositic gabbro, and all carry disseminated sulphides, including pyrrhotite, pyrite, chalcopyrite and pentlandite. Detailed examination of 40,000 feet of diamond drill core indicates that both lithologic and structural controls have operated to localize sulphides. It is estimated that one more season will be required to complete field observations prior to full interpretation of the results.

97. GEOCHEMICAL SAMPLING OF GRANITIC ROCKS IN NEW BRUNSWICK

R. Martin

The sampling phase of a geochemical and petrographic study of the granitic rocks of New Brunswick has been completed. This year, sampling was restricted to the central and southern parts of the province. Mineralized areas, spatially associated with granite plutons, were also visited. Altered exposures were resampled by means of a portable diamond drill.

These rocks are mainly of Devonian age; Ordovician and Precambrian granites, also sampled, are of more limited areal extent.

It is hoped that a regional evaluation of petrographic and trace-element data will provide a greater knowledge of the chemistry of these granitic rocks, and a better understanding of the igneous and tectonic history of the province.

98. GROUNDWATER STUDIES OF SOUTHERN NEW BRUNSWICK

M.L. Parsons

Groundwater data were collected in the New Brunswick portions of map-areas 21 G and 21 H, for the purpose of compiling groundwater probability maps. To assess the quality of the groundwater, eighty samples were obtained from water wells and springs for detailed chemical analysis. Quantitative data of the production of industrial, municipal, and domestic water wells were collected. This information will provide a basis for the first stage in the evaluation of the available groundwater.

In general, water of excellent quality is obtained from bedrock and surficial aquifers, with the exception of those aquifers affected by the occurrence of evaporite sediments of the Mississippian Windsor Group. Pre-Carboniferous aquifers generally yield small quantities of water sufficient for domestic purposes. Carboniferous and Quaternary aquifers may yield larger quantities of water, possibly enough for industrial and municipal purposes.

NOVA SCOTIA

99. MERIGOMISH (11 E/9) MAP-AREA

D.G. Benson

Mapping was completed in the western half of the map-area and the following comments refer to this part only.

A prominent dissected highland, which occupies most of the southern part, is underlain mainly by the Ordovician Brown's Mountain Group and associated igneous rocks. The Brown's Mountain Group consists of dark green andesitic flows, interbedded tuff and greywacke, and minor porphyritic and tuffaceous intermediate volcanic rocks. Their original compositions have been altered by intrusion of granitic to monzonitic rocks of possible late Ordovician age and younger diabase. The entire complex has been highly folded and dips are generally steep.

Slightly folded sedimentary rocks of the Silurian Arisaig Group overlie the complex to the north and in the upper French River valley. The Arisaig Group consists of predominantly grey fine-grained arenaceous sediments of similar composition so that recognition of individual formations is difficult except where there is continuous outcrop. Extensive fossil collections were made at most Arisaig Group outcrops.

The Arisaig Group appears to be in fault contact with the overlying Carboniferous strata. However, near Telford relatively flat-lying Windsor pebble conglomerate is exposed near steeply dipping Arisaig siltstone. This conglomerate is conformably overlain by light greywacke that contains numerous plant fragments of possible Canso correlation (lowest Upper Carboniferous). These plant remains are often pyritized and near Sutherland River there are several small occurrences of base-metal minerals that may have a similar origin. One such occurrence halfway between Telford and Sutherland River contains about 18% Pb, 5.2% Zn, 34% Fe, and 0.1% Cu. Grey and red medium-grained sandstones of the Pictou Group overlie these beds and are well exposed along the coast.

100. COBEQUID MOUNTAINS

D.G. Kelley

Because of scarcity of outcrop and apparent structural complexity in the east end of the Cobequids, compilation of the stratigraphy is tentative.

Sparsely fossiliferous Middle and Upper Silurian fine-grained sedimentary rocks appear to be the oldest rocks in the eastern part of the Cobequid Mountains. Included with these Silurian rocks, in a few places, are basic flows or sills.

Unfossiliferous Silurian(?) rocks are present near the southern boundary of the Cobequids. They comprise a sequence of quartzitic rocks, red and grey siltstone and mudstone, argillite, phyllite, and minor conglomerate. These rocks include interlayered(?) and cross-cutting acidic igneous rocks.

Fine-grained red and minor grey sedimentary rocks are possibly conformable with fossiliferous uppermost Silurian (Stonehouse) in a small area northeast of Earltown. If the rocks are conformable the red beds are probably equivalent to the Knoydart Formation that outcrops farther to the east, in Pictou county[1].

The River John Group (see G.S.C. map 910A)[2] underlies the northeastern end of the Cobequids and, for the most part, is separated from the older rocks by a fault. Gillis[3] divided the River John Group into a lower and upper unit. The lower unit consists of fine-grained red and grey sedimentary rocks with interlayered basalt and the upper unit is mainly conglomerate and sandstone. The lower contact of the group is not exposed, but a drill-hole, 1,980 feet deep, was collared in the lowest exposed part of the lower unit of the River John Group[4]. In the bottom 1,100 feet of the hole, an aggregate thickness of 900 feet of basalt was intercalated with an aggregate thickness of 200 feet of fine-grained sedimentary rocks. The drill hole information and examination of the magnetic maps of the area[5] suggest that the River John Group bottoms in basalt.

Correlation of the lower unit of the River John Group with basic to intermediate igneous rocks and minor sedimentary rocks of the central part of the Cobequids of Tetamagouche map-area (11 E/11) is suggested by vague field relationships. Spores obtained in 1963 from the upper part of the lower River John and from sedimentary lenses in the basic igneous rocks (flows in this case) of the central part of the Cobequids support this suggestion. Spores from the River John Group were determined to be late Early to early Middle Devonian and those from sedimentary lenses in the basic rocks were non-diagnostic. However, the mere presence of spores in the latter case suggests that the rocks containing them are younger than the fossiliferous Middle and Upper Silurian rocks. Also, because the red and grey sedimentary rocks of the lower River John and those intercalated with the basic flows of the central Cobequids are lithologically similar, they are tentatively regarded as being correlative or belonging to one conformable sequence.

The basic to intermediate igneous rocks that contain the few sedimentary interbeds in the central part of the Cobequids are probably both intrusive and extrusive. The igneous rocks are mainly fine to very fine grained, massive to commonly amygdaloidal rocks.

Rhyolitic rocks are in contact with the basic to intermediate igneous rocks in the southern part of the Cobequids of Tetamagouche map-area. The rhyolites are grey to red, aphanitic (porphyritic to non-porphyritic) to fine grained. Some are actually fine-grained granites. The rhyolitic rocks are both intrusive and extrusive. In several places the rhyolitic rocks cut the basic to intermediate rocks and in the western part of Tetamagouche map-area the rhyolitic rocks are interlayered with the basic to intermediate rocks.

The tentative conclusion is that the basic rocks, the rhyolitic rocks, at least some of the granitic rocks, and the lower unit of the River John Group are all Lower Devonian.

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[1] Maehl, R.H.: The older Palaeozoic of Pictou county, Nova Scotia; N.S. Dept. Mines, Memoir 4 (1961).

[2] Geological Survey of Canada: Geological map of the Maritime Provinces, scale 1 inch to 12 miles; Map 910A (1949).

[3] Gillis, J.W.: Geology of northwestern Pictou county, N.S.; unpub. Ph.D. thesis, The Pennsylvania State Univ. (1964).

[4] Stewart, J.S., Roliff, W.A., and Moore, E.S.: Report of the petroleum possibilities of Cumberland and Pictou counties, Nova Scotia; N.S. Dept. Mines, Ann. Rept. 1931, pt. 2 (1932).

[5] Geological Survey of Canada: Aeromagnetic map, Tetamagouche, N.S.; Map 788G (1960).

________________________: Aeromagnetic map, New Glasgow, N.W.; Map 763G (1960).

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101. CONODONTS OF THE STONEHOUSE FORMATION AT ARISAIG

J.A. Legault

Two weeks were spent looking over the type area of the Stonehouse Formation at Arisaig, Nova Scotia. This formation consists mainly of siltstone and shale with a few calcareous bands. Samples were collected mainly from these calcareous bands. These samples will be broken up and the conodont fauna will be described. Zonation of the formation may be attempted if it is warranted. This conodont study should assist in determining the age of the Stonehouse Formation.

PRINCE EDWARD ISLAND

102. PLEISTOCENE GEOLOGY, RUSTICO WEST HALF (11 L/6 W1/2) MAP-AREA

G.H. Crowl

The west half of Rustico (11 L/6) map-area is a hilly district with elevations nearly to 500 feet, the highest on the island. It was glaciated by Wisconsin ice. Hill tops are generally covered with thin sand till, or the till is absent and soil is developed on the sandstone bedrock. Till is usually thicker in the valleys and on the hill slopes. Clay till occurs in some valleys where thick clay shales apparently outcrop. In contrast to the eastern part of the island, glacio-fluvial deposits in the valleys are relatively rare, and some are disconnected rather than continuous.

NEWFOUNDLAND

103. GANDER LAKE WEST HALF (2 D W1/2) MAP-AREA

F.D. Anderson and H. Williams

Geological mapping of Gander Lake west half map-area was completed suitable for 1 inch to 4 mile publication and the results of earlier 1 mile mapping integrated into a regional pattern. The general geology of the map-area is shown in Figure 1.

In the northwest the layered rocks are mainly a southwestward continuation of the Ordovician and Silurian rocks of Notre Dame Bay in Botwood map-area[1], but in addition possibly younger rocks were mapped that are not represented in Notre Dame Bay. In the southwest the layered rocks are essentially of Ordovician age and form a connecting link between the Bay d'Espoir[2] and Gander Lake[3] Groups, which lie toward the south and northeast, respectively. A variety of intrusions, some of batholithic dimensions, have been outlined in the map-area.

Sedimentary (6)* and volcanic (5) rocks in the northwest part of the map-area, earlier assigned respectively to the Devonian and Ordovician, form a southwestward continuation of the Silurian Botwood Group. The Rattling Brook Formation[4] is also tentatively included with the Silurian rocks (6). Ordovician (1a, 3a) and Silurian (5, 6) rocks are interpreted to be in fault contact toward the northwest, whereas the relationships between the rocks of the two systems are in doubt toward the southeast. The Silurian rocks (6) are extensively intruded by granite (10) and diorite (9) and pass southward into migmatites and coarsely crystalline gneisses and schists. Ultrabasic intrusions (8) with associated gabbroic phases (9) appear to intrude Silurian rocks (6) although definite cutting relationships were not observed.

Finely laminated pink siliceous lavas (7), along with siliceous tuffs and agglomerates form a distinctive volcanic assemblage that is thought to overlie Silurian rocks (6) and to represent the youngest layered rocks of the map-area. The siliceous volcanic rocks were earlier assigned to the Ordovician[4,5] but are reclassified as Late Silurian or Devonian for a variety of indirect geological reasons.

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1 Williams, H.: Botwood map-area; Geol. Surv. Can., Map 60-1963 (1964).

2 Jewell, W.B.: Geology and mineral deposits of the Baie d'Espoir area; Geol. Surv. Newfoundland, Bull. 17 (1939).

3 Jenness, S.E.: Terra Nova and Bonavista map-areas, Newfoundland; Geol. Surv. Can., Mem. 327 (1963).

4 Peters, H.R.: Geology of the Stony Lake area, central Newfoundland; M.Sc. Thesis, Dalhousie University (1953).

5 Hriskevitch, M.E.: Little Rattling Brook, Newfoundland; Geol. Surv. Can., Paper 50-17 (1950).

* Numbers in parentheses refer to map-unit numbers on Figure 1.

LEGEND

PALAEOZOIC

DEVONIAN AND EARLIER

10	Granite, granodiorite, syenite
9	Quartz diorite, diorite, gabbro
8	Ultrabasic rocks

SILURIAN OR DEVONIAN

7	Rhyolite, siliceous tuff and agglomerate

SILURIAN

6	Red and grey sandstone, slate, conglomerate
5	Purple and green amygdaloidal flows and pyroclastic rocks

SILURIAN(?)

4	Grey conglomerate and greywacke; 4a, includes basic volcanic rocks

SILURIAN - ORDOVICIAN (undivided)

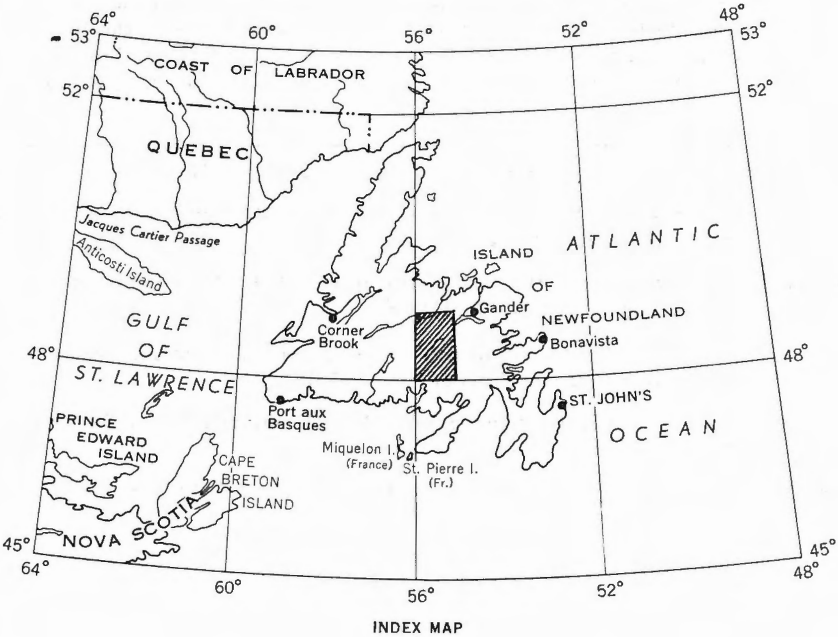
3	Greywacke, slate, grey conglomerate; 3a, basic volcanic rocks
2	Migmatite, schist and gneiss

ORDOVICIAN

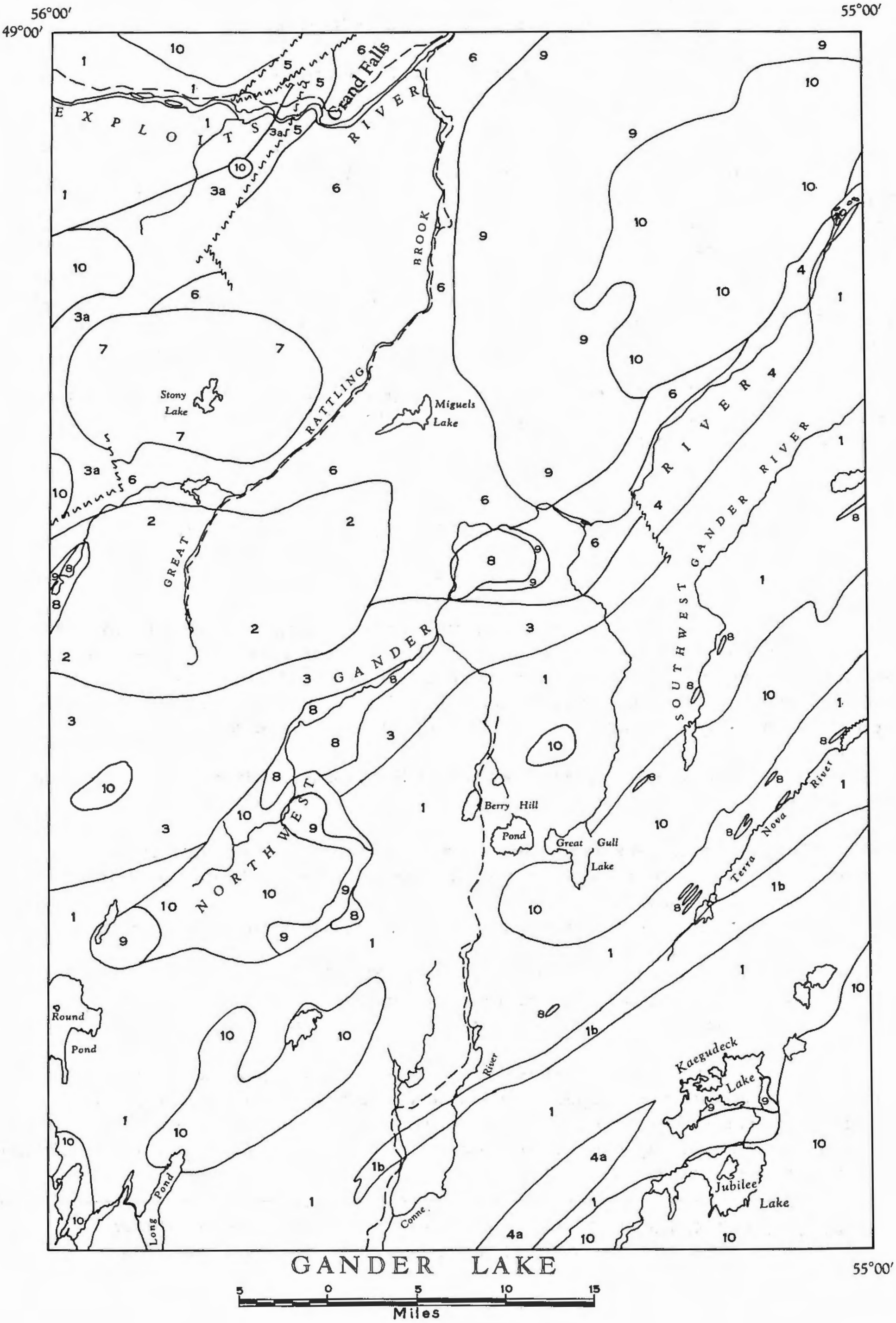
1	Slate, greywacke, phyllite; 1a, includes grey conglomerate and minor volcanic rocks; 1b, quartz-feldspar porphyry

Geologic contact..

Road ....



INDEX MAP


56°00′
49°00′
55°00′
Grand Falls
EXPLOITS RIVER
RATTLING BROOK
GREAT RATTLING BROOK
Stony Lake
Miguels Lake
GANDER RIVER
NORTHWEST GANDER RIVER
SOUTHWEST GANDER RIVER
Berry Hill Pond
Great Gull Lake
Terra Nova River
Round Pond
Long Pond
Conne River
Kaegudeck Lake
Jubilee Lake
GANDER LAKE
55°00′
5 0 5 10 15
Miles

104. STUDIES OF SULPHIDE DEPOSITS

D. Bachinski and D.R.E. Whitmore

Detailed surface mapping on scales of 1" = 40' and 1" = 100' was undertaken during the 1964 field season in the Whalesback Mine area. Surface diamond drill holes were relogged and sampled. A limited amount of underground mapping and sampling was completed. Material from surface and underground has been sampled for thin and polished sections, chlorite analysis, total rock analysis, and sulphur isotope determinations.

An attempt was made to ascertain the gross structure of the volcanic pile in the Whalesback area, with negative results. Correlation of mapping performed to date by British Newfoundland Explorations was initiated.

The Tilt Cove and Gull Pond deposits of First Maritime Mining Corp. were examined and sampled, in addition to the Little Bay Mine of Atlantic Coast Copper Corporation.

105. BIOSTRATIGRAPHIC STUDIES, PORT AU PORT AREA

L.M. Cumming

Lower Ordovician graptolites occur in klippe rocks (Humber Arm shales) at two localities near Port au Port Bay. These fossil occurrences in deformed shales, which lie above gently dipping carbonate rocks of Lower and Middle Ordovician age (St. George and Table Head Formations), provide strong support for the klippe hypothesis postulated by Rodgers and Neale[1].

Petroleum occurrences of the Port au Port Peninsula region are of various types:

1. Oil saturated "Western Sandstone" e.g. south of Two Guts Pond.
2. Oil shales and petroliferous limestone incorporated into the Humber Arm shales.
3. Oil flowage from casing of shallow exploration well on Shoal Point, drilled in 1899.
4. Oily film on waters of brooks flowing into West Bay.
5. Tar blebs in limestone breccia of Round Head.
6. Tarry bitumen in Ordovician limestone fractures.

All these occurrences are related to the capping and associated effects of the base of the klippe. Carbonate rocks beneath the klippe probably constitute source beds. Bituminous dolomite of the Lower Ordovician St. George Formation is extensively exposed on Port au Port Peninsula and at Port au Choix, 165 miles to the northeast.

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

106. PETROGRAPHIC SAMPLING AND DRILL-SITE RECONNAISSANCE, BAY OF ISLANDS IGNEOUS COMPLEX

D.C. Findlay

A detailed sampling program was completed on North Arm Mountain and Table Mountain, two of the four ultramafic-mafic plutons comprising the Bay of Islands complex. The purpose of the sampling was; a) to obtain material for additional petrographic studies to provide background information for a proposed future drilling project on one of the bodies, and; b) to collect material for palaeomagnetic studies as an aid in interpretation of the origin of the banded structures in the rocks of the complex. A total of 940 samples was collected, representing all the rock types of the complex.

Preliminary evaluation of possible drill sites in the area was undertaken, and several alternate site areas satisfying the necessary requirements as to accessibility, water supply availability, and structural and stratigraphic positions in the complex were selected.

107. PORT AUX BASQUES (11 O) MAP-AREA

J.W. Gillis

Geological mapping of Port aux Basques map-area, for publication at a scale of one inch to four miles, was completed. Igneous and metamorphic rocks, and minor sedimentary rocks of Devonian and earlier age underlie all but the northwestern part of the area (Fig. 1). Sedimentary rocks of Carboniferous age occupy the remainder of the region.

Gneisses, schists, granites, diorites, amphibolites, and minor marbles (1a) constitute a major part of the Devonian and earlier rocks. Most of the granitic bodies are elongate parallel to and concordant with the gneisses, schists, and amphibolites; several equidimensional granitic masses, however, cut across gneisses, schists, amphibolites, and other granites. Mafic and ultramafic rocks[1] (1b) underlie a rectangular block in the northwestern part of the pre-Carboniferous terrane. Silicic volcanic rocks and minor sedimentary rocks of the La Poile Group[2] (1c) occur in the southeastern part of the map-area.

The shales, sandstones, conglomerates, slates, and metaquartzites of the Lower to Middle Devonian Bay du Nord Group[2] (2) are exposed in two distinct bands in the eastern part of the area. These strata appear to pass into gneisses, schists, and granitic rocks to the southwest along strike.

Three units are mapped in the Carboniferous: the Mississippian Anguille (3) and Codroy (4) Groups and the Mississippian-Pennsylvanian Searston-Barachois (5) beds[3,4].

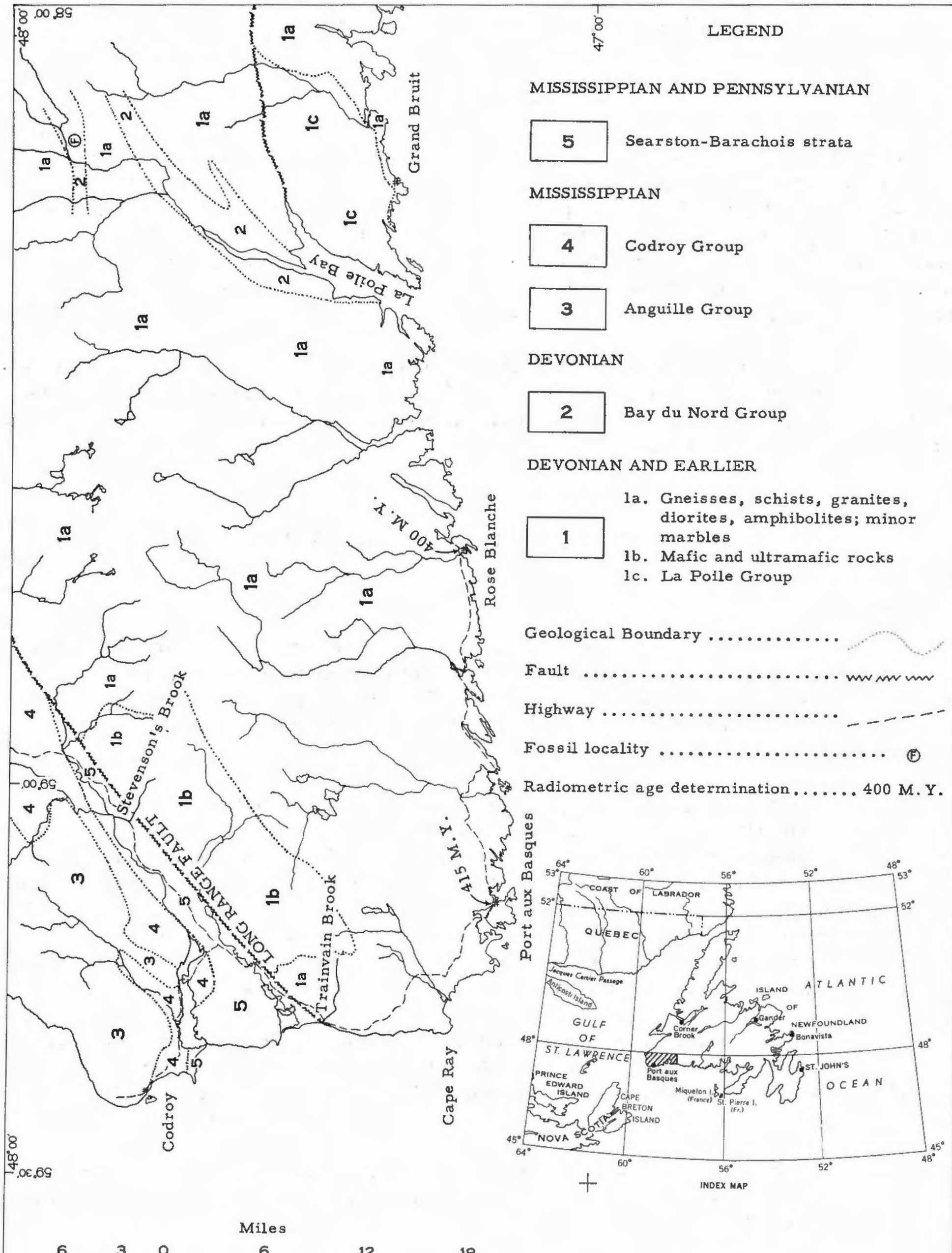
LEGEND
MISSISSIPPIAN AND PENNSYLVANIAN
5 Searston-Barachois strata
MISSISSIPPIAN
4 Codroy Group
3 Anguille Group
DEVONIAN
2 Bay du Nord Group
DEVONIAN AND EARLIER
1
1a. Gneisses, schists, granites, diorites, amphibolites; minor marbles
1b. Mafic and ultramafic rocks
1c. La Poile Group
Geological Boundary
Fault
Highway
Fossil locality
Radiometric age determination .... 400 M.Y.
Grand Bruit
La Poile Bay
Rose Blanche
400 M.Y.
Port aux Basques
415 M.Y.
Cape Ray
Codroy
Trainvain Brook
Stevenson's Brook
LONG RANGE FAULT
48° 00'
58° 00'
47° 00'
59° 00'
59° 30'
Miles
6 3 0 6 12 18
COAST OF LABRADOR
QUEBEC
GULF OF ST. LAWRENCE
ISLAND OF NEWFOUNDLAND
ATLANTIC OCEAN
Corner Brook
Gander
Bonavista
ST. JOHN'S
Port aux Basques
PRINCE EDWARD ISLAND
CAPE BRETON ISLAND
NOVA SCOTIA
INDEX MAP

FIGURE 1

The Long Range fault extends northeastward for 30 miles from the coast near the mouth of Trainvain Brook to the northern boundary of the map-area. This fault separates Devonian and earlier igneous and metamorphic rocks (1a, 1b) to the southeast from Codroy (4) and Searston-Barachois (5) strata to the northwest. Regionally the Carboniferous strata dip towards the fault; locally these beds strike into the fault zone. Steeply dipping beds that are overturned in places, and several small synclines occur in the Carboniferous rocks adjacent to the fault. The fault zone is exposed on the coast one half mile southeast of the highway. Fractured and sheared Devonian and earlier rocks (1a) and somewhat fractured Searston-Barachois (5) strata characterize the fault plane on the coast; at this locality the fault dips 40 degrees to the northwest. Along Stevenson's Brook the fault zone is characterized by highly sheared Devonian and earlier rocks (1b) and Searston-Barachois beds (5); the fault appears to be vertical on Stevenson's Brook. Relative movement along the fault has been southeast side upward with respect to the northwest side. The upthrow on the southeast side and the dip to the northwest suggest that the Long Range fault is a normal fault.

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[1] Phair, George: Geology of the southwestern part of the Long Range, Newfoundland; unpub. Ph.D. thesis, Princeton Univ., Princeton, New Jersey (1948).

[2] Cooper J.R.: La Poile-Cinq Cerf map-area, Newfoundland; Geol. Surv. Can., Mem. 276 (1954).

[3] Bell, W.A.: Early Carboniferous strata of St. Georges Bay area, Newfoundland; Geol. Surv. Can., Bull. 10 (1948).

[4] Baird, D.M. and Cote, P.R.: Lower Carboniferous sedimentary rocks in southwestern Newfoundland and their relations to similar strata in western Cape Breton Island; Bull. Can. Inst. Min. and Met., vol. 57, pp. 509-520 (1964).

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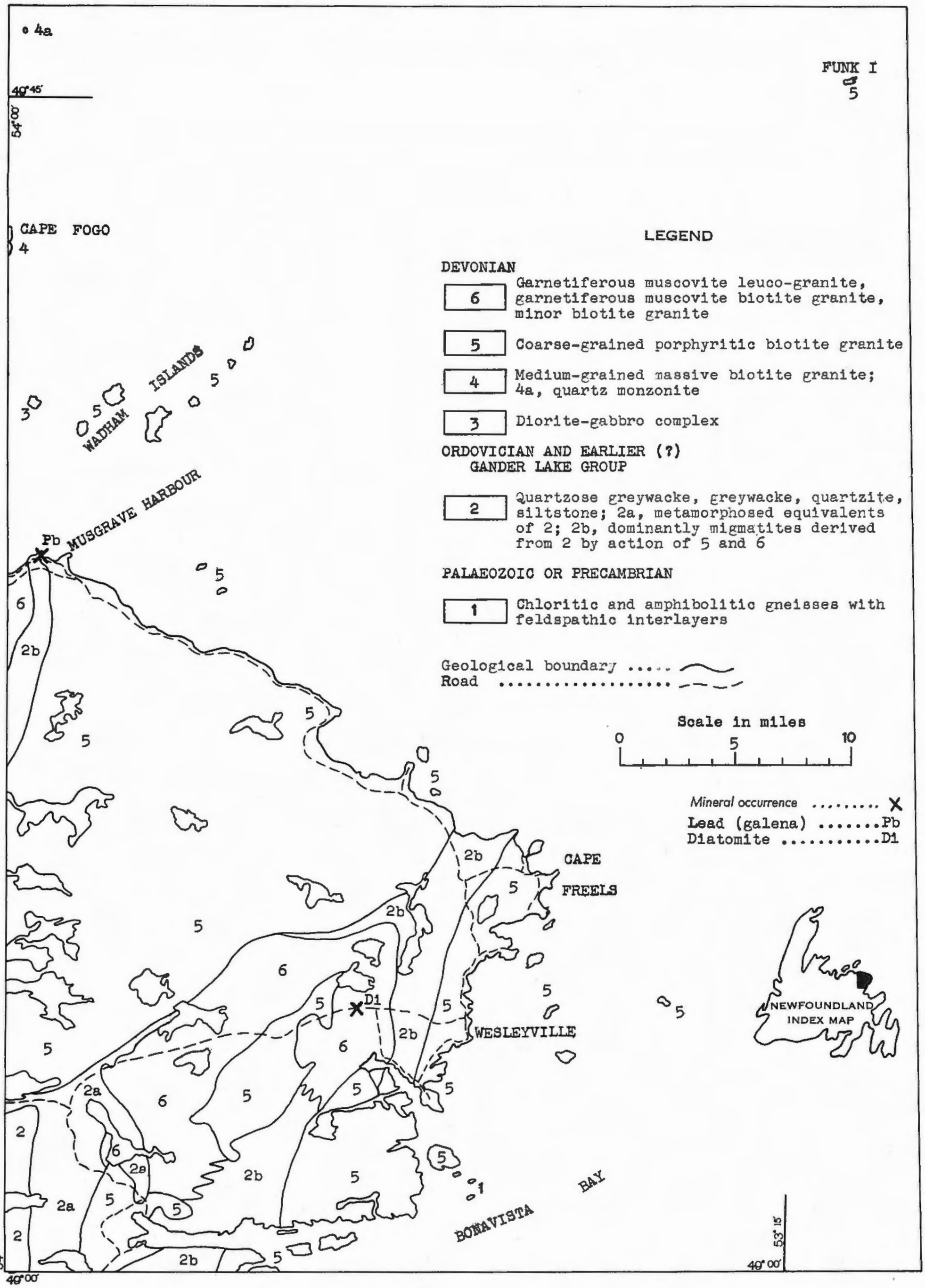
108. SULPHIDE ORES FROM THE NOTRE DAME BAY AREA OF NORTHEASTERN NEWFOUNDLAND

K. Kanehira

About three weeks' field work was done in the Whalesback, Tilt Cove, and Gull Bridge copper mines of the Notre Dame Bay area. Detailed underground mapping and systematic sampling were carried out in the Whalesback mine, while short visits were made to the Tilt Cove and Gull Bridge mines for sampling of ores and rocks.

All the deposits are associated with the Ordovician volcanic rocks. The deposits of the Whalesback occur in sheared basic pillow lavas, the deposits of the Tilt Cove in basic pyroclastic rocks and pillow lavas, and those of the Gull Bridge in moderately metamorphosed volcanic and sedimentary rocks. The close association of sulphides and volcanic rocks seems to suggest a genetic relation between them. Emphasis of the succeeding laboratory work will be put on a mineralogical study of ores.



FUNK I
CAPE FOGO
WADHAM ISLANDS
MUSGRAVE HARBOUR
CAPE FREELS
WESLEYVILLE
BONAVISTA BAY
49°45'
54°00'
49°00'
53°15'
LEGEND
DEVONIAN
6 Garnetiferous muscovite leuco-granite, garnetiferous muscovite biotite granite, minor biotite granite
5 Coarse-grained porphyritic biotite granite
4 Medium-grained massive biotite granite; 4a, quartz monzonite
3 Diorite-gabbro complex
ORDOVICIAN AND EARLIER (?)
GANDER LAKE GROUP
2 Quartzose greywacke, greywacke, quartzite, siltstone; 2a, metamorphosed equivalents of 2; 2b, dominantly migmatites derived from 2 by action of 5 and 6
PALAEOZOIC OR PRECAMBRIAN
1 Chloritic and amphibolitic gneisses with feldspathic interlayers
Geological boundary
Road
Scale in miles
0 5 10
Mineral occurrence X
Lead (galena) Pb
Diatomite Di
NEWFOUNDLAND INDEX MAP

109. GEOLOGICAL RECONNAISSANCE, WESLEYVILLE (2 F) MAP-AREA

H. Williams

Wesleyville map-area is underlain dominantly by granitic rocks of varied nature, but also contains sedimentary (2) and metasedimentary (2a, b) rocks of the Gander Lake Group[1] as well as possible metavolcanic rocks (1) that may represent a northeastward continuation of the Precambrian Love Cove Group[1].

Coarse-grained porphyritic granite (5) is the most extensive granitic rock and extends seaward to off-shore islands up to 36 miles distant, i.e. Funk Island. Lithologically similar granitic rocks can be traced southwestward across central Newfoundland to the south coast of the island, where they have been described under the name Ackley batholith[2].

Leuco-granite (6) cuts Ackley granite (5) and garnetiferous muscovite pegmatites related to leuco-granite (6) cut granite (4) and diorite-gabbro complex (3). The leuco-granite pegmatites are in turn cut by porphyritic basic dykes (not shown in sketch), which are the youngest rocks of the map-area.

Disseminated galena occurs in a small exposure of high-grade metamorphic rocks near Musgrave Harbour. Local occurrences of diatomite are known 5 miles west of Wesleyville.

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[1] Jenness, S.E.: Terra Nova and Bonavista map-areas, Newfoundland; Geol. Surv. Can., Memoir 327 (1963).

[2] Bradley, D.A.: Gisborne Lake and Terrenceville map-areas, Newfoundland; Geol. Surv. Can., Memoir 321 (1962).

GENERAL

110. GEOLOGY OF THE NATIONAL PARKS

D.M. Baird

Field observations for the preparation of geological guidebooks were checked and completed in Banff National Park (Alberta) and Glacier and Mount Revelstoke National Parks (British Columbia). Field observations and photography of scenic and geological features were begun in the Ottawa, Ontario and adjacent Quebec regions as parts of the background for preparation of a guidebook to the geology and scenery of the National Capital district.

111. MARINE GEOLOGY STUDIES, ATLANTIC PROVINCES

G.A. Bartlett

Bottom sampling was carried out in segments of the larger bays and estuaries adjacent to the coasts of Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland from May through October.

Samples were collected by means of Cape Ann fishing boats and a 22-foot freighter canoe, using SCUBA and general oceanographic sampling devices such as Dietz LaFond grabs and small piston corers. Bottom salinities, temperatures, and current directions were recorded. Data were also collected on the Ott of surface sediments, water depths and densities, nutrient source and distance of sample stations from shore.

Visual inspection of the mud-water interface enabled collection and preservation of the maximum "standing crop" of Foraminifera and thus enabled a more precise determination of sedimentation rates based on living/total foraminiferal ratios.

Preliminary investigations indicate that some Foraminifera are much more tolerant to various ecological conditions than limited studies of a small area would indicate. Distribution of many assemblages are related more to sedimentological than biological parameters.

Laboratory analysis and recording of data are continuing.

112. PRELIMINARY STATEMENT ON SEDIMENTOLOGY STUDY OF BEACHES AT BELLEDUNE POINT, CHALEUR BAY, NEW BRUNSWICK

D.E. Buckley

This study was undertaken to determine the amount of sediment undergoing transport on the beach and in the area immediately offshore from

Belledune Point, Chaleur Bay, New Brunswick. The project was conducted at the request of the Canadian Hydrographic Service, who are involved in examining the feasibility of pier construction in that locale.

Belledune Point is composed of coarse sand and gravel, and appears to be an accumulation of sediment due to littoral transport from perhaps a considerable range of coastline to the west and to the southeast. The beach and offshore sediment sampling program serve to outline the areal distribution of sediment in terms of size (gravel, sand, silt) and it appears that the accumulation of coarser bottom material is a direct reflection of more vigorous wave action. In this regard the gravel zone extends much farther off shore on the eastern side of Belledune Point, owing to the much longer 'fetch' in that direction. Several thousand cubic yards of beach gravel have been observed to move from one side of the point to the other during an overnight storm. While only the peripheral configuration of the point is altered during this process, it would appear that material transport in the area is sufficient to warrant careful evaluation prior to pier construction.

113. REGIONAL GEOCHEMICAL STUDY OF THE SLAVE POINT FORMATION IN BRITISH COLUMBIA, ALBERTA, AND THE NORTHWEST TERRITORIES

E.M. Cameron

This project was undertaken to discover if there are regional chemical trends in carbonate horizons, which may be related to areas of reef development. Such trends might provide a useful tool in exploration for reefs.

Sampling of the Slave Point (Devonian) carbonates from the subsurface of northeastern British Columbia, started in 1963, was concluded this year, and the Middle Devonian succession along the south shore of Great Slave Lake was examined. The large quantity of analytical data required for the project is now virtually complete and the results are being prepared for publication.

In the area of study the Slave Point Formation consists of a rather uniform sequence of shelf limestones, which have an irregular westward termination along the margin of a shale basin. A reefal facies is developed along this margin, which has, in places, been altered to a vuggy dolomite. This latter rock forms the reservoir of several important gas fields. Gas discoveries have also been made in the carbonates back from the margin with the shale basin.

Significant, although often subtle, areal variation in the chemistry of the carbonates has been found, which may be related to zones of reef development or other regional facies changes. This variation is shown by elements, such as silicon and aluminum, which are contained within the detrital fraction of the sediments; by elements, such as strontium, which are held within the carbonate crystal lattice; and by elements, such as silicon and magnesium, which have been introduced or mobilized since deposition.

114. REPORT OF A METEORITE AUTHENTICATION TRIP

K.R. Dawson

The writer spent several days examining reported meteorite sites and meteoritic material of Amisk Lake (63 L NE) Saskatchewan, Sioux Narrows (52 E SE) Ontario, and near Parry Sound (41 H NE) Ontario.

Amisk Lake site is characterized by 4 elliptical subsidence pits in the forest-covered clay deposits between the 4-foot cutbank at the lake shore and the outcrops 200-300 feet inland. The immediate surroundings are free of throwout and the trees have not been uprooted except for one clump of partly undercut alders that leans towards the centre of a pit. The clay is exposed from the forest duff strata down, with one exception in which the interior of the pit is covered by duff. All pits had small pools of water at their bottoms. Of the possible explanations—dynamite explosion, meteorite impact, and thermo-karst subsidence—the last explanation is the most likely.

The Sioux Narrows site is on the south shore of Regina Bay on Lake of the Woods. The original report described the sound of explosion and throwout effects that include muddied water, broken branches from an overhanging pine tree, and after the water cleared a white scar on underwater outcrops. A scuba investigation courtesy of Drs. R. Deane and J. Terasmae recovered freshly broken rock fragments, a small quartz vein, and nothing that resembled meteoritic materials. The probable explanation is a dynamite blast planted to test the quartz vein for mineralization.

The "Drocourt Meteorite", a 5-foot diameter boulder of black conglomerate lying on red granite gneiss at mile 41 on the CNR railway north of Parry Sound has intrigued local workmen since the rails were laid past the site. The boulder is surrounded by a ring of chippings and pieces of dynamite casings. It is an excellent example of a monomict conglomerate composed of well rounded pebbles of greenstone weakly held by a matrix of almost black sand.

115. SILURIAN-DEVONIAN VERTEBRATE PALAEONTOLOGY AND STRATIGRAPHY, NOVA SCOTIA, QUEBEC, AND ALBERTA

D.L. Dineley

a) Antigonish, N.S.

All known exposures of the Lower Devonian Knoydart Formation have now been intensively searched for fossils. No recent additions have been made to the pteraspid faunas collected by Dineley. The McArras Brook section and the McAdam Brook section have been re-examined: the Knoydart is now regarded as being comformable upon the Stonehouse Formation.

b) Escuminac, Quebec

Study of the sedimentological and palaeoecological aspects of the Escuminac Formation are underway. Rock samples and further fossil placoderm and bony fish were collected. Many previously unrecorded features appear to be of environmental significance. Adjacent Devonian formations were also searched for fossils but nothing of apparent value was found. The exposures at Campbellton were again visited but nothing of significance was collected. A short report is in preparation concerning the Campbellton rocks, and on the unconformity found below the well-known fish-bearing stratum.

c) Alberta

The exposures of the Yahatinda Formation were visited in company with Dr. J.D. Aitken. At End Mountain a number of stratigraphically important ostracoderms and other fossils were found, but other exposures were not productive to the same degree. Poor weather and snow prevented collecting at a few points, including the type section at Yahatinda.

116. BIOGEOCHEMICAL INVESTIGATIONS

J.A.C. Fortescue

The greater part of the summer of 1964 was spent in Ottawa where a party was occupied, 1) in preparation of samples for chemical analysis, 2) in the development of chemical and spectrographic laboratory facilities, and 3) in the setting up and operation of greenhouse experiments. Two field areas in Northern Ontario were visited and samples were collected from each of them. One area is located north of Iroquois Falls where samples of peat and mineral material were collected from 40 sites located in an experimental area chosen for a special investigation by Mr. A.B. Vincent of the Ontario Department of Lands and Forests. A second field area was located near a drilled, but otherwise undisturbed, mineral deposit in Northern Ontario. In this case some 800 samples of biological materials (soils, peat, and ground and overstory vegetation) were collected.

117. THE BASAL BEDS OF THE LOWER JURASSIC IN THE FOOTHILLS AND ROCKY MOUNTAINS

H. Frebold

As previous studies by the author have shown, the lower beds of the Lower Jurassic are developed in different facies. As a rule, more complete sections are present in the western and northern parts of the area, as for instance, western parts of Crowsnest Pass, west side of Elk River area, Nordegg, Snake Indian River, and farther north. In these areas parts of the Sinemurian and

Toarcian are clearly indicated by guide-fossils. Locally, the Sinemurian is developed in the facies of the Nordegg Member. Contrary to this development are the conditions in more easterly and southern areas, as for instance, eastern parts of Crowsnest Pass, Livingstone Range, and Moose Mountain area. There the Toarcian is still represented in the typical facies of the 'Poker Chip Shale' or 'Paper Shale' with characteristic ammonite faunas (Harpoceras, Dactylioceras) but the Sinemurian shales or the Sinemurian Nordegg Member are missing. However, at the base of the Toarcian a more or less conglomeratic bed, not more than about 2 feet thick, occurs, which contains a varying amount of fossils - predominantly pelecypods and gastropods, of which some seem to be identical with pelecypods and gastropods of the Sinemurian Nordegg Member. The fauna concerned has not yet been studied in detail, but the author is inclined to consider this bed as representing part of the Sinemurian and not as the basal part of the Toarcian as had been assumed previously. Accordingly, the transgression of the Sinemurian sea, so wide-spread in western and northern Canada, would also have reached the eastern Foothills area.

118. GEOLOGY OF IRON ORE DEPOSITS AND IRON-FORMATIONS OF CANADA

G.A. Gross

Iron ranges were investigated near the north end of Baffin Island, Northwest Territories, and in the Yukon Territory, and two studies of iron-formation in Ontario were supervised. Very significant advances were made in the detailed study of the geology and associated magnetic properties of an iron-formation located about 40 miles north of Nakina, Ontario, which was carried out in cooperation with P.J. Hood, with D.F. Sangster in charge of field work (see report by Sangster). The distribution of primary sedimentary facies in Algoma-type iron-formation and various kinds of associated volcanic rocks were mapped by H.P. Wilton (see report by Wilton) near Timagami Lake, Ontario. Data was obtained for interpretation of the history of volcanic activity and related deposition of the iron-formation.

1. Iron Deposits, North Baffin Island, N.W.T.

Large high grade magnetite-hematite iron deposits, discovered near Mary River in 1962 by Mr. Murray Watts and Mr. Ron Sheardown of Baffinland Iron Mines Limited, are widely distributed in highly metamorphosed iron-formations. The potential ore is of exceptional high grade, consistently assaying 69 per cent or more iron, and is mostly hard dense material with special structural qualities. The deposits represent the first substantial amount of naturally occurring high grade iron ore to be added to Canada's extensive reserves of medium and low grade ore.

Investigations to date suggest that the iron ore was formed prior to regional metamorphism and the intrusion of some of the basic dykes and sills by groundwater leaching silica and enriching the iron content of the iron-formation. Recrystallization of the iron-rich material during regional metamorphism led to the formation of both dense and porous types of hard, medium- to fine-grained hematite and magnetite lump ore. The amount of redistribution of iron or removal of silica, if any, during metamorphism is not clearly defined.

Ultrabasic, basic, and granitic rocks containing traces of asbestos and sulphide minerals occur along a major structural lineament that trends northwest and crosses the highly folded and deformed iron-formations and associated metasediments in the region.

2. Iron-Formation, Snake River Area, Yukon and Northwest Territories

The Snake River iron-formation has been explored within an area 30 miles long and 8 miles wide by Crest Exploration Limited, Calgary, Alberta. Geological mapping, chip sampling and bulk sampling on stratigraphic sections, diamond drilling, and an extensive programme testing beneficiation methods has defined the stratigraphy, chemical and mineralogical composition, and physical properties of iron-formation in exceptional detail.

The jasper hematite iron-formation has a maximum thickness of 500 feet, the average iron content is 46 per cent, beds are nearly flat to gently dipping, and several billion tons of iron-formation could be recovered from open cast mines without having to remove any appreciable amount of waste rock. The iron-formation is composed of thin alternating layers of blue hematite, jasper chert and fine-grained clastic layers impregnated with maroon coloured hematite. The iron-formation occurs within a thick formation of conglomerate and mudstone of Late Precambrian or Early Palaeozoic age and thin beds of conglomerate or sandstone are interbedded with jasper hematite iron-formation.

The iron-formation is relatively fresh and unaltered and primary sedimentary features indicate that alternate chemical deposition of silica- and hematite-rich layers was interrupted by the influx of flows of conglomerate and mud, which scoured channels in the soft iron and silica sediments. The iron-formation is believed to have been deposited in depressions on the ocean floor, and slumping and flow of unconsolidated rocks from adjacent fault scarps or basin shelves may have been triggered by movement along bordering faults. Some of the fine-grained clastic beds impregnated with hematite have the appearance of tuff or volcanic ash that settled in soft hematite ooze. The hematite and silica are believed to have been carried in solution by fumarolic waters and precipitated when these solutions were discharged on the sea floor along fault zones. Hematite veins and stockworks in Precambrian rocks in the western part of the area may have been channels through which some of the fumaroles discharged.

119. A PRELIMINARY MARINE SEISMIC SURVEY, GULF OF ST. LAWRENCE

G.D. Hobson

The objective of this project was to commence a systematic study of the geological structure of the Gulf and the area east of Newfoundland to extend known onshore geology to offshore regions and to investigate the extension of the Appalachian region.

Modified sonobuoys were used during a reconnaissance seismic project over three lines, two in the Gulf of St. Lawrence and one on the east coast of Newfoundland. One ship was available for laying out sonobuoys and also to act as a platform for detonating explosives. These three profiles were shot in a cooperative crustal seismic program with Dalhousie University. Later in the season, a second ship was made available and a line was shot from Cheticamp, Cape Breton Island, to Tracadie, New Brunswick, using a conventional marine seismic cable towed behind one ship as the recording vessel and the other ship being used as the shooting vessel. The data have not been compiled and interpreted to date although interesting geological structures below the sea are indicated on a cursory examination of the time-distance graphs. On most profiles four subsurface velocities other than the water arrival were recorded.

120. NAE-RCAF AIRBORNE MAGNETOMETER PROJECT

P.J. Hood and Margaret E. Bower

Sorties over widely separated parts of Canada and the Atlantic Ocean were made during the 1964 high-sensitivity airborne magnetometer trials carried out by the National Aeronautical Establishment and the Royal Canadian Air Force. This project combines military work, instrumentation development, and reconnaissance geophysical exploration. The Geological Survey of Canada has assisted with the non-military aspects of the project.

Two rubidium-vapour magnetometers were installed in a RCAF North Star aircraft, one in a towed bird, the other in a 30-foot tail boom. Magnetic variations were recorded in both digital and analog form; altitude and various types of aircraft motion were also obtained in analog form only. To facilitate automated compilation, the digital data were recorded on Digistore magnetic tape, which can be fed directly to a computer. Aircraft altitude varied, but flights over the sea were made at 200 feet when visibility permitted. Astro, Doppler, and Loran A navigation were used to recover the aircraft track.

Ten aeromagnetic profiles were flown between Baffin Island, Greenland, and Labrador (Figure 1). Although most of the flight lines were at least 50 miles apart, there appear to be strong magnetic trends in a north to northwesterly direction. The slope of the individual anomalies suggests that they originate fairly close to the ocean floor. Only preliminary compilation has been

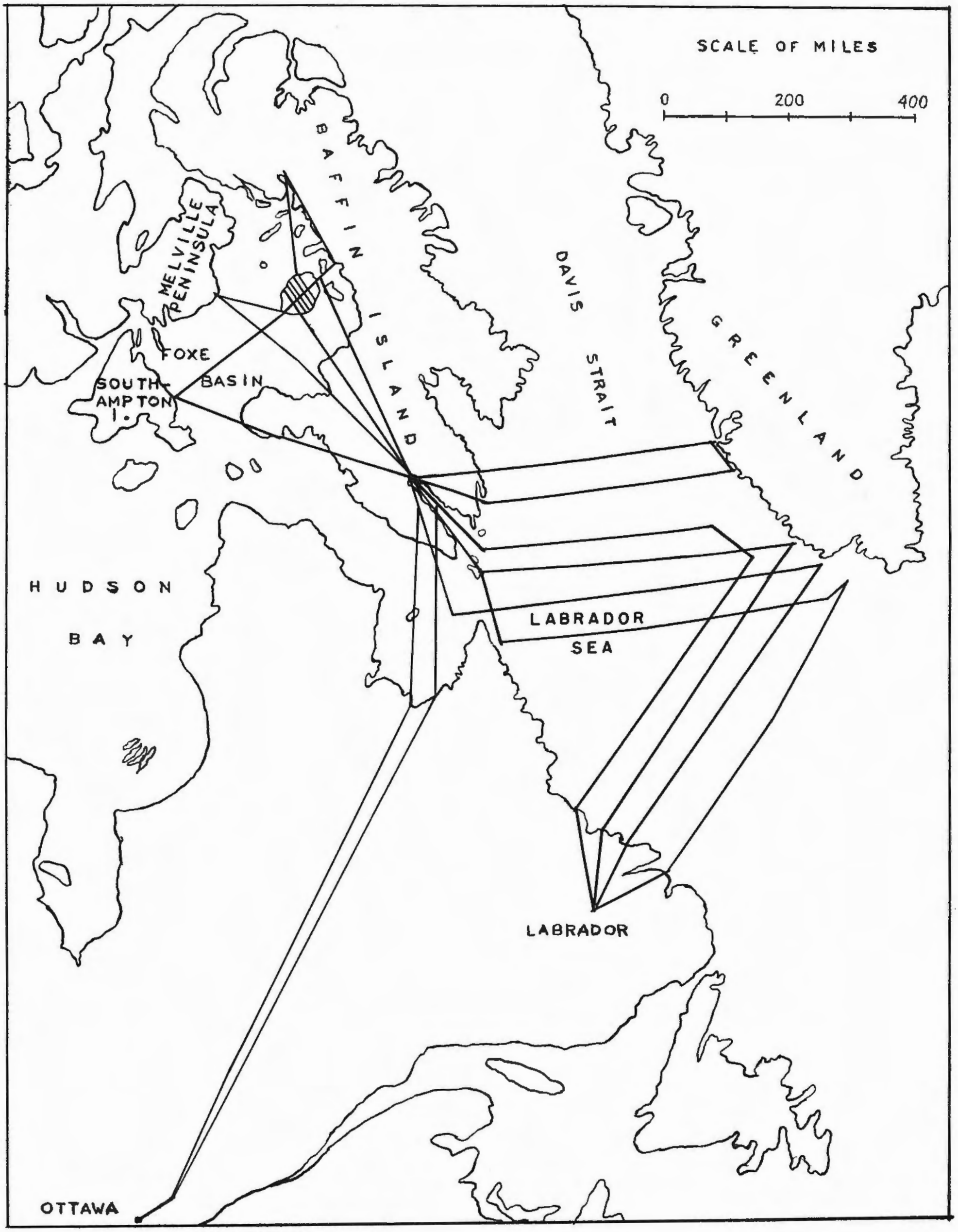

FIGURE I

NAE - RCAF AIRBORNE MAGNETOMETER FLIGHTS completed so far and further analysis of the data is expected to reveal major geological structures, perhaps the suspected branch of the Mid-Atlantic Ridge into the Labrador Sea.

Two flights were made over Foxe Basin, which is covered with Palaeozoic sediments, including five closely-spaced lines over Prince Charles Island. Magnetic activity tends to be low around Prince Charles Island in the centre of the Basin and farther north, although there are some larger anomalies associated with islands. About 50 miles south of Prince Charles Island the anomalies become much sharper and more intense, then decrease again near Southampton Island.

During a flight over northern Quebec an attempt was made to measure the vertical magnetic gradient, making use of the fact that the two magnetometers have a vertical displacement of about 100 feet. Alternate readings were recorded from the bird and inboard magnetometers, and each bird-magnetometer reading was subtracted from the preceding inboard reading. The resulting first derivative profile contained small anomalies whose peaks corresponded to those of large total intensity anomalies, and produced a much better resolution of individual anomalies.

121. POST-WISCONSIN MICROFAUNAS AND SEDIMENTS OF EASTERN CANADA

Kenneth Hooper

Work commenced in May 1964, with the setting-up of laboratories for particle-size analysis of sediments, separation of Foraminifera from sediments, identification of foraminiferal species, and X-ray diffraction studies of the mineralogy of foraminiferal tests.

In mid-May and early June, field collections were made of sediment samples of Pleistocene age from the St. Lawrence Valley (north of Quebec City), Gaspé, and New Brunswick. Some 240 samples were collected, 50 per cent of which are thought to be of marine origin.

Preliminary analysis of the samples was started in June. To date, sieve and pipette analyses have been completed for approximately 50 samples. Graphs and calculations are not yet prepared. Foraminiferal faunas are identified in 30 samples; 20 are barren of fauna.

Recent foraminiferal faunas of the Gulf of St. Lawrence are composed of arenaceous and calcareous forms. Depth zones, based on characteristic faunas can be recognized. Preliminary results for Pleistocene foraminiferal faunas suggest that calcareous species are similar to Recent and living ones, but arenaceous forms are almost entirely absent. Just how closely this generalization correctly reflects Champlain Sea conditions, facies variations, or inadequate sampling, remains to be discovered by further work.

In preliminary X-ray diffraction work on the magnesium content of tests, an experimental method suitable for the analysis of Foraminifera was developed. Calibration curves, and precision and accuracy estimates of the method were determined. Approximately 60 diffraction patterns for 35 specimens from bottom sediments of the Gulf of St. Lawrence and the Atlantic Shelf are now on file. The species are Quinqueloculina seminula, Q. arctica, Q. stalkeri, Q. agglutinata, Elphidium incertum, E. bartletti, E. clavatum, E. sp., Elphidiella arctica, and Nonion labradoricum. The magnesium content of these forms has been determined to an estimated accuracy of approximately 2 per cent.

122. BOTTOM-SEDIMENT STUDIES ON THE SCOTIAN SHELF SOUTHEAST OF HALIFAX, NOVA SCOTIA

L.H. King

The purpose of this project is to carry out a study of marine sediments on the Scotian Shelf in the vicinity of Emerald and Sambro Banks bounded by longitudes 62°20'W and 63°45'W and by latitudes 43°25'N and 44°05'N and to define the sedimentary and oceanographic environment on this section of the shelf. These studies are related to the laboratory project on the constitution of the organic fraction of the marine sediment.

Bottom grab samples were obtained on a 5-mile grid system covering an area of approximately 2,000 square miles. One hundred and thirty three stations were occupied for this purpose and the program was completed as planned.

Field observations indicate that the pattern of sediment distribution is controlled to a large extent by topography. The topographical 'lows' (220-270 metres) are occupied by silt and clay, while the 'highs' (70-110 metres) are characterized by coarse sand and gravel. The extreme isolated 'highs' (approximately 70-90 metres) are generally covered by coarse lag gravel. Areas at intermediate depths (110-220 metres) are commonly covered by fine to medium, well sorted sand, but in some places, especially at depths between 180 and 220 metres, very poorly sorted material occurs. This poorly sorted material is tentatively identified as glacial till.

Sounding lines were run between sampling stations using a 26J Kelvin-Hughes sounder and the records were interpreted from observations on the bottom samples. Correlations were established, which made it possible to differentiate four sediment types on the bottom echo profiles; thus these records can be used to delineate exact geological contacts. Subbottom information was also obtained over the areas occupied by mud.

Five oceanographic stations were occupied across the area to give a complete section in terms of temperature, salinity, and oxygen. The oxygen values ranged from 9.8 ml/L at the surface to 7 at the top of the banks and 4.7 at the bottom of the basins.

Data were also collected on the pH and E_h of 52 sediments. Values of pH ranged from 7.0 to 8.6 and E_h from +300 mv to -450 mv, with an average around -160 mv.

123. MARINE GEOLOGY IN NORTHUMBERLAND STRAIT OFF RICHIBUCTO RIVER, NEW BRUNSWICK

Kate Kranck

Field work was completed for a detailed sedimentological study of an area 15 miles by 5 miles in the Northumberland Strait off Richibucto River, N.B. The work was done in cooperation with the Fisheries Research Board of Canada, who furnished boat facilities and crew for the offshore work. In the immediate sample area 181 offshore stations were completed and 173 samples recovered. Four lines of stations radiating out from the sample area, across Northumberland Strait as well as river, beach, and bedrock samples from the shore region were also collected to provide background information. From the samples collected together with the depth recorder traces the nature of the bottom can be mapped in some detail. The principle sediments found in the area are well sorted, medium-grained sand and coarse gravel and pebbles. Areas of exposed bedrock are prominent within the area and the sand appears to occur in shallow pockets on top of the bedrock. Tidal and longshore currents may keep the rocky ledges clear of sediments and the sand in a constant state of movement. Very little silt and clay was found within the sample area and currents probably prevent fine sediments from settling. The material composing the gravel is dominantly coarse brownish grey sandstone and appears to be locally derived from the Pennsylvanian sandstone formations exposed on shore. A few samples with a more mixed composition and of probable glacial origin were also encountered. Detailed studies of the material gathered, including laboratory analysis of the samples, will provide more detailed information on the distribution of the sediments, submarine topography, and geological history of the area.

124. RECONNAISSANCE GEOLOGICAL EXPLORATION ON THE CONTINENTAL SHELF OFF NOVA SCOTIA

J.I. Marlowe

The initial, reconnaissance phase of a geological exploration program on the continental slope off Nova Scotia was begun during the 1964 season. The purpose of the program is twofold: 1) to determine the extent and nature of any consolidated rock which may outcrop on the continental slope; and 2) to construct from the unconsolidated sediment record an environmental history of the Scotian Shelf and the adjacent deep-sea basin. Work this season consisted of a bottom sampling and sounding program. Submarine core and dredge samples were collected from 58 stations in an area centred on the Gully, a large submarine canyon east of Sable Island, from the edge of the continental shelf to depths exceeding 1,700 fathoms.

Preliminary results indicate the existence of compact and resistant sediment in ledges along the sides of the canyon. Sandstone and hard, micaceous silt were brought up from stations located along a topographic ledge. Preliminary fossil identifications indicate that some of the silt samples may be late Tertiary in age. Faunal assemblages are similar to others found in submarine outcrops on Georges Bank.

Examination of unconsolidated material suggests strongly that a source of sediment, which was deposited under an oxidizing, probably subaerial, environment, was located not far from the study area. Fragile, red shale pebbles, together with basalt grains, occur in red mud layers, which are covered by more recent material apparently derived from the present banks area. This is an interesting occurrence in view of geophysical evidence[1], which points to the existence of a Triassic basin off Halifax.

Future work calls for detailed examination of the features discussed above, in the present study area and elsewhere along the continental slope.

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[1] Guilcher, A.: Continental shelf and slope (Continental Margin); in The Sea, vol. 3; Interscience Publishers, New York, pp. 281-311 (1963).

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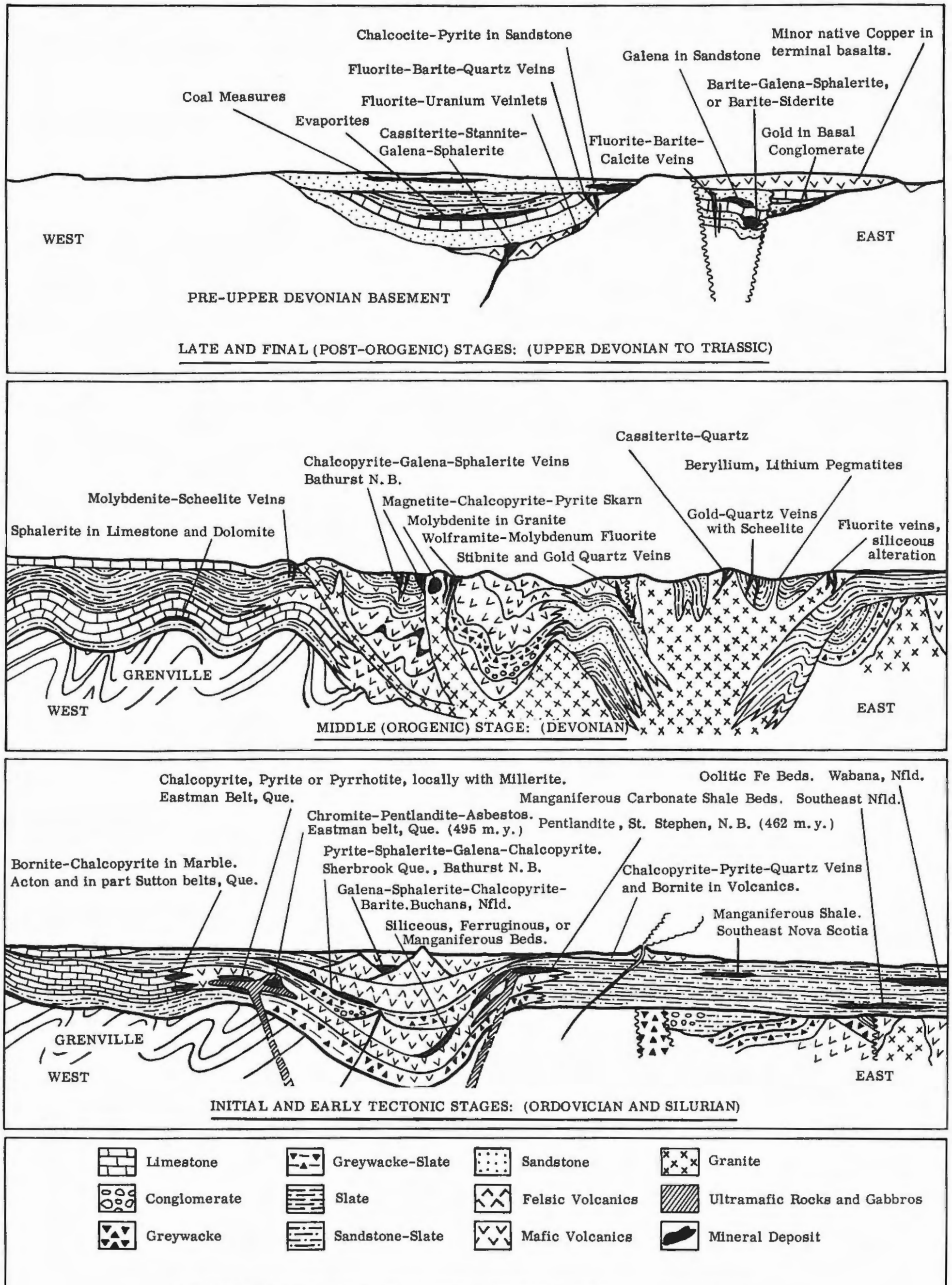
125. METALLOGENIC STUDY, CANADIAN APPALACHIANS

W.D. McCartney

The writer's field work in 1964 was restricted to mines and mineral occurrences in Gaspé Peninsula, Quebec. A preliminary working hypothesis seeking to relate mineralization to the tectonic development of folded geosynclines was published in 1962[1] and has been supported by the writer's field and laboratory studies beginning in 1962, and by the work of others[2].

Results of this work to date are best summarized in the accompanying figure, in which known mineral deposits are depicted in relation to the known age and facies of their wall rocks. The tectonic model is grossly oversimplified. Although the hypothesis is being tested in the Appalachians, the writer believes that a similar idealized model constructed for roughly the Permian to early Tertiary tectonic cycle of the Cordillera would show many similarities. Some types of mineralization would be more extensively developed, other types might be lacking.

The importance of distinguishing the volcanic and sedimentary facies in regional analysis of mineral distribution, as well as the age of the rocks, is emphasized in the study. For example, all semi-concordant or concordant massive pyritic copper or pyritic lead-zinc-copper deposits in Palaeozoic rocks in the Canadian Appalachians are restricted to Ordovician, and in central Newfoundland, Ordovician and possibly Silurian volcanic assemblages. No areal relation is apparent between such deposits and granitic intrusions. On the other hand,



AN IDEALIZED METALLOGENIC MODEL OF THE CANADIAN APPALACHIANS, DEPICTING SOME KNOWN TYPES OF MINERAL OCCURRENCES IN RELATION TO THEIR TECTONIC SETTING AND THE FACIES AND APPROXIMATE AGES OF THEIR WALL-ROCKS gold-arsenopyrite-quartz veins, commonly containing scheelite, are virtually restricted to Ordovician sedimentary rocks near, but not within, Devonian granite in southern Nova Scotia and southern New Brunswick.

The nickel-bearing gabbro at St. Stephen, N.B., was formerly considered Devonian in age. This age conflicted with the writer's hypothesis[1] and a K/Ar determination on biotite gabbro collected by the writer indicated an Ordovician age of 462 m.y. (R. Wanless, personal communication). The important Gaspé Copper deposit in Lower Devonian beds is omitted from the diagram but quartz-feldspar-biotite porphyry at Copper Mountain collected by the writer has indicated a K/Ar age of biotite of 390 m.y. (R. Wanless, personal communication). The age of mineralization is thus almost transitional between the early and middle tectonic stages. Although the skarn deposit at Gaspé Copper contains molybdenum and native bismuth (the latter first observed in polished section in 1964), this mineralization is older than molybdenum, native bismuth and minor stannite (the latter first observed in polished section in 1964) at the Maheux molybdenum property, Whitton township, southern Quebec. Muscovite collected by the writer from the molybdenum-bearing Maheux vein yielded an absolute age of 360 m.y. (R. Wanless, personal communication) and indicates an intimate association of mineralization with the nearby St. Cecile granite stock, which was earlier dated as 362 m.y.[3].

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

[2] Béland, J., Marleau, R., Pérusse, J., and Duguette, G.: Metallic mineralization in the Appalachians of Southern Quebec; Can. Min. Jour., vol. 83, No. 4, pp. 97-100 (1962).

[3] Lowdon, J.A. (comp.): Age determinations by the Geological Survey of Canada Report 1, Isotopic Ages; Geol. Surv. Can., Paper 60-17, p. 37 (1960).

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126. GEOLOGY OF TIN AND BERYLLIUM OCCURRENCES IN CANADA

R. Mulligan

About 2 1/2 months field work was done in 1964, mainly in selected parts of Yukon Territory and northern British Columbia, and in New Brunswick and Nova Scotia. The study was directed mainly toward the distribution of tin and beryllium, and the factors responsible for their apparent concentration in metallogenic provinces. As these elements generally occur in the same metallogenic provinces, much of the material collected for tin analysis can be profitably analyzed for beryllium as well.

The northwestern segment of the Cordilleran tin-belt, as presently conceived, is marked by the presence of cassiterite in placer-gold deposits in the Klondike district, the McQuesten River district, and the Mayo-Dublin Gulch district. Tin also occurs in a small quartz-tourmaline-cassiterite lode deposit at Dublin Gulch, and some of the silver-lead-zinc ores of Keno and Galena Hill contain small but significant amounts of tin. Many of the known cassiterite-bearing streams have granitic bodies outcropping in their source areas, but some do not. Work in these districts included sampling of placer concentrates, examination and sampling of granitoid bodies, veins, and skarns, and collection of various minerals from some of the sulphide ores of the district.

Similar investigations were made in areas west of Kluane Lake and near Atlin, B.C., where cassiterite has been reported in some placer-gold concentrates.

A beryllian-vesuvianite occurrence at Lat. 51°36', Long. 119°02', discovered by R.B. Campbell's field party in 1962, was examined. The beryllian vesuvianite, which contains about 0.02 to 0.05 per cent beryllium, occurs as coarse crystalline masses with garnet and epidote in skarn at the contact between crystalline limestone of the Shuswap Complex and pegmatitic muscovite granite. Material was collected from the skarn and adjacent pegmatite for specimens, mineralogical investigation, and analysis.

In New Brunswick, the Mount Pleasant and Burnt Hill mines were revisited. Exploration work is continuing on a limited scale at Mount Pleasant, and a drilling program has recently been completed at the Burnt Hill mine. Granite samples, to supplement those taken previously, were obtained from tin-beryllium metallogenic belts in New Brunswick and Nova Scotia.

127. GLACIAL STUDIES, EASTERN CANADA

V.K. Prest

Several days were spent on Prince Edward Island mapping a small area in Tormentine E/2 map-area; also several days were taken up on regional 'Island' matters, and in conference with Dr. Crowl in Rustico map-area.

A reconnaissance of eastern New Brunswick, and northern Nova Scotia including Cape Breton Island was made in company with E. Mirynech, specifically to study problems of marine overlap, and direction of late glacial ice-movements, to examine sites of buried organic deposits, and to confer with persons and institutions interested in various aspects of surficial geology and glacial history. The field work and conferences, and the collections made for radio-carbon-dating and palynological study, will serve as a basis for revision of the account of Pleistocene history of the Maritimes for the centennial issue of Economic Geology Series #1.

Field conferences were held in southern Ontario with Drs. Dreimanis and Karrow of the Ontario Department of Mines, Pleistocene field staff, and with Dr. L.J. Chapman of Ontario Research Foundation. These conferences were particularly concerned with the history of the lower Great Lakes but other aspects of deglaciation and of interglacial deposits were also dealt with.

Rather hurried field examinations were made in the Lake Huron and Lake Superior basins pertinent to the picture of deglaciation and lake history and samples were collected for C^{14} and palynological study. Several days were also spent in the Nipigon-Port Arthur region with Mr. S.C. Zoltar of the Ontario Department of Lands and Forests, who has mapped the surficial deposits of a large region extending eastward from Manitoba and has added greatly to knowledge of the physiography and glacial history of northwestern Ontario.

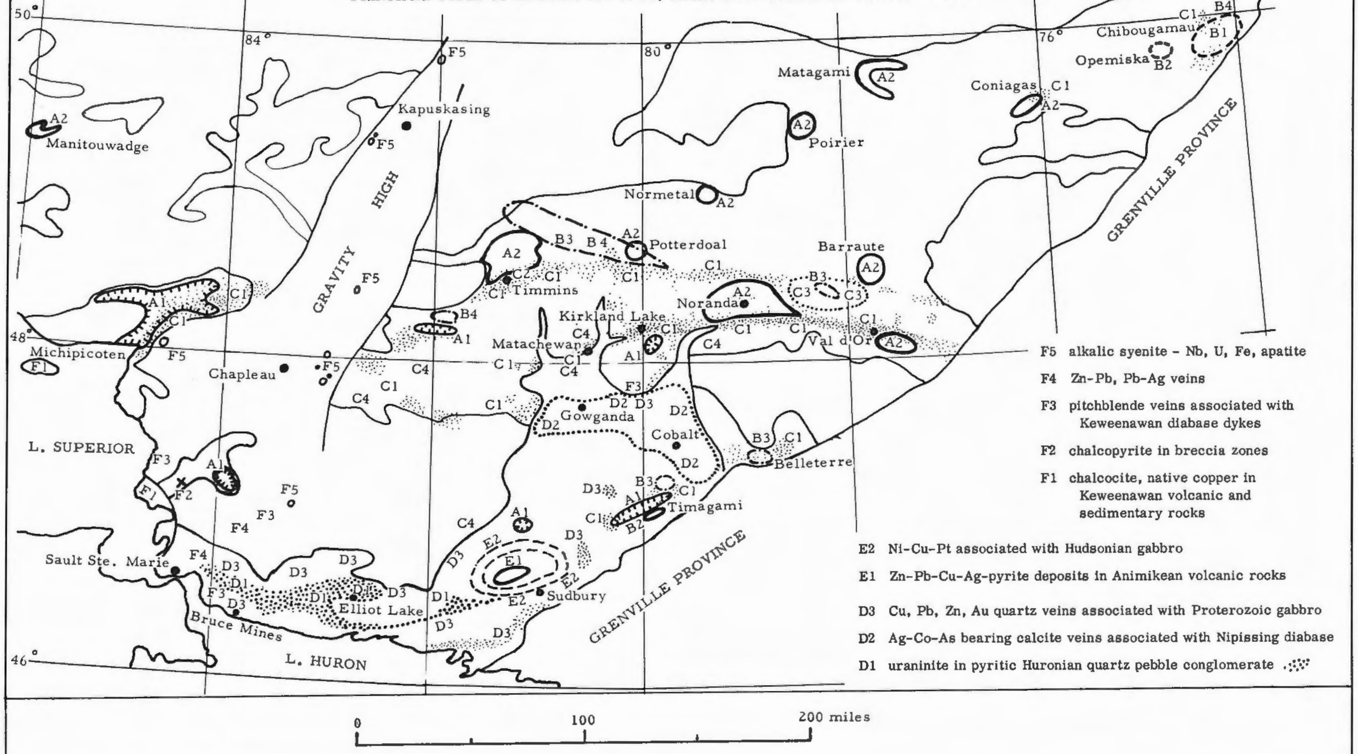
128. METALLOGENIC STUDY, SAULT STE. MARIE TO CHIBOUGAMAU

S.M. Roscoe

During the 1964 field season, the writer studied selected mineral deposits and relevant geological relationships in the Elliot Lake, Sault Ste. Marie, Sudbury, Timmins, Swayze (80 miles southwest of Timmins), Midlothian, Matachewan, Matheson, Kirkland Lake, Noranda, Malartic, and Val d'Or areas. The object of this work and previous field work in 1961 and 1963 was to compare geological environments of mineral deposits in the region and to collect specimens for laboratory investigations. Almost all of the mineral deposit areas in the study region (shown in the accompanying figure) have now been visited. A large proportion of deposits can be classified according to their geological associations and mineralogy as illustrated. Analyses of trace elements in pyrite and other sulphides and lead-isotope analyses provide some support for the procedure of grouping and dating deposits according to their lithological associations. These studies will be reported on elsewhere.

The genesis of massive, base-metal-bearing sulphide deposits has perhaps been the foremost subject of research and discussion by economic geologists in Canada during recent years. Many geologists particularly mine geologists regard them as replacement deposits emplaced in favourable structures as an end product or aftermath of the orogeny that produced the alterations and deformations, which we observe today in their associated rocks. Others, including some who have been associated with successful exploration programs, see much evidence that they were initially formed much earlier, during the deposition of the volcanic-sedimentary sequences in which they occur. If this concept is soundly based, a practical requirement is indicated for exhaustive studies of sequential and lateral variations in lithology, chemistry, and trace-element contents within volcanic-sedimentary belts with emphasis on depositional histories and on correlations.

METALLOGENIC STUDY, SAULT STE. MARIE TO CHIBOUGAMAU -
PRINCIPAL TYPES OF MINERAL DEPOSITS, THEIR GEOLOGICAL ASSOCIATIONS AND AGES



F5 alkalic syenite - Nb, U, Fe, apatite

F4 Zn-Pb, Pb-Ag veins

F3 pitchblende veins associated with Keweenawan diabase dykes

F2 chalcopyrite in breccia zones

F1 chalcocite, native copper in Keweenawan volcanic and sedimentary rocks

E2 Ni-Cu-Pt associated with Hudsonian gabbro

E1 Zn-Pb-Cu-Ag-pyrite deposits in Animikean volcanic rocks

D3 Cu, Pb, Zn, Au quartz veins associated with Proterozoic gabbro

D2 Ag-Co-As bearing calcite veins associated with Nipissing diabase

D1 uraninite in pyritic Huronian quartz pebble conglomerate

A2 Zn, Cu, Ag, Pb, Au in massive iron sulphide deposits in Archaean volcanic rocks

A1 Fe deposits in Archaean iron formation

B4 asbestos in Archaean ultrabasic rocks

B3 Ni, Cu-Ni with ultrabasic rocks and gabbro

B2 Cu veins associated with gabbro-peridotite

B1 Cu, Cu-Au 'veins' with gabbro-anorthosite

C4 Cu-Mo, Pb-Zn veins

C3 Mo, Li, Be in Kenoran pegmatites

C2 Cu disseminated in sodic porphyry

C1 areas of abundant Au deposits

Some of the most significant features of the massive sulphide deposits relevant to this question of origin can be briefly outlined as follows:

1. The base-metal-bearing massive iron sulphide deposits all occur in volcanic or sedimentary strata; most are in acidic volcanic rocks near their contacts with more basic volcanic rocks. Barren sulphide deposits and sulphide-bearing iron-formations occur in similar environments. Chert, graphitic tuffs or sediments, carbonate, nodular or oolitic pyrite, fine-grained laminated pyrite or pyrrhotite and magnetite are found associated with many ore-bearing sulphide deposits as well as with barren sulphide deposits and iron-formations. No analogous possible links are apparent between the strata-bound base-metal deposits and nickeliferous or other types of sulphide deposits that occur in both intrusive rocks and in stratified rocks.

2. Many deposits show some asymmetric zonal features in their ore mineralogy and in patterns of alteration, brecciation, and mineralization in adjacent rocks. The dispositions of these features are not related to the present attitudes of the deposits, but rather to the attitudes and directions of tops of enclosing strata. They therefore indicate that the deposits were formed prior to folding of the strata. Furthermore, it is difficult to envisage mechanisms operative at great depth that could have produced pronounced stratigraphic zoning.

3. Gabbroic and other igneous rocks are found as partitions or dykes within sulphide deposits. There has been considerable argument concerning their age relationships, but the writer is satisfied that many are definitely post-ore and that there is little evidence that any are pre-ore. It would appear then that the deposits may have formed at shallow depths during vulcanism and have been subsequently invaded by intrusive equivalents of volcanic rocks that were deposited above them as well as by later gabbroic rocks and by post-tectonic diabase dykes.

4. Massive sulphide deposits commonly form sheets or lenses whose attitudes conform with those of enclosing strata; many, however, are ribbon-like, pipe-shaped, reef-like, or have great bulges and irregularities that are discordant. Such discordant forms comprise the only important evidence that the sulphides may have replaced rocks, as the contacts of massive ore and host rocks are characteristically sharp.

Many orebodies or parts of orebodies are coincident with folds, breccia zones, faults, or shear zones in the host rocks. This type of relationship is the principal evidence that the ore deposition may have occurred at depth during or subsequent to the major orogeny. This type of evidence, however, must be considered with caution. Some secondary structures may have been developed or initiated far earlier during volcanism; others may have formed during orogeny in locales where pre-existing sulphide deposits interrupted the homogeneity of strata; finally, many deposits may have been severely distorted and perhaps even remobilized and injected into secondary structures during regional metamorphism.

5. Leads in Archaean massive sulphide deposits have isotopic compositions that indicate they were initially extracted from normal source materials 3 billion years or more ago. This is significantly older than the 2.4 - 2.7 billion years for the Kenoran orogeny as dated by K-Ar and Rb-Sr methods. Metamorphic biotite intergrown with chalcopyrite in the Normetal mine has a K-Ar age of 2.6 b.y. These dates are compatable with the hypothesis that the Archaean massive sulphide deposits were formed prior to the main orogeny in the region and were modified in shape and position during folding and metamorphism of their enclosing strata.

Archaean gold deposits occur in a great variety of lithological and structural associations. Differences are also found in assemblages of accessory minerals - such as pyrite, pyrrhotite, chalcopyrite, sphalerite, galena, molybdenite, arsenopyrite, tellurides, scheelite, and tourmaline - that occur sparsely with quartz or quartz-carbonate gangue in these deposits. On the accompanying figure all Archaean gold deposits are grouped together for convenience of illustration. This was not intended to suggest that they have a common and synchronous origin late in Archaean time. They are probably of several ages and origins. Possible systematic relationships between geological environments, mineralogy, age, and genesis of deposits are under continuing study.

One week of the field season was spent in the Elliot Lake uranium area with underground trips and discussions with staffs of the four mines then operating. Some new underground and drill-hole information pertinent to subsurface geological interpretations, ore-reserve estimates, and exploration possibilities was collected. Estimations of uranium resources in the area, however, must still rest largely on exploratory diamond drilling done in the 1954-1958 period.

The Tribag copper prospect was visited in company with P.E. Giblin, Ontario Department of Mines, Resident Geologist at Sault Ste. Marie, who is mapping in the area. The deposit, in a breccia zone in Archaean rocks, contains chalcopyrite associated with quartz, carbonate, and muscovite. A specimen of this muscovite has yielded a K-Ar age of 1,055 m.y. Specimens of pre-breccia and post-breccia basaltic dykes, and nearby Keweenawan basalt were also collected for the purpose of confirming the suspected Keweenawan age of the deposit.

Field assistants were R. DuBerger, D. Fong, P. George, and F. Wong. Mr. Fong made some special studies of some base-metal deposits in the Timmins area and spent part of the season in Ottawa continuing laboratory investigations that he began in 1963. Mr. George studied gold deposits at Timmins and selected gold deposits elsewhere in the region. He is working on an M.Sc. thesis (Queen's University) that deals with the geochemistry of some of these deposits. Mineral deposits maps and geological compilations of the Ontario Department of Mines and the Quebec Department of Natural Resources have greatly expedited this study. The resident geologists who prepared these maps and other provincial geologists have also contributed direct advice, specimens, and other assistance to the project. The writer wishes to acknowledge the cooperation of many mine managers, mine geologists, and exploration geologists.

129. VANADIUM IN EASTERN CANADA

E.R. Rose

One hundred formations of sedimentary and igneous rocks of various types and ages were examined and checked for the presence of vanadium by means of a hydrogen peroxide test in the field. Vanadium was detected in amounts exceeding 0.015 per cent, that of the average crustal rock, in 23 of 122 samples tested, mainly in red beds, dark shales, and ferruginous minerals, but there appears to be little possibility of direct economic recovery from any of these sources unless enriched parts of these formations are located.

Vanadiam was detected in strong traces in titaniferous magnetite associated with the niobium-rich alkaline intrusive complex from Oka, Quebec, and in titaniferous magnetite associated with gabbro north of Millbridge, Ontario, as well as in red-stained granitic rocks west of Stephenville Crossing, Newfoundland. The widespread distribution of vanadium in titaniferous magnetite associated with gabbroic anorthosite in eastern Canada suggests a possibility of economic by-product recovery of vanadium from these sources.

Traces of vanadium were also noted in chromite associated with serpentinized peridotite near Coleraine, Quebec; in dark bituminous shale of Albert Mines, New Brunswick, and of Kettle Point, Ontario; in the oolitic hematite iron ore of Wabana, Newfoundland; as well as in a variety of other rocks and minerals. Investigation of the nature and distribution of these occurrences is in progress.

130. MINERAL COLLECTING AREAS, MARITIME PROVINCES

Ann Sabina

An investigation was made of the mineral and rock collecting localities along the south shore of Nova Scotia (Halifax to Canso), along the Northumberland Strait (Port Hastings to New Brunswick border), in Cape Breton, and in Prince Edward Island. The deposits are accessible to the main highways and branching roads. About 135 localities were investigated.

Most of the deposits provide good specimen material for mineral collectors, and a few of the localities furnish lapidary material. Among the more interesting specimens are: arsenopyrite crystals from several former gold properties; andalusite and specularite from Guysborough county; fluorescent calcite from numerous localities; gypsum, marble, fossil plants, copper minerals from Cape Breton; and barite, hematite, fossil plants in Prince Edward Island. Some rare copper sulphates were identified in specimens from old copper mines in Nova Scotia. Specimens suitable for ornamental purposes include serpentine of various colours, crystalline limestone, and breccias from Cape Breton. Most of the mines visited are no longer in operation; a few active properties can be visited by tourists by special arrangement.

131. GEOLOGICAL SURVEY PALYNOLOGICAL STUDIES

J. Terasmae

1. An investigation of muskeg-forest site relationships at Iroquois Falls, Ontario, a joint project with the Forestry Department, was initiated by selecting a suitable area in the Northern Ontario Clay Belt, where the growth of black spruce (the economically most important tree species) is dependent on the muskeg substratum. Geochemical, groundwater, geological and peat stratigraphical factors will be investigated in relation to forest growth. Palynological, palaeobotanical, and radiocarbon methods will be used in a study of the forest history and muskeg development.

2. Cooperation with the Great Lakes Institute (Toronto, Ontario) and the Toronto Subway construction authorities has continued. Particular attention has been given to study of bottom sediments in the Georgian Bay - Manitoulin Island area in Lake Huron and the raised shore lines in the northern Lake Superior region. Field reconnaissance on the geological relationships was made at several pertinent sites. Samples were collected for palynological studies and radiocarbon dating. Further excavation of the Toronto Subway has enlarged the knowledge of the areal extent and stratigraphic relationships of Pleistocene and post-glacial deposits in the Toronto area.

3. Geophysical investigations (hammer seismic) and geological reconnaissance has been completed in preparation for drilling of 4 cores through Pleistocene sediments (maximum thickness ca. 300 feet) to bedrock in the buried Niagara River gorge at St. David's, Ontario. These studies have established the approximate depth of the gorge and its course from the Whirlpool rapids to St. David's and Lake Ontario. The planned drilling project will aid in:

a) establishing the stratigraphic sequence of Pleistocene deposits in the buried gorge;

b) chronology and stratigraphic correlation of late-Pleistocene events between the Lake Erie and Ontario basins, pertinent to the Great Lakes history; and

c) groundwater in the buried gorge, at present an important local source of water.

4. Sites for 15 collecting stations were selected throughout southern British Columbia for an air-borne pollen survey in British Columbia, a joint project with the Canada Department of Agriculture. Results of this survey will provide basic data for interpretation of fossil pollen and spore assemblages, as such are used in studies of Pleistocene chronology, climatic changes, and vegetation history. It will also provide necessary information on air-borne pollen causing hay-fever and on the distribution of pathogenic fungus spores.

5. Palynological studies and sampling for radiocarbon dating of post-glacial deposits were carried out in Beauceville map-area, Quebec in connection with N.R. Gadd's investigation of surficial deposits and glacial history.

6. Buried, plant-bearing deposits were discovered in the Sherbrooke area, Quebec, by B. McDonald (see account by McDonald elsewhere in this publication) and preliminary palynological studies have indicated probable correlation of this deposit with the St. Pierre beds of the St. Lawrence Lowland[1].

7. A continuing investigation of lake (MacKay Lake, Rockcliffe) and bog (Mer Bleue, east of Ottawa) environments has been initiated in order to gain a better understanding of the development and history of such environments and the deposition of fossiliferous materials under existing habitat conditions. Six different lake environments were selected for detailed continuing limnological study in southern Ontario.

8. Because of the importance of lacustrine sediments in palynological and palaeoecological studies (used for chronological investigations and stratigraphic correlation), methods have been worked out and equipment and instruments tested for limnological field analysis (including depth sounding and measurements of pH, temperature, conductivity, dissolved oxygen, and transparency). SCUBA diving had been employed extensively in studies of recent bottom sediments and plant and animal life zones. A gravity corer has been designed and tested for obtaining short cores of surface sediment in lakes for reconnaissance purpose. Particular emphasis has been placed on the requirement that all equipment and instruments be portable and light weight, for the use in aircraft-supported operations. The studies may have indicated that lacustrine sediments provide a more continuous and better preserved fossil record than bogs and other surficial deposits, and in the northern regions lacustrine beds can be unfrozen even in a permafrost region.

1 Terasmae, J.: Contributions to Canadian palynology No. 2; Geol. Surv. Can., Bull. 56 (1960).

132. TRIASSIC BIOSTRATIGRAPHIC STUDIES, AXEL HEIBERG ISLAND AND NORTHEASTERN BRITISH COLUMBIA

E.T. Tozer

The Lower Triassic stratigraphy and ammonoid faunas of Axel Heiberg Island were studied. New collections were obtained and it is now possible to arrange nearly all the Lower Triassic faunas in a stratigraphic sequence.

The Triassic section at Pardonet Hill, on Peace River, B.C., was studied in detail, resulting in a new interpretation of the structure and the rock and faunal sequence. Formerly the section has been regarded as unbroken by faults[1]. According to the new interpretation a steeply dipping, north-trending fault extends through Pardonet Hill. The fault lies east of the summit and probably reaches the river near the outlet of Cascades Creek. The rocks exposed between localities III and XII[1] are interpreted as "Grey Beds", and the Styrites ireneanus Zone is a repetition, through faulting, of the "Stikinoceras" Zone. The Upper Karnian Tropites locality at V was not found. However, this locality lies very close to the fault; accordingly the placing of the Tropites bed above the "Stikinoceras" Zone, as suggested formerly, seems unjustified. Near the head of Monotis Gully a Tropites fauna, dated as Upper Karnian, was found below a bed with Mojsisovicsites (=Stikinoceras). This discovery reconciles the faunal sequence at Pardonet Hill with that of Nevada[2] and Vancouver Island[3]. Accordingly, the beds with Mojsisovicsites are now regarded as Lower Norian, as proposed by Silberling[2]. The total thickness of the Pardonet Formation is of the order of 700 feet.

Upon completion of the work in British Columbia collections for comparative purposes were obtained from the Triassic formations of southeastern Idaho, and, in collaboration with Dr. Silberling of the U.S. Geological Survey, from the Triassic rocks of western Utah, Nevada, and eastern California.

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[1] McLearn, F.H.: Ammonoid faunas of the Upper Triassic Pardonet Formation, Peace River Foothills, British Columbia; Geol. Surv. Can., Memoir 311, fig. 2, p. 7 (1960).

[2] Silberling, N.J.: Pre-Tertiary stratigraphy and Triassic palaeontology of the Union District, Shoshone Mountains, Nevada; U.S. Geol. Surv., Prof. Paper 332 (1956).

[3] Tozer, E.G.: The sequence of marine Triassic faunas in Western Canada; Geol. Surv. Can., Paper 61-6, p. 15 (1961).

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133. FORAMINERAL STUDIES OF GULF OF ST. LAWRENCE, ST. LAWRENCE AND SAGUENAY RIVERS

G. Vilks

In late August of 1964, samples of bottom sediments were taken from selected areas of Magdalen Shallows, Northumberland Strait between Charlottetown and Birch Point, Chaleur Bay in the vicinity of Grande Riviere, St. Lawrence River from Metis Point to the mouth of Saguenay River, and Saguenay River to Pte. aux Pins. The field program was carried out aboard CNAV "Sackville" in cooperation with the Fisheries Research Board of Canada. The purpose of the sampling was to provide material for the study of Foraminifera of these areas in order to make comparative studies with Arctic fauna on the basis of ecology. This includes relationships to associated sediments and oceanography.

A total of 137 sampling stations were occupied. At each station bottom temperatures and samples of water for salinity measurements were obtained and, in selected areas, bottom photographs were taken to provide information on bottom conditions.

Each of the areas investigated is governed by different ecological conditions with respect to temperature, bathymetry, and type of substrata as follows: the Magdalen Shallows are characterized by relatively cold bottom temperatures ranging from 1.0° to -0.10°C at the time of the survey, an average depth of 70 metres, and substrata consisting of coarse and well sorted sand, cobbles or bedrock. At this time of year the St. Lawrence River bottom temperatures vary between 4° and 2°C within the depth interval of 340 and 50 metres. The bottom consists chiefly of grey and bluish-grey mud with a light brown surface film. In Northumberland Strait relatively high bottom temperatures were recorded, ranging from 7° to 16°C within the depth interval of 10 to 30 metres. The bottom sediment consists chiefly of well sorted red sand, which may contain cobbles of red sandstone.

Prolific foraminiferal fauna are found in muds, but fauna governed by attached or arenaceous forms are found in sands. No Foraminifera were found in Saguenay River beyond Cap Eternite.

GEOLOGICAL COLLECTING

Collection of fossils, rocks, minerals, and other geological data is an important phase of many field projects. Some parties, however, are sent to the field in order to make collections for a specific research project. Such collections are returned to Geological Survey headquarters for further study, and any account of the field work involved can only record the collecting phase. These collections provide the materials for office and laboratory research and subsequent publication in the various reports of the Geological Survey.

Six collecting projects are recorded below.

R.F. Black completed palaeomagnetic sampling of Mesozoic and Cenozoic volcanic and intrusive rocks within Whitehorse (105 D) and Laberge (105 E) map-areas in the Yukon Territory. The following ages and groups of rocks were sampled for virtual geomagnetic pole position determination: Triassic, Lewes River Group; Cretaceous, Hutshi Group and Coast Intrusions; Tertiary, Skukum Group; and Quaternary, Miles Canyon Basalt. Samples for palaeomagnetic correlation with the above groups were collected from the volcanic rocks of uncertain age, volcanic rocks provisionally mapped as belonging to the Hutshi Group, and the Little Ridge volcanic rocks of Jurassic or later age.

M.J. Copeland collected samples for microfossil analysis from strata of Ordovician and Silurian ages on Anticosti Island, in an attempt to establish zonal classification of these rocks based on their contained microfauna. It is anticipated that correlation with similar microfauna from Silurian rocks of Gaspé and other Appalachian areas will result.

C.H.R. Gauthier, from June 1 to September 27 collected more than 19 tons of rocks, minerals, and ores for the preparation of educational and other collections, from about 58 localities in the provinces of New Brunswick, Nova Scotia, Ontario, and Quebec.

R.D. Howie collected oil and gas well data from the Mines Department in Quebec, New Brunswick, Nova Scotia and Prince Edward Island, examined cores from Pacific Fox Harbour C96-V on file in Stellarton, N.S., established the exact location of 41 shallow wells in Nova Scotia, for which samples are on file in Ottawa, obtained and bottled Cable Core samples from N.B.O. Turtle Creek #1, New Brunswick, and obtained samples from N.B.O. Surrey #1, New Brunswick.

D.C. McGregor spent a week collecting 82 samples for spore analysis from the Devonian York River, Battery Point, and Malbaie Formations of the Gaspé Peninsula. These will supplement collections made in 1959-1963, in connection with the writer's study of the Devonian spores of Eastern Canada.

H.R. Steacy collected specimens of rare minerals at four localities in Ontario and Quebec for the National Mineral Collection's Systematic Reference Series, for which the Geological Survey is responsible. Some minerals, notably geikielite, serandite, and spencite, were collected in sufficient quantity to be used for exchanges with organizations and individuals in Canada and abroad for rare minerals lacking from the Survey's collection. Additional collecting trips are planned and will be made to field occurrences as long as weather permits and to mines in the winter months. Grateful acknowledgment is made to the following companies for having granted permission to make collections on their properties: Aluminum Company of Canada Limited, Wakefield, Quebec; Desourdy Construction Limited, Jacques Cartier, Quebec; and Metal Mines Limited, Bancroft Division, Bancroft, Ontario.

AUTHOR INDEX

SUBJECT INDEX

	Report Numbers
Groundwater geology studies	56, 58, 59, 60, 61, 62, 65, 66, 67, 71, 98
Surficial geology studies	2, 3, 9, 18, 28, 29, 32, 54, 70, 75, 80, 90, 91, 93, 102, 127
Structural geology studies	4, 7, 13, 26, 36, 37, 38, 48, 49, 51, 57
Economic geology studies	7, 21, 25, 80, 83, 85, 91, 96, 104, 108, 118, 125, 126, 128, 129, Howie p. 162.
Petrological and mineralogical studies	16, 36, 37, 53, 73, 89, 106, 114, 130, Gauthier p. 162, Steacy p. 163.
Marine geology studies	6, 8, 111, 112, 121, 122, 123, 124, 133
Engineering geology studies	15, 56, 82
Miscellaneous	110, 114