GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

INFORMATION CIRCULAR NO. 5

FIELD WORK, 1961

J. F. Caley, Y. O. Fortier, L. W. Morley, S. C. Robinson, and L. J. Weeks

Compiled by S. E. Jenness

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INTRODUCTION

The following notes describe briefly, by provinces, field projects undertaken by the Geological Survey of Canada during 1961, indicate progress made, and briefly summarize some of the results. The main purpose of most Geological Survey field work is to obtain basic data concerning the geology of Canada. These data, when assembled, interpreted, and published as appropriate maps and reports, guide those engaged in the search for and development of metallic and non-metallic mineral deposits, fuels, and construction materials.

The field projects described involve the study and mapping of bedrock geology, unless otherwise specified.

In most instances, and unless otherwise specified, the scale of publication of geological maps resulting from the field projects can be inferred from the size of the map-areas. Areas involving 1 degree of latitude, and 1 or 2 degrees of longitude (for instance, 32 A E 1/2, or 32 A) are generally mapped for publication on the scale of 1 inch to 4 miles; whereas areas involving 15 minutes of latitude, and 15 or 30 minutes of longitude (for instance, 32 A/1 E 1/2, or 32 A/1) are usually mapped for publication on the scale of 1 inch to 1 mile.

All statements concerning the results of field work are subject to confirmation by office and laboratory study, and publication by the officer concerned through Geological Survey or other media.

Map-areas are designated according to the National Topographic System as revised in 1960.

Insofar as practicable or warranted preliminary maps and/ or reports incorporating the results of the 1961 field work will be released during 1962. The date on which these will be released cannot, however, be forecast accurately. The release of these preliminary reports and maps, and all other Geological Survey publications is, however, announced from time to time by postcards mailed free of charge to all persons or organizations requesting this service.

Geological Survey of Canada headquarters are at 601 Booth Street, Ottawa. Convenient telephone numbers are:

Director, J.M. Harrison	CE-2-8211,	Loc. 4-5817
Chief Geologist, C.S. Lord		Loc. 4-9207
Distribution of Publications, J.L.L. Touchette		Loc. 4-5004

DISTRICT OF FRANKLIN

R.G. Blackadar commenced and completed reconnaissance mapping of the Andrew Gordon Bay (36 B) and Cory Bay (36 G) map-areas on the southwest coast of Baffin Island. Several areas on the east and west sides of this area were not mapped but these are presumed to be underlain by rocks similar to those along strike.

The rocks are an extension of the Grenville-type geology described on Map 43-1960[1]. Cory Bay map-area is covered by an extensive cover of drift through which some bedrock projects; elsewhere exposure is good. Glacial striae directions vary from 20° to 170° and suggest ice movement from north to south. Exposures of magnetite, examined in 1957-58 by Ultra-Shawkey Mines Ltd., were noted and additional small magnetite showings were mapped.

R.L. Christie continued from 1960 a geological reconnaissance of southeast Ellesmere Island. The RCMP post at Alexandra Fiord was used as a base, and transport was provided by dog sledge and aircraft. Coastal reconnaissance extended northward to Bache Peninsula. A journey was made by sledge along the ice-camp from the head of Talbot Inlet to Alexandra Fiord. Aircraft were used to establish camps on Bache Peninsula and at the head of Flagler Fiord, and also to carry out an aerial reconnaissance, with landings, of the western edge of the ice-cap.

The bedrock formations include: Precambrian gneisses and granites; Proterozoic sandstone, shale, and volcanic rocks; and lower Palaeozoic carbonate-rocks. A small area of Tertiary-type, weakly consolidated sandstone with coal beds was discovered.

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[1] Blackadar, R.G.: Mingo Lake, Baffin Island, District of Franklin, N.W.T.; Geol. Surv., Canada, Map 43-1960 (1961).

The gneissic and granitic 'basement' rocks are the northernmost exposures of the Canadian Shield in Canada. The gneisses appear dominantly to be variably quartzitic and garnetiferous quartz-feldspar-biotite rocks of metasedimentary aspect. The banded rocks are more or less intimately intruded or replaced by lesser bodies of granitic aspect: massive red potash granite, dark grey quartz-feldspar-biotite foliated rock, and garnetiferous quartz-feldspar pegmatite. The gneissosity and bedding trend variously northwest to northeast.

A formation probably correlative with the Thule or Admiralty Groups of late Precambrian age is well exposed at and north of Goding Bay. The basal strata comprise about 2,000 feet of sandstone, shale, tuff, and volcanic flows; higher beds comprise at least 4,000 feet of white and light brown sandstone, red shale, and thick lava beds. The formation is faulted and intruded by numerous diabase dykes. The lithology and structural relations of the Goding Bay beds are identical to the Proterozoic beds discovered at Clarence Head in 1960.

Early Palaeozoic limestones and dolomites overlie the basement gneisses on Bache Peninsula. Scattered remnants of Palaeozoic beds lie to the south as a result of the gentle northward dip of the unconformity and the highly dissected nature of the fiord-land.

The possibly Precambrian, Cambrian, and Ordovician beds of Bache Peninsula have been studied and described by geologists since the turn of the century; the "classic" section at the abandoned RCMP post was examined, and numerous others were measured and collected from in 1961. The early Palaeozoic sequence of sandstones, dolomite, limestone, and gypsum was studied and mapped in some detail from the base upward to a horizon tentatively identified as equivalent to about the middle of the Cornwallis Formation. The Palaeozoic beds dip gently northward to expose younger beds in that direction; however, the sections are continually repeated due to prominant east and northeast trending normal faults.

Impure sandstone, conglomerate, and coal beds, probably of Cenozoic age, were discovered at Bartlett Bay on the east coast of Bache Peninsula. The weakly lithified beds disconformably overlie Ordovician limestone and dolomite, and are preserved along the downthrown side of a normal fault.

The Proterozoic and Palaeozoic rocks unconformably overlie the basement gneisses. Diabase dykes intrude the Proterozoic rocks, but are not found in the Palaeozoic rocks.

Faults trending mainly northeast and east cut all formations, including the probably Cenozoic strata. The northerly dip of the Palaeozoic and Cenozoic beds is undoubtedly due to tilting of fault blocks. The bedded rocks are unfolded except for sharp flexures at faults.

Minor occurrences of metallic minerals were observed, but most regions appeared unpromising for prospecting. Copper stain is more abundant along the south coast of Bache Peninsula, and sulphide minerals, heavily disseminated in certain gneiss bands, form "sulphide schist" bodies along the shores of Buchanan Bay. A seam of soft, flaky coal about 15 feet thick is exposed about 3 miles west of the head of Bartlett Bay. Several other seams, about 3 to 5 feet thick, are exposed in the vicinity. Beds of massive, relatively pure gypsum form part of the widespread Ordovician gypsiferous beds, and are well exposed along the isthmus and northern part of Bache Peninsula.

J.G. Fyles studied the surficial geology of a strip of country above 300 miles long (north to south) and 100 miles wide constituting the fiord-land of western Ellesmere Island and eastern Axel Heiberg Island. About 250 "geological" landings were made with a Super Cub aircraft equipped with balloon tires.

High-level fluvial deposits of interglacial and/or preglacial age are widespread throughout the region. These gravels, sands, and silts, which locally attain a thickness of 200 feet or more, constitute remnants of broad valley floors 500 to 1,500 feet above the present valley bottoms. Both these old river plains and the valleys cut through them bear evidence of having been glaciated. Although a convincing till sheet was found beneath these deposits in one locality, it has not been proved that the region was glaciated prior to their deposition. In parts of the region, these deposits contain an abundance of wood (diameter up to 10 inches), as well as buried soils and peat; in a few places the wood has been gnawed by beaver. In other parts of the region, organic remains are conspicuously lacking from the high-level deposits.

A brief visit was made to Meighen Island to compare the deposits described above with the wood-bearing gravel and sand of the Beaufort Formation. Although the two groups of deposits are remarkably similar, it is not safe to conclude that they are of equivalent or overlapping age. Marine silt was discovered beneath the Beaufort gravel and sand on southern Meighen Island. If, as generally assumed, these Beaufort deposits are late Tertiary in age, then the underlying marine silts constitute the only known marine Tertiary strata in the Arctic Archipelago. It is alternatively possible, however, that Meighen Island consists entirely of Pleistocene materials.

Extensive, thick fluvial-plain deposits on Axel Heiberg Island near Flat Sound have been compared by B. Robitaille to the Beaufort Formation, but further examination has revealed various features that are more characteristic of the Eureka Sound Formation. Thus, in the rare fresh exposures these deposits are weakly lithified (i.e. consist of conglomerate, sandstone, and shale), the contained wood is mineralized, and the peaty layers are largely lignitic coal. Moreover, around the margins of the outcrop areas the prevailingly horizontal attitude of these deposits locally gives way to steep dips. On the other hand, these deposits differ from the Eureka Sound Formation elsewhere in that they rest unconformably upon various Mesozoic formations. Moreover, pollen contained in a single sample of peat (or coal) from the upper part of the unit has a Pleistocene rather than Tertiary aspect.

Evidence of former glacial activity (i.e. unrelated to the modern glaciers) was noted on the ground and in air photographs at many localities within the region. It is probable that, at one time or another during the Pleistocene, most of the region has been overridden by glaciers or ice sheets, but the sequence of glacial events remains largely unknown. Isolated glacial striae and grooves and the distribution of erratic boulders have provided evidence of glacial movement away from the principal mountain areas and down the valleys and fiords. In the Eureka Sound-Nansen Sound depression, glacial ice flowed northward north of Stor Island and southward south of this island. Meltwater channels apparently provide evidence of shrinkage of valley glaciers and various independent (remnant?) ice caps rather than an overall orderly marginal retreat in one direction or another across the region.

Various features suggest that the region was overridden by glaciers more than once during the Pleistocene, but conclusive evidence of multiple glaciation remains to be found. Two layers of till or till-like material separated by stratified sediments were found in a few places. Prominent end moraines several miles beyond the margins of the modern glaciers outline the termini of a few late Pleistocene valley glaciers, but it is not known whether these moraines record a pause during general retreat or the limiting stand of an advance. Various contrasts in the freshness of the glaciated landscape are evident. For instance, the heads of some fiord valleys are characterized by polished bedrock surfaces and fresh glacial landforms, whereas adjoining uplands and ridges are surfaced by bedrock rubble, are devoid of fresh outcrops, and bear but scanty evidence of glaciation. One possible, but highly tentative, explanation for such contrasts is that late Pleistocene (late Wisconsin?) glaciers covered only parts of the region and that the last glaciation of the remainder of the region took place much earlier.

Fresh, apparently recent, raised marine features were found up to 500 feet above present sea-level around the northern part of Eureka Sound and up to about 450 feet around the southern part of the sound. Eastward in the various fiord valleys of Ellesmere Island, the highest marine features stand at progressively lower levels, and at the heads of the fiords are only 250 to 300 feet above present sea-level. Various glacio-marine deposits stand at the highest marine level near the heads of the fiords. The regional marine submergence of the fiord-land can be explained most simply in terms of isostatic rebound subsequent to a regional late Pleistocene glacial invasion involving at least an extensive network of thick valley and fiord glaciers. This conclusion is not entirely compatible with the suggestion (above) explaining contrasts in the glaciated landscape.

Thick, solid fragments of Pleistocene marine shells and rare, thick, whole shells are locally strewn about on bedrock and drift surfaces at altitudes higher than the upper limit of marine submergence reported above. Such shells were found in more than a dozen places near Eureka Sound and in a few places along the fiords extending eastward from Eureka Sound. These shells are believed to have been carried into their present elevated position by glaciers moving along the fiords.

G.D. Hobson was seconded from the Geological Survey of Canada to supervise the field and office program of the seismic program of the Polar Continental Shelf Project, which was commenced in 1960 and continued in 1961.

The 1961 survey was conducted more efficiently through extensive use of an S55 helicopter. Eight refraction profiles were completed with reversed profiles and will give a cross-section almost completely across the Sverdrup Basin.

D.R. Horn, from March to August, was attached to the Polar Continental Shelf Project based at Isachsen, District of Franklin. His duties were to commence a detailed study of bottom sediments and submarine topography in the inshore areas and island channels adjacent to the eastern coast of Ellef Ringnes Island, the western coast of Axel Heiberg Island, and the coasts of Amund Ringnes and northern Cornwall Islands. The purpose of the study is to map the distribution of the sediments, interpret the geological history of the deposits, and interpret the physiographic history of the island channels and adjacent inshore areas. Gravel layers together with topographic profiles drawn from soundings support earlier reports on glaciation of ancient rivers when the land stood higher relative to sea level, and the subsequent event of submergence. Office and laboratory examination of field observations and samples are proceeding.

B.R. Pelletier, during April and early May, was attached to the Polar Continental Shelf Project based at Isachsen, District of Franklin. He continued a study, begun in 1960, of the submarine geology of the Arctic continental shelf adjacent to the western Queen Elizabeth Islands. This year reconnaissance traverses were made across parts of the continental shelf between Meighen and Ellef Ringnes Islands. Field observations and a laboratory examination of the inshore and offshore samples obtained during both field seasons indicate the following:

1. In fluvial and inshore deposits there is a direct relationship of decrease in size of detritus with distance of sedimentary transport, and this is concomitant with a reduction in the number of heavy mineral species, a decrease in the percentage of heavy minerals per sample, and a decrease in the mean size of the heavy minerals. This means that under certain conditions, limited to traverses across the strike of a deposit, heavy minerals can be used in attempts at correlation, and can be used as sedimentary tracers to interpret routes of sedimentary transport.

2. Offshore in areas of drifting ice, which contribute sediments to the sea floor, no progressive variation in texture exists. However, where currents are known to occur, the sediment was sorted to a better degree than in areas where currents are extremely slow or absent. This was corroborated by a plot of the sediments over the sampling area. Brownish grey, fresh-smelling sediments with high sand content occurred in areas of moderate circulation of water, whereas green and black mud, sour-smelling, and with low sand content occurred in areas of little or no circulation.

3. Certain characteristic distortions of the isopleths in an areal pattern of a sand-mud lithofacies map indicates that such methods of analyzing data may be useful in demonstrating the existence of longshore currents around deltas and protected bays.

4. X-ray studies indicated that clay minerals were grouped according to the geological formations near the drainage basin and adjacent site of marine deposition. This led to the conclusion that clay minerals, in the Arctic environment at least, can be used as sedimentary tracers.

5. Preliminary spectographic results indicate very little chemical activity in Arctic sediments, and that certain elements may be used as sedimentary tracers.

6. Faunal studies undertaken by F.J.E. Wagner show that a bathymetric change can be indicated by the fauna providing the change is of the order of several hundred metres.

7. Soundings support earlier ideas concerning glaciation of river valleys, when the land stood higher with respect to sea level, followed by submergence.

R. Thorsteinsson, E.T. Tozer, H.P. Trettin and J.W. Kerr completed the first field season of a two year program of reconnaissance studies of the bedrock geology of Axel Heiberg and Ellesmere Islands. In addition to the above-named four staff geologists the party included three pilots, an aircraft mechanic, radio operator, and a cook. Transportation in the field was provided by three Piper Super Cub aircraft (PA18A) under contract from Bradley Air Services of Carp, Ontario. The aircraft were equipped with special, large low-pressure tires enabling landings on unprepared terrain. A base camp was established near the weather station at Eureka on the west coast of Ellesmere Island. The party arrived at Eureka on May 27 and commenced their return to Ottawa on August 31.

Reconnaissance mapping, suitable for publication on the scale of 1 inch to 8 miles, was completed for approximately 30,000 square miles. The area thus covered included Axel Heiberg Island and adjacent regions of Ellesmere Island. Isolated parts of these regions had been previously mapped by members of Operation Franklin in 1955 and by Thorsteinsson and Tozer in 1956 and 1957.

The division of responsibility for coordinating stratigraphic studies and mapping of the various structural-stratigraphic provinces included within the two islands was as follows: early Palaeozoic eugeosyncline - Trettin; early Palaeozoic miogeosyncline - Kerr; Pennsylvanian and Permian rocks of the Sverdrup Basin - Thorsteinsson; Mesozoic and early Tertiary rocks of the Sverdrup Basin - Tozer.

Bedrock within the region investigated ranged from Cambrian to early Tertiary. With the exception of the Mississippian all of the various systems are represented. A great deal of information is already available on the structure and stratigraphy of Axel Heiberg and Ellesmere Islands, Much of this information has been obtained (and published) in recent years by members of the Geological Survey. Important, additional information obtained by the 1961 party is described briefly in the following paragraphs.

A thick and varied sequence of Devonian rocks has been known to occur in southwestern Ellesmere since the classical work of the

Norwegian, Per Schei, about the turn of the century. Hitherto, a problem bearing directly on the age of the folding in northerly regions of Ellesmere has been the apparent absence of authenticated Devonian rocks north of the latitude of Baumen Fiord in southwestern Ellesmere. In 1961, however, Devonian rocks were found to outcrop throughout much of the miogeosynclinal belt that trends northeasterly across Ellesmere Island. As in the case of the Devonian rocks south of Baumen Fiord the Devonian rocks lie conformable upon, and are folded with, Silurian and older rocks.

The presence of early Palaeozoic eugeosynclinal rocks in northern Axel Heiberg was first made known by Thorsteinsson in 1957. In 1961 the regional structure of the eugeosynclinal rocks in this region appears to be that of a broad arch, the long axis of which extends south-southeasterly for a distance of some 40 miles from the northern extremity of Axel Heiberg towards the geographic centre of the island. The regional strike of the eugeosynclinal rocks is north-northwesterly. Strata of Middle Pennsylvanian age rest with angular unconformity upon the eugeosynclinal rocks.

A well-exposed and remarkably complete sequence of eugeosynclinal rocks, aggregating some 40,000 feet thick, was studied by Trettin in the country north of Rens Fiord. Ten lithologic units have been delimited and mapped. The rock succession is described briefly as follows: a lower sequence, about 18,000 feet thick, is composed predominantly of silty and argillaceous slates. Less significant lithologies include dolomite, chert, basic volcanic rocks, and quartzites. These rocks have yielded Ordovician and/or Silurian fossils. They are intruded by several small bodies of quartz-diorite and are partly metamorphosed to hornfels and metaquartzites. An intermediate sequence of rocks consists mainly of siltstone, red sandstone, conglomerate, varicoloured shales, and argillaceous limestone. This sequence is approximately 12,000 feet thick and has yielded fossil fish tentatively identified as Early Devonian. An unconformity is considered to separate the lower and intermediate sequences. The upper sequence of eugeosynclinal rocks comprises turbidites of volcanic sandstone and minor conglomerate, siltstone, shale, and andesitic volcanic rocks. The total thickness of these rocks is about 10,000 feet.

A long-standing problem in the geology of the Arctic Archipelago is the age of the gypsum and anhydrite which form the core of diapiric intrusions along the axial region of the Sverdrup Basin. Relevant to this problem are the ages of two distinct successions of gypsum and anhydrite beds in normal stratigraphic sequence with Pennsylvanian and Permian sediments in northern Axel Heiberg and Ellesmere. These successions were found by Thorsteinsson and Tozer in 1956 and 1957. The older and thinner (25 to 50 feet) of the gypsum and anhydrite sequence is of Middle Pennsylvanian age. The younger unit of gypsum and anhydrite beds attains a thickness up to 1,000 feet. Fossils collected directly above the evaporite beds by Thorsteinsson and Tozer in 1957 were dated as Early Permian. Fossils were collected immediately below these beds in 1961. They are as yet unstudied, but field determinations suggest an Early Permian, or at the earliest, Late Pennsylvanian age.

Biohermal limestone reefs, up to 1,200 feet thick and Early Permian in age, are extensively developed between Hare Fiord and Greely Fiord in northern Ellesmere.

Previous knowledge regarding volcanic activity within the Sverdrup Basin has been limited to (i) a sequence of flows and pyroclastic sediments (Strand Fiord Volcanic Formation) interposed between the Late Cretaceous Kanguk and Hassel Formations in western Axel Heiberg, and (ii) volcanic flows found in juxtaposition with Permian limestone and chert in northern Axel Heiberg (discovered first by Per Schei in 1902). The investigations of 1961 have brought to light evidence of considerably greater volcanic activity in Axel Heiberg and Ellesmere during the development of the Sverdrup Basin. (i) Thick sequences of volcanic flows and pyroclastic rocks occur in the Early Cretaceous Christopher and Isachsen Formations of northern Axel Heiberg. (ii) A relatively thin unit of volcanic flows occurs interposed in Permian chert and carbonate rocks in northern Axel Heiberg (Per Schei's volcanic rocks). (iii) A sequence of volcanic rocks, up to 1,700 feet thick and of Middle Pennsylvanian age, outcrops in northwestern Ellesmere. (iv) A sequence of volcanic flows distinct from the above mentioned rocks, occurs in northwestern Ellesmere. The later sequence rests upon Middle Pennsylvanian limestone, but its upper contact has not been observed.

New information was also obtained on the structural relations of the Tertiary Eureka Sound Formation. The information obtained in previous years is available in Geological Survey publications (G.S.C. map 36-1959; G.S.C. Paper 60-5). Until this year it was supposed that the Tertiary beds rest concordantly upon the Kanguk shale (Upper Cretaceous) throughout most of the Sverdrup Basin. The 1961 field work confirmed that this relationship obtains on western Fosheim Peninsula and on the west side of Axel Heiberg Island. However, it was found that a different situation prevails on eastern Axel Heiberg Island, between the meridian of Depot Point and the central ice caps. In this area Tertiary beds, apparently correlative with the Eureka Sound Formation, rest variously on several different Mesozoic formations, ranging in age from Triassic to Lower Cretaceous. Thus an unconformity occurs beneath the Tertiary beds of eastern Axel Heiberg Island. Despite this unconformity the Tertiary beds have undergone Tertiary folding. It follows that the post-Early Cretaceous structural history of eastern Axel Heiberg Island was more complicated than formerly believed, with at least 2 periods of tectonic activity following the deposition of the Christopher Formation (Early Cretaceous). The field work also confirmed the easterly overstep of the Eureka Sound Formation of eastern Fosheim Peninsula.

DISTRICT OF KEEWATIN

L.S. Collett and P. Sawatzky constructed a sea magnetometer and, in cooperation with the Division of Oceanographic Research, installed it in the Oceanographic ship "Theta", which cruised in Hudson Bay during August and September. The 9,000 line miles of sea magnetometer data obtained will be useful in determining the depth of the sedimentary rock layer beneath the Bay and in tracing major rock trends.

P.J. Hood, under sponsorship of the Division of Oceanographic Research, conducted the first salt-water test of the sub-bottom depth recorder, developed jointly by Hunting Survey Corporation and the University of Toronto. It provides a continuous seismic profile analogous to a geologic cross-section to a depth of several hundred feet. Structural data is accumulated very rapidly with the help of this new development.

This survey has provided sub-surface information along profiles in the southern part of Hudson Bay and through the Omarolluk Sound in the Belcher Islands. It is possible to estimate the depth of unconsolidated sediments covering the bedrock over much of the profile, although, at this stage of the interpretation, the results have not been fully assessed.

R.J. Leslie was attached to the Division of Oceanographic Research from mid-June to late September for the purpose of undertaking a submarine geology program in Hudson Bay. This program, which particularly includes studies on physiography, bottom sediments, and fauna, is part of a larger preliminary oceanographic investigation of Hudson Bay, and will form the basis for future detailed studies in that area. Leslie, on board the M/V Theta, was joined by B.R. Pelletier in September, and both will prepare a joint preliminary paper on the results.

Traverses were made on east-west lines and around the perimeter of Hudson Bay. As this was an integrated oceanographic program involving geophysical studies and submarine geology together with routine oceanographic sampling, the following were indicated:

1. With the aid of a Sparker, sub-bottom echoes were recorded, which indicated the depth of unconsolidated sediment as less than 10 feet over most of the Bay, particularly the central and western parts, but was up to 30 feet in troughs of steeply folded Precambrian rocks.

2. The Sparker survey supervised by P. J. Hood made it possible to delineate areas of flat lying Palaeozoic rocks from the highly folded Precambrian rocks, when they formed the floor of Hudson Bay.

3. Continuous echo-sounding indicated the occurrences of short steep valleys up to 60 feet in depth, many miles off shore, which may represent an older drainage system.

4. Sediments in the central part of Hudson Bay and within a few miles off shore consist chiefly of poorly sorted sand, silt, and clay, with a wide distribution of boulders, thus suggesting considerable ice-rafting. Near shore the sediments have undergone much re-working, so that well washed sands and gravels are common.

Office and laboratory studies of the bottom samples are proceeding.

DISTRICT OF MACKENZIE

R. Kretz continued the study of pegmatites in relation to surrounding rocks began in the spring of 1960. Field examinations were concentrated at selected places in the Yellowknife-Beaulieu area, District of Mackenzie.

At Staple Lake, several hundred pegmatite dykes and irregularly shaped masses were mapped on the scale of 6 inches to 1 mile. Special attention was directed to the orientation of pegmatite masses in relation to planar and linear structures in the enclosing biotite, garnet, and cordierite containing schists. The emplacement of some pegmatite masses, which are circular in plan, has evidently caused no displacement of bedding, foliation, and lineation in the enclosing schists.

At Sparrow Lake and Thompson Lake, an investigation was made of the distribution and character of pegmatite masses in relation to the position of the Sparrow Lake granite and to changes in metamorphic grade in meta-sedimentary rocks of the Yellowknife Group. Mapping was carried out on the scale of 3 inches to 1 mile, 6 inches to 1 mile, 12 inches to 1 mile, 1 inch to 2 feet, and 1 inch to 1 inch. Pegmatite masses occur within granite and within schist, but not within schist of the lowest metamorphic grade. Regional zoning (Fortier, 1947; Hutchinson, 1955)[1] is indicated by the confinement of Li and Ta-Nb minerals to pegmatites enclosed by schist and at some distance from the granite-schist contact. Also, Be in the form of beryl reaches highest concentrations in those pegmatites enclosed by granite and near the granite-schist contact, and again in those pegmatites enclosed by schist and located at some distance from the contact.

Considerable attention was given to information concerning dilation obtainable from intersecting dykes, to inclusions of schist in pegmatite, and to the distribution of minerals within pegmatite masses. In connection with the latter investigation, the sodium cobaltinitrite test to distinguish between potash feldspar and plagioclase was successfully used directly on rock surfaces in the field.

Material was collected to study the regional distribution of Na, Be, K, Li, Ta, and Nb, and to examine profiles across two pegmatite dykes (extending well into the enclosing rocks) with reference to the above listed elements.

J.C. McGlynn continued a regional study of the Precambrian rocks within mapped areas of the District of Mackenzie in order to refine, confirm, or revise the current correlation of the various map units used to date[2].

Structural information on rocks of the Snare and Yellowknife Groups and on the unconformity between these two groups was obtained.

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1 Fortier, Y.O.: Ross Lake Map-area, Northwest Territories; Geol. Surv., Canada, Paper 47-16 (1947).

Hutchinson, R.W.: Regional Zonation of Pegmatites near Ross Lake, District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Bull. 34 (1955).

2 Lord, C.S.: Snare River and Ingray Lake map-areas, Northwest Territories; Geol. Surv., Canada, Mem. 235 (1942).

The effect of Snare deformation, and possibly metamorphism, on rocks of the Yellowknife Group was established. The ages of a number of granitic masses relative to Snare and Yellowknife rocks were established in the field and samples of these rocks obtained for age determination. Also samples of meta-greywacke and shale of the Yellowknife Group were collected with the hope of establishing the metamorphic history of these rocks. Peter Smith assisted Dr. McGlynn and also worked independently on the relationships of a concordant batholith to metamorphism in the Basler Lake area (85 O/13 W 1/2). The field season was devoted to a reconnaissance study of the Basler Lake granite, its age relationship, and the structure of the surrounding rocks. A preliminary sampling plan was devised to test the feasibility of a regional sampling program. It is expected that he will obtain material for a Ph.D. thesis from this study.

K.H. Owens, F. Essex, J. Houlihan, D. Reveler, and J. Lee conducted an aeromagnetic survey of the Muskox Complex which is under study by C.H. Smith of the Geological Survey. This ultrabasic complex is located northeast of Great Bear Lake near Coppermine River. It is one of several bodies that will receive detailed geological and geophysical attention during the international study of the Upper Mantle. This aeromagnetic survey will help delineate the Muskox Complex more fully in horizontal and vertical extent and will act as a guide to the proposed research drilling.

YUKON

C. Gauvreau conducted experiments in the gravels of Klondike and Dominion Creeks with the model MD-1 seismograph to determine whether it could be a useful tool in placer prospecting in this permafrost area.

In the early part of the summer when the depth of permafrost melting was very shallow, accurate determination of depth to bedrock could be obtained if both the geophone and hammer plate were placed on the permafrost.

Later in the season, it became too laborious and time-consuming to dig the necessary 3 or 4 feet to permafrost for each set-up of the hammer.

Results near Dominion Creek were found to be anomalous in that the seismograph recorded twice the depth to bedrock that was believed to be the case from the extrapolation of drilling results. This could be explained either by the presence of a false bedrock at the depth determined by drilling or by an added delay time caused by local melting of permafrost.

It was concluded that the method is useful in May, June, and July, but not in August or September.

L.H. Green and J.A. Roddick completed Operation Ogilvie, an air-assisted reconnaissance of Nash Creek, Larsen Creek, and Dawson map-areas, (106 D, 116 A, and 116B and C E1/2), which was commenced in 1958, but dropped for two years. In 1961 a helicopter was used full time and a fixed-wing aircraft was used part time to supply the party.

Southwest of Tintina Trench, which crosses only the Dawson part of the project area, the rocks consist chiefly of metamorphosed sedimentary rocks and green quartz-chlorite rocks of less certain derivation, generally known as the Klondike Schists. A number of small bodies of granitic, ultrabasic, and volcanic rocks occur in this area.

In Larsen Creek and Nash Creek map-areas, and in that part of Dawson map-area northeast of Tintina Trench, rocks of Precambrian, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, and Jurassic or Cretaceous ages were recognized. The known Precambrian rocks outcrop in a number of dome-like structures elongated to the east or northeast and consist of dark greenish to greyish argillites and phyllites overlain by distinctive orange-weathering dolomite and siltstone. These are commonly overlain unconformably by Palaeozoic carbonate rocks. South of these rocks a large area is underlain by a distinctive map-unit of possible Precambrian or Cambrian age containing maroon and green shales, gritty quartzites, argillite and phyllite and minor chert, limestone, and limy volcanic rocks. South of this unit, massive quartzites (similar to those on Keno and Galena Hills) have been traced from the Davidson Mountains in Nash Creek map-area west across Larsen Creek map-area and into Dawson map-area west of North Klondike River. These quartzites were previously mapped as Precambrian, but one collection of plant fossils from the quartzites and a number of poor collections from the overlying and underlying rocks suggest a late Palaeozoic or an early Mesozoic age.

Structure northeast of Tintina Trench is relatively complex. Over wide areas southerly dips prevail but major thrusting towards the north and isoclinal folding are common and imbricate structure is probable in some places. The structure is simpler near the northern margin of the area where younger rocks commonly lie in open synclines, but even there relatively complex faults and folds are present locally.

Southwest of Tintina Trench placer gold has been recovered from many of the creeks, most commonly those draining areas underlain by green chloritic rocks originally mapped as Klondike Schist. Considerable development work has been done on showings of asbestos in the ultrabasic rocks. Northeast of Tintina Trench the massive quartzites similar to those of Keno and Galena Hills are perhaps the most favourable area for prospecting. Silver-lead showings are known from the Davidson Range in Nash Creek map-area and Little Twelvemile district in Dawson map-area. Further to the north small showings of hematite and copper minerals have been reported.

Geological mapping has now been completed along the Tintina Trench from the southern end northwest to the Yukon-Alaska boundary. The Trench is a major fault and the rocks on either side are believed to differ in age, facies, and metamorphic rank. Tertiary sediments in the Trench are commonly folded indicating relatively recent movements along the structure.

O.L. Hughes, C.F. Gleeson, and C.R. McLeod continued the study and mapping of the surficial geology and of distribution of heavy minerals in the Klondike placer mining district.

Hughes traced a high level bedrock terrace along Yukon River and certain tributaries and subtributaries between Thistle Creek and the Alaska border (about 170 miles), and determined elevations on the bedrock terrace and overlying gravel. On certain tributaries and subtributaries, notably Bonanza and Hunker Creeks, the terrace gravel yielded an important part of the gold production from the creeks. Terrace gravels may be important on other producing tributaries (e.g. Sixtymile River) on which they have received little attention.

Hughes also studied the glacial geology of North Klondike River valley to supplement reconnaissance Pleistocene geology by P. Vernon, who was attached to Operation Ogilvie. Evidence was found of a major glaciation in which ice extended into but not across Tintina Trench. A younger less extensive glaciation affected only the upper reaches of the valley and tributary valleys. The features of the two glaciations are distinguishable on air-photos throughout much of Operation Ogilvie area. Scattered evidence was found in Operation Ogilvie area of a more extensive glaciation older than both the above-mentioned. Geomorphic and stratigraphic evidence was found to show that the younger two at least of the glaciations post-date erosion of the high-level terraces along Yukon River and its tributaries, deposition of gravel on them, and the cutting of the inner valley to more or less the present-day level.

C.F. Gleeson and C.R. McLeod completed a detailed sampling program on Bonanza and Eldorado Creeks and their tributaries. Eighty-one stream gravel samples, seventy-five soil samples and fifty samples from six sections of terrace gravels were taken. Each sample measured one cubic foot.

Forty samples of heavy mineral concentrates were obtained from Klondike Lode Gold Mines. The latter company is doing detailed exploration for lode gold deposits in the Klondike area. The samples that were donated came from some of the many bulldozed cuts that the company opened this year near Eldorado and Bonanza Creeks. Each sample consists of a heavy mineral concentrate obtained by panning and sluicing 3 cubic feet of weathered bedrock.

Sixty gravel samples (1 cu. ft. each) were obtained from terraces and stream beds of Dominion, Sulphur, Gold Run, Quartz, and Eureka Creeks. These streams are located 30 to 50 miles southeast of Dawson City.

Seventy gravel samples (1/2 cu. ft. each) were obtained by O.L. Hughes' party from the terraces and beds of Yukon River and its tributaries as far south as Stewart River and north to Fortymile River.

All samples obtained during the 1961 field season were sized to -8 mesh and sluiced and panned in the field.

The resultant heavy mineral concentrate will be sized and separated using heavy liquids and an Isodynamic separator. Microscopic and X-ray diffraction studies will be made to determine the mineralogy of these samples. Quantitative mineralogical estimates will be made and it is hoped that some correlation will be found between the presence of one or more of the heavy minerals and the occurrence of gold. Also these studies will be helpful in locating sources of other valuable heavy minerals.

D.K. Norris spent 10 days in northern Canada establishing sites for gas caches and appraising stratigraphic sections critical to the geological mapping of the Operation Porcupine area in the 1962 field season. Specifically, the area consists of that part of the Yukon and Northwest Territories north of latitude 65° and west of longitude 132°. It is approximately 80,000 square miles.

The region contains sedimentary rocks ranging in age from Precambrian to Tertiary and both acid and basic intrusive rocks, mainly of Mesozoic age. It has fossil fuel potential and possibly mineral potential, as indicated by the discovery of encouraging quantities of oil and gas in Upper Palaeozoic rocks of the Western Minerals Chance No. 1 well in the Eagle Plain and the reported occurrence of wolframite and molybdenite near Mt. Fitton.

E.B. Owen continued the preliminary investigation of the engineering geology of proposed dam sites in the Yukon. This investigation was commenced in 1959, and is being conducted at the request of the Water Resources Branch, Department of Northern Affairs and National Resources. Five sites were examined on the Yukon River drainage basin; one on White River, one on Kluane River, two on Kathleen River, and one on Ross River. Five more sites were examined within the Mackenzie River drainage basin; two on Frances River and three on Liard River.

YUKON AND BRITISH COLUMBIA

E.D. Kindle completed a study of the geology of the copper deposits of the Yukon. The results will eventually be part of a report on copper deposits of the Yukon and northern British Columbia. The Whitehorse copper belt and the Atlin area were further studied and a first visit was paid to the Carmacka, Carcron, and Aishihik areas. A geological map of the Whitehorse copper belt was completed for publication at a scale of 1 inch to 1 mile. It covers an area 17 miles long by 3 miles wide. The map shows the distribution of copper deposits in limestone. Scheelite was detected in the copper prospect west of the north end of Giltana Lake, in the Aishihik Lake area.

BRITISH COLUMBIA

R.B. Campbell commenced work in, and completed about half of, the Quesnel Lake East Half (93 A E1/2) map-area. In 1960 he completed the west half of the same area[1, 2].

Work in the map-area was greatly facilitated by the use of a helicopter for a period of four weeks. Most of the work was done in the northern part.

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1 Campbell, R.B.: Quesnel Lake (West Half), B.C.; Geol. Surv., Canada, Map 3-1961 (1961).

2 Davis, N.F.G.: Clearwater Lake area; Geol. Surv., Canada, Summ. Rept. 1929 Pt. A.

The north half of the map-area is underlain mainly by Proterozoic and lower Palaeozoic strata of the Kaza and Cariboo Groups. Between the north and east arms of Quesnel Lake, rocks of the upper Cariboo Group are intensely deformed and are highly metamorphosed. Many pegmatite dykes and sills intrude these rocks and, south of Wasko Lakes is a large body of gneissose granodiorite with much pegmatite.

The metamorphic rocks are bounded on the northeast by a fault that extends from near Summit Lake northwesterly to the Matthew River valley below Ghost Lake. Northeast of the fault the rocks are but slightly metamorphosed and in broad areas the bedding is nearly flat-lying. Deformation in these rocks becomes more intense toward the northeast corner of the map-area where folds are strongly overturned toward the southwest.

Mesozoic rocks are believed to be separated by a fault from the older rocks. They are restricted to the southwestern part of the map-area and consist mainly of volcanic rocks, though sedimentary types are not uncommon. In the extreme southwestern part of the map-area Mesozoic rocks are intruded by a body of quartz monzonite or granodiorite, which is known to extend for many miles to the southeast. Molybdenum and copper minerals are associated with this intrusive body.

D.B. Craig, a graduate student at the University of Wisconsin, completed very detailed mapping of a small area of exceptionally well exposed rocks of the Monashee Group in 82 L/16 near Revelstoke, as part of the 'Study of Granites in Canada' in the Kootenay-Columbia region of British Columbia. In this area the Monashee Group consists of schists, gneisses, quartzites, and calc-silicates of sillimanite-garnet grade of metamorphism and associated quartzo-felspathic granitic rocks. All rocks are to some extent penetrated by pegmatitic and leucogranitic material, which is abundant in pelitic facies but sparsely developed in the quartzites. Intensity of felspathization varies from layer to layer as well as along strike within a layer.

The structural pattern is dominated by a consistant set of open synclines and northward-inclined tight anticlines, all with axes oriented to the southwest. Amplitude of the folds ranges from 1/2 inch to over 1/2 mile. An intense, penetrative mineral lineation is developed in all rock types and is shown by sillimanite, biotite, muscovite, and by flattened and elongate grains of quartz and felspar. This lineation is oriented to the southwest at low to moderate plunges and its strike is independent of the trend of the foliation and parallel with the fold axes.

All the quartzo-feldspathic veins and layers and all layers of the gneisses are intensely deformed, which indicates that migmatization, metamorphism, and metasomatism began before the structural deformation and may have continued during this process.

D.C. Findlay, a graduate student at Queen's University, completed detailed mapping and sampling of the Tulameen ultramafic complex, Yale district, B.C. as a contributing project to the Study of Ultramafic Rocks in Canada program.

The Tulameen body is an elongated complex, with a surface area of about 28 square miles, that has intruded metavolcanic and metasedimentary rocks of Triassic age. It is a single intrusion that has undergone mechanical and chemical differentiation during emplacement to form a series of ultramafic and basic rocks ranging from dunite to gabbro. The rock units show a pronounced parallel to sub-parallel arrangement. The complex as a whole has three northwest-trending ultramafic axes that are separated by gabbroic rocks. The geographical distribution of rock types shows an overall pattern; a dunite (locally peridotite) core or median zone is bordered on either side by olivine pyroxenite, hornblende pyroxenite, and gabbro, generally in that order outwards from the median zone. The individual ultramafic axes reflect this pattern to varying degrees; locally one or more of the pattern units are missing, or discontinuous along strike. The pattern is best developed at the north end of the main axis, in the areas of Grasshopper and Olivine Mountains. The distributional pattern at the extremities of the intrusion is uncertain because of poor exposures; however, there are indications that, at the north end at least, the peripheral ultramafic units (olivine pyroxenite, hornblende pyroxenite) join to close off the dunite core.

Contacts of rock units dip moderately to steeply. The dominant dip is to the west, but there are local east dips. Hornblende layering due to mechanical segregation processes during intrusion is common in the hornblende pyroxenite unit; magnetite layering is less common. In the olivine pyroxenite unit discontinuous olivine-rich zones rarely form a crude layering. Primary layering is not present in the dunite and peridotite units.

Variations in the physical parameters and compositions of component minerals of the various rock units are under investigation. Olivine compositions range from Fo_{84} to Fo_{90}. Physical parameters of clinopyroxenes (refractive indices, 2V) show variations that, on the basis of preliminary studies, can be correlated to rock type and geographic positions within the rock distribution pattern.

Precious metal analyses have been carried out by the Mines Branch. The background platinum content of the ultramafic rocks (dunite, olivine, pyroxenite), is about .06 ppm. Platinum occurs in concentrations up to 7 ppm. in association with small chromite segregations in the ultramafic rocks. Palladium has been detected at only one locality; an analysis of material from a small sulphide showing (pyrrhotite and chalcopyrite) in hornblende pyroxenite along the Tulameen River about 1,800 feet upstream (west) from the mouth of Hines Creek gave .19 ppm. Pd. with .25 ppm. Pt.

P.E. Fox, a graduate student at Queen's University, commenced and completed a study of the Adamant batholith in parts of 82 H/12 and 13 and 82 M/9 and 16, as part of the 'Study of Granites in Canada' in the Kootenay-Columbia region of British Columbia.

The long axis of this batholith is oriented east-west across the trend of the regional structure whose northward-trending components are bent aside at the contact of the batholith. The pluton is composed primarily of hornblende granodiorite containing an eccentric core of hypersthene monzonite. Late, flat-lying pegmatite dykes have been emplaced along flat shears in both rock types.

W. L. Fry, Professor of palaeobotany at the University of California, Berkeley, spent about four weeks in the Kamloops-Quesnel area of British Columbia, making additional collections of plant remains from Mio-Pliocene rocks. This work is in connection with Dr. Fry's studies of these and other floras commenced during his service on the staff of the Geological Survey, and has the ultimate objective of determining the floral succession and possible stratigraphic application of these fossil plants.

Work on this project is continuing and several reports are currently in course of preparation.

R.J. Fulton, a graduate student at Northwestern University, continued the study and mapping of the surficial deposits of the Nicola (92 I E 1/2) map-area for publication on the scale of 1 inch to 2 miles. Mr. Fulton is incorporating his results in his doctorate thesis. The field work in 1961 was supervised by J.E. Armstrong.

Two major glaciations separated by an interglacial interval have been established. A lower till found only in two exposures cast little light on an early glaciation. Deposits of sand, silt, and gravel, containing fossils, found up to 250 feet above the present valley floors indicate that, during the interglacial interval, life was established and the interior valley system base level was at least 250 feet above the present level. Ice advance outwash, consisting of gravel, sand, and silt, is found in most of the valleys and is overlain by as much as 100 feet of till. During deglaciation the ice broke into a series of valley tongues, which disrupted the drainage and caused a series of ice margin lakes to form.

H. Gabrielse completed the mapping of the Kechika (94 L) and Rabbit River (94 M) map-areas begun in 1957, and also brought up to 4-mile mapping standards the work done by Operation Stikine in 1956 in the Cry Lake (104 I) and Dease Lake East Half (104 J E 1/2) map-areas[1, 2, 3]. A helicopter was used for about half the field season, it being shared with J.G. Souther farther west.

The general geology of the areas mapped is outlined in Information Circular No. 4[4].

E.C. Halstead commenced the study and mapping of the surficial geology of the Nanaimo-Duncan-Gulf Islands map-areas (92 F/1 E 1/2, G/4, C/16, B/13, B/14), together with A. Treichel, who studied the geohydrology of the same area.

A till sheet covers most of the area mapped and represents the last major ice advance. This till is covered with a veneer of gravel, sand, and in places silt or clay that was deposited in transgressing seas following retreat of the ice and uplift of the land. These features, including beaches and marine deltas, are found at elevations extending from present sea level to more than 450 feet. Logs of drilled wells as well as sea cliffs at Icarus Pt. in the northeast part of the map-area indicate the presence of one or more older tills with interglacial materials between. Material for

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1 Roots, E.F., et al: Stikine River area, Cassiar District, B.C.; Geol. Surv., Canada, Map 9-1957 (1957).

2 Gabrielse, H.: Kechika map-area, Geol. Surv., Canada, Map 57-1959 (1959).

3 Gabrielse, H.: Rabbitt River map-area, Geol. Surv., Canada, Map 2-1961 (1961).

4 Lord, C.S. and Jenness, S.E.: Field Work, 1960; Geol. Surv., Canada, Information Circular No. 4, pp. 13-14 (1961).

C14 dating was collected from 3 localities and includes shells from clays at elevations of 354 and 15 feet above present sea level, and wood and peat that was overlain by 190 feet of unconsolidated surficial deposits. South of Nanaimo, in the Nanaimo River Valley, thick gravel deposits cover a considerable area and may represent outwash associated with an advance of valley ice similar to the Sumas Ice advance in Fraser Valley. Kettles and kames in this area indicate the existence of ice masses at a later date than that which deposited the uppermost till sheet throughout the area. There is then evidence of two and possibly three major ice advances and a possible fourth and youngest advance of valley ice.

Economic aspects of the field investigation include the outlining of permeable deposits that yield large volumes of groundwater and their possible recharge areas. The gravel areas and pits were also mapped to assist with the field assignment being carried out by S. Leaming.

Throughout much of the area, and in particular within the Gulf Islands, groundwater is not plentiful but is the only source of potable water. It is recovered from drilled wells that encounter water in fissures and fracture zones within the shales and to a lesser extent fractures and permeable zones in sandstone. Compilation of the altitudes of the bottom of drilled wells together with altitudes of the thick series of sedimentary rocks is expected to indicate the position and extent of water-bearing zones or horizons and hence facilitate the search for water supplies. Bedrock water has a high iron content. In places where surficial deposits are thick, permeable sediments underlying the upper-till sheet are sources of good quality water. An unconfined aquifer consisting of permeable sand and gravel within the Nanaimo River-Haslam Creek valley provides part of the 23 million gallons of water consumed daily at the Harmac Division pulp mill, MacMillan & Bloedel Ltd., near Nanaimo. (The hydrology of this aquifer was determined initially in 1949 prior to the installation of large capacity wells. Since that time records of this extensive aquifer have been kept, in order to evaluate recharge and discharge relationships.) Within the Cowichan River Valley, similar hydro-geological conditions exist but the aquifer here may not be as extensive.

Abandoned coal workings within the Nanaimo coal field underlie part of the map-area. These workings are flooded and their position and extent was outlined, because this water, although of poor quality, is a possible source for irrigation supplies and is being used in one place to irrigate an 18-hole golf course.

D.W. Hyndman, a graduate student at the University of California, Berkeley, commenced detailed mapping of rocks of the Shuswap

Group and of overlying Mesozoic rocks in an area near Nakusp, B.C. (82 K 4) that lies between the Valhalla Complex to the south (which is being studied by J.E. Reesor) and the Monashee Group to the north (which is being studied by D.B. Craig). Mesozoic rocks of a relatively low grade of metamorphism appear to overlie the high-grade gneisses of the Shuswap Terrane and the Valhalla Complex. The low-grade metamorphic rocks have been intruded by discrete bodies of granodiorite, monzonite, and syenite.

Three broad units have been recognized within the area: (a) intensely-deformed arenaceous and calc-silicate rocks, intimately associated with lenses of quartz-felspar pegmatite and lineated hornblende granodiorite; (b) a group of massive granites, monzonites, and quartz diorites, containing elongate roof pendants of poorly foliated fine-grained quartzo-felspathic schists and hornfelses; and (c) argillites and argillaceous quartzites with intermittent flows and sills of volcanic rocks, which probably belong to the Slocan Group. Unit c contains granitic rocks (granodiorite, monzonite, and syenite) in three east-west belts.

E.J.W. Irish continued field work in Halfway River (94 B) map-area, a project commenced in 1959. During 1961 both Foothills and Rocky Mountains were examined from 56° N. to about 56°45' N. latitude.

The main ranges of the Rocky Mountains are underlain principally by about 5,000 feet of carbonate rocks of Ordovician, Silurian, and Devonian ages. To the southwest the mountains are composed of low grade metamorphic schistose rocks thrust northeast onto the Palaeozoic strata. Within the eastern ranges Devonian carbonates are overlain by shales of Upper Devonian age transitional upward into limestone, siltstone, sandstone, and chert of Mississippian age, totalling about 2,000 feet in thickness. These are succeeded by a few hundred feet of interbedded shale and sandstone, Mississippian or younger in age, separated, in most places, from Triassic strata by a chert band up to 100 feet thick.

The western part of the Foothills is underlain by about 3,500 feet of Lower to Upper Triassic limestone, siltstone, and sandstone. Lower Cretaceous sandstone and shale formations underlie the eastern one-third of the map-area and, also, occur in synclines within folded Triassic rocks. The youngest rocks are sandstones of the Upper Cretaceous Dunvegan Formation.

Within the mountains a few broad anticlines occur but thrust faults are the main means of deformation. Within the Foothills, deformation has resulted from both folding and thrust faulting. Most folds are discontinuous, and the relatively broad synclines are separated by narrow, steep-limbed anticlines.

S. Leaming began a study of the sand and gravel deposits of the Strait of Georgia area. The main work was in the Lower Fraser Valley, but a start was made on Vancouver Island from Victoria to Comox.

G.B. Leech spent part of the field season examining known mineral deposits in Fernie West Half (82 G W 1/2) map-area, mapping of which was completed in 1960[1, 2].

Investigation of mineral deposits along the east side of the Rocky Mountain Trench showed the commonest type to be quartz-ankerite veins in small faults. The veins contain pyrite and one or more of chalcopyrite, pyrrhotite, galena, sphalerite, and hematite. The accessible underground workings of all deposits investigated were mapped. The complex structure along the lower part of Bull River was further elucidated with a few traverses in critical localities. Breccia that is tentatively believed to be a cryptovolcanic structure was investigated on a tributary of Bull River. The Tertiary St. Eugene deposits at the west edge of the Rocky Mountain Trench were visited. Conclusions based on a study of the lead isotope content of certain galena-bearing deposits were reinforced by new field data.

H.W. Little commenced one-mile mapping of the Rossland-Trail (82 F/4) map-area and completed slightly more than half of it. This work was inaugurated in order to determine the relationships between copper-ore deposition and structural geology. Most of the mines are at present inactive.

The east half of the map-area was completed. Fossils, which it is hoped will establish the age of the sedimentary rocks along Pend-d'Oreille River, were obtained at Sevenmile Creek. Collections of fossils of early and late Lower Jurassic (Sinemurian and Toarcian) age were made from the Rossland Group and were identified in the field by Dr. Frebold. The stratigraphy that had been established in Salmo (82 F/3) map-area[3] was

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[1] Leech, G.B.: Fernie Map-area, West Half, B.C.; Geol. Surv., Canada, Paper 58-10 (1959).

[2] Leech, G.B.: Fernie, Kootenay District, B.C.; Geol. Surv., Canada, Map 11-1960 (1960).

[3] Little, H.W.: Salmo Map-Area, B.C.; Geol. Surv., Canada, (Final map, in press).

extended westward. There is evidence that the Sinemurian beds that underlie the Rossland Group in Salmo map-area grade laterally into lavas, so that the base of the Rossland Group appears to be older to the south-west.

Volcanic and some interbedded sedimentary rocks of the Rossland Group between the Waneta (Pend-d'Oreille) fault and Beaver Creek strike northeasterly and dip northwesterly with tops to the north-west. Much of this succession appears to be repeated between Beaver Creek and Bear Creek, and the attitudes are similar. North and northwest of Fruitvale the rocks are for the most part gently folded.

The Waneta fault, which west of Columbia River was formerly thought to be south of the International Boundary, has been traced intermittently westward a short distance north of the boundary to Grouse Ridge. The Waneta fault is offset by a north-trending fault that was traced along the east side of the valley of Nigger Bar Creek, through Violin Lake, along upper Cambridge Creek and just east of the lower part of the creek to Warfield.

Another major fault follows the valley of Beaver Creek northeastward from Columbia River to a point just west of Fruitvale, where it appears to be offset to the east and may represent the southwestern extension of the Doubtful Creek fault of Salmo map-area. A major fault extends from the head of Bear Creek, along Landis Creek northward to the border of Rossland-Trail map-area, where it is about 3/4 mile east of Columbia River.

In the east half of the map-area there was some prospecting and exploration in 1961, but no mining.

J.E. Muller spent part of the season commencing and completing roughly one half of the McLeod Lake (93 J) map-area in co-operation with H.W. Tipper who mapped the other half; then he completed the mapping of the Pine Pass (93 O) map-area, which had been commenced by him in 1959.

The McLeod Lake project included that part of the map-area lying east of the highway and north of Fraser River. A helicopter was used both by Muller and Tipper.

A major fault follows the McLeod Lake - Crooked River valley and farther southeast along Angusmac and Averil Creeks. It continues northward through Pine Pass map-area, east of Parsnip River.

Volcanic, intrusive, sedimentary, and metamorphic rocks, typical of the Interior Cordilleran Region, occur west of this fault and were mapped by H.W. Tipper.

The area east of this fault, up to the east wall of the Parsnip Valley, consists of low hills, mainly below timber-line. Though west of the topographic Rocky Mountain Trench and physiographically part of the Interior Plateau, it was found to be underlain by Cambrian to Devonian carbonate and quartzose sediments, typical of the Rocky Mountain region. Preliminary identification of fossils revealed Cambrian, Ordovician, Silurian, and Devonian ages of rocks present. However, minor zones of greywacke, argillite, and volcanic rock, similar to Mesozoic rocks of the Interior Cordillera also occur. This part of the map-area is broken up by several faults, but detailed structure cannot be mapped adequately owing to scarcity of outcrops.

At least part of Parsnip Valley is underlain by leaf-bearing Tertiary sandstone and shale. They are exposed along the P.G.E. Railway tracks at Reynold Creek, where, with 40 degree southwest dip, they unconformably overlie "Misinchinka schist". To the west they are inferred to be in fault-contact with highly deformed ? Cambrian limestone.

The area northeast of Parsnip River, to the headwater of Anzac River, is underlain by the early Cambrian and older Misinchinka Group, continuing into the Pine pass map-area.

Another important fault separates Misinchinka rocks from Cambrian and Ordovician carbonate and quartzose rocks in the northeastern tip of the area.

An occurrence of magnesite in a 20-foot bed of dolomite was found at the head of Chuyazega Creek.

The balance of the summer after completion of McLeod Lake map-area was spent in the Pine Pass (93 O) map-area, partly with helicopter support. Besides additional mapping traverses various stratigraphic sections were measured.

K.H. Owens, F. Essex, J. Houlihan, J. Lee, and J.W. Kempt conducted an aeromagnetic survey of part of central British Columbia. The cost of this survey was shared by the Department of Mines and Technical Surveys and the British Columbia Department of Mines and Petroleum Resources. The area is roughly between 121° 30' and 125° West longitudes and 52° 15' and 56° 00' North latitudes.

There were no anomalies of extremely high intensity but there was plenty of magnetic character in the area, so that the data should be very helpful in aiding geological mapping, especially as a large part of the area is covered by overburden.

B.R. Pelletier continued his stratigraphic studies of the Triassic formations in the Foothills and Rocky Mountains of northeastern British Columbia. The work was started in 1959 and preliminary results have been published[1].

During 1961, the work was continued from Tuchodi Lakes (94 K) map-area, completed in 1960, into the Halfway River (94 B) map-area and to the south of Peace River. The lower part of the Triassic succession in the eastern ranges is similar to, but considerably thicker than that in more northerly parts. Post-Liard beds include about 300 feet of limestone and dolomite breccia and several hundred feet of limestone probably equivalent to the evaporite succession encountered in wells on the plains to the east.

Analyses of stratigraphy and paleocurrents corroborate earlier reports in that clastic sediments were transported in a general southwesterly direction across a shallow-water platform into a deeper marine basin; also, that these sediments were derived from a source northeast of the present study area. About 22,000 feet of section were examined from more than 20 localities, and several palaeontological collections were made at most of these stations.

In collaboration with personnel from the National Museum and the American Museum of Natural History, Lower Triassic fossil fish were collected at the Wapiti Lake locality. A new discovery of fossil fish was made in Halfway River map-area from platy siltstones near the base of the succession.

J.E. Reesor continued his studies of the granite and metamorphic complexes in the Kootenay-Columbia region of Southeastern

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1 Pelletier, B.R.: Triassic Stratigraphy, Rocky Mountain Foothills, Northeastern British Columbia; Geol. Surv., Canada, Paper 60-2 (1960).

-------------: Triassic Stratigraphy of the Rocky Mountains and Foothills, Northeastern British Columbia; Geol. Surv., Canada, Paper 61-8 (1961).

British Columbia as part of the "Study of Granite in Canada" project. Work on the Valhalla Complex was completed and reconnaissances were made in other parts of the region.

As a result of his studies, the following three belts of granitic and gneissic rocks have been delineated: (a) in Purcell and northern Selkirk Mountains a succession of relatively small, cross-cutting, post-tectonic intrusive plutons, in many cases oriented with long axis perpendicular to the regional structural trend; (b) in central and southern Selkirk Mountains two very large (Nelson and Kuskanax), partly concordant, partly disconcordant granitic plutons with long axes parallel with the regional structural trend; and (c) in southwestern Selkirk and in Monashee Mountains a granitic and gneissic complex associated with a high grade of regional metamorphism.

Field and laboratory studies are now being directed to elucidation of the petrological, structural, and age relationships within each belt and between the three belts.

It is hoped that this regional study will lead to a clearer understanding of the origin and subsequent history of these metamorphic and granitic rocks, and of related mineral deposits. Results of this study will be used in evaluation of work in geologically older terrains where subsequent events have complicated the evidence.

D.F. Sangster, a graduate student at University of British Columbia started, as part of Ph.D. thesis work, a petrographical, mineralogical, and geochemical study of contact metasomatic magnetite deposits in southwestern British Columbia. This is a part of a general study of 'Iron in Canada' carried out by the Geological Survey under the leadership of Dr. G.A. Gross.

Mr. Sangster mapped at the scale of 1 inch to 50 feet, and sampled seven magnetite deposits on Vancouver and Texada Islands. The associated skarn, intrusive, and host rocks were investigated as well as the orebodies proper. Field observations indicate that limestone is necessary for the deposition of magnetite, but that local structural controls are responsible for the concentration of the ore. In four, and possibly five of the deposits studied, this local control has been a syncline, in most cases cut by pre-ore faults which may have provided the channels for the ore solutions. Though the associated skarn assemblage appears to indicate a high temperature environment, the magnetite, which in all cases is post-skarn, appears to be a low-temperature, possibly hydrothermal mineral. This is indicated by the presence of colloidal texture in the magnetite, hair-line fracture fillings in skarn and altered host-rock, and large bodies of magnetite in contact with unaltered, bedded limestone.

J.G. Souther completed the mapping of Chutine[1] (104 F) and Tulsequah[2] (104 K) map-areas, commenced in 1958, and brought up to 4-mile mapping standards the work done during Operation Stikine[3] in the Iskut (104 B), Telegraph Creek (104 G) and west half of Dease Lake (104 J) map-areas. The work of Operation Stikine in the east half of Dease Lake map-area was revised at the same time by H. Gabrielse, and a helicopter was shared by the two officers.

No significant changes or additions to the geological features were encountered beyond those already published.

D.F. Stott completed the stratigraphic study of the Upper Cretaceous Smoky Group, Lower Cretaceous Fort St. John Group, upper part of the Lower Cretaceous Bullhead Group, and equivalent strata in the Foothills of Alberta and British Columbia between Smoky River and Peace River.

During 1961, Lower Cretaceous rocks were examined between Peace and Pine Rivers, and particularly in the Peace River canyon where several type sections are located. During late July, several new sections and other critical exposures near Stony Lake were examined.

The distribution of Cretaceous rocks and generalized structure were mapped. This mapping included a small part of the north-eastern corner of the Pine Pass (93 O) map-area, the eastern half of Half-way River (94 B) map-area, and part of Trutch (94 C) map-area.

Several prominent facies changes occur within the succession. The Gething Formation, containing numerous coal seams near and south of Peace River, grades laterally northward into fine-grained thick-bedded sandstones separated by thin shale beds. The Commotion Formation grades

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1 Souther, J.G.: Chutine map-area, B.C.; Geol. Surv., Canada, Map 7-1959 (1959).

2 Souther, J.G.: Tulsequah map-area, B.C.; Geol. Surv., Canada, Map 6-1960 (1960).

3 Roots, E.F., et al: Stikine River area, B.C.; Geol. Surv., Canada, Map 9-1957 (1957).

laterally into marine siltstone and shale near Peace River. The Gates sandstone, equivalent to the basal Commotion member, disappears northwards, grading into marine shale of the Buckinghorse Formation. The Goodrich sandstones are not recognized along Peace River and apparently grade eastward into shale. However, similar sandstones (Sikanni) reappear along Halfway River north of Peace River and have been traced as far as Trutch.

The lithologic change within the Gething Formation from coal beds to well sorted sands, indicates the probability of nearshore sand deposits north and east of Peace River canyon. Such deposits could be potential oil-bearing horizons. The Sikanni sandstones are also potential reservoir rock although exposure along the Halfway River escarpment eliminates them from serious consideration. The change from nearshore sands to shale found within the Commotion Formation indicates favourable stratigraphic traps in the region of Peace and Pine Rivers.

Dr. Stott commenced stratigraphic studies of the Lower Cretaceous Fort St. John Group and equivalent strata in the Foothills of British Columbia between Peace River and latitude 60°. Several sections were examined between Peace and Sikanni Chief Rivers, but a few localities in the western Foothills were left for later study.

G.C. Taylor continued and almost completed the geological study and mapping of MacDonald Creek (94 K/10) map-area on the Alaska Highway in northeastern British Columbia. The project was commenced in 1960.

The Silurian and Middle Devonian carbonates are abnormally thin (maximum of 3,500 feet) and apparently thicken in all directions away from the map-area. They lie with angular unconformity on arenites and carbonates intruded by gabbro of possible Proterozoic age. The Muncho-McConnell dolomites increase in thickness westwards from 100 feet to 300 feet. An overlying sandstone is unconformably overlain by Middle Devonian breccias, locally with angular relationships. A chert bed within the late Palaeozoic succession of dark shales (about 2,000 feet) may mark the boundary between the Upper Devonian and Mississippian. In the uppermost part sandstones increase in abundance northwards; eastwards carbonates are introduced.

North-northwest trending folds are commonly asymmetric eastwards and locally strongly overturned. Faults are dominately west-dipping; some in the north dip eastward.

Several narrow northwest trending gabbroic dykes cut the Proterozoic (?) rocks; minor copper showings are associated. Barite and fluorite are common in the Middle Devonian breccias.

H.W. Tipper commenced and completed, in conjunction with J.E. Muller, the areal mapping of McLeod Lake (93 J) map-area, the west half of which had been already mapped by J.E. Armstrong[1]. Following completion of McLeod Lake map-area, areal mapping was commenced in Taseko Lake (92 O) map-area. About one-fifth of the latter map-area was mapped.

The work in McLeod Lake map-area was confined to refining the work done in 1946[1], remapping on a better base map, and examining those parts not previously mapped.

The area is heavily drift-covered and outcrop is sparse. Information gained was primarily the areal distribution of rock units ranging in age from Cambrian to Tertiary.

A major fault is believed to extend across the area from McLeod Lake through Averil Creek and southeastward; it marks the division between two distinct geological provinces with Lower Palaeozoic sedimentary rocks (Rocky Mountain stratigraphy) on the east and Mesozoic and Upper Palaeozoic rocks (characteristically volcanic) on the west. Parallel or sub-parallel faults to the west extend across the area separating successive belts of Mississippian (?) rocks, metamorphic rocks, Mesozoic volcanic rocks, and Permian rocks. Minor areas of Tertiary sedimentary and volcanic rocks are distributed throughout the area.

Nothing of economic importance was discovered. A few mineral occurrences (mercury, copper, and tungsten minerals) have been known in the McLeod Lake map-area for some time, but these are small and uneconomic.

Approximately two months were spent in Taseko Lakes (92 O) map-area and much the northeast quarter was mapped. In preparation for operating with a helicopter early in the 1962 field season, several brief examinations of the geology were made in all parts of the area to fully appreciate the problems to be encountered.

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[1] Armstrong, J.E.: Carp Lake area, B.C.; Geol. Surv., Canada, Map 979 A (1949).

Volcanic and sedimentary rocks of Permian, Jurassic, Cretaceous, and Tertiary age were mapped. A belt of Permian volcanic and sedimentary rocks (Cache Creek Group) crosses the northeast quarter trending northwesterly and extends westerly to near Hanceville. Mesozoic sedimentary and volcanic rocks occur southwest of the Permian rocks and extend to the Coast Mountains. Along Chilcotin River, between Hanceville and Fraser River, the Permian and Mesozoic rocks are disrupted by many northwest-trending faults. Volcanic rocks there are thoroughly serpentinized.

Tertiary volcanic and sedimentary rocks of more than one age underlie much of the area of low relief in the northern half of Taseko Lakes map-area.

Granitic rocks underlie the group of hills immediately south of Big Creek post office and on Piltz peak.

J.O. Wheeler completed the areal mapping of Rogers Pass (82 N W1/2) map-area, commenced in 1959. The area straddles the main line of the C.P.R. through the Selkirk Mountains and the Trans-Canada Highway is in process of being relocated to parallel the railway. Considerable previous work has been done in the area[1, 2, 3, 4, 5].

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1 Evans, C.S.: Brisco-Dogtooth map-area, B.C.; Geol. Surv., Canada, Sum. Rept. 1932, pt. A2, pp. 106-176 (1933).

2 Fyles, J.T.: Geological Reconnaissance of the Columbia River between Bluewater Creek and Mica Creek; Ann. Rept., 1959, Minister of Mines, B.C., pp. 90-105 (1960).

3 Okulitch, V.J.: Geology of part of the Selkirk Mountains in the Vicinity of the Main Line of the C.P.R., B.C.; Geol. Surv., Canada, Bull. 14 (1949).

4 Gunning, H.C.: Geology and Mineral Deposits of Big Bend map-area; Geol. Surv., Canada, Sum. Rept. 1928, pt. A, pp. 136-193 (1929).

5 Wheeler, J.O.: Rogers Pass, B.C.; Geol. Surv., Canada, Map 4-1961 (1961).

A major fault, discovered in 1960, extends from Bush River southeast past the northeast ridge of Mt. Laussedat. This fault is apparently part of the Stephen-Dennis fault in Field map-area[1].

Lower Cambrian archeocyathids were discovered by Mr. E. Dodson of Ventures Ltd., north of Downie Lake in the Badshot limestone. Another locality was discovered southeast of Mt. Carson at the head of Mountain Creek.

The belt of metamorphic rocks in the northern Selkirk Mountains appears to be composed principally of rock of the Horsethief Creek Group.

A porphyritic granite body between the headwaters of Fang and Downie Creeks has profoundly deflected the regional structural trend of the Lardeau Group.

The porphyritic granodiorite of the Battle Range is flanked on the north by a body of porphyritic and non-porphyritic granite with abundant pegmatite and greisen zones. The two bodies are separated by a screen of metamorphosed rocks north of Battle Brook.

BRITISH COLUMBIA AND ALBERTA

R.L. Herr spent about 6 weeks during July and August in the southern Foothills and Rocky Mountains of Alberta and British Columbia, studying outcrop sections of the late Palaeozoic and Mesozoic rocks, under the general guidance of R.J.W. Douglas, D.K. Norris, and R.A. Price, each of whom have carried on investigations in this general region.

Typical and anomalous structures were also examined. The main purpose of these studies is to aid in the interpretation of cores and cuttings from wells penetrating these rocks in the structurally complex southern Foothills.

E.W. Mountjoy completed the geological study and mapping of Mount Robson southeast quarter (83 E SE 1/4) map-area commenced in 1959. During 1961, he worked in 83 E/1, 2, and 7 W 1/2. Much of this

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[1] Allan, J.A.: Geology of Field Map-Area, B.C.; Geol. Surv., Canada, Mem. 55 (1914).

area is underlain by Precambrian and Cambrian sediments. A distinct carbonate unit with archaeocyathids occurs in the upper part of the thick quartzose sandstone sequence (Gog Formation) in much of the Main Ranges, and is equivalent to the Mural Formation near Mount Robson. The lower part of the Middle Cambrian succession grades eastward from carbonates about 3,400 feet thick near Mount Robson to a dominantly argillaceous sequence about 1,400 feet thick on Chetamon Mountain. The Chetang and Tatei Formations of Mount Robson district could not be distinguished in this argillaceous sequence.

Investigations of the stratigraphy of the Ancient Wall carbonate reef complex near Mt. Haultain, The Rajah, and Glacier Pass, indicate that the Southesk and Cairn carbonates intertongue with strata of the Mount Hawk and Perdrix Formations.

Stratigraphic studies with Dr. D.J. McLaren have demonstrated that the 500- to 700-foot argillaceous and arenaceous unit in the middle of the Devonian sequence onlaps unconformably onto Southesk limestones near Mount Haultain. In many sections northwest of Mount Haultain this unit is absent and Southesk carbonates are overlain by Palliser limestones.

The surface trace of the Pyramid thrust terminates about 8 miles northwest of Jasper on the southwest side of Mount Zengel, rather than extending northwest (see Geol. Surv., Canada Information Circular No. 4, p. 24). The Main Ranges are broken by a series of southwest-dipping thrust faults. At least three major thrust faults occur between Harvey Lake and Mount Robson. The thrust sheets of the Main Ranges are geometrically similar to those of the Front Ranges.

B.S. Norford commenced a biostratigraphic study of some Ordovician and Silurian rocks in British Columbia and Alberta.

Preliminary work conducted in southern British Columbia and Alberta during 1961 suggests that zoning of the Beaverfoot-Brisco Formation may be possible using macrofossils, but the major part of the formation does form a single mappable unit without major lithologic break at the Ordovician-Silurian boundary. Considerable relief is locally present beneath the sub-Devonian unconformity and similar conditions may possibly prevail to the east in the subsurface. The so-called Ronning Formation of northern British Columbia is probably distinct from the Ronning of the Wrigley region, and may be mostly Llandovery and early Wenlock in age.

R.A. Price commenced a field and laboratory investigation of selected folds in the Foothills and Front Ranges of the southern Rocky Mountains in Alberta and British Columbia (mainly in 82 G E 1/2), for the purpose of establishing 1) the geometric attributes of folds formed in various parts of a layered stratigraphic succession, 2) possible variations in strain geometry related to lithology, or tectonic environment, and 3) possible variations in macro- or micro-fabric of individual beds; thereby providing a basis for extrapolation of fold geometry into the subsurface and reconstruction of the mechanics of deformation during folding.

During 1961, eight individual folds or groups of folds were mapped at scales ranging from 1 inch equals 5 feet to 1 inch equals 1,000 feet. Preliminary analyses of data on hand indicate that in spite of pronounced variations in size and gross form, all the folds exhibit a consistent pattern of internal geometry. All are parallel folds and persistence of parallelism within the folds is related to the development of thrust faults extending from the limbs to the axial regions. Variations in gross form and size are related to lithology and tectonic environment, but the pattern of internal geometry is independent of these factors.

D.L. Scott, a graduate geology student at the University of British Columbia, commenced a study of the stratigraphy of late Palaeozoic rocks (Mississippian, Pennsylvanian, and Permian) in the southern Rocky Mountains and Foothills of Alberta and British Columbia (82 G, J, O). Results of this study are expected to provide material for his doctorate thesis, as well as a suitable report for publication by the Geological Survey. The field work is being supervised by Dr. R.A. Price of the Geological Survey.

Field work during 1961 was confined mainly to Fernie (82 G) map-area. Significant changes in thickness occur in the late Palaeozoic rocks along the Rocky Mountains from southern Flathead Range to upper Elk Valley, but detailed correlation can be maintained throughout the succession and several distinct and persistent faunal zones are apparent. Vertebrate remains and fusulinids were obtained from sandstones in the upper part of the succession at a few localities. Pronounced thinning of the succession occurs from the Rocky Mountains to the Foothills and is accompanied by significant changes in lithofacies.

ALBERTA

J.D. Aitken commenced a stratigraphic study of the pre-Devonian rocks within the area outlined approximately by Cochrane, Lake

Louise, Jasper, and Hinton (82 N,O, 83 B,C,D,E,F), Alberta. During the field season it was found possible to correlate the physical stratigraphy of the Front Ranges between Bow and Red Deer Rivers, with type localities in the Mt. Bosworth (in 82 N/8) and Glacier Lake (in 82 N/15) areas.

The work to date indicates that, contrary to some published work, the pre-Devonian stratigraphy east of the Continental Divide is of a "layer-cake" nature, i.e., the sequence is constant over wide areas.

The "Ghost River Problem" was found subject to a relatively simple solution. It is proposed to erect two formations of distinct lithologies and distributions between the base of the Fairholme Group and the sub-Devonian unconformity. No difficulty has been encountered in locating the sub-Devonian unconformity, and the underlying beds have been correlated with the "Classic" pre-Devonian of the Main Ranges. Observations to date indicate that published references to angular unconformity at the base of the Devonian are incorrect.

A.R. Cameron collected fourteen column samples of various coal seams of the Edmonton Formation of Alberta for a coal petrological study. Seam correlations and detailed petrographic studies of these low-rank, high moisture coals are the objectives of this research project.

E.M. Cameron continued chemical correlation work begun in 1960 in the Lower Cretaceous of western Canada. Through the collection of 500 samples, control field work was extended eastward from Alberta into Saskatchewan and northward to the Peace River. The sampled area now extends 500 miles north to south and 300 miles east to west.

R.J.W. Douglas spent about 5 weeks in parts of the Pincher Creek, Beaver Mines, Blairmore, and Gap map-areas (parts of 82G) in the southern Alberta Foothills in order to obtain additional data critical to the interpretation of structural elements of the Mill Creek thrust sheet relative to the Livingstone and Harland Lakes thrust sheets and interpretation of structural data available from the drilling of recent wells.

Investigations were also made of the tear faults occurring in the Gap, Blairmore, and Mount Head map-areas to determine their relationships to other structures.

W.S. Mackenzie, a graduate student in geology at the University of Toronto, commenced a detailed study of Upper Devonian reefs in the eastern Rocky Mountains in the general vicinity of Brazeau River (83 C), Alberta. It is expected that the study will provide data for his doctorate thesis and that a suitable report will be prepared for the Geological Survey. The purpose of the project is to determine the lithic, biogenic, and petrographic features of the exposed reefs and it is hoped that the study will aid in the understanding of their mode of origin and serve as a standard for comparison of the oil- and gas-bearing reefs known elsewhere in the subsurface in Alberta. The field work for this project is being supervised by Dr. E.W. Mountjoy of the Geological Survey.

During 1961, investigations were made of parts of the Devonian succession, particularly the reef bodies in the Front Ranges near Mount MacKenzie, Mount Meda, and Sawtooth Mountain. Studies of the reefs between Mount MacKenzie and Sarcan Head and between Mount Meda and Mount Isaac in the second Front Range were initiated.

A.W. Norris made a palaeontological and stratigraphical investigation of Devonian outliers and inliers in northwestern Saskatchewan and northeastern Alberta and obtained additional fossil collections from the Slave Point Formation in Northwest Territories and the Waterways Formation in northeastern Alberta.

The purpose of this investigation is threefold: 1) to study isolated exposures of Devonian rocks that, because of inaccessibility, have not been examined by Survey geologists since the time of Robert Bell and R.G. McConnell; 2) to augment fossil collections made in 1957 by Operation Mackenzie, from the Slave Point Formation on the northwest side of Great Slave Lake and 3) to obtain further collections from the Upper Devonian Waterways Formation for monographing purposes.

About 90 per cent of the objective was accomplished. Middle Devonian reefs of the Methy Formation, as well as younger Devonian carbonate beds, were found along the lower part of Firebag River in northeastern Alberta. Conclusive fossil evidence was found to show that the thin sequence of carbonate beds overlapping the west flank of the Presqu'ile dolomite northwest of Sulphur Bay on northwest side of Great Slave Lake actually belongs in the Middle Devonian Sulphur Point Formation rather than the Upper Devonian Hay River Formation. In addition, it was found that the carbonate beds exposed at Point de Roche, southwest shore of Lake Claire, are undoubtedly related to the Middle Devonian sequence outcropping some distance to the northwest and southeast.

A.M. Stalker completed the study and mapping of the surficial geology of Lethbridge East Half (82 H E 1/2) map-area. Several hundred miles of buried preglacial and interglacial valley were traced, and the unglaciated Del Bonita area was delineated.

Correlation of various Laurentide tills was carried on and exposed sections along Oldman River and other rivers were studied. The general directions of movement of glaciers that deposited several of these tills were determined. The southeastern limit of the Foothills erratics train was determined; these erratics extend about 2 miles south of the United States - Canada border near Milk River.

The last ice-sheet retreated from the Lethbridge East Half map-area downslope and in a general north-northeasterly direction. There were many minor oscillations of the ice-front during the retreat, with re-advances of several miles that overan inwash and lake deposits, and formed small moraines. The various successive halts during the retreat of the ice-front can generally be traced.

Many of the large spillways in the Lethbridge and other areas have thick drift beneath their present floors; this suggests they were originally carved during use as glacial spillways during early glaciations, partly filled with drift during the last glaciation, and finally used as melt-water channels during retreat of the last ice-sheet. Following the last glaciation they were not cut to the earlier depth.

SASKATCHEWAN

G.D. Hobson, H.A. MacAulay, and R.A. Hodge conducted defraction and high resolution reflection seismic surveys to assist ground-water geologists by delineating buried river channels in the Estevan and Watrous areas.

In the Estevan area, 5 profiles were run across the location of the suspected buried Missouri River Valley. In spite of the low velocity contrast between overburden and bedrock, the depths by both reflection and refraction methods checked against each other, although the reflection method was easier to interpret. A rather shallow broad channel was delineated. As yet little or no drilling has been done to substantiate these seismic results.

In the Watrous area, only the reflection method was used extensively and although, in general, the results were not as clear cut as in Estevan they were successful in determining that bedrock structure near Cymric dipped gently towards Last Mountain Lake. Also a previously unknown channel near Nokomis was discovered.

The general conclusion from these experimental seismic surveys was that the depth to bedrock can be determined by this method, but that the cost is sufficiently high that it must be carefully balanced against the cost of drilling when it is considered that the drilling gives other information as well.

J.S. Scott spent a few weeks at the end of the field season consulting with Dr. E.A. Christiansen of the Saskatchewan Research Council on Pleistocene stratigraphy problems in Elbow (72 O) map-area. The probable extension of the Condie Moraine was traced into Elbow map-area from Regina (72 I) map-area. Examination of the Whitebear Lake channel in the southwestern corner of Elbow map-area indicates the channel may be part of the ancestral South Saskatchewan River. Because of known gravel occurrences in earlier channels of the river this suggests the possibility of a significant aquifer in an area of low precipitation.

A.M. Toth completed a groundwater survey of the south half of Saskatoon (73 B S1/2) map-area. This project was commenced in 1959. In addition well inventory was completed in 72 P/13, 14, 15, 16; 73 A/10, 11, 12, 13, 14, 15, 16; 73 H/4, 5, and within a strip about 6 miles wide, lying between 73 B and earlier groundwater surveys. These are the only areas for which suitable base maps were available.

Advice was given, on request, to R.C.M.P. and Indian Affairs Branch on water supply problems at localities in Saskatchewan.

Five drilling programs were supervised in the field by Mr. Toth:

1. By Dept. of Public Works drill for stratigraphic and groundwater information near Saskatoon.

2. By Dept. of Public Works drill in Carberry area, Manitoba, to install three observation wells.

3. By contract, a drilling and electrologging program to provide data of assistance to geophysical studies.

4. By contract to study well construction techniques in till in a dry area.

5. By contract to study effectiveness of large diameter shallow wells in till in a dry area.

D.R.E. Whitmore, on behalf of the National Advisory Committee on Geological Research in Canada, continued coordination and technical direction of a comprehensive cooperative study at the Coronation Mine of Hudson Bay Mining and Smelting Co.

Organizations participating in addition to the Hudson Bay Mining and Smelting Co., and the Geological Survey, include the Saskatchewan Research Council, National Research Council, University of Saskatchewan, University of Manitoba, University of Western Ontario, Queen's University, Carleton University, Canadian Aero Service Ltd., and the Surveys and Mapping Branch of the Department of Mines and Technical Surveys.

Field work on a surface map of the Coronation-Birch Lake Mines area, on a scale of 1" = 400' for which the Geological Survey is primarily responsible, is 80% complete. The map covering an area of 32 sq. mi. extends from latitude 54°34' to 54°42' and from longitude 101°57' to 102°03'.

Work completed during the year includes: (1) new planimetric base map using 1960 photographs; (2) aeromagnetic map "Coronation Mine Area"[1]; (3) "Helicopter Electromagnetic Magnetic and Radiometric Survey, Coronation Mine"[2]; and (4) "Temperature of Formation of Coronation Sulphide Orebody"[3].

Work continued during the year on the following projects: gravimetric survey, drift thickness survey, heat flow studies, remanent magnetism of ore and wall rocks, metamorphic petrology and structure of Coronation-Birch Lake area, trace element content of minerals and wall rocks, petrography and trace element study of igneous rocks of the mine area, and modal analysis of the mineral phases present in the orebody using polished sections.

New projects undertaken include temperature and composition study of fluid inclusions in the quartz of the orebody, petrology and

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1 Map 1028G; Geol. Surv., Canada (1961).

2 Unpublished report by A.R. Rattew, Canadian Aero Service Ltd. (1961).

3 Unpublished M.Sc. thesis by C.S. Ferris, Univ. Saskatchewan (1961).

trace element study of basic and ultrabasic sills in the hanging wall and sulphur isotope abundance in early and late sulphide mineralization.

J. Wyder, in cooperation with the Saskatchewan Research Council, conducted experimental resistivity surveys in the Estevan and Watrous areas over much the same ground as the seismic surveys. He found that although he could not with certainty determine the depth to bedrock, he could delineate the planimetric dimensions of buried river valleys with some accuracy. The wide lateral variations in overburden resistivity mitigated against accurate depth interpretations. He also concluded that the method was useful in detecting small shallow aquifers. It was also found that drilling control is a necessity for the most effective use of the resistivity method.

MANITOBA

J.E. Charron continued the groundwater survey of the Red River Basin started in 1959. 1961 field work covered townships 1 to 6, Ranges 1 to 5, east of Principal Meridian. The area is immediately east of that he studied in 1959. Bedrock does not outcrop. Details of aquifers mapped will be presented in a report and maps being prepared.

A drilling program conducted by a Department of Public Works drill showed the existence of a sand and gravel aquifer that further work might prove capable of supplying water for the town of Winkler. In the northeast corner of the area a limestone aquifer capable of producing over a million gallons of water a day warrants further study.

A series of glacial crack features was mapped from aerial photographs and holes drilled into them showed that they consisted of light-coloured silty clay in contrast to the surrounding dark-coloured silty clay.

W.L. Davison commenced and completed the areal mapping of Tadoule Lake (64 J) map-area.

The map-area, which lies entirely within the Canadian Shield, is characterized by areas underlain by granite and granite-gneiss that are separated by sedimentary rocks. The sedimentary sequence comprises quartzite, siltstone, greywacke, conglomeratic greywacke, sandstone, and minor carbonate rocks, together with their metamorphic equivalents; metamorphic effects range from slight in some places to higher grades where the metasediments alternate in zones with granite-gneiss, or are close to a granite-sediment contact. Biotite is always conspicuous in the more highly metamorphosed sediments. Large pegmatites are commonly present as crosscutting bodies; they are generally grey, muscovite- and tourmaline-bearing rocks, but some are pink or reddish, and biotite-bearing.

The granite is commonly reddish, homogeneous, and coarse grained, but some grey porphyritic granite is present locally. The granite also passes through a slightly gneissic phase in places where it is bounded by granite-gneiss, particularly near the northern boundary of the area. Granite-sedimentary contacts, however, are characteristically well-defined, and the intrusive nature of the contacts is evident.

Minor bodies of amphibolite are present within areas of mainly granite-gneiss; few are large enough to be mapped.

Sulphides are rarely visible in rocks of the area, even in small amounts. Altered basic rock, containing disseminated pyrite and other sulphides, is exposed in several places across the tip of an island on Tadoule Lake, at 58°37'N. Lat., 98°21'W. Long. In the northeast corner of the same lake at 58°42'N., 98°14'W., quartz veins with a low content of molybdenite occur.

J.A. Fraser commenced and completed the areal mapping of Kasmere Lake (64 N) map-area.

The map-area is underlain mainly by granite, and granite-gneiss. Sediments and metasediments lie in northeast-trending synclinal belts surrounded by granitic rocks. South of Hasbala Lake, phyllites and argillites are overlain by quartzite and dolomite, strata that may be tentatively correlated with those of the Hurwitz Group described by C.S. Lord[1] in the Keewatin District. They appear to be intruded by massive hornblende-biotite granite containing fluorite. Similar structures comprising strata of higher metamorphic grade may be found near Fort Hall Lake where lime-silicate hornfelses are bordered by biotite schist and garnet-biotite schist that grades outwards into granite-gneiss. Quartzite and feldspathic quartzite, locally well exposed east and north of Kasmere Lake, trend easterly or northeasterly. The southeastern part of

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1 Lord, C.S.: Geological Notes on Southern District of Keewatin, N.W.T.; Geol. Surv., Canada, Paper 53-22 (1953). The name Hurwitz Group was introduced by Wright, G.M., in Geol. Surv., Canada, Paper 55-17 (1955).

the map-area is underlain chiefly by massive granite, in part, coarsely porphyritic, that is known to be younger than the quartzite.

No feature of special economic interest was discovered.

R.W. Klassen, a graduate student in geology at the University of Ohio State, commenced the study of the surficial deposits of that part of Riding Mountain (62K) map-area that lies within the province of Manitoba. The results are expected to provide material for his thesis and a Geological Survey report and map for publication on the scale of 1 inch to 4 miles. The field work was supervised by A.M. Stalker.

There is evidence suggesting that buried valleys are present in the area. One such valley may lie between Miniota, Manitoba and Scissors Creek near Rocanville, Saskatchewan. Another may trend in a southeasterly direction from the junction of the Shell River and Bear Creek in the northwest part of the map-area, towards Birdtail Creek in the central part of the map-area.

Drumlins and fluting near Russell indicate that the last ice advance in this area was towards the southeast.

In the northern part of the map-area a boulder pavement overlies a brown till. This pavement is exposed in many shallow road cuts. It is overlain by 1 foot to 8 feet of brown lodgement till or greyish brown ablation till. The direction of ice-movement indicated by striations on the surface of the large boulders in the boulder pavement corresponds with the direction suggested by the topographic ice-flow features in the vicinity.

R.R. Potter commenced and completed the areal mapping of Gods River (53N) map-area.

Most of the bedrock exposures are confined to a strip, approximately 8 miles wide, that strikes in an easterly direction across the southern part of the map-area. Elsewhere, outcrops are found in the bottom of Fox, Stupart, Hayes, Gods, Stull, and Red Sucker Rivers.

Deposits of glacial till, up to 80 feet thick, were noted in the northern part of the map-area. The till is overlain by 10 to 20 feet of sand and gravel. Glacial striae, as well as long narrow ridges caused by fluting, indicate that the most recent ice-sheet advanced in a southwesterly direction. Older striae suggest an east-southeasterly direction of ice movement.

A wide belt of basic volcanic rocks was traced in an east-southeasterly direction across the southern part of the map-area. Pillow basalt was noted on the Semmens River, near the western boundary of the map-area. Interbedded sedimentary rocks become more abundant to the east, and are predominant near Red Cross Lake. Other belts of similar lithology were noted on Stupart River, 8 miles north of the north end of Stupart Lake, on Gods River 10 miles west of its junction with Red Sucker River, and on Stull River 2 miles north of the southern boundary of the map-area. The rocks at this point on Stull River are highly sheared and silicified. The basic volcanic rocks, as described above are lithologically similar to the Hayes River Group as described by Wright[1].

Conglomerate, greywacke, arkose, and argillite, and their metamorphosed equivalents were noted on Gods River, near and southwest of Sturgeon Falls. This assemblage may be the equivalent of the Oxford Group, or Island Lake Series also described by Wright[1]. Similar rocks were observed on the north shore of Red Cross Lake, and on another lake 5 miles northwest of Red Cross Lake.

Most of the area is underlain by granite and granite-gneiss. A young, medium-grained hornblende-biotite granite was noted in the southwestern part of the map-area. Very sharp contacts between this granite and conglomerates were noted on Gods River, approximately 2 miles west of Sturgeon Falls.

Ultrabasic rocks were noted on Stupart River, approximately 9 miles north-northeast of the north end of Stupart Lake.

Flay-lying limestones and shales of Ordovician age were noted on Gods River, about 28 miles south of the town of Shammatawa. Other outcrops were noted on Gods River, northwest of Shammatawa.

Pyrite occurs as disseminations and fracture-fillings in sheared basic volcanic rocks, just north of the ultrabasic rocks on Stupart River.

A small, irregular quartz-molybdenite vein, with minor pyrite and chalcopyrite, was noted at Marshall Falls on Gods River. It has

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[1] Wright, J.F.: Geology and Gold Prospects of the Areas about Island, Gods and Oxford Lakes, Manitoba; Bull. Can. Inst. Min. Met., No. 244, pp. 440-454 (1932).

a maximum width of 3 feet, and was traced in outcrop and blocks for a distance of nearly 30 feet. It assayed .005 oz/ton Au, and .01 oz/ton Ag.

A swarm of a dozen or more quartz-microcline pegmatite dykes were discovered on the shore, at the northeastern end of Red Cross Lake. These dykes are closely spaced, and vary in width from a few inches, to more than 10 feet. Soft purple lithium mica occurs as bands and disseminations in a few of the dykes. These lithium micas contain an unusually large amount of rubidium. The mineralogy of these dykes is now being investigated by the Geological Survey.

Three similar dykes, each about 2 feet wide, occur on the south shore of a small lake 1/2 mile north of a long sandy point, at the northwestern end of Red Cross Lake. Spodumene has been identified (by X-ray analysis) in these dykes.

ONTARIO

J.A. Donaldson acted as field coordinator of the Roads to Resources project, - a complete geo-scientific appraisal of a rectangular area extending over eight degrees of longitude and two degrees of latitude. The project was commenced in 1959 and, except for minor clean-up phases, was completed in 1961. The coordinator was responsible for inter-Divisional and inter-party planning, coordination, and cooperation, including air transportation. Staff from three divisions of the Geological Survey worked on the project under Dr. Donaldson's direction. In addition to air crew, 29 men were engaged in the project, and were supported by a Beaver and a Piper Super Cub aircraft. The results obtained by the various investigators will be found separately elsewhere in this report.

H.H. Bostock commenced and completed, as part of the Roads to Resources project, the areal mapping of the Lansdowne House (43 D) map-area. Some work had previously been done in the area[1, 2].

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1 Martison, N.W.: Petroleum Possibilities of the James Bay Lowland Area; Ont. Dept. Mines, Ann. Rept. 1952, vol. LXI, pt. 6 (1953).

2 Prest, V.K.: Geology of the Rowlandson Lake Area; Ont. Dept. Mines, Ann. Rept. 1940, vol. LXIX, pt. 8 (1942).

The boundary of Palaeozoic overlap that extends into the eastern part of the area has been changed to the westward in the south, and to the eastward in the north. Bedrock outcrop though scarce (particularly in the eastern part), was more plentiful than expected.

The following previously unknown or imperfectly known rock exposures of possible potential economic importance were located or extended: (1) the areas occupied by the Rowlandson Lake and Fishbasket River basic volcanic bodies were extended to the east; (2) three outcrops of sedimentary rocks along and near the south channel of Attawapiskat River were located at (a) Lat. 52° 03', Long. 87° 17', (b) Lat. 52° 03.5', Long. 87° 06', and (c) Lat. 52° 03.0', Long. 87° 06'; (3) three small areas of basic volcanic rocks and sediments were found in the east-central part of the east half of the map-area, and comprise (a) a belt centered at Lat. 52° 43', Long. 86° 39', (b) a belt centered at Lat. 52° 36', Long. 86° 42', and (c) an irregular area centered at Lat. 52° 21', Long. 86° 36'; (4) a sphene-bearing syenite body 6 miles long extending 2 miles into the map-area was located with its center 6 miles south of the northwestern corner of the map-area.

R.F. Emslie commenced and completed, as part of the Roads to Resources project, the areal mapping of Wunnummin Lake (53A) map-area. Two small parts of the area had been mapped previously[1, 2].

A greenstone belt of variable width was found to connect the previously known greenstone areas at Wunnummin Lake and at Rowlandson Lake approximately 40 miles to the southeast. A broad belt of greenstone was found to extend from the central part of the map-area northeast to join the Wunnummin Lake - Rowlandson Lake belt. Several other small, previously unmapped, greenstone areas were outlined.

Metavolcanic and metasedimentary rocks in these belts typically show low grades of metamorphism.

Magnetic anomalies and greenstone areas were found to show good correspondence.

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1 Prest, V.K.: Geology of the Rowlandson Lake Area; Ont. Dept. Mines, Ann. Rept. 1940, vol. XLIX, pt. 8 (1942).

2 Prest, V.K.: Geology of the Wunnummin Lake Area; Ont. Dept. Mines, Ann. Rept. 1940, vol. XLIX, pt. 8 (1942).

Two small circular magnetic anomalies in the northwest part of the map-area are underlain by drift, but numerous glacial erratics of talc- and serpentine-altered ultrabasic rocks occur immediately south of the southernmost anomaly. The anomalies probably represent ultrabasic plugs.

The granitic rocks comprise foliated to gneissic granodiorites to quartz diorites, migmatite, gneiss, and much hybrid material. Deformed and irregular foliation and gneissosity are common over large areas. Uncontaminated massive granites are remarkably uncommon.

G.D. Jackson commenced and completed, as part of the Roads to Resources project, the areal mapping of the Fort Hope (42M) map-area. The Ontario Department of Mines had done some prior work in the area[1, 2, 3].

Ground work was supplemented by 12 days flying with a Piper Super Cub. The entire area was flown, with special attention being paid to areas difficult of access to ground parties. In the eastern part of the map-area bedrock is exposed almost solely along the larger stream channels.

Previously known sedimentary and volcanic belts have been extended. Volcanic and sedimentary rocks were found to be widespread in the Washi Lake - Gourlie Creek - Goff Lake area, and in the Norton Lake area. In some of these belts the main basic-volcanic rock-unit lies stratigraphically between two units each composed of acidic volcanic rocks and associated interbedded sediments including conglomerates. Small basic and ultrabasic bodies are associated with these belts. There are a large number of diabase dykes within the area, most of which trend in a northwesterly direction.

The granitic rocks within the area have been subdivided into the following field units: foliated granodiorites, massive granites,

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1 Burwash, E.M.: Ont. Dept. Mines, Ann. Rept. 1929, vol. XXXVIII, pt. 2 (1930).

2 Martinson, N.W.: Ont. Dept. Mines, Ann. Rept. 1952, vol. LXI, pt. 6 (1953).

3 Prest, V.K.: Ont. Dept. Mines, Ann. Rept. 1942, vol. LI, pt. 3 (1944).

granodiorites and syenodiorites, and porphyritic granitic rocks. Migmatites and mixed rocks are associated with the granitic rocks.

Little new information was obtained on the lithology and distribution of the Palaeozoic rocks within the map-area.

Several gold, copper, and iron prospects within the map-area received considerable attention from mining interests during the past summer. To date the most interesting prospect is the gold showing at Reserve Lake, upon which considerable trenching and drilling has already been done by Little Long Lac Gold Mines. Drilling was carried out by Felie and McDermott on claims owned by G. LeLiever in the Goff Lake area, and the Pioneer Lake gold showing is being investigated by the same parties. Oliver Iron Mines, Pickands Mather, Ventures, and other companies were also active in the area.

K.R. Dawson continued his study of the Anstruther batholith (part of 31 D NE) as part of the investigation of granites in Canada. Field work involved one month's detailed geological mapping and sampling and a helicopter-assisted gravity survey of the batholith jointly with the Dominion Observatory. It is hoped to establish the subsurface shape and depth of the batholith, and the reasons for its pronounced doming.

Petrological, mineralogical, chemical, and isotopic studies are in progress in efforts to evaluate the origin of the shell-like structures in which sills of massive granite alternate with metasedimentary rocks. A number of deposits of uranium occur in, and peripheral to the batholith and it is hoped to determine if they are genetically related to it.

M.J. Frarey commenced and completed the 1-mile areal mapping of the Bruce Mines (41 J/5) and Lake George (41 K/8 E 1/2) map-areas. This work was a continuation and completion of a program (inaugurated in 1956) of revision and extension of former mapping[1, 2, 3] in the Huronian belt of Ontario.

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1 Logan, W.E.: Geology of Canada, (1863).

2 Collins, W.H.: North Shore of Lake Huron; Geol. Surv., Canada, Mem. 143 (1925).

3 Frarey, M.J.: Wakwekobi Lake, Ont.; Geol. Surv., Canada, Map 6-1961 (1961).

The classical Huronian stratigraphy was investigated in the type area. In particular, there was for the first time, opportunity to restudy the uppermost part of the Huronian succession of Murray and Logan. The stratigraphic positions and the relationships of two of these younger Huronian formations, namely, the "Banded Cherty Quartzite formation" and "Upper White Quartzite formation" of Collins, were confirmed, but two others not restudied by Collins—a second banded cherty quartzite and a quartzite overlying it—are believed to be faulted equivalents of those named. The remainder of the classical succession remains basically unchanged except that there, as in the area to the east, volcanic rocks of the Thessalon Formation occur in the lower part of the sequence.

The contact between the Bruce and Cobalt Groups was observed at several places. No angular unconformity or prolonged erosional interval were indicated. The absence of most of the Bruce Group in the northeast corner of the Bruce Mines map-area is believed due to non-deposition.

The Palaeozoic-Huronian unconformity is exposed at several localities in the northwest corner of the mapped area.

The trace of the Murray Fault, as shown in the part of the area mapped by Collins, was verified. In the west side of the area, it enters a zone of numerous faults and is difficult to define as a single feature.

A number of copper and iron showings were examined. Among them is an interesting low-grade occurrence near Desbarats, which has many of the characteristics of sedimentary copper deposits elsewhere. No new discoveries of importance were made during the mapping, and there is little prospecting activity in the area at present.

N.R. Gadd completed the field study and mapping of the surficial geology of the Ottawa (31 G/5) map-area, Ontario and Quebec. The 1961 field work substantiates Dr. Gadd's conclusions in a recent Survey paper[1].

R.E. Hay completed the 1-mile areal mapping of the Sault Ste. Marie (41 K/9) map-area, commenced in 1959 as part of the revision and extension of earlier mapping of Huronian rocks. It is expected that the results will provide material for a Ph.D. thesis.

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[1] Gadd, N.R.: Surficial Geology of the Ottawa Area; Geol. Surv., Canada, Paper 61-19 (1961).

The area is underlain mainly by Huronian rocks, which overlap towards the northwest on Archaean granite and are themselves overlain by Keweenawan lavas and by Palaeozoic strata.

B.A. Liberty continued from 1959 and 1960 the geological study and mapping of the Palaeozoic rocks of southeastern Ontario, lying south of the Precambrian Shield and between longitude 78° 30' and the Frontenac Axis. Preliminary results have been published[1].

During the 1961 field season mapping was continued easterly in the Bath (31 C/2) and Sydenham (31 C/7) map-areas. All rock units mapped in 1960 (Paper 60-31) were traced to the eastern extent of the area mapped in 1961.

The Selby member of the Rockland Formation was found to be traceable into the Coboconk beds to the west, and the Napanee member of the same formation is traceable into the lower part of the Kirkfield quarry. This finding corroborates earlier conclusions of Liberty[2] and Sinclair[3] that the Kirkfield beds are correlative of the Rockland beds.

Results of joint direction studies have contributed to a more efficient blasting procedure used in one of the limestone quarries in this region.

E. Mirynech completed the study and mapping of the surficial geology of the Kingston (31 C SW) map-area.

Drumlins, striae, and fabric studies indicate that the ice moved across the area in two directions. A northern lobe moved into the Ontario Basin from the northeast while a southern lobe moved in from the east. Previous work has shown that the interlobate ridge to the west was

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1 Liberty, B.A.: Rice Lake - Port Hope and Trenton Map-Areas, Ontario; Geol. Surv., Canada, Paper 60-14 (1960).

-------------: Belleville and Wellington Map-Areas, Ontario; Geol. Surv., Canada, Paper 60-31 (1961).

2 Liberty, B.A.: Palaeozoic Geology of the Lake Simcoe Area, Ontario; Geol. Surv., Canada, Memoir (in press).

3 Sinclair, G.W.: The Age of the Ordovician Kirkfield in Ontario; Ohio Jour. Sci., vol. LIV, No. 1, pp. 31-41 (1954).

overridden by the northern lobe, though no moraine marking the southern limit of this lobe has been found.

Lake Iroquois developed as the ice was making its final retreat from the area. In its final stages it is believed to have extended to the vicinity of Madoc and of Tweed, and probably farther north and northeast. Numerous beaches younger and lower than those of glacial Lake Iroquois were found; some of them are fairly well developed. These indicate that temporary lake stages existed in the Ontario basin prior to the formation of modern Lake Ontario.

Present information suggests that uplift in this region has not been uniform as previously suggested by earlier workers.

V.K. Prest spent part of the summer studying surficial geology in northwestern Ontario, as part of the Roads to Resources project. Much of that time was in the Miminiska (52 P) map-area.

Data were obtained on glacier retreat and glacial lakes held up by the receding ice-sheet.

The relation of the Windigo-Miminiska moraine to late Wisconsin chronology was defined.

The Tyrrell Sea marine limit was located just east of Long. 86° 00', Lat. 53° 00'. A sample of peat resting on the marine clay at this locality was collected for Carbon-14 analysis. A peat sequence was collected for palynological study from a bog above the marine limit at Long. 86° 05', Lat. 52° 43'.

S.M. Roscoe began a study of mineral deposits in the Huronian Belt and adjacent part of the Superior Geological Province in 1961. This particular region was selected for study because of the abundance and variety of known deposits, the existence within a relatively small region of strikingly different geological terrains clearly of at least three different widely-separated ages, and the existence of fairly complete geological coverage.

Mineral occurrences are so numerous in the region that no one person could visit all reported ones. It is hoped that sufficient field studies and laboratory work can be carried out within three years to evaluate the significance of differences between various types of mineral deposits and to extend such an evaluation to many deposits described by others. The objective, beyond classification, is to relate all types of deposits in space and time to the tectonic history of the region and to seek criteria that may aid in evaluation of prospecting possibilities in different areas. The study might incidentally be regarded as a feasibility test for applying a tectonic approach to studies of distribution of mineral deposits in the Canadian Shield.

During the 1961 field season work was concentrated in the part of the Huronian Belt between Sudbury, Lake Timiskaming, and Matachewan, Ontario. The principal mineral deposits in this area are within or very close to extensive sill-like bodies of gabbro, commonly referred to as Nipissing diabase.

Some work was also done in the Sault Ste. Marie to Sudbury area where radioactive occurrences were previously studied. Most other types of mineral deposits are also closely associated with sill-like gabbroic bodies that may well be equivalent in age to the Nipissing diabase. Many deposits in metamorphosed Huronian rocks, however, differ considerably from these. Sudbury deposits were not studied.

Some work was done in pre-Huronian rocks in windows in the Huronian Belt and north of the belt. A variety of deposits occur in these localities; most of these are markedly different from deposits in or close to Nipissing diabase that intrudes the unconformably overlying Huronian rocks.

B.V. Sanford continued his subsurface studies on the Palaeozoic rocks in southwestern Ontario. Field work included examination of subsurface data from deep wells in adjacent regions of the United States —the Michigan Basin and the Appalachian geosyncline—to provide such control as will permit extrapolation of Ontario data beneath the Great Lakes where offshore drilling is taking place.

H.R. Wynne-Edwards, a Professor of Geology at Queen's University, commenced the one-mile areal mapping of the Gananoque (31 C/8), Mallorytown West Half (31 B/5 W 1/2), and Brockville West Half (31 B/12 W 1/2) map-areas. These areas are mainly underlain by Grenville rocks and the project may be considered as a continuation of the Grenville study inaugurated in 1957 by the same officer in the Westport map-area immediately to the north[1].

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[1] Wynne-Edwards, H.R.: Westport Map-area; Geol. Surv., Canada, Map 28-1959 (1959).

It is hoped that this well-exposed and easily accessible area may become a type locality for Grenville structure and petrography, and for flow folding generally.

The Frontenac Axis was also investigated. There are two ages of late Precambrian dykes. The first set trend north-northwest and are typical diabase. They are concentrated at the crest of the axis near Gananoque. The second set are porphyritic, trend northeast, and are chilled against the first set. They will be of assistance in interpreting the post-tectonic history of the Frontenac Axis.

ONTARIO AND QUEBEC

J.J.L. Tremblay continued, with the help of R.A. Freeze, the hydrogeological study of Vaudreuil (31 G/8) map-area, Ontario and Quebec. The project included the geological study and mapping of the surficial deposits; this phase was under the field supervision of H.A. Lee.

Up to about the 250-foot elevation the area is overlain by Champlain Sea clay and recent alluvial deposits. Locally till and glacio-fluvial outwash sands and gravels project through the clay or are exposed by erosion of the clay near Rigaud and near Rivière Beaudette fairly extensive areas of outwash sands and gravels have been exposed by removal of the clay; these sands and gravels are sources of construction materials.

Detailed study of the surficial deposits has shown that discontinuous sand and gravel deposits underlying the Champlain Sea clay or exposed through it provide good water and have transmissiblities up to 20,000 gal. per day per ft. The buried valley found in 1960 was traced by seismic methods. It does not extend to the west, but curves to the north close to Rigaud Mountain. Near St. Lagare station an aquifer test was conducted on the sands filling the buried valley. The results indicate a transmissibility of 40,000 gal. per day per ft. and a storage coefficient of $.3 \times 10^{-3}$. To conduct this test a 10-inch screened well was drilled and five 2-inch sand points installed as observation wells. Difficulties encountered indicate that in such sensitive clay areas it would be more satisfactory to develop a large water supply by driving numerous sand points than by drilling one large well.

QUEBEC

P.R. Eakins, a Professor of Geology at McGill University, commenced the reinvestigation of the Sutton (31 H/2) map-area, which was originally mapped for the Geological Survey by T.H. Clark in 1931, but on which no report was published. The task of updating his earlier work in the light of later regional findings is receiving the full cooperation of Dr. Clark.

The area covers an important Cambro-Ordovician section of the western Appalachian mountain-built belt in Southern Quebec, and extends from the western Appalachian front along Logan's Line to the Sutton-Green Mountains anticlinorial axis. Particular emphasis was placed upon the collection of structural data and the verification of earlier structural interpretations. The attitudes of bedding, several cleavages, and joints and numerous lineations were measured. Several problems were brought out by the study: (1) the subdivision of the Stanbridge "slate formation" and the establishment of its boundaries with the adjoining Morses Line Formation and the Saint Germain complex; (2) the subdivision of the Sutton schists and the correlation of the various components with less metamorphosed formations of nearby sections. These problems require some further field work for their solution.

Structural data collected during the field season will be analysed according to the methods of petrofabrics and a number of oriented thin sections will be studied. This work will be carried out in anticipation of: (1) amplifying the knowledge of the area; (2) testing the validity of petrofabric and tectonic analysis; (3) providing a readily accessible type case-history area in Canada. Structural data collected during the field season has permitted the delineation of early minor fold axes trending northwesterly across the major main northeasterly trending 'Appalachian' structures.

The area is economically interesting basically from the point of view of industrial materials. Limerock is quarried for making piping and concrete aggregate at Sweetsburg, and limestone is quarried for chemical purposes near Bedford. Several sections contain outcrops of serpentine, a potential source of impure talc for filler in rubber, insecticides, and asphalt tiling, and as raw material for Eskimo carving. Some disseminated galena has been observed in the Dunham dolomite northwest of Frelighsburg.

G.D. Hobson, H.A. MacAulay, and R.A. Hodge continued seismic investigations in the Quebec part of Vaudreuil (31 G/8) map-area, northwest of Montreal, to determine the course of a buried river valley. This project was commenced in 1960.

It was found that the buried channel continues northwest to a point near Ste. Marthe where it veers sharply northeast and narrows to a deep channel cut in the bedrock southeast of Mount Rigaud and generally follows the present course of Raquette River. A broadening of the channel is indicated towards Choisy on Ottawa River. A tributary channel also joins this buried channel with St. Lawrence River through St. Dominique.

G.D. Hobson and J.E. Wyder conducted experimental surveys in the Point-du-Lac area near Three Rivers, Quebec, to assess the FS-2 Hammer Seismic and the resistivity methods over a known gas-field occurring in a surficial sand deposit. Many definite reflections were recorded at depths of up to 300 feet. Correlation of these reflections has yet to be done. Resistivity results have not been interpreted yet, but from superficial examination it is obvious that the depth of the top layer of sand can be determined up to depths of 60 feet.

H.A. Lee carried out a stratigraphic and geomorphic study of the unconsolidated sediments in the region Rivière du Loup - Trois Pistoles - Cabano in the province of Quebec. Three definite clays with marine shells were mapped. Two of these clays are stratigraphically lower and hence older than the Leda (Champlain Sea) clay. One is a stony marine clay possibly of ice-shelf origin, and the other, tentatively called the "Trois Pistoles" clay, is non-glacial but is capped by deltaic gravels, which grade laterally into glacial outwash gravels. The Leda clay is capped by 'high Terrace' sands of the ancestral St. Lawrence River. 'Low Terrace' sands are exposed below the 50-foot contour in a strip that is parallel to the present sea coast of St. Lawrence River.

From the geomorphic study, an end moraine tentatively called the "St. Antonin" moraine was mapped for a distance of 20 miles. This moraine has an extensive outwash apron on its distal southeast side, which indicates that the ice mass (from which both moraine and outwash were deposited) lay in the St. Lawrence Lowlands to the north rather than in the highland region to the south.

Two esker systems, older than the "St. Antonin" moraine and outwash, were traced from a few miles south of them across the watershed, elevation 850 feet, into New Brunswick and as far south as the region of Edmundston-Rivière Bleue. Hence deglaciation has now been traced for the first time across the Appalachian mountains. Late reversals of former ice-flow have been noted near Trois Pistoles.

The data obtained on the nature and succession of materials encountered and their degree of water saturation should provide basis for the evaluation of groundwater and foundation conditions, two problems of some importance in this region. The geologic factors affecting growth of peat bogs occurring in commercial quantity in the region were evaluated.

NEW QUEBEC and LABRADOR

K.E. Eade commenced and completed the reconnaissance mapping of the Battle Harbour - Cartwright (13 SE and part of 3 SW) map-area. The project was inaugurated to make use of a wealth of reconnaissance material gathered in the area by British Newfoundland Exploration Ltd. (Brinex), and kindly made available by them to the Survey. A fixed-wing aircraft was used in the work, but was found unsuitable for landing on shallow lakes, which in parts of the area appear to predominate. Previous work is plentiful but, with the exception of work by Brinex, is largely confined to the coastal areas[1, 2, 3, 4, 5].

There are some small areas of Proterozoic rocks, previously known, and a small area of sediments and basalt that were mapped as Cambrian by Christie; otherwise all rocks are Archaean. About 75 per cent of the area is underlain by granite, granitic gneiss, and para-gneiss, each of which form a map unit. The paragneiss contains some quartzite and calc-silicate bands but the unit is not extensive. Approximately 25 per cent of the bedrock comprises an intrusive anorthosite suite consisting

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1 Christie, A.M.: Geology of the Southern Coast of Labrador from Forteau Bay to Cape Porcupine; Geol. Surv., Canada, Paper 51-13 (1951).

2 Christie, A.M., Roscoe, S.M. and Fahrig, W.F.: Central Coast of Labrador Nfld.; Geol. Surv., Canada, Paper 53-14 (1953).

3 Douglas, G.V.: Notes on Localities Visited on the Labrador Coast in 1946 and 1947; Geol. Surv., Canada, Paper 53-1 (1953).

4 Kranck, E.H.: Bedrock Geology of the Seaboard of Labrador between Domino Run and Hopedale, Nfld.; Geol. Surv., Canada, Bull. 26 (1953).

5 Kindle, E.M.: Geography and Geology of Lake Melville District, Labrador Peninsula, Geol. Surv., Canada, Mem. 141 (1924)

of anorthosite, anorthositic-gabbro, gabbro, monzonite, and granodiorite. All appear to be gradational into one another. They form one large mass that includes the Mealy Mountains and also a number of smaller bodies throughout the area mapped. Gneisses in contact with rocks of this suite show increased grade of metamorphism. At the northeast end of the Mealy Mountains the anorthosite-gneiss contact is apparently a fault contact.

Small segregations of titaniferous magnetite are present in the anorthosite. Pyritized shear zones, some containing minor chalcopyrite, occur in the gneisses. These are of scientific rather than economic value.

I.M. Stevenson commenced an extensive airborne reconnaissance project referred to as Operation Leaf River (34; 24 D, E, L, M; 23 C, J W 1/2; the two areas in block 23 are unfinished remnants of Operation Fort George). Fifty-nine thousand square miles of this area were mapped in 1961, or well over half of the total. All of the areas in blocks 23 and 24 were completed together with slightly less than the east half of block 34. It is proposed to continue the operation in 1963. Previous work in the areas includes that of A.P. Low[1] and J. Berard[2].

Particular attention was given to those areas of possible future economic interest. On this operation, Bell G2A helicopters were used in preference to the Bell G2 model used on previous operations in Quebec. The increased range of the Bell G2A made the caching of gas for traverses unnecessary, resulting in a saving of several thousands of dollars in fixed-wing flying. The average cost of the operation was about $2.00[3] per square mile mapped.

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1 Low, A.P.: Ann. Rept., 1887 and 1888, Geol. Surv., Canada, vol. 3 (new series) pt. 2, pp. 1J-26J (1889).

----------: Ann. Rept., 1896, Geol. Surv., Canada, vol. 8, pp. 1L-311L (1898).

----------: Ann. Rept., 1898, Geol. Surv., Canada, vol. 9, pp. 5L-43L (1901).

2 Berard, J.: Que. Dept. Mines; P.R. No. 384 (1959).

----------: Que. Dept. Mines; P.R. No. 342 (1957).

----------: Que. Dept. Mines; P.R. No. 360 (1958).

3 This figure does not include staff wages, cost of equipment, or overhead.

Most of the area is underlain by an assemblage of granite paragneiss, and assorted rocks. Diabase dykes are prevalent in the northern areas. Gabbro and other basic rocks were noted at various localities. Particular attention was paid in examining those areas underlain by iron formation. Sulphide mineralization was noted at several places, usually in association with gabbro sills. A few small areas of greenstone also displayed mineralization, but greenstone bands are not as prevalent as in the area to the south mapped by Operation Fort George[1].

Geologically, area 23C lies within the Grenville sub-province. In its northwestern part the rocks are mainly of the granulite facies, whereas to the southeast the rocks are chiefly of the epidote amphibolite facies.

QUEBEC and NEW BRUNSWICK

R. G. Pirie completed the field study of the geochemistry and other aspects of sedimentation in Chaleur Bay and its tributary rivers. This is part of a Ph.D. thesis to be presented at the University of Indiana.

An entire sampling program to complement and extend that carried out in 1960 was conducted using instruments recommended for physical and chemical oceanography as applied to marine geology. A partial list of the pertinent data recorded includes: water colour, depth of water, turbidity, current velocity and direction, surface and bottom temperatures, Eh and pH of the sediment at the water-sediment interface, chlorinity-salinity by the conductivity method, and colorimetric determination of the total heavy metal content. More detailed studies allowed the preparation of river and estuarine channel profiles, high and low tide sampling, and dissolved oxygen determinations.

A total of 150 sediment samples was collected from Caraquet River, Caraquet Harbour, Caraquet Bay, and the Jaquet River area in New Brunswick. This completed the sampling program of the Chaleur Bay Project as originally outlined in 1960. In the Rivière Bonaventure area of Quebec, a detailed study of 75 samples was completed on the river, estuarine, and bay sediments. In addition, a suite of typical outcrop samples was collected from the major formations represented within the drainage area of Chaleur Bay. It is hoped that clay mineral analyses of the sediments will correlate with the rock types surrounding the Bay. Several 5-liter water samples were collected from the river, estuarine, and marine waters of the

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[1] Geol. Surv., Canada, Maps 23-1957, 23-1958, and 56-1959.

Chaleur Bay area. These samples have been submitted to the Mines Branch of the Department of Mines and Technical Surveys for complete chemical analyses.

Detailed study of the Rivière Bonaventure area was especially rewarding. Studies of current velocities and direction changes at high and low tide provided information regarding the efficiency of sediment transportation within an estuary (Havre de Beaubassin). Numerous profiles and traverse samples of the river and associated estuarine channels were studied.

Eh and pH data are comparable, in a general way, to the data collected during the 1960 field season.

The chemical conditions of the sediment environment in the fresh river water are strongly oxidizing with a pH of 5.5 to 7. The estuarine water sediments of the intertidal zone are strongly reducing with a pH of 7 to 8.5.

Dissolved oxygen contents were determined for water collected at the water-sediment interface. Typical data collected were: up to 4.31 ml./l. for river-water; as low as 1.87 ml./l. for estuarine-water; and from 2.45 to 3.85 ml./l. for open sea-water.

Total heavy-metal contents in the marine sediments were generally 3 to 4 times the background (4 ppm) established in the river sediments. Data were inconclusive with sediments that contained greater than about 30 per cent clay. For this reason, the total heavy-metal concentrations in the estuarine sediments were indeterminable or erratic.

Permanent sample stations were established in the estuary in order to investigate the physical-chemical changes accompanying high and low tides at the water-sediment interface.

Preliminary analyses of the field data collected in the Rivière Bonaventure area appear to indicate a possible definition of several physical-chemical environments within the estuarine and marine sediments.

The method of sampling was entirely by aqualung diving because the gravity coring method provided inadequate amounts of sediment for analyses and, in addition, the cored sediment was obviously biased in size distribution.

NEW BRUNSWICK

R.W. Boyle continued as project leader, coordinating the studies of J.L. Davies, T.H. Pearce, E.W. Present, S.S. Rajah, and Prof. W. Tupper, in the geochemical study of the mineral deposits and associated rocks of the Bathurst-Newcastle base metal district. The project is carried out in a twofold manner: selective detailed mapping, in which all project members participate, and investigation of a topic by each member. The total number of such topics constitutes a coordinated and comprehensive geochemical research project. Selection for mapping is based on the occurrences of deposits, on geological and geochemical aspects of the region, and on previously published but less detailed geological maps.

The Sturgeon River deposit, north of the Millstream River, and the New Larder "U" deposit on Nepisiguit River were both mapped on the scale of 1 inch equals 500 feet.

J.L. Davies, as part of a Ph.D. project, concentrated his investigation of the geology and geochemistry of the iron formation of the whole area. T.H. Pearce concentrated on a petrological and petrofabric study of the quartz-feldspar porphyry and related rocks at the Brunswick No. 6 deposit with a view to determining their origin and relationship to the orebodies. This work is towards a M.Sc. thesis at the University of Western Ontario. E.W. Presant carried on with the collection of soil and rock samples in a study to provide additional information on the amounts, location, and nature of a number of trace elements. Laboratory work on the samples is carried on both in the field and in Ottawa. This includes pH determinations, removal of free iron oxides and oxidation of organic matter in selected samples, determination of water soluble, and soluble and readily available metals in selected soil samples. This work is carried out as part of a M.Sc. project. S.S. Rajah, a Colombo Plan student, studied the gossan overlying Brunswick No. 6 deposit. The gossan was mapped and sampled in detail. Preliminary results indicate it formed both in pre-glacial and post-glacial times. W. Tupper, a Professor of Geology at Carleton University, obtained sulphide samples, waters, and oxidation products in a systematic sulphur-isotope study of the Brunswick No. 6, Nigadoo, and New Calumet deposits.

P.A. Carr continued the hydrogeological studies of the Moncton area. Pertinent bedrock geology was studied under the field supervision of D.G. Kelley.

Three test wells were drilled by the Department of Public

Works, and aquifer tests indicating transmissibilities between 1,000 and 6,000 gallons per day per foot were obtained, which are average for fracture permeable aquifers.

A piezometric map of the area has been submitted for publication. Its marginal notes describe groundwater occurrence, flow, quantity, and quality.

A recorder placed on a test well near the Petitcodiac River at the town of Dieppe shows fluctuations of the groundwater level corresponding to the tidal bore in the river. This is expected to give valuable data on salt-water intrusion problems.

A.Y. Smith, a seasonal employee studying for his doctor's degree at Carleton University, Ottawa, completed, under the supervision of R.W. Boyle, the geochemical sampling of stream sediments and rocks in an area in southern New Brunswick bounded by Petitcodiac River, Bay of Fundy, St. John River, Grand Lake, thence eastward to Moncton.

Nearly 2,000 stream-sediment samples were collected. All were analyzed for Cu, Zn, and Pb in a mobile laboratory in operation for a second season, and this analytical work was thus completed by the end of the field stage of the investigation.

Several large areas of anomalously high concentrations of Pb, Zn, and Cu in stream sediments are indicated and some individual stream-sediment samples contain sufficiently high concentrations of metal to warrant detailed examination. In Kingston Peninsula, north of St. John, substantial increase in background values were found over rocks of probable Precambrian age. Several streams in this area gave anomalous values for lead and copper and would seem to require further examination. In the Albert mines area, south of Moncton, anomalous amounts of the three heavy metals were found to occur over rocks of the Albert Formation, of middle Horton age. In view of the interest in these rocks in Nova Scotia, these anomalies may have economic significance. A similar anomaly was located 2 miles south of Sussex over rocks of Horton age. Several stream systems near the west side of Fundy National Park were found to contain anomalous amounts of copper and lead. Several small deposits of copper are known along the Fundy coast, but these anomalies seem to point to a different and much larger mineralized area.

The study of over 800 bedrock samples, collected in a reconnaissance fashion, and of the sediment samples will serve to establish the relation in metal content of the stream sediments and underlying bedrock.

Most of the known sulphide deposits in the area investigated were sampled in order to study the dispersion patterns of various metals. The analytical requirements for this study are beyond the mainly colorometric facilities of the mobile laboratory.

NOVA SCOTIA

G.A. Bartlett spent part of June and July in the field aboard the patrol boats of the Atlantic Oceanographic Group of Fisheries Research Board of Canada, collecting bottom sediments and fauna on the continental shelf off southeastern Nova Scotia. The remainder of the season was spent in the offices and laboratories of the Geological Survey and Carleton University. Material from the Lamont Laboratories, New York, collected in the vicinities of Sable Island and Brown's Bank, off southeastern Nova Scotia, was also examined.

The purpose of the study is to establish the relationship of fauna to bottom sediments and to bathymetry, using the fauna as a guide. Most specimens in shallow water are indigenous and attach themselves to various objects such as sea moss, and pebbles. Some foraminiferal shells occurring in deeper water are broken and rounded, indicating a history of sedimentary transport, although some forms are indigenous. Heavier adult shells may not be transported by normal marine current, but the juvenile forms may. Further interpretation of the data is proceeding.

D.G. Benson completed the 1-mile areal mapping of the Hopewell (11 E/7) map-area, commenced in 1960[1]. This work is intended partly to give new information on the stratigraphy and structure of the Mississippian rocks of central Nova Scotia, and partly to permit a preliminary detailed study of the Pre-Mississippian rocks of the Antigonish Highlands, which occur in the northeastern corner of the map-area.

The oldest rocks, which underlie the southern part of the map-area, are grey quartz mica schist and quartz wacke of the Meguma Group. They are intruded by Devonian light grey muscovite granite.

Rocks of Silurian and possibly Ordovician age underlie the highland in the northeastern quarter of the map-area. Their structure and

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[1] Benson, D.G.: Hopewell area, N.S.; Geol. Surv., Canada, Map 1-1961 (1961).

stratigraphy are complex. The Silurian Arisaig Group consists of commonly fossiliferous quartz wackes, slates, and quartzites. They are underlain by the unfossiliferous Brown's Mountain Group, composed of basic volcanic rocks and pyroclastic rocks interbedded with argillites and siltstones.

The central part of the map-area is underlain by lower Mississippian rocks of the Horton Group. Their lithology is similar to those in the western half of Hopewell map-area.

Rocks of the Windsor Group underlie the northwestern quarter and unconformably overlie the Silurian highland. The group consists of calcareous and non-calcareous red, green, and grey shales and wackes, dark grey to black limestone and gypsum.

A narrow band of Canso rocks (Upper Mississippian or Lower Pennsylvanian) conformably overlie the Windsor Group and are in fault contact with the Horton Group. The rock types are green argillite, banded grey quartz wacke, and red and green mudstone.

The youngest rocks are in a narrow fault block between the Canso and Horton Groups in the western third of the map-area. These grey silty shales and black carbonaceous shales belong to the Lower Pennsylvanian Riversdale Group.

R.W. Boyle completed the mapping of the Walton area on a scale of 1 inch to 1,000 feet. The area covered is that west of Longitude 64°00' to Avon River and Latitude 45°07' north to the Minas Basin. The recent underground work at the Walton barite-silver mine was investigated and correlated with the surface work. Several indications of barite-silver mineralization along the Windsor-Horton contact were found.

L.S. Collett and P. Sawatzky supervised the continuing sea-magnetometer survey conducted by the Division of Oceanographic Research in the Canadian Hydrographic ships "Baffin" and " Kapuskasing". A total of 16,500 line miles were completed near Sable Island and southwest of the Bay of Fundy. Interesting results for comparison with the seismic data of the Lamont Geological Observatory are now being interpreted by the Geological Survey.

D.G. Kelley completed the revision of the 1-mile areal mapping of Lake Ainslie (11 K/4), Margaree (11 K/7), and Cheticamp (11 K/11).

map-areas[1, 2]. This is a continuation of his mapping of Whycocomagh (11 E/14) map-area[3] to the south.

Field work in 1961 entailed revision of Margaree and Cheticamp map-areas. These map-areas are mainly underlain by Mississippian and Pennsylvanian sedimentary rocks except in places near their eastern boundaries.

The oldest rocks are granitic with inclusions that resemble strata of the Precambrian (?) George River Group and are present only in the southeastern corner of Margaree (11 K/7) map-area.

A volcanic and sedimentary unit along the eastern border (previously referred to as Cambrian) is possibly conformable beneath the Lower Mississippian Horton Group. These rocks contain sandstones with some plant fragments and will be checked for spore content.

The Horton Group was subdivided into two lithologic units. The upper unit consists mainly of grey and red sandstone, siltstone, shale, and minor limestone and conglomerate. The lower unit consists mainly of grit, conglomeratic sandstone and conglomerate, but includes lesser amounts of the above fine-grained rocks.

Some of the strata previously mapped as Windsor Group has been reinterpreted as Mabou Formation in the present study. The thinness of the Windsor Group in most of the two map-areas is probably due either to faulting or non-deposition.

The Canso Group (Mabou Formation) has a distinctive lithology in its lower part (thinly laminated to thinly bedded medium grey and medium dark grey siltstone and shale). The uppermost part of the Mabou Formation in a normal section (mainly red siltstone) is distinct from

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[1] Cameron, H.L.: Margaree and Cheticamp Map-areas, Nova Scotia; Geol. Surv., Canada, Paper 48-11 (1948).

[2] Norman, G.W.H.: Lake Ainslie Map-area, Nova Scotia; Geol. Surv., Canada, Mem. 177 (1935).

[3] Kelley, D.G.: Whycocomagh Map-area, Inverness Co., Nova Scotia; Geol. Surv., Canada, Map 17-1957 (1957).

the overlying massive sandstones of the Riversdale Group (Port Hood Formation). This contact is well exposed at Broad Cove and is conformable.

Seventeen days were spent assisting the Department of Northern Affairs and National Resources searching for suitable stone to be used in the rebuilding of the Fortress of Louisbourg.

After the close of field work in Cape Breton, seven days were spent in making a reconnaissance of the Cobequid Mountains (parts of 11 E/10, 11, 12; 21 H/7, 8, 9) preparatory to a study of the strata of those highlands to be continued in 1962.

F.C. Taylor completed the areal mapping of the Annapolis (21 A) map-area, a continuation of 4-mile mapping of southwestern Nova Scotia commenced in 1959[1, 2]. Approximately fifty per cent of the area had previously been mapped on a scale of 1 inch to 1 mile[3].

Meguma Group rocks, consisting of quartzite and slate, of Lower Ordovician age or earlier, were extended from previous mapping into the area south of Lake Rossignol and into the southwestern corner of the map-area. In the western part of the map-area the presence of Silurian rocks of the White Rock Formation and possibly the Kentville Formation, was established near Sissiboo River. The White Rock Formation is now known to occur sporadically from the type area near Wolfville to Yarmouth on the south coast.

Large areas shown on earlier maps as muscovite granite south and east of New Ross consist chiefly of biotite granite and muscovite-biotite granite. Locally small areas of muscovite granite are present in the northeastern quarter of the map-area and these show gradational boundaries with the biotite-bearing granites. Dykes of muscovite granite locally intrude the biotite granite. Samples of muscovite granite were collected for K-A dating.

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1 Taylor, F.C.: Shelburne, Nova Scotia; Geol. Surv., Canada, Map 44-1960 (1960).

2 Taylor, F.C.: St. Mary's Bay, Nova Scotia; Geol. Surv., Canada, Map 48-1960 (1960).

3 Geol. Surv., Canada, Maps Nos. 1960, 1981, 2153, 2154, 2259, 435A, 436A, 437A, 439A, 440A, 531A, 532A, and 14-1960.

A small outlier of Horton Group rocks of Mississippian age, previously unknown, was located in the valley of Southwest Arm River.

PRINCE EDWARD ISLAND

L. Frankel, Assistant Professor of Geology at the University of Connecticut, Storrs, Connecticut, commenced the geological study and mapping of the bedrock and surficial deposits of Rustico West Half (11 L/6 W 1/2) map-area. The area is underlain by gently folded, plunging, and block faulted beds of late Palaeozoic age.

PRINCE EDWARD ISLAND and NEW BRUNSWICK

C. Gauvreau conducted hammer seismic surveys with the Model MD-1 seismograph in the Montague-Souris areas of Prince Edward Island and near Moncton, New Brunswick. The bedrock velocity of 8,000 feet per second was easily recorded in both these areas and calculations of the depths to bedrock are being completed.

NEWFOUNDLAND

F.D. Anderson continued the areal mapping of the Belleoram (1 M) map-area, commenced in 1960. About sixty per cent of the area has now been completed. Parts of the area had been mapped previously on a scale of 1 inch to 1 mile[1, 2, 3].

In reconciling the data of two nearly contiguous map-areas in the northern part of 1 M, minor refinements were made in the geological

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1 Bradley, D.A.: Gisborne Lake and Terrenceville Map-Areas, Newfoundland; Geol. Surv., Canada, Memoir 321 (in press).

2 Rose, E.R.: Geology of the area between Bonavista, Trinity, and Placentia Bays, Eastern Newfoundland; Nfld. Geol. Surv., Bulletin 32, Pt. II (1948).

3 VanAlstine, R.E.: Geology and Mineral Deposits of the St. Lawrence Area, Burin Peninsula, Newfoundland; Nfld. Geol. Surv., Bulletin 23 (1948).

contacts shown on the maps of Rose (1948) and Bradley (in press). Study of the unmapped parts of the area show that the Bull Arm volcanic Formation of the Musgravetown Group underlies most of Merasheen Island and the smaller islands west of it in Placentia Bay.

South of Terrenceville (1 M/10) map-area small areas underlain by Cambrian rock occur commonly in fault contact with a Precambrian (?) volcanic and intrusive complex that forms the core of Burin Peninsula. Fossil collections from these and other new Cambrian localities are being studied. At one locality - the headland immediately north of Cape Roger Island, Cambrian strata underlie volcanic rocks lithologically similar to some of these classified as Precambrian farther southwest on Burin Peninsula. Hence, detailed work may show that some of the rocks classed as Precambrian may be much younger.

Pyritic, quartz-sericite schists, with at least 10 per cent pyrite, were noted in several Precambrian (?) formations near Boat Harbour, Port Anne, and Great Bona.

R.F. Black, during June and July, collected 280 oriented samples of intrusive, volcanic, and sedimentary rocks from Avalon Peninsula, from near Great Bay de l'Eau in southern Newfoundland, and from near Botwood, Grand Falls, and Springdale in central Newfoundland.

These samples represent eleven geological units, which range in age from Proterozoic to Devonian, with the exception of the Silurian period. The purpose of this work is to refine our knowledge of the polar wandering curve for rocks in eastern North America and to try to detect whether or not any relative rotation of the various thrust sheets in Newfoundland has taken place. Laboratory work will have to be completed before conclusions can be drawn.

E.P. Henderson completed the study of the elevated marine shoreline and associated shore deposits of the coast of Newfoundland from White Bay to Burin Peninsula.

Measurements on uplifted marine features indicate that warped strand lines along the northeastern coast of Newfoundland may differ in elevation from levels suggested by projection of isobases based on work on the west coast. The pattern of post-glacial uplift indicates that shorelines in the eastern parts of the area are older than those to the west, being formed when ice still excluded marine water from the west. This data will provide information about the distribution and pattern of retreat of the late Pleistocene ice cover. Shell samples were collected for identification and dating of the old raised water levels. Marine shells were found at elevations considerably higher than had been reported previously in this region. Investigation of reported cirques in the White Bay area revealed that these are more likely hanging valleys formed when a major glacier flowed out the White Bay depression. Estimates of reserves of sand and gravel contained in late glacial and post-glacial deposits were made. These deposits also affect groundwater supplies and constitute a large part of the available arable land. Plotting of striae and grooves gave a widespread check on ice flow directions.

E.R.W. Neale completed the 4-mile areal mapping of Sandy Lake East Half (12 H E 1/2) map-area, and also the 1-mile mapping of King's Point (12 H/9) map-area. The Sandy Lake East Half map-area was commenced by W.A. Nash under Dr. Neale's supervision in 1960; mapping of the King's Point map-area was commenced in 1959. Both of these projects are part of a study of mineralized Ordovician and Silurian rocks of the Notre Dame Bay region[1, 2, 3, 4, 5].

The 4-mile mapping included an area that extends along the east shore of White Bay 10 miles south of Purbecks Cove and eastward to Wild Cove Pond. Granby Island, near the east shore of White Bay, is underlain by sandstones that resemble the Silurian strata of Sops Arm on the west shore of the bay. This lends support to Murray's suggestion of a century ago, viz. that crystalline limestone along the east shore of the bay (which presumably underlies the sandstone on Granby Island) is correlative with similar rock of Early Palaeozoic age (i.e. Doucers Marble[1, 2]) on the west shore of the bay, and that White Bay is a great synclinal structure.

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1 Betz, F.: Geology and Mineral Deposits of Southern White Bay; Nfld. Geol. Surv., Bull. 24 (1948).

2 Heyl, G.R.: Geology of the Sops Arm Area; Nfld. Geol. Surv., Bull. 8 (1937).

3 Fuller, J.O.: Geology and Mineral Deposits of the Fleur de Lys Area; Nfld. Geol. Surv., Bull. 15 (1941).

4 MacLean, H.J.: Geology and Mineral Deposits of the Little Bay Area; Nfld. Geol. Surv., Bull. 22 (1947).

5 Neale, E.R.W., Nash, W.A., and Innes, G.M.: King's Point, Nfld.; Geol. Surv., Canada, Map 35-1960 (1960).

Gneisses and schists of the Fleur de Lys Group, previously interpreted as Precambrian, underlie the crystalline limestone with apparent conformity and could also be partly of Lower Palaeozoic age.

The 1-mile mapping in the King's Point (12 H/9) map-area was largely confined to the eastern part, which is underlain chiefly by the Ordovician Lush's Bight Group. Numerous top determinations in pillow lavas of the group suggest tight isoclinal folding in the region between Jackson's Cove road and Little Bay road. The rocks in this region probably occupy the northwestern limb of a synclinorium, whereas those southeast of Little Bay road occupy the southeastern limb of this structure. A brief re-examination of the western half of King's Point map-area showed large errors in the location of the Baie Verte road as originally mapped, which will necessitate adjustment in the locations of the geological contacts - particularly west of the road—shown on Map 35-1960.

Pyrite-bearing, altered rhyolitic rocks on the main branches of Rattling Brook, west of the Rattling Brook scarp, resemble the host rocks of a copper prospect east of the scarp, which is currently being examined by the British Newfoundland Exploration Company.

H. Williams commenced the areal mapping of the Botwood (2 E W 1/2) map-area, about 50 per cent of which had previously been mapped on larger scales[1, 2, 3]. The area includes most of the mines, the output of which, nearly a century ago, made Newfoundland one of the world's large copper producers.

Much of the previously mapped area was re-examined preparatory to mapping the remainder. The extent of Ordovician volcanic and sedimentary rocks has been outlined. Lithologic characteristics, in places substantiated by palaeontological evidence, allow approximate correlation throughout the map-area.

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1 Twenhofel, W.H.: The Silurian of Eastern Newfoundland; Am. Jour. Sci., vol. 245, pp. 65-122 (1947).

2 Twenhofel, W.H., and Shrock, R.R.: Silurian Strata of Notre Dame Bay and Exploits Valley, Nfld.; Bull. Geol. Soc. America, vol. 48, pp. 1743-1774 (1937).

3 Hriskevitch, M.E.: Little Rattling Brook, Nfld.; Geol. Surv., Canada, Paper 50-17 (1950).

The discovery of new fossil localities, detailed examination of known localities, and regional mapping, all combine to furnish additional information on problems of the controversial Botwood Group. Palaeontological evidence indicates that certain strata of the Botwood Group, e.g. on Martin Eddy Point, previously referred to as Devonian (?) are actually of Silurian age. Layered rocks south of Norris Arm and Exploits River, formerly interpreted as Ordovician (?) are continuous with rocks included in the Botwood Group in the area to the south. The occurrence of fossiliferous horizons within these rocks points to a Silurian age. The fact that certain members of the Botwood Group contain Silurian fossils, whereas others are conformable with Silurian strata, renders it probable that the entire group belongs to that system.

Investigation of the mineral deposits and a more detailed study of the Ordovician and Silurian relationships are anticipated for the 1962 field season.

GENERAL

D.M. Baird, Head of the Department of Geology, University of Ottawa, continued from 1960 field work required to prepare a series of popular accounts of the geology of each of Canada's National Parks. The accounts are expected to appear in booklet form, and are intended for the interest and education of the average Park visitor. Field work was completed in Terra Nova, Cape Breton, Kootenay, and the three Ontario National Parks.

L.V. Brandon continued a general survey of groundwater conditions and problems in the Yukon and District of Mackenzie and undertook special investigations in the Prairies. Most settlements in the Yukon were visited and advice on domestic supplies will be forwarded by Topical Report. Some areas were found where flowing artesian wells yielded water from below the permafrost. Several settlements in the Great Slave Lake area, not visited in 1960, were visited on request of Indian Affairs Branch, Department of Citizenship and Immigration, and advice on domestic supplies was forwarded. At Pine Point a continuous water recorder was set up to provide data for future investigations.

An aquifer test was carried out at Regina and data were obtained on various other aquifers on the prairies. Sites were selected for drainage-basin studies and observation wells installed in several localities as a start on these studies. A drilling and electrologging program was completed by contract as part of the geophysical methods study of aquifers in drift in southeastern Saskatchewan. Contracts were let for construction of experimental farm wells on community pastures in Saskatchewan. The contract drilling was supervised in the field by A.M. Toth.

Various governmental units, federal, provincial, and municipal, were visited for purpose of exchange of information on ground-water requirements, problems, investigating activities, and other purposes of mutual interest. At the request of Indian Affairs Branch, Department of Citizenship and Immigration, the Engineering departments were visited in all three Prairie Provinces to provide assistance in water supply problems on a number of Indian Reserves. Advice was given on the Indian Reserves problems by A.M. Stalker, A.M. Toth, J.E. Charron, and P. Meyboom.

J.A. Chamberlain carried out a study of the distribution of uranium in natural waters, of the dispersion pattern of uranium in water around known deposits and occurrences, and of hydrogeochemistry as a uranium prospecting tool for the future.

Eleven hundred and fifty samples were collected from lake, creek, swamp, and underground waters in an area of some 3,000 square miles in the region of Bancroft, Ontario. These water samples were analyzed for uranium in a field laboratory by a colorimetric method sensitive to one part per billion.

Most water samples contain less than one part per billion (ppb). Analysis results were obtained up to 720 ppb on samples collected near zones of known uranium mineralization. Several lesser anomalies were recorded, which do not appear to be linked with zones of established uranium concentration.

Uranium hydrogeochemistry may have one application in regional exploration programs and another in detailed prospecting of favourable areas. Slight changes in regional background are related to changes in character of bedrock. Although these changes occur near the lower limit of sensitivity of the analytical method and are difficult to evaluate, they appear to reveal the general outlines of the uraniferous belt in the investigated area.

Superimposed on the subtle regional trends are the high values obtained in waters sampled in the vicinity of orebodies. These decrease rapidly to background levels with increasing distance from anomalous zones and offer narrow targets that may be of use in detailed investigations of specified areas.

M.J. Copeland spent about 4 weeks collecting samples for microfossil analysis from specified sections in Gaspé, Nova Scotia, New Brunswick, and Ontario. Material was obtained from 1) Silurian rocks in the Cobequid area, Nova Scotia, 2) Upper Silurian rocks at Cap des Rosiers - Mt. Joli, in Quebec, 3) Lower Devonian rocks at Dalhousie, New Brunswick, and 4) Middle Ordovician rocks at Lake Timiskaming, Ontario.

The material will be analysed in the laboratory for microfaunal content, and it is hoped that subsequent study will permit the establishment of a zonal classification of the rocks based on the contained ostracod fauna.

A. Debnam, who holds a Post-Doctorate Research Fellowship of the National Research Council at the Geological Survey of Canada, is studying geochemical prospecting methods for petroleum and natural gas. During June and July samples were collected over oil and gas pools in southern Ontario (Morpeth, Colchester, and Gobles), and Alberta (Pincher Creek, Joffre, and Innisfail). Soils from the surface to a depth of 10 feet were taken at sample points located on traverses across the pools. Samples were returned to Ottawa for analysis. In the laboratory the soil gas is removed from the soil by distillation under partial vacuum and collected in a liquid nitrogen cold trap. Analysis of the gas sample is then made by gas chromatography. The gas chromatograph separates the gas into its individual components and quantitatively determines the hydrocarbons. Estimations of ethane, propane, iso-butane, n-butane, iso-pentane, and n-pentane can be made in 10 minutes.

Preliminary results indicate anomalous amounts of these gases in the soil above a gas pool at Morpeth, in southwestern Ontario.

W.F. Fahrig, although attached to Operation Leaf River (see I.M. Stevenson) carried out preliminary investigations on a project that will involve the study of diabase dykes in the Canadian Shield and that will probably be commenced in earnest in 1962.

During the field season he sampled and studied the diabase dykes that intrude the northern part of the Lake Superior Province. Most or all of these dykes belong to a single swarm and enough samples of various types were collected (including oriented samples for palaeomagnetic work) to characterize, date, and generally study the dykes of this swarm. Narrow diabase dykes that intersect the Labrador Trough strata near Schefferville were also sampled.

H. Frebold continued his study of the Jurassic System in Canada. During 1961, studies initiated the previous year were continued in parts of southern Alberta and parts of Montana. Last year's results regarding the correlation of the Swift Formation in Montana with the Green beds, Passage beds, and lowermost Kootenay sandstone in Alberta were confirmed. Use of the formal name "Swift Formation" for the above-mentioned Canadian rocks will be suggested, and the Swift Formation will be subdivided into several members.

The beds in Montana and Alberta not only are similar to one another lithologically; their hitherto-known faunas prove also equivalence in age.

The Canadian *Gryphaea* bed with *Warrenoceras*, *Cobbanites* and many pelecypods correlates with the lower part of the Rierdon Formation in Montana that is also equivalent in age. Younger parts of the Rierdon Formation in Montana are apparently missing in southern Alberta, i.e. the *Gowericeras* and part of the *Kepplerites* zones.

The upper part of the *Corbula munda* beds in southern Alberta corresponds both faunistically and lithologically to the upper Sawtooth Formation in Montana. They contain the *Paracephalites* fauna. The faunal name "upper Sawtooth" will probably be applied to the Canadian upper *Corbula munda* beds.

In the Montana section at Swift Reservoir the "middle Sawtooth" represents a facies that is very typical of the shaly facies of the Canadian Rock Creek Member. Ammonites found in this Montana section prove also the equivalence in age with the Rock Creek Member in southern Alberta.

The Jurassic Section in the Rossland-Trail (82 F/4) map-area, southern British Columbia, was studied with Dr. H.W. Little. Age determinations of various beds, which are important for the interpretation of the structure, were made in the field.

In the past the structural contact of the Devonian Mesozoic in the Banff area has been misinterpreted. The Devonian does not rest on the Cretaceous but on the Fernie Toarcian Paper shale. The Fernie and Kootenay are overturned. These facts could be demonstrated by a detailed palaeontological and stratigraphic study of the rocks concerned, particularly in sections on Mount Cascade and near the Banff traffic circle.

C.H.R. Gauthier collected more than 12 tons of minerals, rocks, and ores from 35 localities in Ontario and Quebec, from which to prepare suites for sale to the public. He also made several short trips to collect rarer minerals for inclusion in the National Reference Collection.

G.A. Gross made a preliminary examination of iron deposits in Central Canada, which shows that highly metamorphosed iron-formations are present between a line that extends from the south shore of Lake of the Woods to the north shore of Lake Nipigon and through O'Sullivan Lake, and another line to the north that extends from the south shore of Red Lake to Pickle Lake and Lansdowne House. Iron-formations within this broad belt are recrystallized, coarser grained than in most other parts of the Superior province, and thus may be particularly interesting from an economic viewpoint.

W.W. Heywood spent three weeks in September in the Baie Comeau area of Quebec continuing the study and development of areal reconnaissance mapping methods that might be applicable to the heavily wooded areas underlain by Grenville-type rocks. This study was inaugurated in 1960. Two Bell 47 G-2A helicopters were released to this project on the completion of Operation Leaf River. Geological personnel included two staff geologists and two seasonal technical officers. A total of 37 hours were flown to complete a quick reconnaissance of about 1,600 square miles. Additional geological information was obtained by traversing construction and paper company roads by car.

The rocks in the area include granite, granite gneiss, and paragneiss, with lesser amounts of gabbro, anorthosite, and amphibolite. Exposures on lake shores, in stream beds, and on cliff faces permit the classification of the major rock types, providing sufficient landings for ground observations are available. Throughout much of the area landings can be made at 1-mile to 2-mile intervals and within a few hundred feet of an outcrop. Future work will require ground traversing in selected areas for control and continuity of the areal observations.

R.D. Howie spent about seven weeks in Quebec and the Maritime provinces visiting appropriate authorities at the respective Departments of Mines in order to obtain available geological data relating to exploration for oil and gas in that part of Canada.

Samples of the Turtle Creek well on file in Fredericton, N.B. were studied and logged. In addition, specified sections of Carboniferous rocks in New Brunswick, Nova Scotia, and Prince Edward Island were examined. This work will aid in the examination of well samples and interpretation of the subsurface stratigraphy in these areas.

B.A. Latour collected data required to maintain an up-to-date estimate of the coal reserves of Canada. He spent three weeks in the field visiting provincial government agencies in Alberta and Saskatchewan and coal operators in southeastern Britsh Columbia, south-central Alberta, and southern Saskatchewan. He also assisted the Indian Affairs Branch, Department of Citizenship and Immigration, in evaluating the coal potentialities of the Blood Indian Agency, Alberta.

W.D. McCartney, in a second season of investigation on 'Fluorine, Barium, and Strontium in Canada', examined some 42 major occurrences and deposits in Eastern Canada.

Barite and fluorite deposits and occurrences are widely distributed in the Maritime Provinces. Mineralization at or near the Windsor-Horton contact appears to be inter-related, with barite either dominant or as a minor constituent in lead-zinc, lead-zinc-silver, siderite and/or hematite, and manganese oxide deposits. Although preponderant production of barite in the Maritimes will probably be from the large deposit at Walton, N.S., the association of barite with lead-zinc-silver deposits may be a useful aid in current exploration.

D.C. McGregor spent about 3 weeks during July and August collecting plant fossils from 1) Cretaceous rocks near Schefferville, Quebec, and 2) Devonian rocks at Sextant Rapids, Abitibi River, in northern Ontario.

The flora at Schefferville is associated with iron ore deposits currently being worked in that district, and mining operations are, therefore, gradually destroying this collecting locality.

Purpose of visiting Sextant Rapids was to obtain Devonian fossil plant specimens for comparison with material of about the same age from the Gaspé region. This comparative material forms part of the basic collections for a continuing project on the Devonian Flora of Canada.

D.J. McLaren spent several weeks examining the Middle-Upper Devonian boundary and collecting fossils in the vicinity of Norman Wells, Carcajou Rock, and Fort Good Hope, Northwest Territories. In addition he visited E.W. Mountjoy in Mount Robson (83 E SE) map-area and conferred with staff of the Western Plains office in Calgary, concerning problems of Devonian stratigraphy and palaeontology.

The field work resulted in the discovery of early Middle Devonian shelly fauna in limestone on Hart River, Yukon Territory, which may be correlated with the Blue Fiord Formation of Southern Ellesmere

Island. In addition goniatites, including Manticoceras, interbedded with shelly faunas formerly considered Givetian in age, were found on Carcajou Ridge, Northwest Territories.

Work on the Frasnian-Famennian boundary in the Alberta Rockies north of Jasper demonstrated that the early Famennian brachiopod fauna of the Lower Palliser and "Alexo" Formations overlie coral-bearing shelf limestones with sharp break and possible erosional interval.

P. Meyboom spent two weeks at the end of the field season doing preliminary investigations in the Annapolis Valley in preparation for a future basin study, and investigated the possibility of providing a large industrial water supply from groundwater sources in Nova Scotia. A favourable area was located and tests are being conducted to determine whether sufficient water can be obtained.

R. Mulligan undertook the investigation of the geology of tin deposits and occurrences in Canada. He investigated the tin-bearing mixed-sulphide deposits in silicified volcanic rocks at Mount Pleasant, N.B., the tin-bearing wolframite-molybdenite-beryl quartz veins and griesens at the Burnt Hill mine and adjacent area north of Maple Grove, N.B., the tin-bearing quartz veins, greisens, and pegmatites of the New Ross district, Nova Scotia, tin-bearing pegmatite and aplite dykes of western Ontario and southeastern Manitoba, and pegmatite dykes and tin-bearing quartz-sulphide veins of the Yellowknife-Beaulieu region, Mackenzie District, N.W.T.

Tin occurrences in the Burnt Hill mine area and the New Ross district are associated with distinctive muscovite-rich granite bodies. These and the other granites of the district were sampled to provide basic data as to the distribution of tin and the geological processes leading to its concentration.

Occurrences in the Cordilleran region remain to be studied.

E.R. Rose completed field studies of the titanium deposits of Canada, a project commenced in 1958, with the examination of several occurrences of ilmenite and titaniferous magnetite in Newfoundland, Quebec, and Ontario. In Newfoundland, he studied the Bishop North, Bishop South, and Hayes prospects in the Steel Mountain area, and the Indian Head, Cliff, and Drill Brook prospects in the Indian Head area. Both the Steel Mountain and Indian Head areas lie within the Stephenville (12 B) map-area[1] in western Newfoundland. In Quebec, Dr. Rose visited occurrences in Roberval, Pontiac, and Gatineau counties, and the Stratmat Magpie (Awater-Lapointe) deposit in Saguenay district. In Ontario he examined occurrences north of Westport in Leeds county, north of Haley in Renfrew county, and an occurrence south of Mattawa in Papineau township.

The Stratmat Magpie titaniferous magnetite deposit is one of the largest deposits of its kind in Canada. It appears to be of a type transitional in position and composition between the high-titanium magnetite deposits characteristically found within gabbroic anorthosites and gabbros, and the low-titanium magnetite deposits found in rocks beyond the parent mafic bodies. It lies mainly in granitic gneiss, where it was evidently emplaced as an iron-titanium rich injection, derived from a parent gabbroic anorthosite body, parts of which are found nearby in the gneiss. The existence of such a large deposit of this type in the gneiss adds incentive to prospect the broad areas around and between anorthositic massifs for iron-titanium deposits.

All anorthositic bodies studied since 1958 by Dr. Rose contain disseminations and concentrations of iron-titanium oxides. These and all other anorthositic bodies in eastern Canada may be considered favourable for potentially economic deposits of these minerals.

J.S. Scott spent most of the field season in New Brunswick, Prince Edward Island, and Nova Scotia, investigating the engineering geology aspects of the following potential engineering projects: the Passamaquoddy Tidal Power Project; the causeway or other connecting structure between

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[1] Riley, G.C.: Stephenville Map-Area, Newfoundland; Geol. Surv., Canada, Memoir 323 (in press).

Baird, D.M.: The Magnetite and Gypsum Deposits of the Sheep Brook - Lookout Brook Area; in Contributions to the Economic Geology of Western Newfoundland; Geol. Surv., Canada, Bull. 27, pp. 20-41 (1954).

Heyl, A.V. and Ronan, J.J.: The Iron Deposits of Indian Head Area; in Contributions to the Economic Geology of Western Newfoundland; Geol. Surv., Canada, Bull. 27, pp. 42-62 (1954).

Tormentine, N.B. and Borden, P.E.I.; and the Chicnecto Canal. Much of the data is available in existing reports, but this was checked in the field and specimens collected on which studies will be made to relate strength and durability parameters to petrography, mineralogy, texture, and structure of the rocks in order that engineering parameters may be assigned to these rocks in the future on the basis of geologic and petrographic examination. Hammer reflection seismic profiles were run in the Tormentine area by the Geophysics Division to assess the usefulness of this instrument in detecting engineering characteristics of these rocks.

At the request of the Department of Fisheries an examination was made of part of the Shubenacadie drainage system to find the cause of the increase of iron and lowering of pH in the stream. This has been causing serious trouble at a fish hatchery. Construction of the Halifax International Airport and a highway had exposed extensive areas of Lower Cambrian pyritiferous slates and consequent oxidation of pyrite has contributed increased iron. Details of the investigation and recommendations for corrective procedures have been forwarded to the Department of Fisheries.

R.F.J. Scoates, a graduate student at the University of Manitoba, under the supervision of C.H. Smith, completed a detailed study of peridotite bodies and associated copper-nickel deposits in the Gordon Lake area (52 L), as part of the study of ultrabasic rocks in Canada. These bodies lie along a complex of shear structures, and are best exposed underground in the Gordon Lake Mine, where they have been mapped and sampled in detail. Nickeliferous copper and iron sulphides occur in the peridotite bodies and in the surrounding gneisses. Laboratory studies are continuing at the University of Manitoba.

C.H. Smith collaborated in the airborne magnetometer survey conducted by the Geological Survey in June over the Muskox Intrusion in the Coppermine River area, District of Mackenzie. In August and September he visited R.F.J. Scoates at Gordon Lake, Ontario, and D.C. Findlay at Tulameen, B.C., then examined certain metamorphosed ultramafic intrusions in northern British Columbia preparatory to possible detailed studies in 1962.

J. Terasmae continued a study of the stratigraphic Pleistocene palynology of Canada. His 1961 field activities were mainly in the Yukon for the purpose of examining sections and collecting plant material in order to support the surficial geology studies of O.L. Hughes in Operation Klondike. The palynological studies in such material will be combined with radiocarbon dating and determination of other Pleistocene fossils. In a reconnaissance of northern Yukon with D.K. Norris, Dr. Terasmae collected palynological material to support future surficial geology studies in those parts. With the assistance of R.J. Mott, he extended his studies to Prince Edward County, Ontario, in support of the investigation of surficial deposits by E. Mirynech. He also completed a preliminary regional field study and collection of plant microfossil assemblages in surficial sediments in Ontario.

INDEX OF FIELD OFFICERS