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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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FIELD WORK, 1960

by

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INTRODUCTION

The following notes describe briefly, by provinces, field projects undertaken by the Geological Survey of Canada during 1960, 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. From time to time, however, as an incidental product of the field work, geological features or mineral occurrences are noted that might be of immediate or direct economic interest. Data concerning some of these warrant prompt release, in advance of the Survey's more formal Preliminary Series reports. Facts concerning a few such items are included in the following notes, but the mention of such items does not necessarily imply economic merit beyond what is obvious from the facts stated.

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. Data for this Information Circular were obtained by C.S. Lord by interview with the field officers concerned. Each officer checked the typed record of his interview. S.E. Jenness compiled this Circular from these checked records.

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 1960 field work will be released during 1961. 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:

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DISTRICT OF FRANKLIN

R.G. Blackadar completed field work within Macdonald Island (35 P) and Mingo Lake (36 A) map-areas on the southern coast of Baffin Island. His preliminary geological map of most of Macdonald Island map-area and the southern part of Mingo Lake map-area was published early in 1960.[1]

Most of the 1960 field season was spent in Mingo Lake map-area, and the field work completed outstanding parts of that map-area except as follows: (1) the northwest corner was not completely mapped; (2) an area of Precambrian rocks between Mingo Lake and longitude 73° was not completely mapped; and (3) the area northeast of the line extending northwest from Mingo Lake to Ankpar River, presumably underlain by Ordovician rocks, and with little or no outcrop, was not mapped. Southwest of the line between Mingo Lake and Ankpar River the rocks are, in general, a northwesterly extension of the Grenville-type geology described on Map 55-1959.[1]

R.L. Christie commenced and completed the reconnaissance geological study and mapping of southeast Ellesmere Island (Lat. 76° 00' to 77° 30', and Long. 78° 00' to 86° 00') as for publication on the scale of 1 inch to 8 miles. Field work involved mainly coastal reconnaissance, and the examination of areas readily accessible from the coast. Reconnaissance inland was limited to an overland sledge crossing from Makinson Inlet to Starnes Fiord, and to several flights and landings using a Piper Super Cub aircraft.

The western part of the mapped area is underlain by relatively little distrubed sedimentary rocks of Palaeozoic and later ages. The eastern part is underlain by Precambrian gneisses, quartzites, granites, and other rocks of the Canadian Shield. The general geological features of the mapped area, and a generalized boundary between the above two systems of rocks, is shown on Map 21-1959[2], which resulted from an exploratory survey by Operation Franklin in 1955.

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1 Blackadar, R.G.: Hobart Island, Baffin Island, District of Franklin, N.W.T.; Geol. Surv., Canada, Map 55-1959 (1960)

2 Fortier, Y.O., et al: Southern Ellesmere, Graham, and North Kent Islands, District of Franklin, N.W.T.; Geol. Surv., Canada, Map 21-1959 (1959)

The "basement" Precambrian rocks, in the eastern part of the mapped area, form two lithological groups: dark feldspar - quartz - amphibole gneisses of granitic aspect to the west; and quartzites, gneisses, and marbles of metasedimentary aspect to the east. Minor amounts of leucocratic granite are intimately associated with both groups. The gneissosity and bedding generally trend north-northwest to northwest.

Small (up to about 2 miles in length) remnants of a formation tentatively correlated with the Thule or Admiralty Inlet groups of late Precambrian age were discovered at Clarence Head and Cape Combermere. They comprise a few hundred feet of sandstone, shale, and lavas, and are intruded by diabase dykes.

Early Palaeozoic limestones and dolomites unconformably overlie the basement gneisses and occupy the western part of the mapped area. The rugged terrain and numerous faults result in an extremely complex eastern border, many outlying patches of carbonate rock, and enclosed exposures of Precambrian gneiss. The Palaeozoic beds dip gently northward and westward, and, as a result, progressively younger Palaeozoic beds are exposed to the northwest. The base of the Palaeozoic section was studied in detail at several places. The section comprises, mainly, some thousands of feet of fossiliferous dolomites and limestones of slightly varying types. Fossils tentatively identified as Cambrian type were found about 100 feet above the base of the section. The lower Palaeozoic dolomites pass abruptly upwards into red shales and brown-weathering sandstones. These are correlated with the Devonian Eids, Blue Fiord, Bird Fiord, and Okse Bay formations shown on Map 21-1959. Sand, mud, and coal, probably of Cenozoic age, are exposed along the south shore of Baumann Fiord.

Field work in the Palaeozoic rocks included the detailed measurement, description, and collection of fossils from Cambrian, Ordovician, and as yet undated but possibly post-Ordovician strata exposed in Grise Fiord.

On the east side of Fram Fiord a fossiliferous limestone bed, a few feet thick, contains crystal-lined cavities, 3 to 4 mm across, filled with what was identified in the field as thin, amber oil. The limestone is probably of Cambrian age, and is much faulted, and is a part of a Palaeozoic outlier resting on pre-Cambrian granitic gneiss.

B.G. Craig was attached to Operation Back River as geologist responsible for the surficial geology of an area roughly bounded by longitudes 90° - 102°, latitude 66° north to the Arctic coast and the Isthmus of Boothia.

Ice-flow features in the area indicate that, early in the period of retreat, movement was northeasterly toward the Gulf of Boothia and northwesterly toward Victoria Strait and Queen Maud Gulf. Later, all ice movement was northwesterly as the ice front retreated toward the Keewatin ice divide.

Marine transgression during and following the retreat of the ice was extensive, especially west of Chantrey Inlet. Here marine silt and clay and shoreline features are found up to about 500 feet above sea-level, some 40 to 50 miles inland from the present coast. Although evidence is scanty, an arm of the sea probably extended up the valley of the Back River. Adelaide Peninsula was completely inundated. Southeast of Chantrey Inlet along the lower reaches of the Hayes River the limit of marine transgression is well marked at about 500 feet above sea-level. On Boothia Peninsula, within the District of Keewatin, the marine limit is not well marked, but was probably 650 to 700 feet above present sea-level.

A varied and abundant molluscan fauna was found in the emerged marine bottom deposits and in some of the raised shoreline and deltaic deposits.

J.G. Fyles, despite transportation difficulties, completed the reconnaissance mapping of the surficial geology of Banks, Victoria, and Stefansson Islands, a project commenced in 1959. In 1960, he made observations throughout much of Banks Island, and in the Prince Albert Peninsula - Richard Collinson Inlet region of Victoria Island.

Banks Island, inasmuch as it lies astride the northwestern front of the "Wisconsin" ice, and has retained evidence of older and more extensive ice advances, promises to afford an unusually complete record of the Pleistocene history of the Arctic. All, or nearly all, of Banks Island was glaciated by continental ice. The latest ice extended northwesterly across Prince of Wales Strait to cover only the eastern part of Banks Island. On the other hand, evidence was found that two or perhaps three earlier ice sheets had extended farther northwesterly into central and northwestern Banks Island. These and other preliminary conclusions were outlined in a recent Geological Survey publication.[1]

W.W. Heywood, J.D. Aitken, W.L. Davison, M. Tremblay, and J.L. Blanchard mapped, as for publication on the scale of 1 inch to 8 miles, about 55,000 square miles in the northwest corner of the District of Keewatin, N.W.T. The project was known as Operation Back River. The mapped area is bounded as follows: the 102nd meridian south from the Arctic Coast to latitude 67° 00', thence east to the 100th meridian, thence south to the 66th parallel, thence east to the 90th meridian, thence north to the Arctic Coast in Pelly Bay, thence northerly and westerly along the Arctic Coast and the District of Franklin boundary to the coast at the 102nd meridian. B.G. Craig was attached to the party as officer responsible for the surficial geology. The party was supported by two Bell Model 47G helicopters, a Norseman aircraft, and a Cessna 180 aircraft operating only on floats. Three main caches of aircraft fuel were set out from Baker Lake, prior to the survey, by a DC3 aircraft equipped with ski-wheel landing gear. The

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[1] Craig, B.G., and Fyles, J.G.: Pleistocene Geology of Arctic Canada; Geol. Surv., Canada, Paper 60-10 (1960)

operating field season was from 7 June to 22 August.

No new information was obtained concerning the ill-fated Franklin expedition of 1845-47, although it is generally accepted that the last survivors of that expedition perished in the general vicinity of Montreal Island, near the centre of the project area.[1]

The remains of what was probably a cairn built by Dease and Simpson during their explorations of 1839 were found on Cape Britannia.

The oldest rocks recognized are schists and gneisses derived from sedimentary and volcanic rocks. They occupy a belt, up to about 40 miles wide, that extends southwesterly from the east boundary of the mapped area at latitude 67°10', almost to the south boundary at longitude 93°30'. They are intruded by numerous plugs and irregular bodies, of peridotite and altered peridotite, up about 2 1/2 miles in maximum dimension. Gossans are numerous. Much of the remainder of the mapped area is underlain by granitic, gneissic, and highly schistose rocks. A belt of mainly crystalline limestone, dolomite, and quartzite, 4 to 6 miles wide, extends about 120 miles northeasterly from latitude 67°10', longitude 95°50'. This belt appears to be younger than the widespread granitic, gneissic, and highly schistose rocks, but is cut by granitic and pegmatitic dykes and sills.

Nearly horizontal Ordovician and Silurian limestone, dolomite, and sandstone underlie Adelaide Peninsula, and the western coastal plain of Boothia Peninsula between Cape Selkirk and Spence Bay.

G. D. Hobson, during most of the field season, was on loan to the Polar Continental Shelf project where he was engaged in seismic investigations on and in the vicinity of Ellef Ringnes, Borden, and Meighen Islands, District of Franklin. The objective of these seismic surveys included: determinations of crustal thickness; depth to "basement" rocks; information concerning the various units of Palaeozoic and Mesozoic strata overlying the "basement", including their seismic velocities; and the thickness of the Meighen Island ice cap.

B.R. Pelletier, during late April, May, and early June, was attached to the Polar Continental Shelf Project based at Isachsen, District of Franklin. His duties were to commence a study of the submarine geology of the Project area. Bottom samples for sedimentological, geochemical, and palaeontological studies were obtained by: (1) off-shore traverses to ocean stations in Sverdrup and Peary Channels, Prince Gustaf Adolf Sea, Wilkins and Ballantyne Straits, and on ocean traverses northwest of Ellef Ringnes Island to intersect the continental slope; and (2) river and in-shore traverses. Several drainage basins sampled are underlain by rocks of a single formation; others by two or more formations. Office and laboratory studies of the samples are proceeding.

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[1] Wright, N.: Quest for Franklin; William Heinemann Limited, London (1959)

Submarine topography suggests a drowning of perhaps 1,300 feet. Thus much of the evidence of the last glaciation, presumably by ice not much more than 1,000 feet thick, now lies beneath the sea.

DISTRICT OF MACKENZIE

L.V. Brandon completed ground-water surveys of most of the settlements of the District of Mackenzie, including those of the Mackenzie River system from Fort Smith to the Arctic Coast. Advice concerning the availability of domestic supplies of ground water at various settlements has been requested by, and forwarded to, the Department of Northern Affairs and National Resources and to the Indian Affairs Branch of the Department of Citizenship and Immigration.

Studies at settlements on the Mackenzie River showed that permafrost was sporadic or of limited thickness south of the Arctic Circle and, therefore, that ground water should be sought at these places by the methods and principles used in southern Canada. North of the Arctic Circle, however, permafrost is likely to be so thick and extensive as to preclude the existence of available ground water.

R. Kretz spent most of the field season in the Beaulieu[1] (85 I) and Prosperous Lake[2] (85 J/8) map-areas, Northwest Territories, where he started a study of the mobility of rock-forming elements under metamorphic conditions, with particular reference to pertinent information available from pegmatite bodies and their immediately adjacent host rocks. Appropriate samples were collected for office and laboratory study by petrographic, spectrographic, chemical, and other means.

J.C. McGlynn, formerly Resident Geologist at Yellowknife, commenced 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. A purpose of this study was to test the new concepts of the geological history of the Great Slave Lake - Great Bear Lake region as suggested by Ross and McGlynn in a paper presented at the 1958 Annual Meeting of the C.I.M.M. in Vancouver.

Studies of the Nonacho group were made from camps on Thekulthili Lake and Hjalmar Lake. Field relations indicate that the granites that have in the past been mapped[3,4,5] as older than the Nonacho

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[1] Henderson, J.F.: Beaulieu River, District of Mackenzie, N.W.T.; Geol. Surv., Canada, Map 581A (1941)

[2] Jolliffe, A.W.: Prosperous Lake, District of Mackenzie, N.W.T.; Geol. Surv., Canada, Map 868A (1946)

[3] Henderson, J.F.: Taltson Lake; Geol. Surv., Canada, Map 525A (1936)

[4] Henderson, J.F.: Nonacho Lake; Geol. Surv., Canada, Map 526A (1939)

[5] Wilson, J.T.: Fort Smith; Geol. Surv., Canada, Map 607A (1941)

sediments are in fact younger. Dr. McGlynn's current conclusion is that all granitic rocks in this area are of about the same age, and younger than the Nonacho sediments. It is possible, however, that evidence of an older granite has been destroyed by its remobilization. A correlation of the Nonacho and Tazin sediments is thus possible, but rocks of these groups were not found in contact. Rocks of the Nonacho group are, however, structurally conformable with granitized equivalents of the Tazin group.

Studies of the Snare and Yellowknife groups of rocks made from camps on Basler, Kwejinne, and Arseno Lakes confirmed the major features of the geological legends of Maps 690A[1] and 697A.[2] It was found that the Basler group as proposed by Ross and McGlynn does not in fact exist. Snare rocks of shelf facies overlie unconformably the Yellowknife group of greywackes, shales, and basic volcanic rocks. Snare rocks were also found unconformably overlying granitic rocks that cut formations of the Yellowknife group. These relations were found in several places in Basler and Kwejinne Lakes and southwest of Basler Lake. In the same areas some of the rocks that had been mapped as Yellowknife group were found to underlie the Snare rocks conformably and are, therefore, now mapped as Snare group. Near Arseno Lake rocks of the Snare group overlie, without structural discordance, rocks that have been mapped as Yellowknife and are separated from the latter by what is interpreted as a paraconglomerate or tilloid. If this interpretation is correct, then in this area and in the area north to Mesa Lake there is no record of the break in sedimentation or of an unconformity between strata of the Snare and Yellowknife groups.

Studies of the Cameron and Echo Bay groups[3] were made near Balachey Lake, and by spot checking elsewhere using a Cessna aircraft. Porphyritic volcanic and intrusive rocks are overlain unconformably by Cameron Bay conglomerates and grits, which in turn seem to be overlain and cut by porphyritic rocks lithologically similar to the underlying porphyries. Some rocks mapped by Parsons[3] as Echo Bay conglomerates are in fact volcanic breccias. Volcanic and sedimentary rocks previously[3] included with Snare rocks west of Wopmay Lake and around Self Lake are lithologically similar to the rather unique formations of the Echo Bay - Cameron Bay groups, and it is proposed that these rocks be called Echo Bay - Cameron Bay rather than Snare. Rocks south and west of Grant Lake and on Wopmay Lake, that Lord[3] suggested might be Cameron Bay, are in McGlynn's opinion definitely Cameron Bay.

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1 Lord, C.S.: Snare River; Geol. Surv., Canada, Map 690A (1942)

2 Lord, C.S.: Ingray Lake; Geol. Surv., Canada, Map 697A (1942)

3 Lord, C.S. and Parsons, W.H.: Camsell River; Geol. Surv., Canada, Map 1014A (1952)

This correlation is based on lithologic similarity, but since the lithologies involved are unique the correlation is considered to be fairly sound.

K.H. Owens, accompanied by F. Essex, J. Houlihan, A. Decaire, J. Kempt, J. Lee, and D. Reveler made aeromagnetic surveys between latitudes 59°45' - 63°00' and longitudes 107°30' - 112°00', District of Mackenzie and northern Saskatchewan. These surveys involved 702.45 hours flying time (including ferry and test flights) and 67,460 line-miles of flying in an Aero Commander 680 aircraft. The surveys were two-thirds completed in 1960.

A magnetic anomaly with an intensity of more than 8,000 gammas above background were found in Wholdaia Lake (75 SE) map-area. Its centre is at latitude 61°05'30", longitude 107°46'15", about 5 1/2 miles north 80 degrees east from the northeast end of Quinn Lake. The anomaly trends northeast, and is about 1 1/2 miles long and 1 mile wide. It was outlined by flights 1,000 feet above the ground spaced at 1/4 mile intervals. The bedrock geology of this region is shown on Map 8-1959.[1]

An aeromagnetic survey was also made of an area approximately 15 miles square, a few miles southwest of Flin Flon, Manitoba, in the centre of which is the Coronation mine. Flight lines were flown at 1/4 mile intervals, with a terrain clearance of 500 feet. The results of this project will contribute to the comprehensive study of the Coronation mine presently being undertaken. (See under D.R.E. Whitmore, Saskatchewan, in this report.)

Aeromagnetic flights were also flown between latitudes 45°30' - 48°00' and longitudes 78°45' - 80°15' in Ontario and Quebec to complete the aeromagnetic survey started in this region in 1959.[2]

C.H. Smith completed the detailed mapping phase of his study of the Muskox Complex[3] (parts of 86 J/2, 6, 11, 14; 86 O/3) in the Big Bend of the Coppermine River. Field work started in 1959, and results have been compiled on a scale of 1 inch to 1,000 feet.

The Complex has been traced for 75 miles. Its northern part contains a series of gently inclined layers composed, from bottom to top, of dunite, peridotite, pyroxenite with various proportions of orthopyroxene and clinopyroxene, hypersthene gabbro, granophyric gabbro, and granophyre. Within one pyroxenite unit is a layer containing disseminated chromite and copper-nickel sulphides. This layer was traced for 3 miles.

The rocks of the roof of the Complex cut those of the Hornby Bay group, which apparently conformably underlies the Coppermine River basalts. A biotite age from the Muskox intrusion by the

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[1] Taylor, F.: Penylan Lake - Firedrake Lake, District of Mackenzie, N.W.T.; Geol. Surv., Canada, Map 8-1959 (1959)

[2] Lord, C.S.: Field Work, 1959; Geol. Surv., Canada, Information Circular No. 3 (1960)

[3] Fraser, J.A. et al: North-Central District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Map 18-1960 (1960)

potassium-argon method is 1,155 million years, probably about the age of the Coppermine basalts.

W.G. Smitheringale, a graduate student at the Massachusetts Institute of Technology employed by the Geological Survey for the 1960 field season, investigated the engineering geology at 10 proposed dam-sites on the South Nahanni River, Northwest Territories, as a member of a field party of the Water Resources Branch, Department of Northern Affairs and National Resources. The results of this project are being made available to the Water Resources Branch at whose request the work was undertaken.

YUKON

O.L. Hughes and C.R. McLeod commenced the study and mapping of the surficial geology and geomorphology of the Klondike placer mining district. It is hoped that this project, which is expected to require several seasons field work, will provide basic data that will extend the life of the placer mining industry. Most of the 1960 field season was spent in Ogilvie (115 O), McQuesten West Half (115 P W 1/2), and Carmacks North Half (115 I N 1/2) map-areas, in a preliminary study of the Pleistocene stratigraphy as exposed in various sections along Hunker and Bonanza creeks, in Tintina Trench, and along Stewart and Pelly Rivers. In addition, C.R. McLeod obtained heavy mineral concentrates from creek and bench gravels, and from various kinds of decomposed bedrock. The suites of heavy minerals obtained from these concentrates will be studied with special reference to the origin, mode of concentration, and localization of the gold and other placer deposits.

As only part of the project area was glaciated, these studies may provide an unusual opportunity for the unravelling of the Pleistocene history of the extreme northwest mainland of Canada.

E.D. Kindle commenced and nearly completed a study of the copper deposits of the Yukon, the results of which will be incorporated ultimately in a report on the copper deposits of the Cordillera. About 40 copper-bearing properties were examined, including copper deposits of the Rainy Hollow and Atlin districts in British Columbia.

Spectroscopic analyses show that iron-rich ores throughout the Whitehorse copper belt contain between 0.01 and 0.1 per cent gallium. A representative sample of nickel ore from the Canalask property on White River contained a similar amount of this metal.

E.B. Owen continued the preliminary investigation of the engineering geology of proposed dam sites in the Yukon River drainage basin. 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. Two sites were examined on

Pelly River, and seven on the Yukon River between the mouth of Pelly River and the Alaska-Yukon boundary.

The seven sites investigated on Yukon River lie beyond the limit of the last glaciation and consequently bedrock is deeply weathered. Frozen ground was encountered at all seven sites. One site lies astride the boundary between glaciated and unglaciated ground. This boundary is also the boundary between unfrozen and frozen ground, the latter being confined at this place to the unglaciated terrain.

J.A. Roddick and L.H. Green completed a helicopter-and Beaver-supported project known as Operation Pelly. The project included the geological mapping, in detail appropriate to publication on a scale of 1 inch to 4 miles, of Wolf Lake North Half (105 B N 1/2), Quiet Lake (105 F), and Finlayson Lake (105 G) map-areas in 1959; and Sheldon Lake (105 J), Tay River (105 K), most of Nahanni (105 I), and the northeast corner of Francis Lake (105 H) map-areas in 1960. The total area mapped during the 1960 field season was approximately 14,000 square miles.

The major geological units trend northwesterly, more or less parallel to Tintina Valley on the southwest and the Mackenzie Mountains on the northeast. Most of the 1960 field work was concentrated between these two major structural and topographic features.

Tay River (105 K) map-area southwest of Tintina Valley is underlain mainly by highly deformed Lower Palaeozoic phyllites, carbonates, and argillaceous rocks. Southwest of these rocks, in the extreme south-west corner of the map-area, are gneisses, schists and granitic rocks.

Tay River map-area, immediately northeast of Tintina Valley, is occupied by the Anvil Range, the core of which consists of biotite quartz monzonite. These rocks, which are probably Cretaceous, intrude a series of banded granulites, hornfels, phyllites, and slates (some of which have been converted to micaceous schists and gneisses) of probable Upper Devonian age. Several thousand feet of altered andesitic flows and pyroclastic rocks overlie this sequence on the northeast, and are in fault contact with highly deformed beds of black shale and chert, quartzite, and limestone in which Mississippian fossils were found. In the northwest corner of Tay River map-area these strata are overlain by thick beds of chert pebble conglomerate, which thin to the east. In Tay River Valley, north of the Anvil Range, are shales and sandstone of Triassic age, but owing to poor exposures, their relationship to the Mississippian rocks is not known. Much of the area between Tay River and the South MacMillan-Riddell River Valley is covered by gently folded dacites and andesites whose thickness exceeds 5,000 feet and whose age is thought to be Tertiary. Emerging from beneath these volcanic rocks, on the south side of South MacMillan River Valley is a thick and extensive sequence of chert and shale, both of which are generally black. These rocks contain Ordovician and Silurian fossils, and in the northeast corner of Tay River map-area overlie Beltian-like strata of Precambrian age.

The Precambrian strata extend southeasterly across the Sheldon Lake (105 J) map-area, into the southern Nahanni (105 I) and northern Francis Lake (105 H) map-areas. Distinctive in the upper section of these rocks are beds of green and maroon shale, which are exceptionally persistent along strike. The lower section is characterized by massive, coarse, quartzites. The most abundant rocks in both sections are quartzites and interbedded shale and slate. Carbonate beds, commonly sandy or silty, were found at several horizons in both upper and lower sections. Most of the northeast half of Sheldon Lake map-area is underlain by the Ordovician-Silurian cherts and shales. To the northeast near the Yukon—Northwest Territories boundary in Nahanni map-area, the cherts appear to give way to argillaceous rocks, and, farther east, across the South Nahanni River, the argillaceous rocks give way to carbonates. The south central part of Sheldon map-area contains only scattered outcrops, but the geology appears to be an extension of that in the Tay River map-area.

Rocks ranging in age from Precambrian, through Cambrian, Ordovician, and Silurian, to Devonian were recognized northeast of South Nahanni River. These rocks consist chiefly of carbonates, and argillaceous limestones, with some shale and quartzite, and are moderately folded. The lower part of this sequence is present southwest of South Nahanni River in a highly deformed belt in which northeasterly-directed, recumbent folding and thrusting are common. Where the deformation is most extreme the argillaceous rocks have been converted to phyllites, but, in general, the rocks show little thermal metamorphism. Precambrian rocks underlie the southwestern part of Nahanni map-area.

Where granitic stocks intrude the extremely deformed belt southwest of South Nahanni River, the Cambrian carbonate rocks are commonly mineralized with arsenopyrite, pyrite, chalcopyrite, galena, sphalerite, scheelite, and molybdenite. The known tungsten deposits in this region, including those of Canada Tungsten Mining Corporation, are in these rocks.

Roddick and Green also spent a few days in the Nash Creek (106 D), Larsen Creek (116 A), and Dawson (116 B and 116 C E 1/2) map-areas conducting preliminary reconnaissance mapping and caching gasoline in preparation for a future helicopter-supported project to be known as Operation Ogilvie.

BRITISH COLUMBIA

R.B. Campbell completed field work in the Quesnel Lake West Half (93 A W 1/2) map-area, a project initiated in 1959 and completed in 1960 with the aid of a helicopter for a period of about three weeks.

The southeast corner of the map-area is underlain mainly by medium-grained hornblende-biotite quartz monzonite, except that Tertiary lavas cover a large area south of Horsefly River. Small exposures of Mesozoic volcanic and sedimentary rocks were mapped.

The geology of the north half of the map-area may be divided along a line extending northwesterly from Spanish Lake to Sovereign Mountain (5 miles east of the northwest corner of the map-area). Southwest of the line are Mesozoic volcanic and sedimentary rocks that range in age from Upper Triassic through Lower Jurassic, and may be, in part, of Middle Jurassic age. Northeast of this line, which is believed to be the locus of a major fault, are intensely deformed metamorphic rocks of the Cariboo group of lower Palaeozoic age. Granitic intrusions immediately northwest of the North Arm of Quesnel Lake are probably of Mesozoic age, but those on either side of the lower Cariboo River may be Palaeozoic in age.

Along the contact between the Mesozoic and Cariboo group rocks are three serpentinized ultramafic bodies each of which is 1 mile or more in length. Very short and sparse asbestos fibre was observed in the most northerly of these bodies. The location of these bodies may be seen on published maps of the Geological Survey[1] upon which they are shown as "amphibolite and other basic rocks". The two northernmost of these bodies can be reached very easily from the newly completed development road that extends up Sovereign Creek and down Reddish Creek to Swift River.

D.B. Craig, a post-graduate student at the University of Wisconsin, commenced detailed mapping of rocks of the Monashee group near Revelstoke as part of the special investigations of the granitic rocks in Canada being conducted by Dr. J.E. Reesor. Approximately 80 square miles of Monashee group rocks were mapped at a scale of 1 inch to 1/2 mile.

North of Blanket Mountain[2] these rocks are predominently schist, biotite-quartz-plagioclase paragneiss, and quartzite. On the north flank of the mountain, and southward, pegmatite, pegmatitic granite, and granitic gneiss are abundant and are conformable and interlayered with meta-sedimentary rocks. Quartzite bands and masses were mapped at a scale of 1 inch to 1/2 mile. The entire mass consists of an apparently conformable repeated succession of quartzite, biotite schist, biotite-garnet schist, and biotite-quartz-feldspar gneiss. Much deformation, as indicated by lineation, minor isoclinal recumbent folds, and related features, is concentrated in the zones of schist and schistose gneiss immediately below the layers of quartzite. Part of only one large-scale fold was found, and further information on such folds awaits elucidation of a recognizable "stratigraphic" sequence.

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[1] Lang, A.H.: Cariboo Mountain, B.C.; Geol. Surv., Canada, Map 563A (1940)

----------: Chiaz Creek, B.C.; Geol. Surv., Canada, Map 564A (1940)

[2] Jones, A.G.: Vernon, Kamloops, Osoyoos, and Kootenay Districts, British Columbia; Geol. Surv., Canada, Map 1059A (1960)

D.C. Findlay, a post-graduate student at Queen's University, commenced a detailed investigation of the Tulameen ultrabasic complex (parts of 92 H/7 N 1/2 and 92 H/10 S 1/2). The project will provide data for a Ph.D. thesis to be submitted to Queen's University, and for an appropriate report for publication by the Geological Survey. The project is being supervised by C.H. Smith as a phase of his continuing study of the ultrabasic rocks of Canada.

The Tulameen complex[1] underlies an area of about 28 square miles. It is about 11 miles long, from northwest to southeast, and 2 to 3 miles wide. The rocks of the complex have intruded folded and metamorphosed volcanic and minor sedimentary rocks of the Triassic Nicola group. Near the north end of the intrusion is an elongated, irregularly shaped core of ultrabasic rocks (dunite, peridotite, and serpentinite) about 3 miles long and 1 mile wide. This is enclosed by a moderately to steeply west-dipping series of basic rocks that include pyroxenite, olivine pyroxenite, amphibole pyroxenite, feldspathic pyroxenite, and gabbro members. In addition to enclosing the northern core, the basic rocks comprise the central and southern parts of the complex.

The northern part of the complex was mapped on the scale of 1 inch to 1,000 feet during the 1960 field season. Forthcoming laboratory investigations are expected to include the study of the distribution of platinum group metals within the complex.

R.J. Fulton, a graduate geology student at Northwestern University, commenced the study and mapping of the surficial deposits of Nicola (92 I E 1/2) map-area for publication on the scale of 1 inch to 2 miles. The results are expected to provide material for his doctorate thesis and a suitable Geological Survey map and report. The field work was supervised by H.S. Bostock and J.G. Fyles of the Geological Survey staff. Evidence was found for two major glaciations separated by an interglacial interval of sufficient duration for the establishment of vegetation and the deposition of at least 75 feet of sand, silt, and gravel.

H. Gabrielse, with the aid of a helicopter and a Piper Super Cub, completed the geological mapping of approximately 80 per cent of Kechika (94 L) and Rabbit River (94 M) map-areas, British Columbia. Most of the field season was spent in Rabbit River map-area, where field work was completed in the Kechika range and extreme southwest corner of the map-area, in the Terminal Range of the northern Rocky Mountains in the southeast corner of the map-area, and within most of that part of the map-area lying north of the Alaska Highway and Liard River. The following remarks apply to the 1960 field work within Rabbit River map-area.

Well exposed strata ranging in age from Precambrian to Devonian are exposed in a northwesterly plunging anticlinorium in the

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1 Rice, H.M.A.: Geology and Mineral Deposits of the Princeton Map-area, British Columbia; Geol. Surv., Canada, Mem. 243 (1947)

Terminal Range of the Rocky Mountains in the southeast part of the map-area. The Precambrian rocks consist of cross-bedded, sandy limestones and dolomites, sandstones, quartzites, and argillites. The Cambrian rocks are of similar lithology, but include a conspicuous, coarse conglomerate unit. This sequence is overlain by a thick assemblage of thin-bedded, argillaceous limestones and calcareous phyllites presumably of Cambro-Ordovician age. Well bedded, highly fossiliferous Silurian dolomites are overlain by poorly fossiliferous, distinctly bedded, light grey and dark grey dolomites that are in turn overlain by a prominent orange- and buff-weathering brecciated limestone, limestone, and dolomite unit. The uppermost beds exposed in the anticlinorium are of Middle Devonian age and consist of a lower, dark grey, dolomite member, and an upper, well-bedded, fossiliferous, light grey limestone member.

Lower Cambrian limestone and quartzite outcrop in the Cassiar Mountains southwest of Hidden Valley Creek in the extreme southwest corner of the map-area. The adjacent Kechika Ranges are underlain by thin-bedded limestone, argillaceous limestone, and calcareous phyllite of Cambro-Ordovician age, and by several small infolded remnants of Mississippian carbonate rocks.

Carbonate rocks of Silurian and Devonian age underlie much of the map-area north of the Alaska Highway. Cambrian rocks about 4 miles southeast of Smith River airport seem to be separated from adjacent Silurian strata by a fault. On the other hand, similar Cambrian rocks 7 miles south-southwest of the airport are overlain unconformably by Silurian strata. Argillaceous limestone, possibly of Cambro-Ordovician age, outcrops in many of the stream cuts and low-lying areas, particularly west of Coal River.

Devono-Mississippian shales and sandstones disconformably overlie Middle Devonian carbonate rocks north of Liard Hotsprings, and are in fault contact with similar rocks southwest of Liard River in the same region.

Devono-Mississippian (?) clastic rocks outcrop along the lower reaches of Rabbit and Kechika Rivers and along Liard River.

A prominent ridge east of Tatisno Creek is underlain by green and grey phyllitic slate, sandstone, and quartz-pebble conglomerate, possibly of Cambrian and/or Precambrian age.

In general the structural trends south of Liard River are northwest. North of the river the trends are north to northeast. Major southwest-dipping thrust faults along Liard River, southwest of Liard River bridge, separate these two areas of differing structural trends. Thin-bedded strata along Kechika, Rabbit, Red, and Turnagain Rivers are intensely contorted.

E.C. Halstead and B. Treichel completed a ground-water investigation of the east coast of Vancouver Island from Courtenay to Campbell River. This was a continuation of the project commenced in 1959, when the area between Nanaimo and Courtenay was investigated. The project also included Hornby and Denman Islands (mapped in 1959) and the south half of Quadra Islands.

The ground-water investigation outlined an aquifer below till that underlies the Comox area. This aquifer yields approximately 1,000,000 gallons daily to meet the demands of the densely populated agricultural area as well as the village of Comox and the Comox Air Base. Recharge to this aquifer is contributed in part by infiltration of rainfall through permeable glacio-marine surficial deposits and partly from surface sources such as streams and rivers that rise in the mountains west of the field area.

E.J.W. Irish continued field work in the Halfway River (94 B) map-area, a project commenced in 1959. In 1960, he studied and mapped a strip of territory extending northwesterly from Gold Bar to Robb Lake, thence south-southeasterly to the mouth of Nabesche River. This work, together with information obtained along the valley of Peace River in 1959, indicates several lateral facies changes both from east to west, and from north to south.

G.B. Leech, with the aid of a G2 helicopter, completed the areal mapping of Fernie West Half (82 G W 1/2) map-area. The 1960 field work was mainly east of Bull River and north of Fernie, and on the west flank of the Rocky Mountain Trench near Wardner. Preliminary results of the 1959 and earlier seasons in this map-area have been published.[1]

The amygdaloidal andesitic rocks (part of unit 20, Map 11-1960)[1] near Wild Horse River that were believed to be volcanic rocks of Silurian or Devonian age are instead intrusive rocks of unknown age, and the shale and limestone grouped with them in unit 21 belong to the McKay group (unit 18). Other amygdaloidal andesitic rocks found in 1960 to underlie more than half a square mile of the Bull River valley at latitude 50° may, however, be extrusive.

The region east of the Bull River is characterized by folds overturned eastward and by important eastward-directed thrust faults.

Gypsum of Devonian age underlies the east flank of Bull River valley from Sulphur Creek to the north boundary of the map-area. It also underlies parts of the floor of the valley. Outcrops are few, but exposures up to 100 feet high occur 11 miles north of Sulphur Creek.

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1 Leech, G.B.: Fernie Map-area, West Half, B.C.; Geol. Surv., Canada Paper 58-10, (1958)

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Breccia-conglomerate that occurs along the south side of the Moyie fault at Peavine Creek (unit 14 of Map 11-1960)[1], and on Lamb Creek, is believed to be of Devonian age and to be a further indication that the Moyie fault is near the site of a northeast-trending Palaeozoic fault zone.

A granodioritic stock (included in unit 11, Map 15-1957)[2] on Hellroaring Creek, 7 miles west of the map-area, contains mica with the Precambrian age of 705 million years, as determined by the potassium-argon method in Geological Survey laboratories.

J.E. Muller, using a helicopter during part of the summer, completed field work in all but the extreme northeast corner of Pine Pass (93 O) map-area to a standard acceptable for a preliminary geological map on a scale of 1 inch to 4 miles. Additional field work will be required before a final map can be prepared.

The southwest corner of the map-area lies within the Interior Plateau, the northeast corner within the Plains. Between these, from southwest to northeast, are: the Rocky Mountain Trench; the Rocky Mountains, here only one range, about 16 miles wide; the Front Range; and the Foothills.

The Interior Plateau is underlain mainly by rocks of the Wolverine metamorphic complex of gneiss and schist. Other rocks are granitic intrusions, and volcanic and sedimentary strata of late Palaeozoic and early Mesozoic age.

The metamorphic complex is faulted against lower Palaeozoic sediments that form the low hills, and presumably the floor, of the Rocky Mountain Trench. These rocks are highly disturbed, but in other respects appear similar to the lower Palaeozoic strata of the Rocky Mountains. The physical expression of the Trench could be due to low resistance to erosion of these highly fractured rocks. Minor erosional remnants of Tertiary and Cretaceous sediments overlie these rocks in the Trench.

The Precambrian and/or lower Cambrian Misinchinka schists (Map 907A)[3] form plateau-like mountains that occupy most of the Rocky Mountains proper between the Rocky Mountain Trench and Pine Pass. They comprise a lower unit of chlorite schist, schistose grit, and conglomerate; an intermediate unit of limestone and schist; and an upper unit of slate, schistose greywacke, and quartzite. Typical Rocky Mountain topography is developed in the northeastern part of the main Rocky Mountains, which are underlain by carbonate rocks and quartzites ranging in age from Cambrian to Devonian. The belt underlain by these strata is about 4 miles wide (Murray Range) at Pine Pass, but widens

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[1] Leech, G.B.: Fernie (West Half), B.C.; Geol. Surv., Canada, Map 11-1960 (1960)

[2] Leech, G.B.: St. Mary Lake, Kootenay District, B.C.; Geol. Surv., Canada, Map 15-1957 (1957)

[3] Armstrong, J.E.: Fort St. James, British Columbia; Geol. Surv., Canada, Map 907A (1948)

towards the northwest and southeast. This minimum width at Pine Pass is caused by the local absence of Ordovician to Middle Devonian strata, and may mark the southwesterly extension of the "Peace River Arch". Flat eastward overthrusts are the dominating structures in the Rocky Mountains proper.

The Front Range, immediately northeast of Pine Pass, is a belt, 4 to 8 miles wide, of mainly Mississippian and Triassic sedimentary rocks. The strata are intricately folded and faulted.

The Foothills are underlain mainly by Lower Cretaceous sandstones and shales, with Upper Triassic strata exposed in cores of anticlines. The structure is typically one of asymmetrical, faulted, or box-shaped anticlines, with smaller wrinkles superimposed. Farther northeast flat synclines and anticlines of Lower Cretaceous Gething and Fort St. John groups, with a few prominent thrust-faults, occupy the northeastern edge of the folded belt.

B.R. Pelletier and E.T. Tozer combined parties to study the stratigraphy and palaeontology of the Triassic rocks in the Foothills and Rocky Mountains of northeastern British Columbia. Dr. Pelletier commenced stratigraphic studies of these rocks in 1959, and his preliminary results have been published.[1] His 1960 field work was in Tuchodi Lakes (94 K) and Toad River (94 N) map-areas. The combined parties studied some 22,000 feet of Triassic sections from 20 localities.

For the first time Upper Triassic strata have been recognized in Tuchodi Lakes and Toad River map-areas. In Tuchodi Lakes map-area the Triassic sequence extends as high as Karnian. In the western part of Toad River map-area it reaches the Norian (Pardonet equivalent).

In the western parts of both map-areas the Liard sandstones are replaced by dark siltstones of Toad-Pardonet facies.

J.E. Reesor continued, from 1958 and 1959, his detailed studies of the Valhalla Complex in Passmore (82 L/12) and Burton (82 L/13) map-areas. Field mapping, on a scale of 2 inches to 1 mile, was virtually completed in 1960, but the structural synthesis and petrological study of the complex is continuing. These studies are part of the 'Study of Granite in Canada' project, and are directed toward the understanding of the origin and emplacement of the granitic rocks in this single, well-defined orogenic unit in southern British Columbia. It is hoped that the results of this study will provide a pattern for progressive geological work elsewhere in the Cordillera and in Canada generally.

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

About 400 square miles have been mapped in Passmore and Burton map-areas during the last three field seasons. This work has outlined a gneiss dome within the Valhalla Mountains. The dome is bounded by shattered leucogranite on the east between Slocan Lake and Passmore; by porphyritic leucogranite gneiss on the south; by a variety of granitic rocks intruded by later pink hornblende and/or biotite granite (Coryell) on the west; and by less metamorphosed sedimentary rocks, some of which are of Lower Jurassic age, in the synclinal culmination to the north.

The Valhalla gneiss dome, measuring about 18 miles from east to west and 15 miles from north to south, consists of an interlayered succession of migmatites, hybrid gneisses, net-veined augen gneiss, garnet leucogranite gneiss, and porphyroblastic leucogranite gneiss that dips gently outward from a centre in Gwillim Creek. The dips become progressively steeper towards the west. Lineation is a prominent structural feature in all layers. It generally trends between 85° 00' and 120° 00', and has formed parallel to the direction of tectonic transport.

The dome is thought to have been formed by thrusting of augen gneiss from the west between and over layers of migmatite and hybrid gneiss regionally metamorphosed to sillimanite-almandite grade. During the consequent up-arching, the overlying hybrid gneiss was locally incompetently folded, stretched, separated, and granitized. Paragneiss on the south flank of the dome shows minor isoclinal recumbent folds and associated mineral lineation with consistent east to south-southeast trend. On the northwest and north flank of the dome axial lines of folds and lineation range irregularly in trend from north to east. In this zone the proportion of granitic material exceeds 75 per cent in the mixed gneiss, and the resulting incompetent mixture apparently produced no consistent trend in the minor associated structures.

An over-pattern of nearly contemporaneous open, gentle folds, difficult to recognize until plotted on the map, warps the lineation and minor fold axes, but apparently does not constitute a major, definable, second period of deformation.

J.G. Souther completed all but about 5 per cent of the field mapping of the Sumdum (104 F) and Tulsequah (104 K) map-areas, a project initiated in 1958. The use, during part of the summer, of a helicopter and a Piper Super Cub greatly facilitated the field operations, most of which were in the west half of the Tulsequah map-area.

The general geological features of the west half of Tulsequah map-area are much as would be inferred from a perusal of the two preliminary geological maps already published for this project.[1]

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[1] Souther, J.G.: Chutine, Cassiar District, British Columbia; Geol. Surv. Canada, Map 7-1959 (1959)

------------: Tulsequah, Cassiar District, British Columbia; Geol. Surv., Canada, Map 6-1960 (1960)

D.F. Stott completed the field study of the Upper Cretaceous Smoky group in the Foothills of Alberta and British Columbia between Smoky River and Peace River. This study was commenced in 1958, along with the study of the succession, lithology, and correlation of the Lower Cretaceous Fort St. John group, the upper part of the Lower Cretaceous Bullhead group, and equivalent strata. Field study of the Lower Cretaceous strata was extended from Bullmoose Creek northwesterly to beyond Moberly River. One more month of field work in the vicinity of Peace River Canyon is needed to complete this phase of the project.

Dr. Stott also commenced and completed the 4-mile mapping of Dawson Creek (93 P) map-area. This map-area is underlain by Upper and Lower Cretaceous strata except in the extreme southwest corner, southwest of Bullmoose Mountain, which is underlain by Nikanassin and older rocks. These non-Cretaceous rocks were not mapped. Significant facies changes were noted within the Commotion and Goodrich formations of the Fort St. John group, and the Kaskapau formation of the Smoky group. The nonmarine beds of the Commotion formation, found on Bullmoose Mountain, grade northwesterly into marine sediments. A sandstone, mapped as the Goodrich formation, makes its appearance in the middle of the upper Fort St. John shales in the southern part of the map-area, and thickens northwesterly to become much thicker in the northwest corner of the map-area. The succession of sandstones that are present in the middle of the Kaskapau formation south of John Hart Highway thins and ends toward the southeast.

Dr. Stott also mapped the Lower Cretaceous Fort St. John group strata in the northeast corner of Pine Pass (93 O) map-area, where they occur in several broad synclines and anticlines, which are broken by a few northwesterly-trending thrust faults.

G.C. Taylor commenced the geological study and mapping of MacDonald Creek (94 K/10) map-area on the Alaska Highway in north-eastern British Columbia. It is underlain by rocks of probable Proterozoic, early and late Palaeozoic, and Mesozoic ages, comprising approximately 12,000 feet of section. The pre-middle Devonian sediments are predominantly carbonates, whereas the post-middle Devonian sediments are mainly of clastic origin. The Mountain belt is characterized by west dipping thrust faults, the Mountain front by overturned folds, and the Foothills belt by gentle folds.

Proterozoic strata underlie much of the south-central part of the map-area. They are cut by numerous persistent basic dykes, the maximum observed width of which is about 60 feet. Small amounts of copper minerals were noted here and there along the borders of some of these intrusions. Barite and associated fluorite are common within probable Lower Devonian strata.

H.W. Tipper, with the aid of a helicopter for about three weeks, completed the mapping of the Prince George (93 G) map-area. This project was commenced in 1959. The 1960 field work was in the northeast three-quarters of the map-area.

Tertiary lavas, which are widespread in the southwest corner of the map-area, underlie only minor parts of the rest of the area, where the following variety of rocks were encountered: sedimentary and volcanic formations of the Cariboo, Slide Mountain, and Cache Creek groups; serpentinized peridotite; sedimentary and volcanic members of the Takla group; and Mesozoic granitic rocks including Topley intrusions.

Several major faults, each trending about north 15 degrees west, extend across, or nearly across the map-area, within a belt about 20 miles wide, the northeast side of which lies close to Prince George. The southwest edge of the belt, about 20 miles southwest of Prince George, is believed to be the southeasterly extension of the Pinchi fault.

Seven bodies of post-Permian, pre-Upper Triassic (?) serpentinized peridotite were mapped in the west half of the map-area. One elongate body, 2 miles wide and more than 6 miles long, forms the crest of Sinkut Mountain and extends beyond the map-area. One large body forming the mass of Bobtail Mountain extends 12 miles from near the west end of Norman Lake to the south end of Naltesby Lake and has a maximum width near the south end of 5 miles. A third body, with a length of 2 miles and a width of 1.5 miles, forms a hill on the east side of Chilako River 6 miles west of Baldy Hughes Mountain. The other four bodies occur in the Telegraph Range, all with a north-south elongation. The most northerly of these is 6 miles east of Tagai Lake and extends northeasterly for 3.5 miles with a width of 1/2 mile. Another of these four bodies is 1 mile wide and extends 3 miles south from a point 6.5 miles on bearing 110° from Tagai Lake, thus forming the west flank of Telegraph Range. A third body is sub-parallel to the second and 2 miles east of it; from its northern end it maintains a width of 1 mile for 9 miles south and may continue to Blackwater River. The fourth body measures 3 miles by 1 mile, parallels the third at its south end, and lies 1/2 mile east. These last two bodies of peridotite form the east flank of the Telegraph Range. The peridotite bodies were mapped mainly from the air.

Chrysotile asbestos was observed in four of the seven peridotite bodies described above. Three of these occurrences are reported here for the first time. The four asbestos occurrences were noted on a total of only seven ground traverses across the peridotite bodies. Their locations are as follows: (1) on Sinkut Mountain, in a road-cut 1/2 mile from the B.C. Forestry lookout, where a small amount of slip fibre was noted; this or another deposit on Sinkut Mountain has been called tremolite asbestos in a report[1] in which nickel is also mentioned; (2) on Bobtail Mountain, between elevation 3,700 and 4,200 feet on the extreme southwest ridge about 1 1/2 miles from the south end of Naltesby Lake, where cross-fibre asbestos with fibre lengths of 1/4 to 1/2 inch occurs in veins up to 3 feet long; these veins are widely spaced for the most part, but in one place four such veins occurred in a distance of 2 feet; (3) on the west side of Telegraph Range from a point 6 1/2 miles on

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[1] B.C. Minister of Mines Report, 1930, p. 147 (1931)

bearing 110° from Tagai Lake, where cross-fibre with a length up to 1/4 inch occurs in veins 2 to 3 feet long, widely distributed for 1/2 mile across the width of a peridotite body; and (4) at a point 6 miles on a bearing 280° from Baldy Hughes Mountain (about 25 miles southwest of Prince George), where fibre 1/16 long was observed.

J.O. Wheeler commenced the geological mapping of Rogers Pass (Illecillewaet) (82 N W 1/2) map-area late in 1959, and after a full field season in 1960, with the aid, part time, of a G2 helicopter, has completed preliminary coverage of most of the map-area, except the southwest corner. It is expected that another season will be required to fill in various gaps, to study critical areas, and to otherwise refine the work to 4-mile standard.

All of Glacier National Park is in the map-area. Dr. Wheeler examined Nakimu caves near Glacier, probably the largest known caves in Canada, during the field season, and his report on them has been forwarded to the National Parks Branch of the Department of Northern Affairs and National Resources.

Rogers Pass map-area straddles the Rocky Mountain Trench. The Rockies, to the northeast, are underlain principally by Lower Cambrian quartzite, Middle and Upper Cambrian limestone and dolomite, and Upper Cambrian and Lower Ordovician slate, dolomite, and limestone. Mount Wilson quartzite and Upper Devonian carbonate beds outcrop here and there, mainly along the Continental Divide. The formations have been deformed into folds whose axes are more or less parallel with the Rocky Mountain Trench and whose axial planes, with a few exceptions, dip west to vertical. The rocks are also broken by several west-dipping thrust and normal faults. A major fault, which brings undivided Cambrian limestone onto both Lower and Upper Cambrian units, extends from the northwest corner of the map-area southeast past the northeast ridge of Mount Laussedat, just east of the map-area.

The eastern half of the Dogtooth Mountains[1], southwest of the Trench, is underlain by Lower Cambrian limestone, slate, and quartzite and by slates and quartzites of the Horsethief Creek Series. These formations are broken by normal and west-dipping thrust faults, which are parallel with the Rocky Mountain Trench, and by northeast-trending tear faults. Folds trend northwest. The western part of the Dogtooth Mountains, and the northernmost Purcell Mountains, are composed almost entirely of Horsethief Creek rocks, which are deformed into tight, northwest-trending folds that are generally overturned to the northeast.

The Selkirk Mountains, lying west and northwest of the Dogtooth Mountains, comprise mainly sedimentary and metamorphic rocks of the Horsethief Creek series: quartzite, slate, and minor greenstone of the Hamill series; Badshot limestone; and slate, limestone, and quartzite of the Lardeau series. These formations are intruded by the Adamant

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

Range and Battle Range granitic batholiths. Northwest of the mouth of Mountain Creek, rocks apparently belonging to the Horsethief Creek series are metamorphosed to garnet-, staurolite-, and kyanite-bearing schists. Northwest of the mouth of Bush River, formations east of the Rocky Mountain Trench are similarly metamorphosed over a width up to 3 miles.[1]

Structures trend north-northwest in the southern Selkirk Mountains, but trend about northwest north of Mountain Creek. East of a line through Glacier and Mount Sir Sanford the structure is characterized by folds overturned to the northeast and by west-dipping thrust faults. West of this line folds and faults dip in the opposite direction. West of Tangier River the formations plunge steeply and do not conform to the regional northwest trend.

North of the mouth of Bush River the Trench is less than a mile wide and is apparently underlain by a fault zone that separates siliceous metamorphic rocks of the Selkirk Mountains from metamorphosed limestones and quartzites of the Rocky Mountains.

BRITISH COLUMBIA AND ALBERTA

D.K. Norris spent five weeks in the field, and concluded investigations of various critical geological features in and near Blairmore (82 G/9 W 1/2), Beehive Mountain (82 J/2 E 1/2), Carbondale River (82 G/8 W 1/2), and Livingstone River (82 J/1 W 1/2) map-areas in order to obtain structural and stratigraphic data required for finalizing reports on these map-areas, on the Kootenay and Rocky Mountain formations, and on specific structures associated with the Laramide deformation.

Overturned and refolded panels of Mesozoic rocks at the head of Carbondale River and immediately east of the High Rock Range were restudied in order to shed some light on the mechanics of deformation of these incompetent rocks in sub-Lewis thrust structures. This work will result in some revision of Map 14-1958.[2]

The mechanical behaviour of rocks in the stratigraphic interval between the top of the Fernie group and the lower part of the Blairmore group is believed to have been a controlling factor in thrust and fold mechanics in the southern Cordillera. Accordingly, the geometry of small scale structures on Grassy Mountain north of Blairmore, involving rocks of this stratigraphic interval, was studied in detail.

Additional data on remanent magnetism, from samples collected during 1960, sustains the preliminary conclusion[3] that the orientation of the horizontal component of magnetic factors is the same

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

[2] Norris, D.K.: Beehive Mountain, Alberta and British Columbia; Geol. Surv., Canada, Paper 58-5 (1958)

[3] Lord, C.S.: Field Work, 1959; Geol. Surv., Canada, Information Circular No. 3, p. 19 (1960)

at common stratigraphic levels in the Lewis thrust plate in the Flathead and Clarke Ranges, and hence that the rocks of the plate near North Kootenay Pass underwent little if any differential rotation in a horizontal plane during thrust faulting.

R.A. Price continued, from 1958 and 1959, and completed the reconnaissance geological investigation of Fernie East Half (82 G E 1/2) map-area. Field work was confined mainly to 82 G/10, 82 G/15, and part of 82 G/1.

Southwesterly dipping normal faults along the west side of Loop Ridge and Ericson Ridge offset thrust faults and mark the northward extension, to the 50th parallel, of the zone of normal faulting, which includes the prominent Flathead fault.[1]

Reef-like dolomitic masses, which are in part highly porous, occur in the upper part of the Fairholme group at several localities in the northern part of the Flathead Range, and at Windsor Mountain in the Clark Range.

Coarse, indurated mid-Tertiary conglomerates and/or fanglomerates in the northwest quarter of 82 G/1 were found to be derived from the upthrown side of the Flathead fault, deposited along the downthrown side, and later tilted in response to continued movement along the fault. These relations imply that the fault was active during Eocene-Oligocene time. On the other hand, no evidence of significant late Pleistocene movement was noted.

A.M. Stalker completed the study and mapping of the surficial deposits of Fernie East Half (82 G E 1/2) map-area. He had mapped the southern 60 per cent of the area in 1959.

An unglaciated area in the Porcupine Hills has been completely outlined. The lower limit of this area at the south end of the hills is at elevation 5,400, whereas at the north end it is at elevation 5,600. These elevation differences are believed to be due to the gradient of the Laurentide ice sheet at its maximum.

The western boundary of the Laurentide ice has now been traced throughout the length of the map-area, and four distinct Cordilleran (?) tills have been recognized.

Dr. Stalker also commenced, in 1960, the study and mapping of the surficial deposits of the Lethbridge East Half (82 H E 1/2) map-area, Alberta. He completed about half of this map-area, comprising a central east-west strip, and river sections beyond this.

Much time was spent in till studies (orientation studies and stone counts) required to establish the correlation (or otherwise) of the numerous till outcrops. At least seven tills are present, but much

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[1] Price, R.A.: Flathead, British Columbia and Alberta; Geol. Surv., Canada, Map 1-1959 (1959)

more work is required to complete correlations and thereby fix the number and sequence of the tills.

About 50 square miles in the extreme southwest corner of the Lethbridge East Half map-area was not glaciated.

During the field season Dr. Stalker visited Waterton and Banff National Parks in connection with the National Parks geological interpretive program.

ALBERTA

E. W. Mountjoy continued the geological study and mapping of Mount Robson Southeast Quarter (83 E SE 1/4) map-area, a project commenced in 1959, and in 1960 worked in the southwest quarter of 83 E/8, all of 83 E/1 except the southwest quarter, and in the northeast quarter of 83 E/2. Field work in about 60 per cent of the map-area is now complete.

All of the 1960 field work was within Jasper National Park. Most of the area examined is underlain by Cambrian, Devonian, and Carboniferous sediments. Middle Cambrian and Upper Cambrian strata are 2, 600 and 3, 000 feet thick respectively, in the mountain range between Chetamon Mountain and The Rajah. The unfossiliferous carbonate unit that occurs beneath the Devonian in the de Smet range and Ancient Wall is lithologically identical to parts of the thick Upper Cambrian sequence that outcrops farther southwest. Thus, presumably, the carbonate unit is likewise of Upper Cambrian age. The south edge of the Ancient Wall Devonian "reef" complex is on the east ridges of Mt. Haultain and in the valley southeast of The Rajah.

Gypsum occurs locally in the Triassic Whitehorse formation between Mt. Stornoway and the Snake Indian River.

The northern extension of the Pyramid thrust occ[illegible]ar the head of the south fork of the Snake Indian River. There, abo[illegible]500 feet of the Precambrian Hector formation overlie the thrust and underlie the Lower Cambrian Gog formation. Immediately beneath the fault are Lower Ordovician strata.

Amoeboceras sp., together with *Buchia concentrica* (Sowerby), was found at two localities near Snake Indian Falls in Upper Fernie (Jurassic) strata, about 100 feet above the top of the Green Beds. This fossil was previously unknown from the Fernie group and suggests an upper Oxfordian age for these and adjacent strata.

ALBERTA AND SASKATCHEWAN

L.P. Tremblay started and completed the geological study and mapping of the unmapped Precambrian rocks within Bitumont (74 E) map-area, Alberta, and within Clearwater (74 F) and Frobisher Lake (74 C) map-areas, Saskatchewan. This amounted to the study and mapping of approximately the northeast quarter of Bitumont, the west half of Clearwater, and the northeast half of Frobisher Lake.

In Bitumont (74 E) map-area, outcrops are numerous within an area extending northwesterly from Johnson Lake to the north boundary of the map-area, but are rare elsewhere. The outcrop area is underlain by granite accompanied by pegmatite, and by coarse granitic gneisses, some of which are rich in biotite.

Athabasca sandstone, although poorly exposed, presumably underlies the Clearwater West Half (74 F W 1/2) map-area north of latitude 57° 45'. The rest of the map-area has few outcrops except that part east of longitude 109° 15'. Outcrops are mainly granitic gneiss, which is almost devoid of mafic minerals, and minor amounts of quartzite.

In Frobisher Lake (74 C) map-area outcrops are common, and consist mainly of fine-grained quartz feldspar biotite gneiss and coarse-grained granite. A few outcrops of gabbroic or anorthositic rocks occur along Clearwater River east of longitude 109° 00'. Outcrops along this part of the river are, however, so widely scattered that the extent of the gabbroic and anorthositic rocks could not be determined with certainty. They may represent the southwesterly extension of a belt of similar rocks mapped by Sproule in Clearwater East Half map-area.[1]

The post-Precambrian strata do not outcrop near the assumed southwestern edge of the Precambrian Shield within these three map-areas. Thus the edge of the Shield was defined only approximately.

SASKATCHEWAN

E. Hall concluded a reconnaissance ground-water survey, commenced by him in 1958, of the 11,500 square miles of Saskatchewan lying within the Souris River watershed. The purpose of the project is to bring up to date, and to supplement, the Survey's 1935 ground-water inventory of that region.

Five new automatic water level records were installed to bring the total to seven within the Souris River basin. These have been located so as to provide water level information on the various types of aquifers within the area.

Water levels were measured at the beginning and end of the field season. These indicate that water levels in wells in unconsolidated deposits are, in general, higher than during 1958 and 1959. Water levels in bedrock aquifers indicate the same trend, but to a much smaller degree.

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1 Sproule, J.C.: Upper Clearwater River, Northern Saskatchewan; Geol. Surv., Canada, Map 578A (1941)

Five test wells were drilled by the Public Works Department on behalf of the Geological Survey and under the direction of Mr. Hall. One, near Bienfait, was drilled through approximately 200 feet of the Ravenscrag formation to provide stratigraphic information and furnish a well in which changes of water level in the bedrock can be recorded. Another, approximately 10 miles north of Estevan, was drilled into the buried pre-Glacial Missouri River channel and encountered a 21-foot thick aquifer below a depth of 347 feet. During development this well was pumped at the rate of 85 imperial gallons a minute, with a drawdown of approximately 40 feet. Two holes adjacent to this well were required to complete a profile across the buried channel, and another was drilled near Frobisher, Saskatchewan, to obtain information on the easterly extension of the same channel.

J.S. Scott completed his studies and mapping of the surficial deposits of Elbow (72 O) map-area as for publication on a scale of 1 inch to 4 miles.

The surficial deposits include: (1) till, which rests on bedrock; (2) proglacial sand, silt, and clay, which are confined to the lowland areas, where they overlie the till; and (3) extensive deposits of aeolian modified sand and fluviatile deposits. Evidence was found for only one major ice advance. The contour of the bedrock surface will be interpreted from available drill hole data as a means of evaluating the ground-water potential of the map-area.

A.M. Toth commenced, in 1959, a ground-water survey of Saskatoon South Half (73 B S 1/2) map-area, and of a narrow strip of the northern part of Elbow (73 O) map-area from which ground-water inventory data had not been collected previously. The results of the 1959 work have been incorporated in the recently published Paper 60-25[1], describing the ground-water resources of the Rural Municipality of Cory. The survey was continued during 1960 and field work completed within somewhat more than the southern half of the project area.

Various buried glacial and pre-glacial channels were identified from water well inventory data and from electrologs. These channels are potential sources of large supplies of ground water from depths ranging from 300 to 400 feet. Their courses are reflected by slight depressions in the present land surface and, because railway tracks have been so located as to follow the favourable grades afforded by these depressions, the tracks in most cases follow the buried valleys.

D.R.E. Whitmore, on behalf of the National Advisory Committee on Geological Research in Canada, undertook the coordination and technical direction of a comprehensive cooperative study of the copper-bearing Coronation Mine of Hudson Bay Mining and Smelting Company.

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[1] Toth, A.M.: Ground-water Resources of the Rural Municipality of Cory (No. 344), Saskatchewan; Geol. Surv., Canada, Paper 60-25 (1960)

Field work started in May, shortly after the first mine production.

As the head of a Geological Survey field party Dr. Whitmore started the preparation of a surface geological map, on a field scale of 1 inch to 400 feet, of an area extending from the Palaeozoic escarpment just south of Coronation Mine, north to the Birch Lake Mine. The map-area measures about 8 miles from north to south, and about 4 miles from east to west; and is bounded by latitudes 54° 34' and 54° 42', and by longitudes 101° 57' and 102° 03'. The southern third of the area was mapped in 1960. Areas close to the mine, and underground, were mapped on scales of 1 inch to 100 feet, and 1 inch to 20 feet. Drill core available from the initial exploration program was re-logged.

Organizations participating in the project, in addition to the Hudson Bay Mining and Smelting Company, and the Geological Survey of Canada, include the Saskatchewan Research Council, National Research Council, University of Saskatchewan, University of Manitoba, University f Western Ontario, Queen's University, Canadian Aero Service Limited, d the Surveys and Mapping Branch of the Department of Mines and chnical Surveys.

Studies by participating agencies include, or are expected to include: a gravimetric survey; magnetic, electromagnetic, and scintillometer surveys; heat flow; remanent magnetism of ore and wall rocks; partition ratios of certain trace elements; Co, Ni, Zn, Cu, and Cd content of pyrite and pyrrhotite from orebody and wall rocks; petrography and trace element content of the Coronation granodiorite; temperatures of formation of sulphide bodies, using pyrrhotite and pyrrhotite-sphalerite geothermometers; modal analysis of polished sections of a systematic suite of samples from the orebodies; and metal distribution within the mine, as determined from mine assay data.

The field phase of the project is expected to be completed by late 1963.

MANITOBA

C.K. Bell revised and completed the geological mapping of Cross Lake (63 I) map-area, commenced by H.C. Horwood[1] in 1933 and 1934. The generalized results of Horwood's work are incorporated in Map 850A.[2]

Three bodies of meta-volcanic rocks were mapped as the Hayes River group. The first extends east from Cross Lake, through Butterfly Lake, along the Echimamish and Hayes Rivers, to Max Lake.

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[1] Horwood, H.C.: Granitization in the Cross Lake Region, Manitoba; Royal Soc. Canada, Sec. IV, 1936, pp. 99-117

[2] Geological Map of Manitoba; Bureau of Geology and Topography, Canada, Map 850A (1946)

The second follows the Carrot River to Oxford Lake, and continues east to the Oxford-Knee Lake area. The third and minor mass extends southwest along the north shore of Cross Lake to Cross Lake Settlement. The group consists of massive andesites, sheared pillow lavas, chlorite schists, amphibolites and minor agglomerate, ignimbrites and tuffs. Sediments varying from coarse conglomerates and pebble conglomerates to grits, arkoses, greywackes, and argillites accompany the Hayes River group at Cross Lake. These volcanic and sedimentary rocks grade into granite gneiss, which ranges in composition from granite, through granodiorite, to tonalite, and underlies most of the map-area. In places mafic segregations comprise 15 per cent of the gneiss and were probably derived from included volcanic and sedimentary rocks. Minor bodies of massive pink leucogranite, leucoaplite, and pegmatite are scattered through the gneissic, volcanic, and sedimentary rocks. Peridotite, serpentinite, gabbro, and diorite are associated with the volcanic rocks on Carrot River and west of Pipestone Lake. Anorthosite and labradorite-hornblende porphyry occur scattered within an area bounded by Hairy and Butterfly Lakes on the east and by the south shore of Pipestone Lake on the west. Rare north-trending diabase dykes intrude all the above rocks.

A small zone of slightly silicified chrysotile asbestos occurs within a serpentinite mass on the Carrot River. This occurrence, because of its small size, is of mineralogical interest only.

J.E. Charron made a ground-water survey of that part of the Red River Basin within Townships 7 to 12, Ranges 1 to 5, West of Principal Meridian. The area is immediately north of that he studied in 1959, and lies between Winnipeg and Portage La Prairie. Bedrock does not outcrop.

About 80 per cent of the area lacks any known source of potable water from surficial or bedrock sources.

Information from about 1,100 water wells will be used to prepare a preliminary map outlining: (1) unconfined sand aquifers, overlying Lake Agassiz clay, wherein potable water is likely to occur at depths of less than 25 feet; (2) sand and gravel aquifers, accompanying till and underlying Lake Agassiz clay, from which boreholes are likely to result in non-flowing artesian wells of potable water at depths ranging from 90 to 175 feet; and (3) a bedrock aquifer likely to afford non-flowing artesian wells of potable water at depths of 40 to 80 feet. A minor bedrock aquifer in the southeast corner of the area will provide flowing saline artesian wells from depths of 190 feet or more.

K.L. Currie commenced and concluded the geological study and mapping of Whiskey Jack Lake (64 K) map-area. Much of the southeast half of the map-area, and the extreme northwest corner, is almost devoid of outcrops. About 70 per cent of the remainder is underlain by massive to gneissic granitic rocks; and 30 per cent by gneisses and schists, some or all of which may have been derived from sedimentary and volcanic formations. A belt of sheared and faulted rocks, several miles wide, extends at least 60 miles northeast from Zangeza Bay of Reindeer Lake.

ONTARIO

Late in 1958 the Government of Ontario agreed to share with the Government of Canada, under the Federal "Roads to Resources" Plan, the cost of constructing various roads intended to aid in the development of the natural resources of Ontario. Before consideration could be given to extending this agreement to include the construction of a road or roads north from such points as Red Lake, Uchi Lake, Pickle Lake, and Nakina, it was apparent that extensive geological and related surveys were needed to assess the mineral potential of Northwestern Ontario.

An agreement reached in the spring of 1959 between the Ontario Department of Mines and the Federal Department of Mines and Technical Surveys called for geological surveys of 48,000 square miles by the Geological Survey of Canada, comprising the following 1° by 2° map-areas: 53 A,B,C; 52 N,O,P; 42 M; and 43 D. It also called for an aeromagnetic survey of 60,000 square miles, to be completed by late 1960, comprising the above map-areas together with the north halves of 52 I, J, K and 42 L. The Ontario government was to provide 75 per cent of the cost of the aeromagnetic survey, including preparation of maps, the Federal government would provide the rest of the costs.

The aeromagnetic maps have now been published, and an initial geological mapping project, by J.A. Donaldson, of Trout Lake (52 N) map-area was completed in 1959 and the results published in 1960.[1] Donaldson's work served as a pilot project to provide logistic and operational data required to plan the ground surveys of the remaining seven map-areas. Four map-areas were completed in 1960, as follows: North Spirit Lake (53 C), North Caribou Lake (53 B), Lake St. Joseph (52 O), and Miminiska (52 P). Three remain to be completed in 1961.

S. Duffell, in 1960, acted as co-ordinator of the Roads to Resources project. He was responsible for inter-Divisional and inter-party planning, co-ordination, and cooperation, and for common services including air transportation. Survey staff from the Regional Geology, Economic Geology, and Geophysics Divisions worked on the project under Dr. Duffell's direction. The combined field operations involved, in addition to air crews, about 48 men, eight of whom were from the Survey staff. The project was supported by a Beaver and Piper Super Cub aircraft throughout the season, and a Model G1 Bell helicopter for two weeks at the close of the season.

The field program in 1960 encompassed bedrock and surficial geology mapping, geochemical studies, and geophysical studies of magnetic anomalies. It included the following personnel, whose field work results are included elsewhere in this report: C.A. Carruthers, J.A. Donaldson, R.F. Emslie, and G.D. Jackson, bedrock mapping; V.K. Prest, surficial geology; R.H.C. Holman, geochemical studies;

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1 Donaldson, J.A.: Trout Lake, Kenora District, Ontario; Geol. Surv., Canada, Map 58-1959 (1960)

and A.S. MacLaren, aeromagnetic interpretion. The use of the Piper Super Cub for hopping from small lake to small lake and observing outcrops from the air enabled far greater map coverage than would have been otherwise possible.

A summary account of the 1959, 1960, and projected 1961 phases of the Roads to Resources project has been published.[1]

C.A. Carruthers, working as a party chief in the Roads to Resources project under the direction of Dr. Duffell, commenced and completed the geological mapping of North Caribou Lake (53 B) map-area in northwestern Ontario.

Field work resulted in the extension of a belt of sedimentary and volcanic rocks, originally mapped by Satterly[2], southeasterly from Zeemel Lake to the east border of the map-area at Forester Lake. Another belt of mainly volcanic rocks was outlined for about 19 miles east from Sasiginaga Lake, with a maximum known width of about 3 miles. Sedimentary and volcanic rocks trend southwesterly from Zeemel Lake through Libert Lake, beyond which they grade into a southwesterly-trending belt of paragneiss and orthogneiss.

Several ultrabasic bodies not previously known occur within or close to the belt of sedimentary and volcanic rocks outlined by Satterly in the North Caribou Lake area. The largest of these is about 3 miles long and several hundred feet wide.

J.A. Donaldson commenced and completed the reconnaissance mapping of North Spirit Lake (53 C) map-area in northwestern Ontario, as part of the Roads to Resources project. Groundwork was supplemented by Piper Super Cub traverses in a two week period and by helicopter traverses in a four day period.

Bedrock is well exposed except that outcrops are widely scattered southeast of MacDowell River. About 20 per cent of the map-area has been described in four Ontario Department of Mines reports.[3] Checking of some of the sedimentary and volcanic bodies mentioned in these reports did not extend their boundaries significantly, and the precise stratigraphic sequence of the sedimentary and volcanic rocks is not clear in most places.

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1 Lord, C.S.: Careful Planning Plots "Roads to Resources"; Northern Miner, Nov. 24, 1960, pp. 11 and 15

2 Satterly, J.: Geology of the Windigo-North Caribou Lakes Area; Ont. Dept. Mines, Vol. 48, pt. 9, 1939

3 Bateman, J.D.: North Spirit Lake; Ont. Dept. Mines, Vol. 47, pt. 7, 1938

Hurst, M.E.: Favourable Lake and Sandy Lake; Ont. Dept. Mines, Vol. 38 pt. 2, 1929

Satterly, J.: Sandy Lake; Ont. Dept. Mines, Vol. 47, pt. 7, 1938

Windigo North Caribou Lakes; Ont. Dept. Mines, Vol. 48, Most of the rest of the map-area is underlain by porphyritic granodiorite, massive white leucocratic granodiorite, massive pink leucocratic granite, or gneissic quartz diorite to quartz monzonite, each of which forms a practical field map unit. Serpentinite outcrops along the northeast arm of Hornby Lakes, and small bodies of diorite and gabbro are abundant.

R.F. Emslie commenced and completed the reconnaissance mapping of Lake St. Joseph (52 O) map-area in northwestern Ontario, as part of the Roads to Resources project. Groundwork was supplemented by nine days flying ("puddle-jumping") with a Super Piper Cub to fill in the granitoid areas.

Some revision was made of the geology in the southeast corner of the map-area, as published by Dyer.[1] Greenstones were found to be widespread along and near the Savant Lake - Pickle Crow Road between Albany River and Dona Lake. Previously known sedimentary and volcanic belts were somewhat extended, and the intervening granitoid areas were mapped and subdivided into the following field units: undivided granitic rocks; regionally foliated granites, granodiorites, and quartz diorites; massive granites and granodiorites; and porphyritic varieties of the latter two units.

G.D. Jackson commenced and completed the reconnaissance mapping of Miminiska (52 P) map-area in northwestern Ontario, as part of the Roads to Resources project. Groundwork was supplemented by about ten days flying with a Piper Super Cub, mainly in areas of sparse granitic outcrops.

As a result of the 1960 field work, the Keezhik Lake greenstone belt is now believed to extend northwesterly to within about 3 miles of the junction of Trading River and Otoskwin River. Several previously unknown bodies of anorthosite and gabbroic anorthosite were mapped between the prominent easterly arm of Shabuskwia Lake and Kilbarry Lake. The largest of these may be 3 miles long and 1/2 mile wide.

K.R. Dawson commenced, as one phase of the Survey's investigation of granitic rocks of Canada, a detailed and comprehensive study of the Anstruther batholith.[2] The object of the project is to provide a detailed description of the intrusion and its geological environment, and to explain how, when, and why these features were developed.

Mapping of the batholith and immediately adjacent rocks, on a field scale of 1 inch to 1/2 mile, was started within an area bounded by latitudes 44°43' and 44°56', and longitudes 78°06' and 78°25' (parts

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[1] Dyer, W.E.: Pashkokogan-Misehkow Area, District of Thunder Bay, Ontario; Ont. Dept. Mines, Map 42E (1933)

[2] Hewitt, D.F.: Haliburton-Bancroft Area, Province of Ontario; Ont. Dept. Mines, Map No. 1957B (1957)

of 31 D NE). About 162 samples and specimens were collected for geochemical, petrographic, magnetic susceptibility, specific gravity, and other laboratory studies now proceeding.

M.J. Frarey completed the geological study and mapping of Wakwekobi (41 J/6) and Dean Lake (41 J/3) map-areas. The north-half of Wakwekobi map-area was mapped in 1959, and the results published as Map 3-1960.[1]

The southern part of the project-area, mapped in 1960, is crossed by the Murray fault, which trends about west-northwesterly through the mid point of the south boundary of Wakwekobi map-area. North of this fault are mainly strata of the Gowganda formation, and diabase bodies. South of the fault the map-areas are underlain mainly by granitic pre-Huronian basement rocks, and by diabase.

Within areas underlain by Gowganda strata, formations of the Bruce group are exposed here and there due to repetition caused by faulting. Diabasic intrusions probably mask a number of faults. In the southwest corner of the project-area, the Thessalon greenstone, shown on former Geological Survey maps as diabase (Map 155A)[2], or as Keweenawan lava (Map 1969)[3], was found to consist of basaltic and rhyolitic flows apparently conformably above basal beds of the Bruce group. Strata of the Bruce group occur in the north channel of Lake Huron about 5 1/2 miles off shore on the Grant group of islands. These islands were uncoloured on Map 1063A[4], and were shown as Palaeozoic on Map 155A.[2]

N.R. Gadd completed the mapping and field study of the surficial deposits within a triangular area on the Ontario side of the Ottawa River, including the Chalk River Research Establishment of Atomic Energy of Canada Limited. The area mapped is bounded on the west by the main transmission line that extends south from the Des Joachims dam, on the south by the "Old Achray Road" and the Petawawa River, and on the east by the Ottawa River.

Only one period of glaciation was recognized. The ice moved southerly or southwesterly, except that in its waning stages movement was influenced locally by major valleys so that the youngest striations near the Ottawa River trend southeasterly, about parallel to the river.

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1 Frarey, M.J.: Wakwekobi Lake, Algoma District, Ontario; Geol. Surv., Canada, Map 3-1960 (1960)

2 Lake Huron Sheet, Ontario; Geol. Surv., Canada, Map 155A, (3rd Edn) (1933)

3 Collins, W.H.: Bruce Mines, Algoma District, Ontario; Geol. Surv., Canada, Map 1969 (1925)

4 Sudbury; Sudbury, Algoma, Timiskaming, Nipissing, Manitoulin and Parry Sound Districts, Ontario; Geol. Surv., Canada, Map 1063A (1958)

A glacial moraine of gravel and boulders in the southeast corner of the map-area now forms a chain of islands and linear shoals that extends easterly, from Indian Point at Camp Petawawa, across the Ottawa River. This moraine acted as a dam, and a small glacial lake formed on its upstream side in the Ottawa Valley. Sediments deposited in this lake are found chiefly in the vicinity of Deep River. On complete deglaciation of the map-area, water levels rose and overtopped the morainal dam. Sediments, chiefly sand, then accumulated in the Ottawa basin. These deposits, up to about 110 feet thick, now form the Petawawa Plain. They were deposited in part by glacial meltwaters from the north, and in part from waters that drained the glacial Great Lakes easterly through the Fossmill Channel (Petawawa River) into the Ottawa Valley. Distinctive gravels of this channel interfinger with the above sediments of the Petawawa Plain near the mouth of the Petawawa River. This suggests that the glacial Great Lakes were being drained through the Fossmill Channel at a time when the Ottawa Valley was deeply inundated, possibly by the Champlain Sea.

Terraces, and other evidences of wave action on an esker near Meilleurs Bay, suggest that the map-area was inundated to a maximum elevation of about 600 feet above present sea-level. A few fragments of marine shells in sands of the above terraces suggest that the inundation was by marine water, presumably of the Champlain Sea.

Dr. Gadd also obtained, from time to time during 1960, stratigraphic data pertinent to the geological study and mapping of the surficial geology of the Ottawa (31 G/5) map-area. This project was started in 1956, but progress has been delayed by a higher priority commitment in the Chalk River area. One full field season should complete the field phase of the Ottawa area project.

R.E. Hay, a seasonal employee studying for his Ph.D. degree at McGill University, continued, under the supervision of M.J. Frarey, the investigation of Sault Ste. Marie (41 K/9) map-area. It is anticipated that this project will afford data for Mr. Hay's doctorate thesis, and an appropriate geological map and report for publication by the Geological Survey.

R.H.C. Holman commenced two simultaneous investigations in 1960: (1) reconnaissance geochemical sampling of bedrock within 52 O, P and 53 B, C, with the cooperation of the bedrock parties in these four map-areas; and (2) detailed geochemical sampling of bedrock within and adjacent to five greenstone belts in the Lake St. Joseph (52 O) map-area. These geochemical studies form part of the Roads to Resources project in northwestern Ontario.

Some 4,900 samples were collected during reconnaissance bedrock traverses of Messrs Donaldson, Carruthers, Emslie, and Jackson, and about 2,100 detailed samples were collected by seasonal employee G.A. Reilly and three assistants in the greenstone belts of the Lake St. Joseph (52 O) map-area. Samples were shipped to Ottawa for treatment and for analysis for copper and zinc (some analyses for arsenic were also prepared). The results of these analyses are being plotted on transparencies on a scale of 1 inch to 4 miles, one transparency for each metal for each of four 4-mile map-area.

Preliminary contouring of the copper and zinc transparencies show orderly variations and a contour pattern comparable to that obtained previously in Nova Scotia in similar studies.[1] The significance of these variations remains to be evaluated with the aid of bedrock and magnetic data, and by comparison with similar plots and variations for other elements yet to be determined.

B.A. Liberty, in 1959, commenced the geological study and mapping of the Palaeozoic strata of southeastern Ontario lying south of the Canadian Shield and between longitude 78° 30' and the Frontenac Axis. The preliminary results of the 1959 field work (longitude 78° 30' - 77° 30') were published recently as Paper 60-14.[2]

During the 1960 field season this work was continued easterly, and mapping completed within Wellington (30 N/14), Belleville (31 C/3), and the western third of Tweed (31 C/6) map-area. All geological units mapped in 1959 (Paper 60-14) were traced easterly across the territory mapped in 1960. Glacial features indicate that the last ice movement in Belleville and Wellington map-areas was westerly (about 280 degrees), out of the Lake Ontario depression.

A.S. MacLaren, prior to the 1960 field season, outlined anomalies on available aeromagnetic maps and interpreted their meaning for personnel conducting reconnaissance bedrock mapping for the Roads to Resources project in northwestern Ontario.

Dr. MacLaren spent most of the field season in North Caribou Lake (53 B) and Lake St. Joseph (52 O) map-areas, but spent some time in each of North Spirit Lake (53 C) and Trout Lake (52 N) map-areas. Field work involved (1) checking interpretation of selected anomalies on available maps and mapping the geology of some of these in detail, and (2) measuring magnetic susceptibilities.

The object of the field work was (1) to learn more about the interpretation of magnetic maps in general, and (2) to gain experience with the interpretation of magnetic maps of this area, thereby facilitating later interpretation of magnetic maps of North Spirit Lake (53 C), Trout Lake (52 N), and Miminiska (52 P) map-areas, and particularly those of

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[1] Holman, R.H.C.: Geochemical Maps Showing Distribution of Copper, Lead, Zinc, and Combined Metals in Northern Mainland Nova Scotia; Geol. Surv., Canada, Maps 25-1959, 26-1959, 27-1959, and 33-1959 (1959)

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

three map-areas (53 A, 43 D, and 42 M) required for the 1961 ground geology program. Extensive overburden in three areas scheduled for 1961 renders great the need for an adequate interpretation of the magnetic maps.

Magnetic susceptibility measurements on various rock types (perhaps 50 to 100 on ten rock types) showed susceptibility to vary from place to place in individual rock bodies, and from place to to place within different bodies of similar rock. Thus magnetic susceptibility is not diagnostic of the rock type, and not a reliable factor in interpreting magnetic maps.

A more or less circular "Jackpine Lake structure", at the northwest corner of Lake St. Joseph map-area, is the surface expression of folded and intruded gneissic rocks, and is not a crater as was suggested in the press[1] and on television last April.

E. Mirynech, in 1958 and 1959, commenced and completed the study and mapping of the surficial deposits of Trenton (31 C/4) and Presqu'ile (30 N/13) map-areas as for publication on a scale of 1 inch to 1 mile. In 1960 he commenced a similar investigation of Kingston (31 C SW) map-area (which includes the Trenton and Presqu'ile map-areas) for publication on a scale of 1 inch to 2 miles, and by the end of the field season had nearly completed field work in Campbellford (31 C/5) map-area.

The field work has refined the boundaries of glacial Lake Iroquois as outlined by Coleman[2] and confirmed his contention that the Lake extended into what is now Rice Lake. Current work indicates that it extended at least as far west as the mouth of Indian River, and possibly to the mouth of Otonabee River.

V.K. Prest, during the 1960 field season, examined surficial features within Trout Lake (52 N), Lake St. Joseph (52 O), Miminiska (52 P), North Spirit Lake (53 C), and North Caribou Lake (53 B), as part of the Roads to Resources project in northwestern Ontario. The features had been selected by means of an air photo interpretation made by P.A. Carr during the winter of 1959-60, and from day to day progress accounts from the 1960 bedrock field parties. Dr. Prest thus acted as Pleistocene coordinator for all data forthcoming from this project.

A revised version of the extent of Lake Agassiz in this region is needed as a result of the 1960 field work.

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1 "Giant Crater Discovered", Ottawa Journal, Apr. 9, 1960

2 Coleman, A.P.: Lake Iroquois; Ont. Dept. Mines, Map No. 45 f (1936)

S.R. Sopher, a graduate geology student from Carleton University, spent part of the field season obtaining oriented samples of the Sudbury irruptive and associated rocks; and the remainder of the season studying their palaeomagnetic characteristics. The study is continuing in the Survey laboratories and is expected to provide material for a Master's thesis and for an appropriate Survey report. About 240 samples were collected, mainly from the norite and micropegmatite. The object of the study is to obtain information, by palaeomagnetic methods, concerning the structural history of the Sudbury Basin. Preliminary results suggest that the norite and micropegmatite were folded to their present basin-like form after consolidation.

J. Terasmae and R.J. Mott concluded a study of stratigraphic palynology in Ontario. The project is expected to result in the correlation of late- and post-glacial events of the Great Lakes, James Bay Lowlands, and Ottawa and St. Lawrence valley regions. Other field work included an examination of the surficial geology at the proposed Ontario Hydro dam sites on Mattagami River. This aided in the identification, required for engineering purposes, of surficial materials encountered in test borings.

QUEBEC

G.D. Hobson spent part of the field season in Vaudreuil East Half (31 G/8 E 1/2) map-area, Quebec, where he used conventional seismic instruments and the refraction method to outline an elongated depression or channel in bedrock, some 1 to 2 miles wide, now filled with sand overlain by clay, and extending west-southwesterly from near Belle Plage to the vicinity of St. Clet. (See also J.J.L. Tremblay below.)

J.J.L. Tremblay completed a groundwater survey of Vaudreuil East Half (31 G/8 E 1/2) map-area. The main aquifers were found to be: (1) the Ordovician March formation of dolomitic limestone that in many places immediately underlies the surficial deposits; and (2) sand, which lies in depressions in bedrock, and is overlain and confined by clay.

It is anticipated that the forthcoming report will include: (1) piezometric contours of the March formation; (2) limits and piezometric contours of the sand aquifer; and (3) a contour map of the bedrock surface, compiled from drill hole and seismic data.

An elongate depression or channel in bedrock, some 1 to 2 miles wide, now filled with sand overlain by clay, extends west-southwesterly from near Belle Plage to the vicinity of St. Clet. Boreholes drilled through the clay to sand anywhere within this channel are likely to provide abundant good quality water by artesian flow.

QUEBEC AND LABRADOR

W.F. Fahrig spent about a month in the field familiarizing himself with the field work of J.M. Harrison and the late J.E. Howell on a detailed section of the Labrador Trough northeasterly through Schefferville. This project, started by J.M. Harrison in 1950, consisted of a detailed study of the structure and stratigraphy of a strip of ground extending northeasterly from the western boundary of the Labrador Trough through what is now Schefferville to Attikamagen Lake. The results of this study were compiled on a field scale of 1 inch to 500 feet. About six party-seasons were devoted to the project, the last field work being by J.E. Howell in 1954. Dr. Howell was drowned late that field season, and the project was inactive until the spring of 1960. Dr. Fahrig is now engaged in the preparation of a final report and map incorporating the results of the field work of Drs. Harrison and Howell.

I.M. Stevenson spent about five weeks of the summer preparing for Operation Leaf River, a helicopter-supported geological reconnaissance expected to map the following areas in 1961: 24 D, E, L, and M; and 34 A, H, I, and P. It is also anticipated that the following map-areas will be mapped immediately prior to, or following, Operation Leaf River in 1961, or as a part of an Operation to succeed Leaf River: 23 C, 23 G W 1/2, and 23 J W 1/2. These latter three map-areas are unmapped areas lying between the ground mapped by Operation Fort George, and areas in the vicinity of the Labrador Trough mapped by conventional ground methods.

Seven camp sites in the Operation area were selected during a reconnaissance with a Cessna 180 aircraft, and a Canso aircraft, operating out of Fort Chimo, was used to cache aviation gas in the Operation area.

Several reconnaissance flights were made over the Operation area, and landings made here and there for a cursory examination of the rocks. With the exception of a narrow strip of Trough-type rocks along the extreme eastern border of the Operation area, the entire area appears to be underlain by gneisses, schists, and related granitic rocks. Several specimens of granitic rock were obtained for age determination. A few boulders of quartzite and greenstone were observed in the drift at one or two localities suggesting that such rocks may occur in places in the Operation area.

H.R. Wynne-Edwards, of the Department of Geology, Queen's University, was employed by the Geological Survey for the field season and completed the geological study and mapping of Ossokmanuan (23 H W 1/2) map-area. This project area includes the southeastern end of the Labrador Trough as shown on the geological map of Canada (Map 1045 A).

QUEBEC AND NEW BRUNSWICK

G. Pirie, a graduate geology student now at the University of Indiana, commenced, under the supervision of R. Boyle, a study of the geochemistry and other features of the sediments of Chaleur Bay and its tributary rivers. The purpose of the project, intended to afford data for a Ph.D. thesis and a Geological Survey report, is to determine the factors governing the distribution of such trace elements as copper, lead, and zinc within sediments deposited in fresh, brackish, and marine waters. Outcrop samples, and samples of river, shore, and marine bay sediments were collected from Port Daniel Bay, Bonaventure Inlet, Cascapedia Bay, Carleton Bay, Nouvelle Bay, and Restigouche River, and rivers tributary to these features. Laboratory studies, and probably field work, will be required before a report is warranted.

NEW BRUNSWICK

R.W. Boyle continued his geochemical study of the mineral deposits and associated sediments of the Bathurst-Newcastle base metal district, New Brunswick. The field work required for one phase of this project was completed, and included: (1) the study, sampling, and mapping of Brunswick No. 6 orebody and vicinity on a scale of 1 inch to 100 feet, and the preparation of plans and sections showing the distribution of lead, zinc, copper, and silver within the orebody; (2) the study, mapping, and sampling of Bathurst (Drummond) Iron Mines and vicinity, likewise on a scale of 1 inch to 100 feet; (3) similar work within an area of 86 square miles centered on these deposits, on a scale of 1 inch to 1,000 feet; and (4) a geochemical and geological study of gossans.

P.A. Carr commenced and completed a ground-water survey of Moncton West Half (21 I/2 W 1/2) and Hillsborough West Half (21 H/15 W 1/2) map-areas. Bedrock is the principal ground-water source in these two areas. The Boss Point formation as outlined by Gussow[1] was found to be an excellent aquifer. It underlies the extreme southeast corner of Moncton West Half map-area, and much of Hillsborough West Half map-area.

Salt water intrusion is probable if overpumping occurs in the various bedrock aquifers adjacent to the Petitcodiac River near Moncton. These areas of possible encroachment will be described and outlined in the ground-water resources report being prepared.

H.A. Lee completed studies of the surficial geology of outstanding parts of Andover (21 J/12), Florenceville (21 J/5), and Woodstock (21 J/4) map-areas and commenced and completed studies of the surficial geology of Canterbury (21 G/14) map-area. This completes the 1-mile mapping of the surficial deposits along the St. John River between Edmunston and Fredericton.

[1] Gussow, W.C.: Carboniferous Stratigraphy and Structural Geology of New Brunswick, Canada; Bull. Am. Assoc. Petrol. Geol., Vol. 37, pp. 1713-1816, 1953

A. Y. Smith, a seasonal employee studying for his doctor's degree at Carleton University, Ottawa, continued, under the supervision of R. W. Boyle, a geochemical reconnaissance of that part of New Brunswick bounded by the Bay of Fundy, the Petitcodiac River, New Brunswick Highway No. 30 to its junction with New Brunswick Highway No. 9, New Brunswick Highway No. 9 to its junction with the St. John River, thence downstream to the city of Saint John.

The results of the first year's field work on this project (1959), indicating the lead, zinc, copper, and total heavy metal content of samples of stream sediments, have been published.[1] During 1960 the geochemical reconnaissance was continued so as to complete field work within Alma (21 H/10), Hillsborough (21 H/15), and Moncton (21 I/2) map-areas. The sampling program was expanded to include stream sediments, outcrops, and stream and spring waters. Metal determinations were made in the field in a new, specially designed, trailer geochemical laboratory. A preliminary report on this 1960 work is not warranted at this time.

In addition, Mr. Smith completed his examination and sampling of "red-bed" copper deposits of southeastern New Brunswick and adjacent Nova Scotia. The data obtained are expected to provide the basis for a Ph.D. thesis at Carleton University, and for an appropriate publication by the Geological Survey.

W.H. Poole, in 1959, mapped Doaktown West Half (McNamee) (21 J/9 W 1/2) map-area and the eastern one-third of Hayesville (21 J/10) map-area.[2] In 1960 he completed the project by mapping the western two-thirds of Hayesville map-area. The 1960 work resulted in substantial revisions of the previous geological map of most of Hayesville map-area.[3]

The western and northwestern edge of the Hayesville (21 J/10) map-area is underlain by foliated granites and minor gneiss, both of which are probably oder than Devonian. The granites intruded Ordovician strata that border them on the southeast. Foliation and gneissosity in the granites and gneiss trend northeast to east. Strongly foliated red granites and mylonite were found along the strong, east-trending lineament 1/2 mile north of the map-area.

The geology of the southeast part of Hayesville map-area has been published on Map 19-1960.[2]

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[1] Smith, A.Y.: Heavy-Metal (Zn, Pb, Cu) Content of Stream Sediments of Part of Westmoreland County, New Brunswick; Geol. Surv., Canada, Paper 59-12 (1960)

[2] Poole, W.H.: Hayesville and McNamee Map-areas, York, Northumberland, and Carleton Counties, New Brunswick; Geol. Surv., Canada, Paper 60-15 (1960)

[3] Young, G.A.: Burnthill Brook Map-area, New Brunswick; Geol. Surv., Canada, Sum. Rept. 1917, pt. F, pp. 1-15 (1918)

A central belt that trends northeasterly through the centre of the map-area, and which lies between the foliated granite and gneiss in the northwest corner and previously mapped[1] strata in the southeast corner, is underlain by Ordovician sedimentary and volcanic rocks and numerous granitic intrusions.

The Ordovician sedimentary and volcanic rocks trend northeasterly and appear to be extensions of the rocks associated with the mineral deposits of the Bathurst-Newcastle area to the northeast. Two major map-units were outlined. One consists of quartzite and argillaceous rocks ranging from argillite to spotted argillite and schist or hornfels near granite contacts. The other map-unit contains a variety of rocks, of which graded greywacke and argillite, generally as hornfels, are dominant. Greenstone and a few definite flows are common; chert, andesite, and rhyolite tuff and breccia are less common.

Several bodies of Devonian (?) granite cut Ordovician strata of the above northeasterly trending belt. Six small and younger (?) bodies of buff-weathering granites are interspersed amongst these massive intrusions and contain small occurrences of molybdenite, fluorite, beryl, and wolframite. Some of these bodies have horizontal to gently dipping upper contacts. An area for some 12 miles northeast and east of Burnt Hill Tungsten mine may be underlain at depth by similar granite. Near and at the mine, the above minerals, and many others, occur in northwesterly-trending quartz veins cutting quartzite and spotted argillite and hornfels. A quartz vein several inches wide, with molybdenite, was found cutting quartzite and spotted hornfels on the western tributary of Sisters Brook.

NOVA SCOTIA

D.G. Benson mapped the western half of Hopewell (11 E/7) map-area. The principal geological features trend easterly and are much as would be expected from a perusal of the geological map of the Truro map-area[2] immediately to the west.

The oldest rocks, found in the southeast corner of the map-area, are greenish grey sericitic slate and schistose quartzite of the Meguma group. They are intruded by Devonian light grey muscovite granite.

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1 Poole, W.H.: Hayesville and McNamee Map-areas, York, Northumberland and Carleton Counties, New Brunswick; Geol. Surv., Canada, Paper 60-15 (1960)

2 Stevenson, I.M.: Truro, Colchester, Hants, and Pictou Counties, Nova Scotia; Geol. Surv., Canada, Map 1058A (1958)

Lower Mississippian rocks of the Horton group underlie about half the map-area and occupy a central, easterly trending belt. The principal rock types outlined are, from oldest to youngest: (1) medium to dark grey siltstone and fine-grained sandstone; (2) light to dark grey conglomerate and coarse-grained sandstone; and (3) red mudstone and siltstone, and grey quartz-rich sandstone and conglomerate. Detailed mapping of well exposed Horton rocks showed the structure to be very complex.

Lower Windsor rocks outcrop in the southern part of the map-area, and overlie both Horton and Meguma strata. They are mainly anhydrite and gypsum with some black fragmental limestone and dark grey, red, and green calcareous shale and mudstone.

Canso rocks of Upper Mississippian age underlie the northeast corner of the map-area, and are bounded on the west and south by a fault, the trace of which is convex towards the southwest. They are greenish-grey and purple argillite and mudstone with minor silty shale and siltstone. Veinlets of specularite are common.

Faults that trend easterly across the map-area separate strata of the lower Pennsylvanian Riversdale group from Horton formations on the south, and from Canso and Cumberland and/or Pictou rocks on the north. The Riversdale rocks include grey silty shale, carbonaceous shale, and laminated sandstone.

The youngest rocks, found in the northwest corner of the map-area, are light grey and brownish grey, fine- and medium-grained sandstone, minor red conglomerate, and black shale of the Cumberland and/or Pictou (Pennsylvanian) group.

D.G. Kelley commenced the revision of the previous geological maps of Cheticamp (11 K/11)[1], Margaree (11 K/6)[1], and Lake Ainslie (11 K/3)[2] map-areas, western Cape Breton Island. The entire field season was spent in Lake Ainslie map-area, and it is expected that another field season will suffice to complete the revision of all three map-areas.

Rocks of the Horton group (unit 6, Map 282A)[2], which underlie much of Lake Ainslie map-area, were subdivided into two map-units. The upper unit consists mainly of red and grey sandstone, siltstone, shale, and minor limestone and conglomerate. This assemblage

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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 Sheet, Inverness County, Nova Scotia; Geol. Surv., Canada, Map 282A (1933)

is correlated with units 4a and 4b of Map 17-1957.[1] The lower unit consists mainly of grit, conglomeratic sandstone, and conglomerate, but includes lesser amounts of the above fine-grained rocks. This lower assemblage is correlated with units 4c and 4d of Map 17-1957.

The volcanic and sedimentary rocks shown on the east half of Map 282A (unit 5a) are of either Lower Carboniferous or Upper Devonian age. This revised age is inferred from their stratigraphic position, and from the presence in them of plant fragments near the base of the section on Cooper Brook. It is hoped that samples collected from these strata will yield spores that will permit a more precise statement as to age.

Very small amounts of disseminated galena are common in the basal Windsor limestone throughout the map-area. Galena and sphalerite were noted on the north branch of a small brook where it cuts across the small outlier of Windsor strata (unit 7, Map 282A) about 1/2 mile southeast of the settlement of Lake Ainslie (East-side). The minerals are in basal Windsor limestone strata. These strata stand nearly vertical, and outcrop in the bank of the brook across a stratigraphic thickness of about 10 feet. Parts of the outcrop are concealed by drift, but exposed parts are well mineralized. A selected sample, assayed by the Geological Survey, contained: lead, 5.44 per cent; and zinc, 2.14 per cent.

E. Schiller, a graduate student now at the University of Utah, completed the geological study and mapping of Guysborough (11 F/5) map-area. The project is expected to provide data for Mr. Schiller's doctorate thesis, and appropriate maps and reports for publication by the Geological Survey.

F.C. Taylor, in 1960, completed field work in Shelburne (21 O, P) map-area, a project he had started in 1959. He then commenced work in Eastport East Half (21 B E 1/2) and Annapolis West Half (21 A W 1/2) map-areas, and completed field work in the western one-third of this new project area.

Slates, biotite quartzites, and andalusite schists of the Meguma group of Lower Ordovician age underlie most of the Shelburne (21 O, P) map-area. In the Yarmouth district, these rocks are overlain by the White Rock formation of quartzite and slate. These rocks are, in turn, overlain by tuffs, andesite flows, and metamorphosed volcanic rocks that occupy the core of a syncline that extends north-northeast from Yarmouth Harbour. Devonian granite intruded all rock types throughout the map-area, and in places has converted biotite quartzites to garnet-biotite-feldspar-quartz gneisses.

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[1] Kelley, D.G.: Whycocomagh, Inverness County, Cape Breton Island, Nova Scotia; Geol. Surv., Canada, Map 17-1957 (1957)

The sedimentary rocks are, so far as known, devoid of fossils. Primary structures suitable for determinations of tops are rare. Outcrops are scarce, except along the coast.

A pegmatite dyke, 2,500 feet southeast of Brazil Lake crossroads near the northwest corner of Shelburne map-area, contains spodumene and beryl. The dyke strikes about north 40 degrees east. It is at least 16 feet thick and exposed for 70 feet along the strike. The outcrop contains about 11 per cent spodumene and about 0.5 per cent beryl. Pegmatite float along the Brazil Lake - Pleasant Valley road suggests that the dyke extends northward to that road or beyond.

In Eastport East Half (21 B E 1/2) map-area, and the mapped western third of Annapolis West Half (21 A W 1/2) map-area the Meguma group biotite quartzite and slate predominate. Near Cape St. Mary, the White Rock formation, and overlying volcanic rocks, occupy a syncline and extend north-northeasterly inland for about 4 miles.

PRINCE EDWARD ISLAND

R.F. Black collected nearly 250 samples of red Carboniferous sandstone from widely distributed localities throughout Prince Edward Island for palaeomagnetic studies. A few other samples were obtained for the same purpose from similar rocks on Cape Tormentine, and from an olivine diabase dyke on the Island. Laboratory studies under way are expected to define the position of the palaeomagnetic pole at the time of deposition of these strata, and thus to give an indication of their age. Work done to date has afforded no evidence that the strata sampled are of more than one general age.

G.H. Crowl, Chairman, Department of Geology and Geography, Ohio Wesleyan University, was employed in Ottawa where he compiled and completed manuscripts for preliminary maps and reports incorporating the results of past years' field studies of the bedrock and surficial geology of Mount Stewart (11 L/7) and Souris (11 L/8) map-areas. In addition, a brief visit was made to the field to obtain critical data required to finalize these manuscripts.

L. Frankel, assistant professor of geology at the University of Connecticut, Storrs, Connecticut, as a seasonal employee, commenced and completed the geological study and mapping of the bedrock and surficial deposits of Rustico East Half (11 L/6 E 1/2) map-area.

NEWFOUNDLAND

F.D. Anderson commenced the geological study and mapping of Paradise (1 M E 1/2) map-area, a task that includes the reconciliation, refinement, and incorporation of two nearly contiguous maps[1, 2] of the northern part of the map-area.

Quartz sericite schist and chlorite schist on Dunn River about 3 1/2 miles southeast of the Burin Road bridge contain about 10 per cent finely disseminated pyrite across a width of about 2, 000 feet. This mineralized zone probably strikes northeasterly.

E.P. Henderson commenced a study of the elevated marine shoreline and associated shore deposits of the coast of Newfoundland from White Bay to Trinity Bay, and on Burin Peninsula. Field work for the gap in this stretch of coast line — Avalon Peninsula — was completed by Dr. Henderson in 1959.[3]

In 1960 studies were made of elevated marine shorelines and associated shore deposits along the eastern and northeastern Newfoundland coasts from the Isthmus of Avalon to the vicinity of Lewisporte on Notre Dame Bay. Elevations of topographic features of constructional and destructional origin formed during the period of higher water levels of the post-glacial seas were measured. These features included wave-cut and wave-built terraces, beaches, bars, spits, tombolas, shore cliffs, and shallow water gravel, sand and silt deposits. Particular attention was paid to forms that may have originated immediately after deglaciation of their sites and hence indicate a maximum stand against the land of the late glacial seas. Some of the largest constructional forms, however, appear to have been built of outwash of somewhat later origin when a late readvance of ice in the interior of the island brought outwash to the coast along some of the larger stream valleys. Elevations of the highest shore features were found to increase progressively from about 30 feet above the sea at the Isthmus of Avalon, to over 150 feet above the water on the east side of Notre Dame Bay.

The more massive stratified gravel deposits form much of the sparse agricultural land adjacent to many Newfoundland communities. They are also good sources of potable water. Many provide large reserves of gravel and sand suitable for constructing and maintaining roads, for paving, and for other building and engineering purposes.

The distribution and character of the deposits assist in interpreting the sequence of events during late Pleistocene and Recent times. Stratigraphical relationships suggest that a considerable readvance of the ice from the interior of the island took place late in Pleistocene

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[1] Rose, E.R.: Geology of the Area Between Bonavista, Trinity, and Placentia Bays, Eastern Newfoundland; Geol. Surv., Newfoundland; Bull. 32, Pt. II, (1948)

[2] Bradley, D.A.: Gisborne Lake and Terrenceville Map-areas, Newfoundland; Geol. Surv., Canada, Memoir 321 (in press)

[3] Henderson, E.P.: Surficial Geology, St. John's, Newfoundland; Geol. Surv., Canada, Map 35-1959 (1960)

time to reach the coast in at least one place.

Four miles northwest of Glovertown, in a kame terrace along the south slope of Northwest Brook valley, is a large unexploited deposit of gravel and sand. The terrace extends westward for 2 1/2 miles from the end of the northwest arm of Alexander Bay to where Northwest Brook has cut through the stratified deposits. West of that stream the formation continues a further 3 miles to the Trans Canada Highway as a wide, flat-topped ridge. The ridge appears to be composed largely of sands representing deltaic materials accumulated in Alexander Bay when that body of water stood some 100 feet higher than at present and extended as an arm of the sea westward from its present position into the depression now occupied by Gambo Pond. It is interrupted by knolls, probably kames, that appear to contain coarser materials than the surrounding flats. A large pit where the Trans Canada Highway intersects the ridge exposes thick sands (with only minor gravels) that are suitable for asphalt pavement or concrete. These sands are being utilized in the current paving program for the Trans Canada Highway. The gravels of the ridge and kame terrace east of the highway are of potential value for maintaining the secondary gravel roads in the Glovertown area, for an access road could easily be constructed over the flat deltaic deposits to remove material from the gravelly knolls near the highway, or to tap the apparently large reserves of gravel in the kame terrace 3 miles to the east.

W.A. Nash, under the direction of E.R.W. Neale, mapped previously unstudied parts of Sandy Lake East Half (12 H E 1/2) map-area as for publication on the scale of 1 inch to 4 miles. Maps of much of the eastern half of this map-area, on the scale of 1 inch to 1 mile, have been published by the Geological Survey.

Rocks of all periods from Precambrian to Pennsylvanian are represented in the map-area. The 1960 work shows that the Fleur de Lys group of pre-Ordovician (Precambrian?) age outcrops on the east side of White Bay and extends southwestward to Birchy Lake and Sandy Lake, where it may be cut off by a fault. Southwesternmost exposures of this group are highly granitized. This group is bounded on the east by a belt of serpentinized ultrabasic bodies that extends from Baie Verte to Birchy Lake. East of the ultrabasic belt, a sequence of Silurian (?) clastic sediments and basic to silicic volcanics, previously recognized near Mic Mac Lake[1], was traced southward to Sheffield Lake from where it extends southwestward along the southeast shore of Birchy Lake. South of Sheffield Lake the entire southwest corner of the map-area is underlain by hornblende granite.

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

The main ultrabasic belt contains the Baie Verte asbestos deposit of Advocate Mines Limited and several other asbestos prospects. West of this main belt, within the granitic gneisses of Fleur de Lys group, a newly discovered body of altered ultrabasic rock 4 miles long extends from near the southwest end of Birchy Lake northward towards the Trans Canada Highway. A single outcrop of serpentinite along a brook that flows northwestward into the outlet of Birchy Lake may be either part of this body or a southwestward extension of the main belt. Both these new occurrences merit prospecting for asbestos and chromite.

GENERAL

D.M. Baird, Head of the Department of Geology, University of Ottawa, commenced 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 Fundy, Prince Edward Island, Yoho, and Jasper National Parks.

E.M. Cameron spent about six weeks in the field as part of his investigations into the geochemistry of sandstones of Western Canada.

Samples of the Lower Cretaceous Blairmore group of the Alberta Foothills, and its equivalents of the Plains, were taken at close intervals from two outcrop sections and from the cores of seven wells. The outcrop sections are at Mill Creek near Pincher Creek, and at Sheep River, west of Turner Valley. The wells sampled comprise Imperial Battle Lake No. 1 on the west, AHCE Elk Point No. 3 on the east near the east boundary of Alberta, and five other more or less equally spaced intervening wells. Outcrop sections were sampled every 15 feet where practicable, cores were sampled every 5 feet where possible.

Samples have been analysed, by rapid chemical methods, for Na_2O, K_2O, and total carbonate. The barium content, by quantitative spectrograph methods, has been determined for about half the samples. The Na_2O, and $Na_2O + K_2O$ contents appear to be most diagnostic.

Preliminary results suggest the following: (1) the Upper Blairmore formation is markedly different chemically from the Lower Blairmore. This difference appears to be caused by the presence of abundant volcanic detritus in the Upper Blairmore strata. The difference is as distinct in the plains' samples as in the Foothills' samples; (2) the alkali elements can be used to correlate beds over long distances; (3) low total alkali content apparently characteristic of reservoir rocks is caused by (a) low volcanic content (low Na), and (b) low argillaceous content (low K); and (4) progressive variations in the alkali metal content of beds from one locality to another indicate progressive lithological changes and thus may be of aid in detecting certain types of stratigraphic traps.

J.A. Chamberlain continued his study of radioactive deposits of Canada. His 1960 field work included geological studies and extensive sampling at the Port Radium and Rayrock mines, District of Mackenzie; various mines in the Beaverlodge area, Saskatchewan; and the Faraday mine, Bancroft District, Ontario. It is expected that the data and material collected will permit a study of the geochemistry of the mineralized bodies and their enclosing wall rocks, and thus provide information concerning the distribution of trace elements in the vicinity of the ore deposits.

M.J. Copeland collected material for a detailed study of the microfossils (mainly ostracods) of: (1) the Middle Silurian Rochester formation of southwestern Ontario; (2) the Upper Silurian Jones Creek formation of southern New Brunswick; (3) the Lower Devonian Dalhousie formation near Dalhousie, New Brunswick; and (4) the Mesozoic clays near Shubenacadie, Nova Scotia. Material obtained from the Rochester and Dalhousie formations has afforded abundant diagnostic ostracods; that from the Jones Creek formation has not yet been processed in the laboratory. The Shubenacadie clays were found to be devoid of microfossils.

L.M. Cumming collected pre-Carboniferous fossils from a number of localities in Gaspé, Northern New Brunswick, and the island of Newfoundland, spending about a third of the field season in each of these districts.

Particularly substantial diagnostic collections were obtained from: Middle Cambrian strata of Red Island, Placentia Bay, and from Ordovician strata of Notre Dame Bay, Newfoundland; Silurian formations of South Catchers Pond, King's Point map-area, Newfoundland; and Lower Devonian strata near Murdockville, Quebec. Fossils were searched for, without success, in parts of the Tetagouche and Springdale groups, Newfoundland. Other 1960 collections will supplement previous palaeontological data now being incorporated in a manuscript for a Geological Survey Bulletin describing pre-Carboniferous faunas of northern New Brunswick.

H. Frebold spent about two months of the 1960 field season examining Jurassic sections in Colorado, Wyoming, South Dakota, and Montana; in the Rocky Mountains and Foothills of Alberta between the 49th Parallel and Edson; and in the Nelson and Salmo map-areas, British Columbia. These studies were made in the company of several geologists of the United States Geological Survey, with the object of obtaining a better understanding of the stratigraphy, palaeontology, and correlation of the Jurassic system within Canada.

The lithology and faunas of the Upper Jurassic proved to be essentially the same within the Canadian and United States areas examined. The lower Callovian Corbula munda, Gryphaea, and Grey beds in Canada are equivalent to the Rierdon formation in the United States; the Canadian Green beds, Passage beds, and the lowermost Kootenay sandstone correlate with the Swift formation in Montana. The Middle Jurassic of the United

States' western interior does not show such close similarities to the outcrops of the Middle Jurassic in western Canada, but there are close relationships to the subsurface in the plains of Alberta, Saskatchewan, and Manitoba.

As there is no Lower Jurassic in the areas visited in the United States, no comparisons with the Canadian Lower Jurassic could be made.

Dr. Frebold subsequently continued his Jurassic studies, particularly within the Blairmore (82 G/9 W 1/2) and Carbondale River (82 G/8 W 1/2) map-areas. (See also account of D.K. Norris, British Columbia and Alberta, in this report.) Faunas were found that have not previously been recognized in this part of Canada.

C.H.R. Gauthier collected more than 17 tons of rocks and minerals from which to prepare suites for sale to the public. The material was collected from numerous localities in Ontario and Quebec, and from southeastern Manitoba.

G.A. Gross, since 1957, has been engaged in a study of iron deposits of Canada, and during the 1960 field season completed field work required for an Economic Geology Series report on this subject. The 1960 studies were confined to the Labrador Trough and its southwesterly extension as far as the recently discovered iron ranges of the Siegneley River area, thus supplementing and revising his previous work[1] in these parts of Quebec and Newfoundland (Labrador).

B.A. Latour continued to collect data required to maintain an up-to-date estimate of the coal reserves of Canada, and to make such visits as seemed appropriate for liaison for contact purposes. He spent about one month in the field. He also visited provincial government agencies and operators in Saskatchewan and Alberta, and the Crowsnest area of British Columbia.

W.D. McCartney began a study of barium, fluorine, and strontium deposits of Canada, a project expected to result in the publication of an Economic Geology Series report. About 28 deposits were examined, including those near Madoc, Ontario, a group of deposits in northeastern and southeastern British Columbia, and scattered deposits in southern British Columbia and Yukon. Another field season should conclude the field phase of the project.

In northern British Columbia fluorite, barite, and calcite lacking discernible sulphides replace Middle Devonian (Ramparts)

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[1] Gross, G.A.: Iron Formations and Geology of Labrador Geosyncline; Geol. Surv., Canada, Paper 60-30 (1961)

----------- : Iron Deposits Near Ungava Bay, Quebec; Geol. Surv., Canada, Bull. 82, (in press) limestone[1] at scattered localities near the Alaska Highway from mile 397 to, and probably beyond, Liard Hot Springs. Favoured stratigraphic positions are low in the formation near either limestone breccia or buff-weathering calcareous beds, or at the top of the formation unconformably below shale. Deposits range from irregular bodies to tabular deposits that resemble beds. The barite commonly forms conspicuous white exposures, whereas fluorite in limestone is commonly faded and inconspicuous, forming dark-weathering outcrops.

D.C. McGregor completed, from 1959, collections required for an office and laboratory study of the Devonian Palaeobotany of Eastern Canada. Collections made include those from the Devonian Gaspe sandstone and equivalents, the younger Malbaie formation and the older Grande Greve and uppermost Silurian formations, all in the vicinity of Gaspe Bay and Lower Restigouche River[2, 3]; and from Devonian strata at MacAdam Lake, Cape Breton County, Nova Scotia.

Additional field work included a visit to the type section of the Ghost River formation, on the Ghost River about 7 miles east-northeast of Lake Minnewanka, Alberta. Vascular plants of undoubted Devonian age were obtained from this formation 20 feet above the top of the Arctomys formation (Upper Cambrian). Projected studies of the megaflora and microflora are expected to provide new evidence for the age of the controversial Ghost River beds. This is the only known Devonian megaflora in Canada south of the Mackenzie River basin.

R. Mulligan concluded his field study of beryllium occurrences of Canada, and will now prepare an Economic Geology Series report incorporating the results of several seasons' field work.

1960 field work included the following examinations: in the vicinity of the Cassiar batholith near the British Columbia - Yukon boundary; west of the Rocky Mountain Trench near Tete Jaune, British Columbia; Woolsey Creek, east of Revelstoke, British Columbia; Angus Creek and Lightning Creek near St. Mary Lake, Marysville, British Columbia; Bernic Lake area, east of Lac du Bonnet, Manitoba; Riviere du Poste, Maskinonge County, and Maissonneuve Mine, Berthier County, Quebec; Bellecombe and LaCorne Townships, Abitibi County, Quebec; and Cartier Township, Joliette County; Lyonne district, Roberval County; Tache, Harvey, Jonquiere, and Temagami townships in Chicoutimi County; LaCoste township in Charlebois County; Wentworth township in Argenteuil County, all in Quebec.

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[1] Williams, M.Y.: Geological Investigations Along the Alaska Highway from Fort Nelson, British Columbia to Watson Lake, Yukon; Geol. Surv., Canada, Paper 44-28 (1944)

[2] McGerrigle, H.W.: The Geology of Eastern Gaspe; Que. Dept. Mines, Geol. Rept. No. 35 (1950)

[3] McGregor, D.C.: Palaeobotanical Excursion to the Gaspe Peninsula, New Brunswick, and Northwestern Nova Scotia; Geol. Surv., Canada, Misc. Publ. No. 59, (1959)

Preliminary studies suggest that, within the Cordilleran region, beryllium is most plentiful in rocks bordering the Cassiar batholith and within those bordering the eastern flank of the Nelson batholith. Spectroscope analyses made to date of mica from beryl-bearing pegmatites from various parts of Canada have shown that not all such mica contains an anomalously high beryllium content. It is doubtful, therefore, that the beryllium content of mica in pegmatites is a reliable indicator of the presence or absence of beryl.

E.R. Rose completed his third field season studying the titanium deposits of Canada, and has commenced the preparation of an Economic Geology Series report on that topic. Ilmenite and titaniferous magnetite deposits visited in 1960 included those of Mine Centre - Bad Vermilion Lake, and Matthews (Yankee) - Newboro, in Ontario; and Havre St. Pierre - Lac Tio, Sept. Iles, St. Urbain, and Pontiac county in Quebec.

C.H. Stockwell, and other Survey officers, in 1959 obtained samples for age determination from most parts of the Canadian Shield. The ages of these rocks are required to refine current knowledge of Precambrian geochronology, and for the compilation of the Tectonic Map of Canada now well in hand under Dr. Stockwell's direction. During 1960, the latter officer collected about 90 samples for these purposes in the region between Chibougamau, Kenora, North Bay, and Hearst, thus filling in a major gap in the 1959 sampling program.

Some of the potassium-argon ages determined from the 1959 samples are listed in Paper 60-17[1], which includes all potassium-argon age measurements completed in Geological Survey laboratories to 31 December, 1959. Other results will appear in a forthcoming successor paper, to include all potassium-argon age measurements made by the Geological Survey during the calendar year 1960.

M. Tremblay, W.W. Heywood, and K.L. Currie, using two Bell helicopters as traversing aircraft, mapped most of Pembroke West Half (31 F W 1/2) map-areas as for publication on the scale of 1 inch to 4 miles. The field work was done between mid-September and early October. The main object of the project was to determine the feasibility of reconnaissance geological mapping, by helicopter traverses, of Grenville rocks. Several other senior Geological Survey officers visited the project from time to time to make independent evaluations of the method. The results of the project suggest that helicopter traverses should be considered one of the fundamental methods of geological reconnaissance in the Grenville province, but that the method must, generally, be used in appropriate combination with other methods as local conditions dictate.

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1 Lowdon, J.A.: Age Determinations by the Geological Survey of Canada, Report 1, Isotopic Ages; Geol. Surv., Canada, Paper 60-17 (1960)

G.M. Wright commenced a regional study of the geology, terrain, access, facilities, and other associated factors within and on the borders of the Grenville geological province, Ontario, Quebec, and Newfoundland (Labrador). The purpose of this study is to: (1) assess the feasibility of initiating a program of reconnaissance geological mapping in the Grenville province; and (2) make recommendations as to the various methods that might be applied. About 40 days were devoted to this project in 1960, during which time a network of road traverses were completed within that part of the Grenville province lying between the Ottawa River and the Shelter Bay - Gagnonville Railway of Quebec Cartier Mining Company.

INDEX OF FIELD OFFICERS