CANADA

DEPARTMENT OF MINES

AND

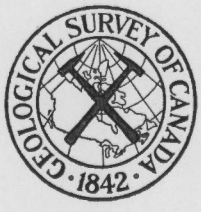
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

ANNUAL REPORT

CALENDAR YEAR 1960

FOR GEOLOGICAL SURVEY USE ONLY



OTTAWA
1961

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

ANNUAL REPORT - CALENDAR YEAR 1960

Note - The enclosed data are those submitted for the 1960 Departmental Annual Report. They have been re-arranged for ready reference, but have not been carefully edited. They are intended only for Geological Survey office use and record.

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13 June, 1961

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ANNUAL REPORT - CALENDAR YEAR 1960

GEOLOGICAL SURVEY OF CANADA

INTRODUCTION

by

J. M. Harrison, Director

Most of the resources of the Geological Survey of Canada were used in mapping and studying the geology of the country and for laboratory and office research required to interpret the field data and issue it as soon as possible in the form of comprehensive maps and reports. Equally important were the development of new instruments and techniques to expedite the work both in the field and in the laboratories, and fundamental research projects to further the science of geology.

The Survey placed 87 parties in the field in 1960, an increase of 11 parties over the previous year. Of these, 42 parties were involved in bedrock mapping, chiefly the reconnaissance mapping of remote or little-known areas, and an additional 18 parties conducted ground-water surveys and mapping of surficial deposits. The remaining 26 parties made detailed or special investigations of a geochemical, geophysical, mineralogical, or economic nature.

Field work was completed (or nearly so) on 43 of the seasons 87 projects, covering approximately 185,000 square miles. An additional 89,000 square miles were under investigation in reconnaissance projects not yet completed, as well as a considerable area in geophysical surveys, geochemical surveys, and special projects not confined to regular map-areas.

Helicopter reconnaissance operations during the past few years have been highly successful in speeding up the preliminary geological mapping of Canada. In 1960 helicopters were used on several operations. Operation Pelly, covering 21,000 square miles in the Yukon mapped to 4-mile standards, was brought to a successful completion after three years. Operation Back River utilized two helicopters and three fixed-wing aircraft to map approximately 55,000 square miles of the Arctic coastal region near Back River. On a trial basis, five field parties shared one helicopter in British Columbia, and the method proved so successful that it will be re-employed in the future. It permitted a reduction of field mapping time by 50 per cent or more, and an overall reduction of field mapping costs by 20 to 50 per cent.

As part of the Federal-Provincial 'Roads to Resources' program, personnel of the Geological Survey conducted geophysical studies of magnetic anomalies, geochemical studies, and mapped the surficial and bedrock geology of four 1° by 2° map-areas in Northern Ontario. Eight Survey geologists and 40 other field personnel, including student assistants, were involved in this aircraft-supported reconnaissance mapping operation. Approximately 25,000 square miles of terrain were mapped suitable for publication on a scale of

1 inch to 4 miles. These investigations will play an important role in planning the development of this part of Ontario.

At the end of 1960, the Survey had completed the preliminary field mapping of about three-fifths of Canada, and had published geological maps on about half. Progress towards the completion of the preliminary mapping of the entire country by about 1970 has been satisfactory as a result of the top priority assigned to this task.

Recent increases in the size of the Survey's geological staff have not only aided in speeding up the preliminary mapping of Canada, but have also played an important role in permitting a greater number of the staff to commence studies of specific fundamental geological problems. The increased number of geologists being directed into such studies is a most welcome and healthy trend.

All geological investigations are dependent upon many types of laboratory facilities, and as more geological problems are investigated heavier strain is put on the laboratory staff each year. The excellent cooperation between field and laboratory personnel in carrying out the many research projects has been most gratifying.

A major divisional reorganization of the geological Survey occurred in late 1959, which resulted in the reduction of divisions from six to five and the establishment of a Special Projects unit. Minor changes have been made within the five divisions since that time. A chart showing the organization of the Geological Survey as of January 1961 is included in this report.

Grants-in-aid totalling $50,000 were made to 13 universities in support of 29 research projects. This amount was the same as that provided in 1958 and 1959. These grants are awarded on the advice of the National Committee on Research in Geological Sciences from funds provided by parliament to the Geological Survey. Twelve of the 29 were new projects.

The determination of 157 potassium-argon ages by the Survey during 1960, most of which were on Precambrian rocks, has provided much needed data for a satisfactory account of the geological history of the Canadian Shield.

DISTRIBUTION OF PARTIES BY AREA AND FUNCTION

Province or District	Bedrock Mapping	Surficial Mapping	Ground-water Survey	Geophysics	Geochemistry	Stratigraphy and Palaeontology	Mineral Deposits Mineralogy, & Petrology	Other	Total
Franklin	2	1							3
Keewatin	1								1
Mackenzie	1		1	1	1		1	1	6
Yukon	1	1					1	1	4
British Columbia	9	1	1			2	3		16
British Columbia & Alberta	1					1			2
Alberta	2	1							3
Alberta & Saskatchewan	1								1
Saskatchewan		1	2				1		4
Manitoba	2		1						3
Ontario	4	3		2	1		1	1	12
Quebec			1						1
New Quebec & Labrador	3								3
New Brunswick	1	1	1		2				5
Nova Scotia	4								4
Prince Edward Island		1		1					2
Atlantic Provinces & Quebec					1				1
Newfoundland	2	1							3
Miscellaneous					1	5	6	2	14
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REGIONAL GEOLOGY DIVISION

L. J. Weeks, Chief

INTRODUCTION

The Regional Geology Division is responsible for geological mapping and basic research in the Appalachian, Cordilleran, and Canadian Shield physiographic provinces.

During 1960 work was carried on in connection with 141 active field projects. Of this number, 13 were commenced in 1960; 16 were completed; 11 were classified as inactive (mostly because of the resignation of the officer in charge); and 2 were discontinued. Thus 113 active field projects are carried over to 1961.

During the 1960 field season, a technical staff of 43 was allocated as follows:

office work	4
supervisory field work	3
operations	11
preparation for operations	2
correlation, etc.	3
4-mile mapping	14
1-mile mapping	6
TOTAL	43

In 1960 the scientific staff of the Division submitted 49 manuscripts for critical reading and editing. These fell in the following categories:

Preliminary maps	25
Final maps	17
Memoirs	4
Bulletins	2
Paper (without maps)	1

The detailed reports of the Regional Sections follow.

REPORTS ON SECTIONS

APPALACHIAN SECTION

E.R.W. Neale

Field Activities

During the 1960 field season, seven field parties of the Appalachian Section carried out standard geological mapping in the Atlantic Provinces. Four of these parties were engaged in mapping for publication at 1 inch to 1 mile and three parties were engaged in mapping for publication at 1 inch to 4 miles.

Distribution of parties by provinces was as follows:

Province	N.T.S. Sheet	Proj.No.	Party Chief	Scale
New Brunswick	21 J/10, 21 J/9W½	59-32	W.H. Poole	1" = 1 mi.
Nova Scotia	11 K/11, 6, 3	60-28	D.G. Kelley	1" = 1 mi.
Nova Scotia	11 E/7	60-30	D.G. Benson	1" = 1 mi.
Nova Scotia	11 F/5	59-35	E.A. Schiller	1" = 1 mi.
Nova Scotia	(20 O,P; 21 B E½, (21 A W/2	(59-34 (60-29	F.C. Taylor	1" = 4 mi.
Newfoundland	12 H E½	60-31	W.A. Nash	1" = 4 mi.
Newfoundland	1 M E½	60-32	F.D. Anderson	1" = 4 mi.

Supervisory and Office Activities

In addition, E.R.W. Neale carried out an inspection tour of four of these parties, spent approximately a month with the Nash field party in Sandy Lake East Half map-area, Newfoundland, and continued geological investigation of the King's Point area, Newfoundland.

Sixteen manuscripts were submitted through the section in 1960. These included five 1" = 1 mile preliminary maps, two 1" = 4 mile preliminary maps, 1 preliminary paper, 4 final maps at 1" = 1 mile with descriptive notes, and four memoirs. These sixteen manuscripts together with one preliminary paper submitted in 1959 have been processed and submitted to the Geological Manuscripts Unit.

Personnel

S.E. Jenness was transferred from this section to the Geological Manuscripts Unit in mid year.

D.G. Benson, a new recruit, joined the section in April.

Membership on Committees

F.D. Anderson - Equipment Committee

W.H. Poole - Legislation Committee, Professional Institute;
- Chairman, Appalachian Discussion Group

E.R.W. Neale - Absolute Age Committee;
- Chairman, Geologists Group, Professional Institute

D.G. Kelley - Council Representative, Professional Institute

Membership in Societies

	Sigma Xi	C.I.M.M.	G.S.A.	G.A.C.	M.A.C.	A.A.P.G.	S.E.P.M.
Anderson				★			
Benson							
Kelley	X			★		X	X
Neale	X	X	X	★	X		
Poole	X		X	★			
Taylor			X	★			

★ indicates Fellow
X indicates Member

Outside Publications

Benson, D.G.: Application of the Sphalerite Geothermometer to some northern New Brunswick Sulphide Deposits; Econ. Geol. vol. 55, pp. 818-826, 1960.

Jenness, S.E.: Late Pleistocene Glaciation of Eastern Newfoundland; Bull. Geol. Soc. America, vol. 71, pp. 161-180, 1960.

Neale, E.R.W. and Kelley, D.G.: Stratigraphy and Structure of Mississippian Rocks of Northern Cape Breton Island; Proc. Geol. Assoc. Canada, vol. 12, pp. 77-94, 1960.

Outside Talk

E.R.W. Neale and D.G. Kelley presented the above paper to the annual joint meeting of the C.I.M.M. and G.A.C. in April, 1960.

EASTERN SHIELD SECTION

S. Duffell

Field Activities

During the 1960 field season seven field parties carried out standard geological mapping in the Provinces of Ontario and Quebec. Five of these were for publication on a scale of 1 inch to 4 miles and two on a scale of 1 inch to 1 mile.

Distribution of parties by provinces was as follows:

Province	N.T.S. Sheet	Proj.No.	Party Chief	Scale
Ontario	53 C	59-19	J.A. Donaldson	1" = 4 mi.
Ontario	52 O	59-19	R.F. Emslie	1" = 4 mi.
Ontario	52 P	59-19	G.D. Jackson	1" = 4 mi.
Ontario	53 B	59-19	C.A. Carruthers	1" = 4 mi.
Que. & Nfld.	23 H W½	60-25	H.R. Wynne-Edwards	1" = 4 mi.
Ontario	41 L 9	59-25	R.E. Hay	1" = 1 mi.
Ontario	41 J 6 41 J 3	59-20	M.J. Frarey	1" = 1 mi.

In addition, S. Duffell acted as coordinator of the Roads to Resources Project 59-19 in N.W. Ontario. This was a combined project including staff from the Regional Geology, Economic Geology, and Geophysics Divisions. A total of 48 men were involved in the project which was supported by a Beaver and Piper Super Cub aircraft throughout the season and a model G.1 Bell Helicopter for about two weeks at the close of the season. The Piper Super Cub proved most useful in actual mapping procedures in hopping from small lake to small lake and observing outcrops from the air. The use of this aircraft enabled far greater coverage than would have been possible otherwise.

I.M. Stevenson spent the summer making field preparations, putting in gas caches and selecting camp sites for Operation Leaf River to commence in 1961. The Operation will cover parts of NTS Blocks 23, 24, and 34.

W.F. Fahrig spent a month in the Labrador Trough studying structure and stratigraphy to complete the work started by J.M. Harrison and J.E. Howell under project 49-13.

Office Activities

K.E. Eade remained in the Ottawa office during the summer to work on maps and reports resulting from Operation Fort George.

Ten manuscripts were submitted through the section during the year. These included three preliminary and two final maps and marginal notes for publication on a scale of 1 inch to 4 miles; one preliminary map and accompanying report for publication at 1 inch to 2 miles; two final and one preliminary maps with marginal notes to be published at 1 inch to 1 mile; and one memoir.

Personnel

R.F. Emslie completed his resident requirements at Northwestern University early in May and joined the staff of the Survey as a T.O. 3, occupying a Geologist 2 position later the same month.

J.A. Donaldson spent the winter season at the Survey completing his report on the Trout Lake area (52 N), as well as his thesis on the Marion Lake area of Quebec and Newfoundland (23 I/13). He successfully defended his thesis at Johns Hopkins University and was granted his Ph.D. in May. As a result he was reclassified from T.O. 3 to Geologist 2.

S.H. Kranck left the employ of the Survey in November.

Membership on Committees

K.E. Eade - Chairman, Equipment Committee, Geological Survey

W.F. Fahrig - Member, Committee on Absolute Age

S. Duffell - Executive Member, Ottawa Branch, C.I.M.M.

Membership in Societies

	G.S.A.	G.A.C.	C.I.M.M.	A.I.N.A.
Donaldson, J.A.		★		
Duffell, S.	X	★	★	
Eade, K.E.		★	X Sr.M.	
Emslie, R.F.				
Fahrig, W.F.				★
Frarey, M.J.			X Ottawa Branch	
Jackson, G.D.				
Stevenson, I.M.				

★ indicates Fellow
X indicates Member

Outside Publication

Stevenson, I.M.: Some New Occurrences of Triassic Sedimentary Rocks in Chedabucto Bay Area, Nova Scotia; Bull. Geol. Soc. America, vol. 71, pp. 1807-1808, 1960.

Outside Talks

S.H. Kranck spoke at the Annual Meeting of the C.I.M.M. in Toronto in May on the subject "Clearwater Lake, Quebec. A Tertiary Caldera".

K.E. Eade participated in the symposium on "Airborne Methods in Mapping" at the Ottawa Branch of the C.I.M.M. in February.

WESTERN SHIELD SECTION

G. M. Wright

Field Activities

W.W. Heywood, M. Tremblay, and W.L. Davison carried out field assignments (Operation Back River) in District of Keewatin; J.C. McGlynn in

District of MacKenzie; L.P. Tremblay in Saskatchewan; and C.K. Bell and K.L. Currie in Manitoba. Short reports of these projects will be found in Information Circular No. 4 at the end of this volume.

In addition, J.A. Fraser arranged for the establishment of P.O.L. caches for Operation Bathurst.

W.W. Heywood and M. Tremblay carried out a trial reconnaissance by helicopter of wooded Grenville terrain near Killaloe, Ontario, using aircraft under the same contract as for Operation Back River. As an intermediate step, these machines stopped over "en route" to assist in the clean-up of the 1960 Roads to Resources program in Northwestern Ontario.

G.M. Wright was on loan to the Eastern Canadian Shield Section for special studies in the Grenville. Mr. B.J. Keating most ably assisted in this project, but his services could only be retained until November.

Personnel

R.G. Blackadar and R.L. Christie were transferred to the Fuels and Stratigraphy Division, Arctic Islands Section.

K.L. Currie joined the staff as a Geologist Gr. 2 in May.

H.A. Quinn resigned from the Geological Survey in March, and accepted a position in industry.

G.C. Riley resigned in July to accept a teaching position at the University of Hong Kong.

M. Tremblay portrayed Pere Noel at the annual Christmas Party for children.

L.P. Tremblay checked translations of abstracts for the Geological Manuscripts Unit.

G.M. Wright attended a course on Government Administration at the Civil Defense College, Arnprior, March 20 to April 1.

Membership on Committees

J.A. Fraser - Secretary, and subsequently Vice-Chairman, Geologists Group, Professional Institute

G.C. Riley - Member, Salaries Committee, Professional Institute

G.M. Wright - Member, Committee on Absolute Age

Membership in Societies

	C.I.M.M.	G.A.C.	G.S.A.	A.I.N.A.	M.A.C.	Other
Bell, C.K.	X (Ottawa Br.)	★	X		X	G.S.
Currie, K.L.					X	E.I.C. A.P.E. (Ont.)
Davison, W.L.				X		
Fraser, J.A.	X (Ottawa Br.)					A.P.E. (Ont.)
Heywood, W.W.	X	★	X	X		
McGlynn, J.C.	X	★				
Tremblay, L.P.	X (Ottawa Br.)	★				
Tremblay, M.	X	★		X		G.S.A.A.; I.M.M.
Wright, G.M.	X (Ottawa Br.)	★		X		

★ indicates Fellow
X indicates Member

Outside Talks

C.K. Bell gave talks on the activities of the Geological Survey of Canada to the Richelieu Club of Ottawa, the Optimists Club of Ottawa, and to the Prescott High School (Vocational Guidance Day).

J.A. Fraser presented a paper on the Precambrain Geology of the Arctic Mainland to the Arctic Symposium at Calgary in January.

J.C. McGlynn spoke on the Mineral Potential of the Northwest Territories to the Western Annual Meeting, C.I.M.M., at Vancouver in October.

M. Tremblay spoke on Diamonds in South Africa to the Ottawa Valley Mineral Association, the Carleton Geological Club, and, at the National Museum, on the Wednesday evening and Saturday morning (children) programs.

G.M. Wright lectured on geological surveys in Northern Canada at Defense Research Board in March.

CORDILLERAN SECTION

H. S. Bostock

Field Activities

In the summer of 1960, nine of the scientific staff were employed on field work, one on a supervisory tour, and one in the office at Ottawa. The field work was primarily exploration study and standard mapping of 4-mile map-areas. Operation Pelly, covering 21,000 square miles, was brought to a very successful completion after three years. This year helicopter and plane were used in close coordination and 9,000 square miles were completed to 4-mile standards. In addition an air reconnaissance map was made of 5,000 square miles adjacent to the operation area on the east. Among the other seven field parties, all in British Columbia, 4 square degrees, or approximately 12,000 square miles of standard maps were completed. Progress was made on other projects as well, and another 25 square degrees or about 63,000 square miles should be completed in 1961. Five parties in British Columbia shared a single helicopter for the entire season.

Distribution of parties by provinces was as follows:

Province	N.T.S. Sheet	Proj.No.	Party Chief	Scale
Yukon	105 H,I,J,K	58-9	J.A. Roddick L.H. Green	1" = 4 mi.
B.C.	104 K,F	58-10	J.G. Souther	1" = 4 mi.
B.C.	94 L,M	57-6	H. Gabrielse	1" = 4 mi.
B.C.	93 O	59-11	J.E. Muller	1" = 4 mi.
B.C.	93 G	59-9	H.W. Tipper	1" = 4 mi.
B.C.	93 A	59-12	R.B. Campbell	1" = 4 mi.
B.C.	82 N W½	59-10	J.O. Wheeler	1" = 4 mi.
B.C.	82 G W½	56-6	G.B. Leech	1" = 4 mi.

Supervisory and Office Activities

H.S. Bostock spent parts of July and August on a supervisory tour of field parties in the Yukon and British Columbia. He visited O.L. Hughes to help acquaint him with the surficial geology and the main lode and placer mining operations of the Klondike region. He also visited Operation Pelly, the Canada Tungsten Mining Company prospect, Dr. Stuart Holland of the B.C. Department of Mines and Petroleum Resources in Victoria, and R. Fulton, who had started work on the Pleistocene geology around Kamloops. On the invitation of the Dominion Observatory, Dr. Bostock also visited the Astrophysical Observatory at White Lake.

While on leave in London, England, H.S. Bostock attended a private luncheon with the Directors of the Consolidated Zinc Corporation and also held a meeting in his office of officials of that Corporation and the Yukon Consolidated Gold Corporation. It is thought that these meetings had an influence on the subsequent appointment of a research geologist and the starting of a new vigorous exploration policy by their corporations in the Klondike region.

Dr. Little completed the compilation of the new 20-mile Geological map of British Columbia.

Twenty-four manuscripts were submitted to, and forwarded by, the section in 1960. They included: three preliminary reports and maps; five preliminary maps and notes; four memoirs; nine final maps; one bulletin; and two papers.

Personnel

W.J.P. Crawford and I.M. Sweet were retained after the summer field season as seasonal employees during the winters of 1959-60 and 1960-61 respectively. They assisted some of the field officers in sorting their specimens, indexing and studying air photographs, and in plotting data on maps from notes and air photographs. More personnel of this type could be used by the staff of the Section.

Membership on Committees

H.S. Bostock	- Canadian Board on Geographical Names
H. Gabrielse	- Secretary, Geologist Group, Professional Institute
L.H. Green	- Equipment Committee
G.B. Leech	- Committee on Absolute Age; - Committee on Exhibitions; - Committee on Research in Stable Isotopes; - Canadian Representative for the Standing Committee on Geology and Geography for the 10th Pacific Science Congress; - Chairman, Sub-Committee Student Essays, C.I.M.M.
H.W. Little	- Pay Research Committee
J.O. Wheeler	- Eastern Vice-President, Canadian Alpine Club; - Sub-Committee on Glaciology of the Associate Committee on Geodesy and Geography, N.R.C.

Membership in Societies

	R.S.C.	G.A.C.	M.A.C.	C.I.M.M.	P.D.A.	A.I.N.A.	R.C.G.S.	G.S.A.
Bostock	X	★		X	X	X		★
Campbell				X				X
Gabrielse		★	X	X				X
Green		★						
Leech	X			X			X	X
Little								X
Muller				X				X
Roddick		★		X				X
Souther								
Tipper								
Wheeler		★						X

★ indicates Fellow
X indicates Member

Outside Publications

Green, L.H., Roddick, J.A., and Wheeler, J.O.: A Geological Reconnaissance of Pelly Mountains and Vicinity, Southeastern Yukon; Can. Min. Jour., vol. 84, pp. 96-99, 1960.

Gabrielse, H.: The Genesis of Chrysotile Asbestos in the Cassiar Asbestos Deposit, Northern British Columbia; Econ. Geol., vol. 55, pp. 327-337, 1960.

Gabrielse, H., and Wheeler, J.O.: Tectonic Framework of Southern Yukon and Northeastern B.C., Canada; (Abst.) Bull. Geol. Soc. Amer., vol. 71, p. 1869, 1960.

Wheeler, J.O.: Mesozoic Tectonics of Central Southern Yukon; Proc. Geol. Assoc. Canada, vol. XI, pp. 23-43, 1959.

Outside Talks

H. Gabrielse presented a paper, co-authored by J.O. Wheeler, entitled "Tectonic Framework of Southern Yukon and Northwestern B.C." at

the Annual Meeting of the Geological Society of America at Denver in November. An expanded text of the paper is being published as a paper by the Geological Survey.

G.B. Leech presented a paper, co-authored by R.K. Wanless, on "Lead Isotope Studies of Mineral Deposits and Potassium-Argon Age Measurements of Intrusive Bodies in the East Kootenay District of British Columbia" at the Annual Western Meeting of the C.I.M.M. in Vancouver.

J.A. Roddick, J.O. Wheeler, and L.H. Green authored a paper that was presented by Roddick at the Prospectors Convention in Toronto. The paper was entitled "A Geological Reconnaissance of Pelly Mountains and Vicinity, South-eastern Yukon".

FUELS AND STRATIGRAPHY DIVISION

J. F. Caley, Chief

INTRODUCTION

The principal work of the division is to determine the succession, age, lithologic character, structure, and correlation of the sedimentary bedrock formations in Canada; to map the surface and subsurface distribution of these formations in specified areas; to carry on studies in palaeobotany, palynology, and invertebrate palaeontology; and to conduct research on the petrography and palynology of coal seams.

This work is basically research and is aimed at furnishing data and information necessary in the exploration for the fossil fuels (oil, gas, and coal) and to the assessment of the general mineral potentialities of a given region.

To facilitate this work the division is constituted as follows:

(a) Petroleum Geology Section - R.J.W. Douglas, Head.

(b) Stratigraphic Palaeontology Section - D.J. McLaren, Head.

(c) Coal Research Section - P.A. Hacquebard, Head.

(d) Arctic Islands Section - R. Thorsteinsson, Head.

(e) Western Plains Oil and Gas Office, (Calgary, Alberta) - R.T.D. Wickenden, Officer-in-Charge.

As the fossil fuels originate in, and are intimately associated with the sedimentary rocks, any addition to knowledge of the origin, constitution, age, correlation, environment of deposition, and structure of these strata will find application in the search for additional reserves.

A total of 182,835 rock cuttings from wells drilled for oil and gas were received at Ottawa and prepared for microscopic examination. These represent about 1.8 million feet of drilling comprising 809 wells distributed as follows: Alberta 561; Ontario 243; Quebec 1; New Brunswick and Nova Scotia 4. In addition about 48,000 samples, not yet prepared for examination, were received during the year.

Acknowledgement is made to the following persons and organizations through whose cooperation, information and/or drilling samples were received: W.A. Roliff, Imperial Oil Limited, for samples, cores, and general information on exploratory activity in Eastern Canada; B. Graham Rogers, Chief Officer, Geological Department of Industry and Natural Resources, Charlottetown, for general information on drilling in P.E.I.; W.D. Brittain, Chief Inspector, Department of Energy Resources, for drillers logs and samples of wells drilled in Ontario; Oil and Gas Conservation Board, Province of Alberta, for periodic drilling reports, electric logs and samples of wells drilled in Alberta; Petroleum and Natural Gas Branch, Department of Mines and Petroleum Resources, Victoria, B.C., for well samples, interim reports, and maps dealing with exploratory activity; Petroleum and Natural Gas Branch, Department of Natural Resources, Regina, for reports on drilling and production and other related information, and for well samples; Mines Branch, Department of Mines and Natural Resources, Winnipeg, for drilling reports and well samples; Quebec Department of Mines for data regarding well locations in Quebec; Nova Scotia Department of Mines for making available drilling information in Nova Scotia; New Brunswick Department of Mines for supplying drilling data in New Brunswick; and to officers of many oil companies for much useful information on oil and gas exploration in many parts of Canada.

The services of the division at Ottawa were extended to visiting geologists, engineers, and palaeontologists of several operating oil companies and institutions who examined well samples and fossils made available to them. Companies represented during the year included Trans-Canada Pipe Lines Limited, Haliburton Well Service, Welex Well Service, Rio Tinto Canadian Exploration, Blue Water Oil and Gas Limited, Union Gas Company of Canada, Limited, Imperial Oil Limited, Sun Oil Company, Leitch Gold Mines, Kennco Explorations (Canada) Limited, Shell Oil Company of Canada, Pure Oil Company, Place Gas & Oil Company, Chato Industries, Consumers Gas Company, Britalta Oil Company, El Paso Natural Gas Company, California Standard Company, Mobil Oil of Canada, and Plymouth Oil Company.

The division continued its cooperation with the Department of Northern Affairs and National Resources, by furnishing geological information and opinion on matters concerning deep drilling north of the 60th parallel, and on evaluation of possible mines and minerals on specified parcels of land. Through the Western Plains Oil and Gas Office in Calgary, the division also contributed geological data to the schedule of wells prepared by that Department.

SPECIAL PROJECTS

The following outside projects undertaken upon request were either completed or commenced during the year.

1. Contribution to the Basement Rocks project of the American Association of Petroleum Geologists. L.M. Cumming, R.D. Howie, and B.V. Sanford completed preparation of material on Eastern Canada for this project, and final submission was made to the Association early in the Autumn of 1960.

2. Coal Reserves of Canada. B.A. Latour completed a study, commenced in December 1959, of the coal reserves of Canada for submission to the Royal (Rand) Commission on Coal. This project resulted in Topical Report No. 17, Geological Survey of Canada, which was issued during the summer. Mr. Latour also prepared a special report entitled, "Estimate of Coal Reserves in the Lingen Block, Sydney, N.S." for the Commission.

   Mr. Latour also continued the work of collecting and compiling data necessary for estimating the coal reserves of Canada. About four weeks were spent in visiting mines and prospects in Saskatchewan, Alberta, and British Columbia, and all pertinent available data were obtained from that region. While in Alberta, Mr. Latour cooperated with the Supervisor of Mineral Resources, Indian Affairs Branch, Department of Citizenship and Immigration, in the evaluation of coal potentialities on the Gleichen Indian Reserve, northeast of Calgary. He also prepared memoranda and supplied information for departmental use, answered inquiries relating to Canadian coal deposits and reserves, and cooperated with the Coal Research Section on structural problems related to coal seams in Nova Scotia.

3. Subsurface Stratigraphy in Southwestern Ontario. B.V. Sanford continued his study of the subsurface stratigraphy, structure, and oil and gas possibilities of southwestern Ontario. During the year a detailed study of the Silurian system in southwestern Ontario was commenced, which should lead to a report and series of contour and isopach maps for publication under the title "Subsurface Stratigraphy of Silurian Rocks in Southwestern Ontario". Mr. Sanford determined formation tops in a large number of wells for inclusion in the Annual Report of the Ontario Fuel Board. He also spent a few weeks during the summer visiting oil and gas companies and obtaining geological information on recent discoveries beneath Lake Erie and the adjoining land area.

4. Collection of Oil and Gas Data, Maritime Provinces. R.D. Howie continued collecting, assembling, and studying all available current information on drilling and exploration for oil and gas in the Maritime Provinces. He also visited the appropriate authorities at the respective Departments of Mines of Quebec, New Brunswick, Nova Scotia, and Prince Edward Island to discuss matters of mutual concern pertaining to the exchange of drilling information. At the request of the Mines Branch, Department of Mines and Technical Surveys, geological information relative to the possibility of underground gas storage in the St. Lawrence Lowland area of Quebec was assembled and submitted.

5. Collection of Oil and Gas Data, Western Canada. B. MacLean continued collecting, compiling, and evaluating information on current developments in oil and gas exploration and production in western Canada, and the preparation of regional maps showing geographic and geological distribution of oil and gas fields, and pipe lines and refineries in the four western provinces. Progress was made on compilation of a stratigraphic penetration map of Alberta, showing location of all exploratory wells, and the deepest formation reached by each. Data on drilling and production were compiled and submitted for publication in the annual review prepared by the International Oil Scouts Association and Society of Petroleum Engineers of A.I.M.E. Toward the end of the year, Mr. MacLean commenced a continuing project designed to compile and assess geological and geophysical information contained in the large and growing number of permit reports obtained through cooperation of the Department of Northern Affairs and National Resources.

PERSONNEL

Hans Frebold was appointed Senior Research Palaeontologist and was succeeded as Head, Stratigraphic Palaeontology Section, by D.J. McLaren. This change recognizes Dr. Frebold's international reputation as a palaeontologist, geologist, and authority on the Jurassic system, and permits him to devote his entire time to these professional duties.

Miss A.E. Stafford retired after some years of service and was succeeded by Mrs. A.M. Lemoine as Clerk 3 in Stratigraphic Palaeontology. R. Shea joined the staff of the preparation laboratory of this unit in June. G.C. Taylor and B.S. Norford joined the Petroleum Geology and Stratigraphic Palaeontology Sections as geologist and palaeontologist respectively. In Calgary, C.F. Burk, R.M. Procter, and J.D. Aitken joined the staff of the Western Plains Oil and Gas office as geologists. I.M. Harris resigned from that office in September. Mrs. L. Shields and N. McCracken were transferred to the Library and Geological Cartography Unit respectively.

MEMBERSHIP ON COMMITTEES

J.F. Caley
- Representative for Eastern Canada, A.A.P.G. Basement Rocks Project, 1959-1962.
- Associate Editor, Eastern Canada, A.A.P.G. 1961-62.
- Member, Committee for Publication, A.A.P.G.
- Member, Permanent Council, World Petroleum Congresses, 1959-1964.

MEMBERSHIP IN SOCIETIES

J.F. Caley
- Fellow, Royal Society of Canada
- Fellow, Geological Society of America
- Member, American Association of Petroleum Geologists
- Fellow, Geological Association of Canada
- Fellow, Canadian Geographical Society

REPORTS ON SECTIONS AND LABORATORIES

Reports on the five Sections, as prepared by the respective Section Heads, follow. The report for the Western Plains Oil and Gas office was written by Helen R. Belyea in the absence of R.T.D. Wickenden, Officer-in-Charge.

PETROLEUM GEOLOGY SECTION

R.J.W. Douglas

Field Activities

R.L. Herr examined the cuttings from several wells drilled in the southern Foothills of Alberta. These data are basic to the interpretation of both the regional structure and the detailed structure of the oil and gas fields of the region. About a month was spent in the field examining core and stratigraphic sections exposed near the wells.

E.J.W. Irish continued geological mapping of the Halfway River (94B) map-area of northwestern British Columbia, on a scale of 1 inch to 4 miles. The Foothills, which occupy the central part of the area, were examined and stratigraphic data obtained on the Mississippian, Triassic, and Cretaceous. Folds in the Foothills belt, which are potentially productive of oil and gas from older rocks, are discontinuous, broad, flat-topped, steep-flanked anticlines and narrow, sharply crested anticlines.

B.A. Liberty continued geological mapping, on a scale of 1 inch to 4 miles, of Palaeozoic strata on the southwest flank of the Frontenac axis in southwestern Ontario. Stratigraphic information of importance to the correlation of the succession in southwestern Ontario with that of the Ottawa basin and of New York state was obtained. The region includes the classical development and type sections of many of the Ordovician formations.

E.W. Mountjoy continued mapping of the Mount Robson SE¼ map-area (83E SE¼) of Alberta on a scale of 1 inch to 4 miles. This map-area lies in the Rocky Mountain vicinity of Jasper National Park. Field work in 1960 was mainly in the central part where sediments of Cambrian, Ordovician, Devonian, and Carboniferous ages were studied, with particular attention directed to the relationship of the older formations to the pre-Devonian unconformity. Gypsum was found in the Triassic near Mt. Stornaway, and fossils were found that date part of the Fernie group as upper Oxfordian.

D.K. Norris spent five weeks investigating various initial geological features of several areas previously mapped in the Foothills of southern Alberta near Crowsnest Pass. These features have a bearing on the structural interpretation of the region.

B.R. Pelletier continued stratigraphic studies of the Triassic of northeastern British Columbia near the Alaska Highway. The Triassic rocks were found to vary in facies from near shore environments in the east to deeper water conditions of deposition in the west and to be thicker in the west as a result of divergence and presence of younger beds beneath the pre-Cretaceous unconformity.

R.A. Price completed mapping of the Fernie E/2 map-area (82 GE½) of British Columbia and Alberta, on a scale of 1 inch to 4 miles. The map-area spans the Rocky Mountains and Foothills at the International Border. The structure near recent deep drilling was studied and the zone of normal faults that cut Laramide thrusts was found to extend to the north border of

the area. Fanglomerates deposited during displacement on the normal faults indicate Eocene-Oligocene activity. Contributions to the general stratigraphy include observations on the distribution of upper Devonian reefs within the area and supervision of studies by D.C. Scott on late Palaeozoic beds.

D.F. Stott continued stratigraphic studies of the Upper Cretaceous, Smoky group, and the Lower Cretaceous Fort St. John and Bullhead groups in the Foothills and Plains of northeastern British Columbia, south of Peace River. Study of the Smoky group was completed with examination of the northwesternmost exposures of arenaceous facies of the group. The Lower Cretaceous study was extended northward to the region of the type sections of most of the formations of the Peace River region. Reconnaissance geological mapping of the region traversed was continued in northeastern 93 O and completed in Dawson Creek map-area (93 P).

G.C. Taylor commenced geological mapping of the MacDonald Creek map-area (94 K/10) of northeastern British Columbia. The area is astride the Alaska Highway and rocks ranging in age from Cretaceous to Proterozoic are present. Mineralization is associated with igneous rocks that are intrusive into the Proterozoic below the pre-Palaeozoic unconformity. The Palaeozoic stratigraphy differs from that in other regions and will constitute a readily accurate standard for the northern Rocky Mountains.

Office Activities

R.J.W. Douglas and D.K. Norris continued compilation of reports and maps of data obtained during operation Mackenzie in 1957. Completed were Virginia Falls (95F), Sibbeston Lake (95G), Camsell Bend (95J), and Root River (95K) map-areas on a scale of 1 inch to 4 miles, with accompanying reports on the stratigraphy, structure, and economic features. Two 4-mile areas (95, N and O) remain to be compiled.

Membership on Committees

Douglas, R.J.W.
- Member of Canadian National Committee, World Petroleum Congresses 1960-1963.
- Member, Library Committee
- Member, Committee on Stable Isotopes
- Member, Committee on Age Determination

Howie, R.D.
- Member, Committee on Tectonic Map of Canada

Norris, D.K.
- Advisor to Dominion Observatory on geological aspects of circular features (craters) in Canada.
- Chairman, Ottawa Section, Society for Experimental Stress Analysis.

Pelletier, B.R.
- Geological Advisor, Polar Shelf Project and Liaison Officer on Submarine Geology programs for Department of M. & T.S.
- Member, C.I.M.M. Committee for judging student essays in geology.

Membership in Societies

	GSA	AAPG	ASPG	CIMM	GAC	MBGS	RSC	Sigma Xi	Others
Taylor, G.C.	★							X	
Irish, E.J.E.		X	X	X					
Liberty, B.A.	★	X	X	X	X	X			
Mountjoy, E.W.		X	X	X					X BCPE
Pelletier, B.R.				X				X	
Price, R.A.	X		X	X				X	
Stott, D.F.	X	X	X						
Sanford, B.V.						X			
Norris, D.K.	★		X						X RASC - SESA
Douglas, R.J.W.	★		X				★		

★ indicates Fellow
X indicates Member

Outside Publications

Douglas, R.J.W. and Norris, D.K.: Stratigraphy and Structure of Upper Mackenzie River Region, N.W.T. and Yukon, Abstract, Canadian Oil and Gas Industries, April 1960.

Sanford, B.V.: Developments in Eastern Canada, Bull. Am. Assoc. Pet. Geol., vol. 44, No. 6, June 1960. (with D. Jardine and J.E.S. Milne).

Liberty, B.A.: Outliers within the area of the Canadian Shield: Their Import. Abstract, Roy. Soc. Canada, Sec. IV, p. 36, 1960.

Liberty, B.A., Millman, P.M., Clark, J.F., Willmore, P.L., and Innes, M.J.S.: The Brent Crater: Dominion Observatory Pub., vol. 24, No. 1, 1960.

Mountjoy, E.W.: Regional Structure of Rocky Mountains in Jasper Area, Canada; Abstract, Geol. Soc. Amer., vol. 71, p. 2070, 1960.

Pelletier, B.R.: Measurement of Grain Diameters in Thin Section with the use of the Strip Gauge. Carleton University, Department of Geology, Geological Paper 60-1.

Price, R.A.: The Lewis Thrust Sheet in the Southeastern Cordillera of Canada; (Abstract), Bull. Geol. Soc. Amer., vol. 71, p. 1947, 1960.

ARCTIC ISLANDS SECTION

Field Activities

R.G. Blackadar completed the reconnaissance mapping of Mingo Lake (36 A) and Macdonald Island (35 P) map-areas in Southern Baffin Island. A preliminary map was forwarded in November for publication.

R.L. Christie completed the reconnaissance mapping of southeastern Ellesmere Island from Grise Fiord RCMP post, and commenced the preparation of a map and report on this area.

Office Activities

R. Thorsteinsson carried out office duties during much of the summer of 1960, but attended the 21st International Geological Congress held in Copenhagen in August. He completed and submitted a report entitled "The History and Geology of Meighen Island", which is to be published as a G.S.C. Bulletin. He also completed the study and preparation of reports on collections of fusulinids and graptolites submitted by other members of the G.S.C. He continued the preparation of two memoirs, entitled "Banks, Victoria, and Stefansson Islands, District of Franklin, Northwest Territories" and "Western Queen Elizabeth Islands, Arctic Archipelago", both of which are co-authored by E.T. Tozer. These memoirs are expected to be submitted before May 1961.

R.G. Blackadar prepared a paper entitled "Field Methods and Logistics" for presentation at the Annual Meeting of the CIMM, completed office work and laboratory studies on a bulletin entitled "Basic Intrusive Rocks of the Queen Elizabeth Islands, the manuscript of which was submitted in November, and continued the revision of data for a memoir (to be co-authored by R.R.H. Lemon of the Royal Ontario Museum) on the Admiralty Inlet area, Baffin Island.

R.L. Christie completed the preparation of a manuscript on the geology of northern Ellesmere Island, which is expected to be published as a G.S.C. Bulletin. He also completed a structural-geological compilation map of northeastern Ellesmere Island, combining field and airphoto interpretations, and prepared notes on methods for reconnaissance and other mapping of glacier-hung Arctic mountainous regions. The performance and potential use of aircraft in such terrain was evaluated in part from experience gained during the summer of 1960 when a Piper Cub equipped with large wheels was used for field work on southeastern Ellesmere Island. A suite of specimens from Dr. Christie's 1955 traverse of the Coast Intrusive belt of British Columbia together with a brief report on the specimens were submitted to the Survey's permanent collection.

Membership on Committees

R.G. Blackadar
- Member, Equipment Committee, Geological Survey of Canada
- Member, Equipment Committee, Department of Mines and Technical Surveys
- Secretary, Arctic Circle of Ottawa
- Assistant to Editor, Arctic Circular

Membership in Societies

	G.S.A.	A.I.N.A.	R.S.C.	G.A.C.	M.A.C.
Thorsteinsson, R.	X	★	★		
Blackadar, R.G.	X	★			
Christie, R.L.				★	X

★ indicates Fellow
X indicates Member

Outside Publications

Blackadar, R.G.: Age of the Metamorphic Complex of Northernmost Ellesmere Island; Arctic, vol. 13, No. 1, pp. 51-52, 1960.

The Geological Survey of Canada in the North, Northern Affairs Bulletin, vol. 7, No. 3, pp.36-39, 1960.

Field Activities of the Geological Survey of Canada in the Canadian Arctic 1959, Arctic Circular, vol. 13, No. 1, pp. 5-8, 1960.

Precambrian Geology of the Arctic Islands, Can. Min. Jour., vol. 81, No. 4, pp. 108-110, 1960.

Outside Talks

R. Thorsteinsson read two papers at the First International Symposium on Arctic Geology held at Calgary in January, and a third paper at the Mines Minister's Conference in Quebec City in October. The papers were entitled "Lower Palaeozoic Stratigraphy of the Arctic Archipelago", "The Structural History of the Arctic Archipelago", and "Geology of Arctic Archipelago" respectively. He also served as Distinguished Lecturer for the AAPG from November 3 to December 8.

R.G. Blackadar presented two papers at the First International Symposium on Arctic Geology at Calgary in January. They were entitled "Arctic Geology -- Field Methods and Logistics", and "Precambrian Geology of Arctic Canada Part I". He also delivered a paper, entitled "Precambrian Geology of Arctic Islands" at the annual meeting of the Prospectors and Developers Association, at Toronto, in March.

STRATIGRAPHIC PALAEONTOLOGY SECTION

General

A total of 143 reports were prepared by members of the section on 1,237 separate lots of fossils submitted by Survey geologists, and by Provincial Surveys, Oil Companies, and private individuals.

Forty-three separate loans of fossil collections (exclusive of types) were made to outside workers or institutions in all parts of the world during the year. Some of these were to 15 outside experts on particular classes of fossils who are carrying out research on them specifically for the Geological Survey of Canada.

Thirty geologists from universities, oil companies, and foreign Surveys have visited the Section to examine fossil collections or to consult with one or more of the palaeontologists.

Type Collections

A total of 596 types reported in publications during 1960 were added to the Type Collections of the Survey. Publications in which these types are reported are as follows:

GSC Bull.	52	Pleistocene fossils British Columbia	19 types reported
	53	Jurassic fossils Alberta and B.C.	16
	55	Oligocene insects British Columbia	68
	59	Jurassic fossils Arctic	59
	60	Canadian Arthropoda	44
GSC Mem.	309	Permian fossils Arctic	155
	314	Mississippian fossils Nova Scotia	38
		Total	399

Outside publications

Norford, B.S. (Shell Oil Co.), Pal., vol. 3, pt. 2	1
Pedder, A.E.H. (Triad Oil Co.), Pal., vol. 3, pt. 2	20
Copeland, M.J. (GSC), Pal., vol. 3, pt. 1	21
Boucot, A.J. (MIT), J. Pal., vol. 34, No. 3	3
McCammon, H., Man. Dept. Mines Pub. 59-6	152
Total	197

Numerous type specimens of the Survey collection have been redescribed and/or refigured during the year as well, to be found not only in the publications listed above, but also in the following:

Gill, E.D., and Castor, K.E., Bull. Am. Pal., vol. 41, No. 185 (Univ. of Cincinnati).

Kesling, R.V., Contr. Mus. Pal., Univ. of Michigan, vol. 15, No. 8.

Nelson, S.J., J. Pal., vol. 34, No. 1 (Univ. of Alberta)

Palmer, A.R., U.S.G.S. Prof. Paper 334-C

Ross, J.P., J. Pal., vol. 34, No. 6 (Yale Univ.)

Types have been borrowed by 21 outside specialists, at their request.

Field and Office Activities

Dr. Hans Frebold, Senior Research Palaeontologist

1) Field Activities

Spent about two months studying the Jurassic rocks in the western interior of the United States and Western Canada and their correlation.

2) Office Projects

A. Completed 18 reports on fossils submitted for identification and age determinations. Sixteen of the 18 collections were from staff officers, 1 was from the B.C. Dept. of Mines, and 1 was from an oil company.

B. Neared completion of a study of the Lower Jurassic faunas of southern Yukon and northwestern British Columbia.

Dr. T.E. Bolton

1) Field Activities

Study of Lower to Upper Silurian rocks and faunas of the Hamilton region, southwestern Ontario.

2) Laboratory and Office Projects

A. Identification of, and reports on, 3 Silurian collections submitted by staff members.

B. Ordovician and Silurian faunas of Anticosti Island, Quebec - the commencement of a preliminary stratigraphic report for the G.S.C.

C. Study of the Silurian faunas of Ontario mainland and Manitoulin Island, a continuing project; concentrated investigation of Middle Silurian Eramosa faunas.

D. Preparation of the Lexicon of Stratigraphic Names of Canada. This project occupied much of Dr. Bolton's time during the year.

E. Curatorial duties relative to the GSC Type Collection of invertebrate fossils. A catalogue of type Pelecypoda is underway.

Dr. M.J. Copeland

1) Field Activities

Collections for microfossils were made from the following areas:

Dalhousie, N.B. (L. Devonian)
Jones Creek, N.B. (U. Silurian)
Shubenacadie, N.S. (Cretaceous ?)
Antigonish, N.S. (U. Silurian - L. Devonian)
Hamilton-Niagara Falls, Ont. (M. Silurian, Rochester shale)

2) Laboratory and Office Projects

A. Preparation of 17 microfaunal reports.

B. Disintegration of approximately 650 samples for analyses, and microscopic examination of most of these samples.

C. Acid etching of numerous samples.

D. Completion of studies of the following:
   a. some Arctic Leperditiid Ostracoda
   b. Devonian Conchostraca from Melville Island, Canadian Arctic
   c. Lower Mississippian microfaunas from Crowsnest Pass, Alberta.

E. Studies on the following were continued:
   a. Middle Ordovician Ostracoda, Lake Timiskaming, Ont.
   b. Lower Devonian Ostracoda, Dalhousie, N.B.
   c. Upper Silurian Ostracoda, Arisaig, N.S.
   d. Jurassic microfaunas, Western Canada
   e. Rochester formation Ostracoda, Southern Ontario.

Dr. L.M. Cumming

1) Field Activities

Regional study of Lower Palaeozoic palaeontology in Newfoundland, New Brunswick, and Gaspé.

2) Office Projects

A. Prepared a number of routine fossil reports on material submitted for identification.

B. With R.D. Howie, completed a map showing contours on basement rocks in eastern Canada, part of a special project sponsored by the AAPG. An outgrowth of this project involving the preparation of a report entitled "Basement Rock Features in the Canadian Appalachians" was nearly completed. Its objective is to summarize information concerning the rocks that are considered 'basement' for oil and gas exploration in the Appalachian region.

Dr. J.A. Jeletzky

1) Field Activities

A seven day collecting trip in Eastern Colorado and Western Kansas.

2) Office and Laboratory Projects

A. Prepared 4 fossil reports on 68 lots of fossils from the Cretaceous of Western Canada.

B. Continued preparation of Memoir manuscript on Mesozoic Rocks of Quatsino Sound.

C. Submitted for publication a third preliminary report on the stratigraphic results of field work on the western slopes of the Richardson Mountains.

D. Prepared and submitted a paper on the Cretaceous and Tertiary structural history of the eastern Richardson Mountains and its broad regional significance, to the First International Arctic Symposium.

E. Continued studies of the Cretaceous marine zones of the western interior of Canada (Project 107).

Dr. D.C. McGregor

1) Field Activities

A. Spent eleven weeks completing the field study of the Devonian flora of the Gaspé - Maritimes region, a project commenced in 1959. Made additional collections from the Cape Bona Ami, Grande Grève, York River, Battery Point, and Malbaie formations in the Gaspé area, as well as from the "Campbellton beds", and from the MacAdam Lake formation of Cape Breton Island.

B. Spent four days visiting a newly discovered plant locality in the type section of the Ghost River formation west of Calgary, Alberta.

C. Spent two weeks obtaining comparative material from the Early Devonian floras of Beartooth Butte, Wyoming, and Salt River Canyon, Arizona.

D. Visited the spore laboratory of Imperial Oil Limited, Calgary.

2) Office and Laboratory Projects

A. Studied and prepared 21 reports on megafossil and microfossil plants submitted.

B. Conducted routine laboratory preparations of rock specimens for the detection of presence and kind of plant microfossils on submitted samples.

C. Continued the compilation of reference slide collection and photographic record of plant microfossils of known age (Project 192).

D. Prepared a paper on a new genus and five new species of Early Devonian spores, for publication as a GSC Bulletin.

E. Commenced the description and evaluation of plant mega- and microfossils from the type section of the Ghost River formation. Megafossil specimens have been selected and submitted to the Photographic Section. Microfossils have been extracted, prepared, and photographed (Project 224).

F. Commenced a laboratory study of, and manuscript preparation on, microfossils from the Ordovician Red River formation. Microfossils have been extracted and prepared, plates are ready, and first draft of manuscript begun (Project 225).

G. Undertook a botanic (morphologic and taxonomic) study of Early Devonian floras of eastern Canada. The preliminary sorting and selection of specimens is under way, and 50 megafossil specimens have been submitted to the Photographic Section.

Dr. D.J. McLaren

1) Field Activities

Nil

2) Laboratory and Office Projects

A. Prepared 14 fossil reports on Devonian faunas from Western and Arctic Canada.

B. Continued building up the Devonian Index Collection of corals and brachiopods.

C. Continued work on a Monograph of Camarotoechiid brachiopods of the Middle and early Upper Devonian of Western Canada. The photographing of the fossils was completed and the manuscript was expected to be completed before March 1961.

D. Continued work on Upper Devonian rock nomenclature in southern Northwest Territories and northern Alberta. This project was a joint undertaking with Dr. H.R. Belyea.

E. Began work on rugose corals from Horn Plateau reef, Devonian, Northwest Territories.

Dr. B.S. Norford

1) Field Activities

Nil (joined staff of GSC August, 1960)

2) Office Projects

A. Prepared 8 palaeontological reports on material submitted by officers of the Survey and external agencies, comprising information on 261 collections.

B. Commenced the study of Late Ordovician and Silurian fauna of southern British Columbia (Project 218).

C. Commenced the study of fauna in Cirrus Mountain "Halysites" beds, Banff Park, Alberta (Project 219).

D. Neared completion of a manuscript, jointly authored with C.O. Dunbar, C.A. Ross, J.P. Ross, and John Troelsen, on the faunas and correlation of the late Palaeozoic rocks of northeast Greenland, to be submitted to Meddelelser om Gronland.

Dr. A.W. Norris

1) Field Activities

Nil

2) Laboratory and Office Projects

A. Assisted in identifying and preparing office reports on seven or more Devonian fossil collections submitted by Survey geologists.

B. Completed a final report on Middle Devonian and older Palaeozoic rocks of the Slave River map-area, Northwest Territories, field work for which was done by members of Operation Mackenzie in 1957. The report includes descriptions of rock units, faunal lists and distribution, and maps. This report was submitted for publication as a GSC memoir.

C. Commenced a preliminary compilation of data for a similar final report on the Silurian and older Palaeozoic rocks in the upper Mackenzie basin west of Mackenzie River.

D. Continued studies of the age and fauna of a late Middle Devonian reef on Horn Plateau. Photography of all the brachiopods was completed, and identifications and descriptions of the brachiopods was about two-thirds completed.

Dr. G.W. Sinclair

1) Field Activities

Spent several days examining temporary exposures or otherwise important material in the vicinity of Ottawa.

2) Office Projects

A. Examined and reported on 74 lots of submitted fossil collections from areas of Ordovician rocks in Central and Arctic Canada.

B. Continued the study of Ordovician fossils.

C. Continued preparation, with Dr. Kranck, of a report on Clearwater Lake outlier, New Quebec. This will be submitted as a GSC Bulletin.

D. Continued preparation of a bulletin on material from Adelaide Peninsula.

E. Continued preparation of a bulletin, jointly with Drs. McGregor and Fry, giving a description of stratigraphy and summary of faunas of the Cat Head formation, Manitoba.

F. Prepared a paper on principles of taxonomy and nomenclature of formational units in a region of shallow, fluctuating seas, with special reference to the Middle Ordovician of Central Ontario. An abstract of this paper was presented at the Royal Society of Canada meeting in Kingston.

Dr. E.T. Tozer

1) Field Activities

Studied Triassic faunas and biostratigraphy in northeastern British Columbia.

2) Laboratory and Office Projects

A. Prepared 11 reports on Triassic collections submitted by staff members and the B.C. Dept. of Mines.

B. Prepared papers for presentation at the First International Symposium on Arctic Geology, the AAPG Symposium on Frontier Regions in World Oil Exploration, and for an AAPG Distinguished Lecture Tour.

C. Prepared, with R. Thorsteinsson, a geological report on Banks, Victoria, and Stefansson Islands, Northwest Territories.

D. Prepared, with R. Thorsteinsson, a memoir manuscript on the western Queen Elizabeth Islands.

E. Commenced study of some ammonite faunas, new to northeastern British Columbia, which were discovered in 1960.

T.T. Uyeno

1) Field Activities

Week-end collecting from local Ordovician rocks.

2) Office and Laboratory Projects

A. Was responsible for curating and handling all fossil collections submitted to the section for identification, subsequent to their cataloguing by the preparation laboratories. Maintained records of their distribution to individual palaeontologists and supervised their return to final storage when reports are submitted.

B. Prepared a detailed cross-indexed card catalogue of all fossil reports in section files to date, showing collector, date, locality, age, and author of report.

C. Maintained records of all gifts and loans of fossil material made and received by the Section.

D. Under Dr. Sinclair's guidance commenced identification of Ordovician fossils from Gaspé collected by Dr. Sinclair. Also commenced working on local Ordovician fossils to become familiar with the main fossil groups in this region.

Dr. F.J.E. Wagner

1) Field Activities

Nil

2) Laboratory and Office Projects

A. Identified Pleistocene fossils submitted by staff members and by others, and prepared reports on them.

B. Spent most of available time on the compilation of data for the "Lexicon of Canadian Geologic Names".

C. Commenced a study of fossils collected by personnel of the Polar Continental Shelf Project.

Palaeontology Preparation Laboratory

Personnel: Mr. Botte (in charge), Mr. Callahan, Mr. Matte, Mr. Shea

Temporary helpers: Mr. Claude, Mr. Prudhomme

Following is a table outlining the services performed by the Palaeontology Preparation Laboratory during 1960.

Name	Saw Cuts	Thin Sects.	Polished Sects.	Rubber Molds	Plaster Casts	Peels.	Plaster Jackets	Disintegrates
Bell, W.A.	12	12	1	10	0	0	21	0
Bolton, T.E.	45	21	0	0	0	0	0	0
Copeland, M.J.	2	2	0	0	0	0	0	351
Frebold, H.	34	0	0	17	17	0	0	0
Jeletzky, J.A.	2	0	0	78	78	0	0	0
McGregor, D.C.	7	7	0	0	0	0	0	0
McLaren, D.J.	290	272	14	42	66	0	0	0
Norford, B.S.	95	87	0	8	8	0	0	0
Norris, A.W.	45	29	0	5	5	0	0	0
Sartenaer, P.	0	0	0	263	499	0	0	0
Sinclair, G.W.	23	22	4	5	5	0	0	0
Thorsteinsson, R.	79	31	16	0	0	0	0	0
Tozer, E.T.	1	1	0	8	8	0	16	0
Survey Geologists	215	58	1	10	10	25	5	0
Visiting Geologists	47	23	2	0	0	0	0	0
Total:	897	565	38	446	696	25	42	351

Boxes received during field season	187
Localities entered in catalogue	4515
Parcels shipped	59

Membership on Committees

Dr. Bolton
- Member, GSC Committee on Stratigraphic Nomenclature
- Member, Publications Committee, Geol. Assoc. Canada
- Assistant to Editor, Geol. Assoc. Canada
- Commissioner, Amer. Comm. on Stratigraphic Nomenclature
- North American Representative, Comite Francais de Stratigraphie
- Member, Program Committee, C.I.M.M. (Ottawa Branch)

Dr. Copeland - Member, Coal Committee, Geological Society of America

Dr. Jeletzky - Member, U.S. National Research Council Cretaceous Committee

Dr. McLaren - Member, Research Committee of Soc. Econ. Palaeontologists and mineralogists.

Membership in Societies

	AAPG	AINA	ASPG	CIMM	OT.BR.	GAC	GGS	GSA	GSF	GSL	MBGS	OAS	PA	PgA	PS	PSG	PSJ	RCGS	SSZ	SXi	GVB	BSA	ECA	RSC	DGS
Frebold	X																							X	X
Bolton				X		★					X		X		X										
Copeland	X					★		X					X		X										
Cumming				X		★							X		X			★							
Jeletzky							X	★					★		X						X				
McGregor													X		X							X	X		
McLaren	X							X		X			X		X										
Norford			X							X			X		X					X				
Sinclair								★	X	★		★			★	X	X		X						
Tozer		★						X					X	X	X										
Uyeno															X										
Wagner															X			★		X					

★ indicates Fellow
X indicates Member

Outside Publications

Bolton, T.E., and Lee, P.K.: Post-Glacial Marine Overlap of Anticosti Island, Quebec; Proc. Geol. Assoc. Canada, vol. 12.

Copeland, M.J.: Ostracoda from the Upper Silurian Stonehouse formation, Arisaig, Nova Scotia, Canada; Palaeontology, vol. 3, pp. 93-103, 1960.

Jeletzky, J.A.: Youngest Marine Rocks in Western Interior of North America and the Age of the Triceratops-beds; with Remarks on Comparable Dinosaur-bearing Beds Outside North America; Proc. XXI Intern. Geol. Congress Norden, Sect. 5, 1960, 15 pp.

The Age of the Triceratops-beds and Comparable Dinosaur-bearing Beds Outside of North America; (Abst.) Bull. Geol. Soc. America, vol. 71, pp. 1896-1897.

McGregor, D.C.: Devonian Spores from Melville Island, Canadian Arctic Archipelago; Palaeontology, vol. 3, pp. 26-44, 1960.

Norford, B.S.: A Well-Preserved Dinobolus from the Sandpile Group (Middle Silurian) of Northern British Columbia; Palaeontology, vol. 3, pp. 242-244, 1960.

COAL RESEARCH SECTION

P.A. Hacquebard

Coal Petrography

Study of Canadian Coking Coals

This study is being conducted cooperatively by the Coal Research Section and the Fuels and Mining Practice Division of the Mines Branch. The program was initiated in the fall of 1957 with a detailed examination of the Harbour seam of the Sydney coalfield and the Bellevue No. 1 seam of the Crowsnest field. The initial phase of the investigation was completed during 1960. It consisted of establishing a correlation between the petrography and the physico-chemical properties of the coals and cokes examined. The results were described in a report by Hacquebard and Tibbetts, and presented at the Twelfth Dominion-Provincial Coal Research Conference, held in Ottawa in October 1960. From this investigation it became apparent that the coking phenomena cannot be explained solely by the physico-chemical properties of the coal, but that the petrographic composition should also be considered. It provides data on individual coal particles in a coke charge, whereas the physico-chemical analyses give only information on the charge as a whole. The report suggests future testing on certain blends of Cape Breton coals in order to obtain a stronger metallurgical coke, and indicates which portion of the Bellevue No. 1 seam is most suitable for coking purposes.

As a result of this joint investigation the Mines Branch intends to erect a new pilot coke-oven plant in Ottawa, to test, on a semi-commercial scale, the blending theories that were developed in the completed part of the investigation. These tests will require close petrographic and physico-chemical control, which will constitute the second part of the research program. It is hoped that the tests will get started during 1961.

Apart from correlating the petrography with the physico-chemical properties, the regional variations in the petrographic composition of column samples of the two seams examined were studied also. For the Harbour seam this work was completed, and the results were incorporated in the report previously mentioned. For the Bellevue No. 1 seam this study is still in progress, and will be reported on by Mr. T.F. Birmingham during the first quarter of 1961.

The completed project, which was temporarily interrupted in 1959, on account of the transfer of the Section from Sydney to Ottawa, consisted of a study, by Birmingham and Hacquebard, of the following samples:

(a) From Harbour seam: 10 complete column samples (each divided into 4 or 5 divisions); 16 screen sizes obtained from Dominion Nos. 12 and 26 collieries; and 3 manually selected megascopic types.

(b) From Bellevue No. 1 seam: 6 channel samples collected for testing with the experimental laboratory coke-oven (each divided into 2 parts); 8 screen sizes; and 1 sample of mine-run coal.

Special Projects

1. Study of Facies Changes in Harbour Seam. A.R. Cameron spent the year 1960 in completing his Ph.D thesis, entitled "Some Petrological Aspects of the Harbour Seam, Sydney Coalfield, Nova Scotia". This dissertation is expected to form the basis of a Survey publication. The time was utilized in analyzing the megascopic and microscopic data, in literature research, in the drafting of approximately 30 figures, and in actual writing of the text.

   The objectives involve the application of megascopic data in the tracings of facies changes in the Harbour seam, and the development of a natural system of expressing microscopic information. This system was utilized to describe the facies changes of selected dull layers of this seam, and to interpret their mode of origin in the ancient peat bogs.

2. Reflectance Measurements of Coal. For this project T.F. Birmingham made a literature study, inquired about necessary equipment and spent one week at the Pennsylvania State University to learn more about the technique and the value of reflectance measurements.

   The project will not become operational until 1961, because of the difficulty in obtaining essential parts of the equipment. In 1961 the method will first be tested and instruments calibrated, after which it will be used in connection with rank determinations for the study of coking coals, as well as to obtain data on regional metamorphism of sedimentary rocks of terrestrial origin.

3. Exchange of Foreign Coals for Petrographic Analyses. This project was proposed by the Commonwealth Committee on Fuel Research during the Second Specialist Conference held in London (England) in 1956. No action was taken on it until 1960, when the coordinator, Mr. H.R. Brown of the Coal Research Section of C.S.I.R.O. in Sydney, Australia, got the project started.

   Its objective is to broaden the experience in coal petrography and its application, by the examination of a wider range of coals than is available in any one particular country. For this purpose each participating Commonwealth country was requested to send two to five samples of various coal seams to the Coal Section of C.S.I.R.O., which in turn would prepare and circulate polished grain mounts of these samples to the various laboratories.

   Our contribution to this project during 1960 was as follows:

1) Six samples of three Canadian coking coals, one from Cape Breton and two from the Crowsnest field, were prepared and sent to Mr. Brown. 2) Petrographic analyses of four Australian and five British coals were made by Hacquebard and Birmingham, and the results were forwarded to Mr. Brown. In December 1960 the following samples were received, on which analyses will be completed early in 1961: four coals from New Zealand, five from South Africa, and six from Canada. At present the total number of participating countries is not known.

4. Review Article on "Industrial Applications of Coal Petrography." The proposal for this article was made by the Coal Group of the G.S.A. during its 1959 annual meeting at Pittsburgh. P.A. Hacquebard was asked to act as senior author, with A.R. Cameron and J.S. Harrison, of the Illinois Survey, as co-authors. The report is to be presented during the 1961 annual meeting.

In 1960 the senior author organized a division of the literature survey necessary for this project, and he contacted various European colleagues for literature references. No great progress was made, however, which was due in part to Cameron devoting his time to the completion of his thesis, and Hacquebard devoting his time to the previously mentioned projects.

Carboniferous Palynology

Spore Investigation of the Coal Seams of the Pictou Coalfield.

M.S. Barss continued with the spore studies of this field, the scope of which became greatly enlarged during 1960. The original investigation, dealing with the vertical distribution of the spore genera throughout the stratigraphic section of this field and the correlation problem that existed between the coals of Westville and those of Stellarton, was completed in the middle of 1960. However, the new drilling activities carried out to find remaining pockets of mineable coal, require a spore study of a greatly increased number of samples. These samples were required for detailed seam correlations in order that the local structure could be better understood, thus increasing the chance of finding remaining areas of mineable coal.

During the summer of 1960, Barss and Hacquebard collected 45 additional samples in the field, to which some 30 coals were added from boreholes drilled during the year. Of this number, the spore histograms of 27 samples were completed, bringing the total to 67 histograms that have been prepared for this project to the end of the year.

The examination of such a great number of samples is necessary for the following reasons: 1) In the 10,000 ft. stratigraphic section of the Stellarton series there are at least 33 coal horizons (of which 15 were mined at one time or another); 2) Of each coal seam at least two samples are required to establish the lateral variation in the spore distribution; 3) The stratigraphic position of part of the section, containing only a few coals, is in doubt. This makes it necessary to examine the known part of the section in great detail. For this reason samples of even the thinnest coal layers are included in this investigation.

The results obtained so-far have been very encouraging. It was found that the lateral variation within one seam is only minor, and that separate coals have distinctly different histograms. Only in a very few instances were somewhat similar diagrams encountered, but in those cases the patterns presented in overlying and underlying coals are sufficiently characteristic to permit a stratigraphic separation.

Spore Study of the Coal Seams of the Springhill Coalfield.

J.R. Donaldson continued with this investigation. During the year he examined 16 coal horizons. Contrary to the histograms prepared of the Pictou coals, those of Springhill show not nearly as much difference between the various seams. This is due foremost to a great preponderance of one particular type, which in all seams studied reached 70 per cent and more. In cases such as these, it is necessary to concentrate more on the accessory spores, which requires a higher spore count, and takes considerably more time. In the 16 histograms available, differences are apparent, but more detailed work remains to be done, and about 14 more samples need to be studied, before a decision can be reached on the correlation of the No. 3 seam in the area south of Syndicate Slope. This correlation is of great importance to the new mining activities commenced during 1960 at the old Syndicate Slope, because it governs the extent to which the No. 3 seam can be mined from this opening. Depending on the correlation there may or may not be a fault of major displacement that separates the 3.7 million tons outlined by the 1959 drilling in the anticlinal region, from the 2.7 million tons estimated to lie in the Syndicate Slope area.

In view of the above significance of the results of the spore correlation, and the difficulties encountered in separating histograms of different Springhill coals, it was decided to include a spore study of the roof shales. For this purpose, some 20 samples were taken from the 1959 borings and will be studied in 1961.

Spore Study of Samples submitted for Age Determinations.

During 1960 M.S. Barss prepared the following reports on samples submitted by field geologists.

1. Sandstone exposure, N. shore of Governor's Island, P.E.I., for Dr. V.K. Prest. Age: Pictou group.

2. Sample of coal from Imperial MacDougall #1 Well, P.E.I., submitted by Dr. W. Roliff of Imperial Oil Co. Ltd. Age: Stephanian (younger than any known Pictou strata of the Maritimes).

3. Relationship of beds cut in Imperial MacDougall #1 Well, with surface rocks in New Brunswick.

4. Coal outcrop samples of New Brunswick, submitted by Mr. J. Hamilton of the Department of Mines of New Brunswick. Age: two samples, Pictou group, two samples, Horton group.

5. Shale and coal from surface exposure in Guysborough Co., N.S. for E.A. Schiller. Age: Horton group.

6. Shale samples from Stewiacke area, N.S., for Dr. D.G. Benson. Age: Pictou and Horton groups.

7. Shale from Dingwall area, N.S. for Dr. W.A. Bell. Age: Windsor group.

Spore Study of the Coal Horizons of New Brunswick.

This is a continuing project, but because of activities in other fields, little progress was made during 1960. Of the 65 samples on hand, M.S. Barss had examined 27 by the end of 1960.

Special Projects

For the 1960 Sheffield (England) meeting of the International Committee for Microflora of the Palaeozoic, Hacquebard and Barss wrote a contribution entitled: "Different Structural Developments of Spore Coat in Equatorial Region in Palaeozoic Spores". Barss further prepared slides and identified certain specific types for the exchange program organized by this Committee.

Other Activities and Projects

Compilation of Panel for Seven-Foot-High Display Book

Hacquebard and Barss prepared the text, the photographs, and the diagrams for a departmental display panel entitled "Microscopic Coal Research". This panel portrays the constitution of coal, the principles of coal petrology and its application to coal geology and coal utilization, and the principles of palynology and its application to the correlation of coal seams and geological age determinations. The panel consists of eight sections and is illustrated with 26 photo-micrographs and 4 diagrams.

1960 Field Trip to Nova Scotia and Newfoundland.

From June 25 to July 29 Hacquebard and Barss visited various areas of Carboniferous rocks in Nova Scotia and Newfoundland. A total of 108 samples were collected in 10 different areas for the spore investigation dealing with the stratigraphic sequence of the Mississippian and Pennsylvanian, and for the study of the Pictou coalfield. Samples of coals, shales, and sandstones were obtained.

Drilling for Coal in Pictou Coalfield.

In June 1960 the Nova Scotia Department of Mines started a drilling program in the Pictou coalfield, with the objective of locating remaining areas of mineable coal. As was done with the Springhill drilling project

during 1959, Dr. J.P. Nowlan, the Deputy Minister of Mines of Nova Scotia, requested the assistance of the Coal Research Section, for seam correlations and interpretations of the drill results. This request was approved, and as a result more coal samples were collected during the summer and J.R. Donaldson went to Stellarton for three months (from September to December) to examine the cores and assist with the borehole locations. By the end of the year 14 boreholes had been drilled and Donaldson logged 5,000 feet of core.

Four areas were examined with the drill, namely Linacy, Stewart, McLeod, and Norah. At Linacy the drilling was done in connection with a new opening on the Fraser seam. It showed that the area is badly faulted and not suitable for any sizeable extraction. At Norah the purpose of the drilling was to inspect the quality of the coals at the base of the Albion member. Several coals were cut, but all were too high in ash-content to warrant mining. At McLeod the drilling was carried out to find the continuation of the Foord seam on the east side of East River. This project was still in progress at the end of the year. At Stewart, located at the southeast corner of the town of New Glasgow, the results obtained on four boreholes were most encouraging. They showed that the Stewart seam is between 3 and 4 feet thick, that it is folded in a synclinal basin, and that it can readily be mined. The drilling in this area will be continued in 1961, with the objective of finding the amount of mineable coal contained in this seam. The four boreholes, which are located within 500 feet of the outcrop, have indicated the presence of about 100,000 tons of total coal, and it is expected that this figure may at least be tripled when the new results become available.

Publication of Results Obtained in the 1959 Drilling Project for Coal at Springhill.

In January 1960, the following preliminary maps of the No. 3 seam, on which a drilling project was carried out in 1959, were completed and forwarded to Dr. Nowlan in Halifax: 1) three maps showing correlation of boreholes; 2) contour plan; and 3) seam sections. Authorization to publish the work done on the Springhill project was obtained, but owing to the uncertainty regarding the correlation of the No. 3 seam, a report was not prepared. As was the case with spore studies of Springhill coals, the spore investigation carried out to solve this problem encountered difficulties and was delayed on account of Donaldson's activities in Stellarton. It is envisaged that during 1961 the Springhill report will be completed, and it is intended to incorporate the results of the spore investigation in this report, and ultimately in the Survey publication.

Outside Publication

Hacquebard, P.A.: The value of a quantitative separation of the maceral vitrinite into its constituents telinite and collinite for the petrography of coking coals. - Proc. Intern. Comm. for Coal Petrology, No. 3, pp. 131-139, 1960.

Reports

During 1960 one report was submitted for publication in the Proc. 12th Dominion-Provincial Research Conference, a second was submitted to the 1960 Sheffield (England) meeting of the Int. Comm. for Microflora of the Palaeozoic, and seven brief reports on age determinations by means of fossil spores were prepared.

WESTERN PLAINS SECTION

Helen R. Belyea

General

Use of the facilities offered by the Calgary office for the oil and gas industry declined somewhat in 1960 as compared to 1959. This reflected the general downward trend in the petroleum industry itself. During 1959 there were 2,266 visitors for the first eleven months, as compared to 2,146 for the first eleven months of 1960. Of the 2,146 visitors, 1,010 came to examine samples, 970 to buy publications, and 166 to confer with members of the staff, or to use the library. Publications sales for 1959 came to $3,017.90. During the first eleven months of 1960, they came to $2,537.14, a slight decline over the previous year. A total of 196,560 samples, mostly from wildcat wells were received during the first eleven months of 1960, from the western provinces. This illustrates the definite decline in drilling as compared to 1959, when 259,014 samples were received during the same period. Approximately 6,400 mechanical logs of wildcat wells were received in the same period.

As a result of the increased staff, plans were made for expanding office space on the 4th floor of the Customs Building early in 1961. Samples stored on the 4th floor of the Customs Building were removed to the basement, partly to allow for increased office and filing space, and partly to remove the weight of the samples from the 4th floor, where it is not believed to be entirely safe.

During the year, core from wells drilled in the Northwest Territories and stored by the Department of Northern Affairs and National Resources was moved from Hay River to storage in the basement of the Customs Building, where it is readily available to members of the oil industry and the staff of the Geological Survey. The wisdom of this move has been demonstrated by the large number of oil industry personnel who have been examining cores.

Members of the staff attended several conventions - Belyea, Price, and Pugh attended the Arctic symposium in Calgary; Proctor attended the Petroleum and Natural Gas Division of the C.I.M. in Calgary; Price attended the G.S.A. regional meetings in Rapid City, North Dakota, and examined Cretaceous outcrop sections there at that time; Belyea and Price attended the A.A.P.G. - A.S.P.G. convention in Banff.

Field and Office Activities

Dr. J.D. Aitken, from May 27 to August 30, was attached to Operation Back River in the district of Keewatin, on loan to the Regional Geology Division from the Fuels and Stratigraphy Division. His duties during this period consisted of bedrock mapping (almost entirely Precambrian rocks), and assisting Dr. Heywood with administrative aspects of the program.

Since August 30th, Dr. Aitken has been studying pre-Devonian sequences from cores and cuttings in the Northwest Territories and re-logging all pre-Devonian sections penetrated by wells of the Canol Project. In addition to the above, Dr. Aitken is doing a sub-surface study of wells penetrating the Pre-Devonian in Northeastern British Columbia. In connection with this, he is compiling a bibliography and index of the pre-Devonian of Western Canada.

Dr. Aitken's Memoir, No. 307, "Atlin District", British Columbia, submitted in 1956, was published during the year.

Helen R. Belyea was in charge of the office during Dr. Wickenden's absence. She continued studies on Middle and Upper Devonian in the southern Northwest Territories, Northern Alberta, and northeastern British Columbia, with the immediate object of preparation of reports on the Devonian of that area. This work necessitated the examination of cores of deep wells stored in Dawson Creek, and at Edmonton, Alberta. A joint report with D.J. McLaren on Upper Devonian nomenclature in the southern Northwest Territories was prepared. Tops of geological formations for wells in the Northwest Territories were picked for publication in the Schedule of Wells, published by the Department of Northern Affairs and National Resources. Earlier Schedules were revised at the same time. Two papers submitted in 1959 were published: Paper 59-2, "Devonian Elk Point Group, Central and Southern Alberta", and Paper 59-15, "Distribution of some Reefs and Banks of the Upper Devonian Woodbend and Fairholme Groups in Alberta and eastern British Columbia". A pamphlet - "The Story of the Mountains in Banff National Park" was published during 1960.

Miss Belyea acted in an advisory capacity to the National Parks Branch for the preparation of geological signs at points of interest and supplied texts for self-guiding leaflets for Nature Trails in both Banff and Yoho Parks. This occasioned several visits to the Park for conferences with the personnel there. She was also invited to give geological lectures and field trips to the Park Warden's School in May, and to the Interpretive Officer's course in July.

Miss Belyea served on the Nomenclature Committee of the Alberta Society of Petroleum Geologists and was named as Chairman of the Upper Devonian Committee for Western Canada for the Symposium on Canadian Sedimentary Basins, to be held in Calgary in the fall of 1961.

Dr. C.F. Burk, Jr. has begun a project on the subsurface Upper Cretaceous stratigraphy of west-central Alberta and adjacent British Columbia. The interval under study includes approximately the Upper Cretaceous Alberta group in an area of about 26,800 sq. miles, bounded to the west by the Rocky Mountains, to the north by 56° North Latitude, to the east by 116° West Longitude, and to the south by 53° North Latitude. He has to date established a

correlation network over the area by means of electric logs and is engaged in correlating other logs from this network, the electric log correlation to be followed by core and sample examination.

Leon L. Price completed a report on the Subsurface Correlations in the Kootenay formation of the Canmore area, Alberta, and a report on the "Lower Cretaceous of southeastern Saskatchewan". As a part of his work on the Cretaceous, he examined Lower Cretaceous outcrops on the Red Deer River, Manitoba. He also began work on a report to show the relationships between the Swan River group of the outcrop area and the subsurface formations of the Lower Cretaceous of southwestern Saskatchewan.

Mr. Price served with the Tectonic Map Committee, Western Plains group, and as part of this project, completed a contour map on the base of the Favel formation in Manitoba and the base of the Fish Scales of northeastern British Columbia. He also recorded the geological description of continuous core taken from the site of the potash mines at Esterhazy, Saskatchewan, and collected fossils from the material.

R.M. Procter began a subsurface study of the Mississippian Pennsylvanian and Permain systems of northeastern British Columbia. This required some time to be spent obtaining fossil and lithologic collections from cores of wells drilled for oil and gas in northeastern British Columbia. As a result of this, he made a collection of a large and diversified fauna. Preliminary work indicates that significant changes will have to be made in age assignments of stratigraphic units now in use in the area. As an aid to the analysis, an acetate peel technique has been applied and shown to be the only practical method for location of microfossils in limestones without resorting to thin section.

Dr. Procter made an effort to examine Upper Palaeozoic sections in the foothills belt of Alberta and British Columbia and to gain familiarity with the units to be examined in the sub-surface.

An abstract of Dr. Procter's thesis was published in "Dissertation Abstracts, University of Kansas".

Dr. D.C. Pugh has been engaged in a study of insoluble residues from the Upper Devonian, Edmonton area, Alberta. This has comprised a study of samples taken at 5-foot intervals from the cores of the type section of the Beaverhill Lake formation and a core through the Redwater Reef in the Redwater field. In addition he supervised the "summer help", who completed a key-sort punch card system for all wildcat wells in western Canada.

ECONOMIC GEOLOGY DIVISION

Y. O. Fortier, Chief

INTRODUCTION

The activities of the Economic Geology Division are herewith reviewed by section. Concerning the division in general, stress was placed

on the maintenance of the best professional and technological standards. Therefore, efforts were made to assure a favorable atmosphere of research and to make available the best means of carrying out such a task. During the past year, there has been some recasting into sections of basic working units, producing a new divisional set-up. As a result the division now comprises four distinct sections, each of which reports as follows.

REPORTS ON SECTIONS AND LABORATORIES

GEOLOGY OF MINERAL DEPOSITS SECTION

D.R.E. Whitmore

Field Activities

Officers of the Section mapped and made field studies of the geological setting of mineral deposits throughout the country. This included the principal uranium producing deposits studied by J.A. Chamberlain, iron deposits of Labrador and Quebec by G.A. Gross, titaniferous deposits of Ontario and Quebec by E. Rose, copper deposits of the Yukon by E.D. Kindle, beryllium deposits of northwestern and central Canada by R. Mulligan, placer deposits by C.R. McLeod, and occurrences of barium, strontium, and fluorine bearing minerals by W.D. McCartney.

Full details of this field work are given in the Survey's Information Circular No. 4. However, it is interesting to note in passing that J.A. Chamberlain was able to make extensive and possibly irreplaceable mineralogical collections from the Eldorado mine at Port Radium before this historic and fascinating mine was shut down permanently during the summer.

A project of the National Advisory Committee involving the comprehensive study of a single mine from many points of view was initiated at the Coronation Mine in Saskatchewan under D.R.E. Whitmore. Although an officer of the Survey acts as coordinator of the project, much of the actual study is being undertaken by persons working at universities in Ontario, Saskatchewan, and Manitoba supported in part by funds from the National Research Council and Saskatchewan Research Council. Some assistance has come from Canadian Aero Source, as well as from Hudson Bay Mining and Smelting Co., owners of the mine.

Office Activities

As well as the office and laboratory studies by the officers concerned arising from the field work mentioned above, S.M. Roscoe continued work on a final report dealing with the geological setting and origin of the Elliott Lake uranium deposits. He also acted as Division Chief during the absence of Y.O. Fortier who attended the International Geological Congress in Copenhagen.

Other office projects of interest now being undertaken are comparative pitchblende age determinations within small areas of a single specimen to throw additional light on the mobility of uranium. This will be done by J.A. Chamberlain in cooperation with R. Wanless. W.D. McCartney will study the possibility that in sulphur-poor environments lead may be incorporated in barite rather than form galena. R. Mulligan continues to respond to many inquiries by firms interested in lithium, beryllium, and caesium. During the year J. Silman of International Mineral and Chemical Corp. gave a lecture to members of the Section on beryllium and its mode of occurrence in North America.

Membership on Committees

G.A. Gross served on a committee reorganizing the Economic Geology files. He also advised the Geology Division of the C.I.M. regarding the organization of the Symposium on Iron Deposits at the Annual Meeting in Toronto.

W.D. McCartney was appointed at year's end to act on the Branch Equipment Committee.

W.D. McCartney and D.R.E. Whitmore acted on a committee with members of the Petrological Sciences Division in preparation of a new mineral collection and pamphlet illustrating Raw Materials of the Canadian Mineral Industry.

R. Mulligan, E.D. Kindle, G.A. Gross, D.R.E. Whitmore and in particular W.D. McCartney contributed to the metallogenic map of Canada, which in manuscript form was exhibited at the International Geological Congress.

S.M. Roscoe was appointed to the Data Processing Committee.

S.M. Roscoe and J.A. Chamberlain laid out and ordered equipment for a pro-mineralography laboratory.

S.M. Roscoe and D.R.E. Whitmore together served on a committee to improve the polished section preparation facilities in the Branch.

E.R. Rose served on the Exhibits Committee arranging for exhibits in Logan Hall.

D.R.E. Whitmore served on the Stable Isotope Committee of the Branch. He also was appointed to the Student Essay Committee of the C.I.M.

Membership in Societies

	CIM	GAC	MAC	GSA	SEG	RSC	Other
J.A. Chamberlain	x	x	x				Sigma Xi
G.A. Gross	x	x		x	x		Sigma Xi
E. Kindle	x	x	x			x	
W.D. McCartney		x					
C.R. McLeod		x					
E. Rose	x	x	x				
D.R.E. Whitmore	x	x		x	x		

Outside Publications

Chamberlain, J.A.: Structural History of the Beaverlodge Area; Econ. Geol., vol. 55, pp. 617-618, 1960.

Gross, G.A.: Iron Formations in the Labrador Geosyncline; U. of Minnesota 1st Ann. Min. Symposium.

Roscoe, S.M.: Huronian Uraniferous Conglomerates; Econ. Geol., vol. 55, pp. 410-414, 1960.

Outside Talks

G.A. Gross lectured on "Metamorphism of Iron Formations and its bearing on their Beneficiation" at the annual meeting C.I.M.M. in Toronto.

S.M. Roscoe lectured on "Definition, Subdivision, and Correlation of the Huronian Rocks" at the annual meeting C.I.M.M. in Toronto.

GEOCHEMICAL SECTION

R. W. Boyle

General

During 1960 research in geochemical prospecting was carried out in two field areas, one in northwestern Ontario over a broad terrain as part of the "Roads to Resources program", and the other over a more restricted area in southeastern New Brunswick. Three field parties did geochemical field work, one on the geochemistry of the lead-zinc-copper deposits of Bathurst, New Brunswick, another on the geochemistry of pegmatites in Northwest Territories and northern Manitoba, and a third collected samples for geochemical work from the Lower Cretaceous sediments of Alberta. In addition laboratory research on the chemistry of ore geneses, isotope geochemistry, geochemical prospecting, and sedimentary geochemistry was continued.

In December the radiochemistry laboratory was fully equipped and became operative.

A mobile geochemical laboratory suitable for colorimetric and other analyses was designed, built, and put into service in southern New Brunswick.

A mobile spectrographic laboratory has been designed by Dr. R.H.C. Holman and will be built and put into operation in 1961.

Additions to the permanent staff during 1960 included George Mihailov, a technician now working in the Geochemical Trace Element Laboratory. A.Y. Smith, now pursuing Ph.D. studies at Carleton University, headed a summer field party, and J.L. Davies, I.D. McGregor, and C.H. Smallwood were in charge of geochemical sub-parties in the Bathurst-Newcastle area. G. Reilly has joined the staff as a temporary winter seasonal assistant to Dr. R.H.C. Holman.

Members of the staff attended several meetings and conferences, some of which are as follows:

Mrs. M.A. Jardine, while in Europe on leave, spent a day at the Royal School of Mines, Geochemical Laboratories, where she saw some of the latest techniques and instruments in Dr. J.S. Webb's laboratories. Mrs. Jardine also presented a paper entitled "Rapid Methods for the Determination of Trace Elements in Geological Samples" at the annual meeting of the Chemical Institute of Canada, Ottawa, Ontario, June 13th.

E.M. Cameron attended the Scripps Institute of Oceanography, La Jolla, California, for ten days in February. The purpose of the visit was to study the latest techniques in marine geology and marine geochemistry and to learn the various instrumentation in these fields. Afterwards Dr. Cameron visited the Laboratories of Applied Research Corp. Ltd. in Los Angeles to study the application of the Quantograph to geochemical problems.

R.W. Boyle attended the annual meeting of the Geological Society of America, held in Denver in early November, for the purpose of acting as chairman of one of the sessions on isotope geology and geochemistry.

R. Kretz attended the annual meeting of the Geological Society of America, held in Denver in early November.

R.H.C. Holman attended the Annual meeting of the A.I.M.E. in New York in February. He also visited the U.S.G.S. in Denver to acquire information about field spectrographic techniques, and attended an applied spectrography course at the University of Arizona in August to gain knowledge of the most recent techniques.

R.A. Washington delivered a talk to grade 11 and 12 students of Smooth Rock Falls, Ontario, high school, on the history and general work of the Geological Survey.

Field and Laboratory Activities

A.Y. Smith, with 3 men, continued the geochemical reconnaissance of southeastern New Brunswick into Albert County. In addition to stream sediments, the sampling was expanded to include bedrock and natural stream and spring waters. Sampling and other field work was also completed by Mr. Smith, on the "Red-bed" copper deposits of New Brunswick and Nova Scotia. Mr. Smith will use this data for a Ph.D dissertation at Carleton University. Laboratory work, including mineralogical, chemical, trace element, and isotopic studies on the field samples, is now underway.

As an aid to the more efficient operation of geochemical surveys, Mr. Smith put into operation a new mobile geochemical laboratory. This

trailer laboratory operated efficiently and in addition to providing data for Smith's field party also supplied a number of analyses for one of the Survey's ground water geologists, and for the Fisheries Research Board of Canada who were investigating pollution of the Miramichi and other salmon streams.

R.W. Boyle continued field work on the geochemistry of the zinc-lead-copper deposits of Bathurst, New Brunswick. The mapping of the Brunswick No. 6 deposit was completed at 100 feet = 1 inch, and plans and sections showing the distribution of Zn, Pb, Cu, and Ag within the orebody were completed. These incorporated the results of more than 10,000 essays and analyses provided by Brunswick Mining and Smelting Co. Ltd.

Dr. Boyle has completed a laboratory study of the soils, waters, rocks, and ores in the Keno Hill - Galena Hill area. The results of this work are now being compiled in a memoir. Most of the samples from the Walton barite mine and surrounding area have also been examined and detailed laboratory work on them has just begun.

J.L. Davies, a Survey assistant working under the supervision of Dr. Boyle, completed the mapping, at a scale of 100 feet = 1 inch, and detailed sampling of the Drummond Iron Pit. Mr. Davies also examined and sampled all available drill core in the vicinity of the iron deposit and visited and sampled other similar iron formations both in New Brunswick and Nova Scotia. The results of this work will provide material for a Ph.D. dissertation at Carleton University.

I.D. MacGregor, a Survey assistant working under the supervision of Dr. Boyle, commenced a geochemical and geological study of the gossans of the Bathurst-Newcastle area. Samples of all types of gossans and water from springs in and around the orebodies were systematically collected. This work will continue in 1961.

E. Presant spent three weeks in the Bathurst area collecting soil samples for geochemical work. About 350 samples were taken from 80 localities within a 40-mile radius of Bathurst, many from zones directly over known orebodies. Studies of the amounts, location, modes of occurrence, and types of bonding of lead, zinc, copper, and silver in the soils are now underway on these samples, and the data obtained will supply material for a M.Sc. thesis at Carleton University.

C.H. Smallwood, under the supervision of Dr. Boyle, mapped and collected rock and ore samples in an area covering 86 square miles centered on the Brunswick No. 6 orebody and Austin Brook Iron Deposits in the Bathurst area of New Brunswick. This area was mapped at a scale of 1,000 feet = 1 inch and will provide fill-in data for the overall geochemical project on the Bathurst ores.

E.M. Cameron spent six weeks collecting samples of lower Cretaceous sediments from outcrops and available drill cores in southern and central Alberta. The purpose of these samples is to work out geochemical correlations and from these to develop methods for finding stratigraphic traps for oil and gas.

Dr. Cameron continued a laboratory study on various sedimentary rocks. Six weeks were spent in the spring of 1960, developing methods of trace analyses in the spectrographic laboratory. In the summer a rapid

analytical method for the determination of carbonates in sediments was developed and more than 1,000 samples were processed.

In addition Dr. Cameron has been engaged in organizing the facilities and set up of a quantograph for rapid and precise spectrographic analyses for the geochemistry section.

R. Kretz spent three months in Northwest Territories, Northern Manitoba, and the Grenville region of Ontario and Quebec, studying the geochemistry of certain pegmatitic bodies. The studies involved a preliminary investigation of the source of the elements in the pegmatites, and the chemical and thermodynamic relationships of these elements both in the pegmatites and their enclosing country rocks. Structural studies with regard to the emplacement of the pegmatites were also carried out in the Yellowknife area. It is hoped that these studies will give a more realistic idea of the origin of pegmatites than that now current.

Dr. Kretz also continued his laboratory study of metamorphic rocks and pegmatites. Co-existing minerals in metamorphic rocks and pegmatites have been separated and are being analysed for major and trace elements and the results will be treated from a thermodynamic viewpoint.

R.H.C. Holman commenced a large scale geochemical reconnaissance in northwestern Ontario in the area covered by the "Roads to Resources program." Bedrock sampling by geologists engaged in 4-mile mapping was carried out, samples being collected at 1-mile intervals along traverses. Detailed sampling was also done in selected greenstone belts as an aid in the interpretation of the reconnaissance data. The purpose of this reconnaissance work is to study the possibility of establishing regional geochemical provinces for various elements, with a view to directing the attention of prospectors to areas of higher than average metal content.

Dr. Holman continued laboratory work on samples collected on the "Roads to Resources Project" in northwestern Ontario. Compilation of the analytical results obtained from the laboratories during the summer is in progress.

Geochemical Laboratory

M. A. Jardine

A total of 7,646 samples including rocks, soils, sediments, minerals, precipitates, and water were analysed for a variety of elements by colorimetric procedures. The metal content ranged from as little as a few tenths of a part per million to five or six per cent. In all, a total of 23,889 analyses were carried out on these samples, of which 20,922 were done in the period from mid-May to early September by five student assistants employed temporarily in the laboratory during the summer.

Considerable time was spent last year teaching trace element analytical methods. Mr. G. Mensah of the Geological Survey of Ghana spent 3½ months (18th January until 28th April) in the laboratory. Mr. Puri of the Geological Survey of India spent one week learning the different methods(4th April until 8th April). Both these men were in Canada under the Colombo Plan. Of

the five summer assistants only one had previous experience in trace analysis and she had been trained by the writer the previous year. The others all had to be taught prior to proceeding with the summer programme. Mrs. Webster of Carleton University spent one week with me (3rd October until 7th October) and Mr. Taylor of the Fisheries Research Board spent one day learning how to analyse waters for trace amounts of copper and zinc.

Early in the year the equipment and reagents to cover all the requirements of the forthcoming large scale analytical programme planned for the summer were ordered.

The five assistants employed in the laboratory during the summer were: Miss J. Ainslie, Miss T. Hyde-Clarke, Miss C. Brewer, Miss J. Paul, and Miss C. Hunt. Special mention should be made of Miss Ainslie and Miss Hyde-Clarke, who contributed very largely to the success of the summer's work.

On September 15th, Mr. George Mihailov joined the laboratory as a permanent Technician I. He is gradually learning the different analytical procedures and seems to be settling down very satisfactorily.

All the samples analysed except 40 copper determinations carried out for Dr. B. Kendrick of the Dept. of Agriculture were submitted by members of the Geochemistry Section.

Early in the summer the writer prepared and presented a paper at the Annual Meeting of the Chemical Institute of Canada held in Ottawa from the 13th - 15th June.

With all these other activities there was little time for any concentrated development work. A colorimetric method for determining tin was tried out and the results observed were found to compare favourably with spectrographic data. Also a comparison was made of the dithiol and thiocyanate methods for determining molybdenum. Up to date dithiol has been used in the laboratory but this reagent is expensive and very unstable. The two methods were found to give very similar results and to be equally convenient. Fairly recently a new stable source of dithiol - zinc dithiol - has become commercially available - this has still to be tested out. Apart from this, many of the routine methods used had to be specially adapted to cover the specific requirements of the various sample types submitted for analysis.

A summary of the analyses carried out during the year is attached at the end of this report. Most of the analyses were for the N.W. Ontario project. To date 6,432 samples have been analysed involving a total of 17,917 determinations. All the samples have been analysed for copper and zinc and over 4,000 for arsenic. Some antimony determinations have also been carried out. There is still a back log of approximately 1,000 samples. These had not been crushed and ground by the end of summer. Mr. Mihailov is proceeding with them during the winter.

R.W. Boyle submitted 882 samples requiring 4,736 determinations. The rest of the analyses were made up of samples submitted by E.M. Cameron, L. Davies, S. Puri, and A.Y. Smith.

Summary of Analyses of Work Completed, 1960-61

(1) For Geochemistry Section

Project	Field Geologist	Type of Sample	Metals Analysed	No. of Samples	No. of Analyses
Yellowknife	R. W. Boyle	Tuffs	Sn, Co.	11	22
"	"	Rocks	Sb, As	10	20
Keno Hill	R. W. Boyle	Soils	Sb	71	71
"	"	"	As	131	131
"	"	"	Sn, W	4	8
"	"	"	Cu,Pb,Zn	7	42
"	"	"	Pb,Zn,Cu W,Sn,As,Sb	15	150
"	"	"	As,Sb	165	393
"	"	Rocks	Sb	25	25
"	"	"	As,Sb,W	34	102
"	"	"	Pb,Cu,Zn,As Sb.	8	68
"	"	Precipitates	Cu,Pb,Zn,As Sb.	5	40
"	"	Fesulphides & Oxides	Cu,Pb,Zn As,Sb,W,Mo.	6	60
"	"	Barite	Cu,Pb,Zn As,Sb	4	32
"	"	Minerals	Cu,Pb,Zn,As Sb,W,Mo	6	66
"	"	Pyrites	Cu,Pb,Zn,As Sb	14	112
New Brunswick	R. W. Boyle	Gravels, Gossans & Sulphides	Cu,Pb,Zn, As,Sb	43	344
"	"	"	"	16	143

Project	Field Geologist	Type of Sample	Metals Analysed	No. of Samples	No. of Analyses
Walton, N.S.	R. W. Boyle	Rocks	Cu,Pb,Zn,As Sb.	251	2453
"	"	Gypsum	Cu,Pb,Zn,As Sb.	4	32
Chisel Lake Manitoba	R. W. Boyle	Precipitates	Cu,Pb,Zn,As Sb.	52	422
Western Canada	E.M. Cameron	Sedimentary rocks	Pb,Zn,As,Sb	52	322
New Brunswick	L. Davies	Rocks	Cu,Pb,Zn,As Sb	39	303
N.W. Ontario	R. Holman	Rocks	Cu,Pb,Zn,As Sb,Mo,W,N. Co,Sn,Cu	24	336
"	"	"	Cu,Zn,As	5751	16,468
"	"	"	Zn,Cu	420	840
"	"	"	Zn,Cu	12	48
"	"	Rocks	Sb	225	225
	S. Puri	Rocks & Minerals	Cu,Mo	32	64
New Brunswick	A.Y. Smith	Stream Sediments	Cu,Pb,Zn	57	171
"	"	Rocks	Cu,Pb,Zn	112	336
Totals				7,606	23,849

(2) Outside Geochemistry Section

	Sampler	Type of Sample	Metals Analysed	No. of Samples	No. of Analyses
Sackville Swamp, New Brunswick	B. Kendrick Dept. of Agriculture	Peat & Sand	Cu	40	40
Total				40	40
Grand Total				7,646	23,889

Radiochemistry Laboratory

R. A. Washington

Alterations and Special Installations

After much delay, the alterations and special installations (e.g. filters for fume hood exhaust) required to allow the use of radio-isotopes in the laboratory have been completed, with one or two minor exceptions. A licence to purchase radio-isotopes has been applied for, and work can begin as soon as it is issued.

Literature Research

An extensive literature search has been carried out to learn the extent and significance of the work that has been done on the subjects that are of interest here. It is apparent that a great deal of work remains to be done. Past studies of diffusion rates, solubility, and adsorption using geological material are scarce, and those that have been made are frequently of dubious value. In general, the doubtful value of these studies has been inherent in the techniques used; the measurement of rather small diffusion coefficients, solubility products, and adsorption coefficients, using classical techniques can be exceedingly difficult and time-consuming. It is expected that accurate, reproducible data in these fields will be obtained much more easily and quickly using radioactive tracers.

In addition, a compilation has been made of the English translations that are available in the G.S.C. library of papers on geochemistry published in foreign languages. This compilation was published in Geochemical News, No. 23, August (1960).

Preliminary Tests and Studies

A series of tests have been made on the operation of the Nuclear-Chicago model D-47 counter that was obtained for the laboratory. In particular,

the long-term stability and reproducibility, and the plateau characteristics (length and slope of the operating plateau) were measured. Although the plateau slope was not found to be as low as might be desired, the long-term stability and reproducibility were good. In general, the operating characteristics were found to be quite good, and certainly more than adequate for the intended purpose. Consideration is being given to the possibility of improving the characteristics by modifications to the pre-amplifier and scaler circuits.

In addition, some preliminary measurements were made of the approximate pH range in which precipitation of potassium aluminium silicate occurs. The tests were rapid and not too rigorous, so that the results cannot be regarded as conclusive, but it was observed that immediate precipitation occurred in the range from about pH 4 to pH 9 or 10.

Proposed Research

In consultation with Dr. R.W. Boyle and other members of the geochemistry section, the following studies have been planned:

(1) Amount of adsorption and co-precipitation of trace elements (e.g. Cu, Pb, Zn) on hydrous oxides of iron, will be measured as a function of pH, rate of precipitation, oxygen and CO_2 content of the solution, temperature and oxidation potential of the system.

(2) Amount of adsorption of trace elements from solution on quartz, (crystalline and massive), sandstone, feldspar, apatite, calcite, and various other rocks and minerals will be measured. The effects of variation of pH, temperature, and other parameters will also be studied. This is planned as a preliminary study, to be carried out in greater detail and over a wide range of variables as time goes on.

(3) Production of standard samples for geochemical analysis has been discussed, and a number of typical samples have been collected. It is planned to have these crushed, ground and analysed by several different techniques including activation analysis. The results will then be used to provide standard samples of known composition as checks on wet chemical and spectrographic analytical processes in the field and in the laboratory.

(4) A number of discussions have been held with Mrs. M.A. Jardine as to the possibilities of using radiotracers to study the accuracy of the routine trace element analytical techniques now being used, and to develop new techniques. No definite program has been developed, but several problems have been discussed that appear to be amenable to application of the radiotracer technique. Further talks will be held and the program will be developed as time permits.

(5) Discussions have been held with Dr. E.M. Cameron about the possible applications of radioactive tracers to studies of sedimentary rocks. Several important problems appear to be capable of attack using these techniques, and further discussions will be held and the program will be developed as time permits.

(6) Several geologists from outside the geochemistry section have expressed interest in the use of radiochemical techniques in attacking their problems. Unfortunately, it will be impossible to undertake any major work other than that outlined above until the planned program is well under way.

Minor problems may be tackled from time to time, if upon consultation they appear suitable. Space in the laboratory and free advice on laboratory techniques and precautions will nearly always be available for those who wish to carry out their own short-term projects.

Sample Preparation Laboratory

P. J. Lavergne

More rapid methods of crushing, grinding, screening, sizing, and preparation of powdered samples for rapid analyses were introduced, in 1960, by the use of automated equipment. With such equipment contamination has been reduced to a point where it is not of any consequence in trace element work. During the year 11,586 samples were crushed and ground and 11,252 were powdered for trace element analysis. Some 1,300 samples received special treatment. A summary of the work completed in 1960, follows:

	Crush	Grinding	Sizing	Superpan	Frantz	Weighing of Fraction	Ball Mill grinding Paint Shaker	Leaching in Acids
Dr. Boyle	300	300	225	250	175			125
Dr. Cameron	1,000	1,000					1,000	
Dr. Holman	9,000	9,000					9,000	
Dr. Puri	30	30	30	30	25			
Dr. Whitmore	4	4	4	4	4			
Mr. A. Smith	1,200	1,200					1,200	
Mr. R. McLeod			30	30		30 x 12 360		
Mrs. Jardine	52	52					52	
Total	11,586	11,586	289	314	204	360	11,252	125

Several changes to laboratory equipment were made during the year - the paint shaker was adapted to receive 6 grinding disks; the paint shaker jaw was reinforced; and the rock crusher was converted to finer crushing, thus eliminating a grinding step used for hard rock. Machines were frequently dismounted to replace or weld broken parts, and various parts and materials were requisitioned. Supervision and instruction was given to 2 labourers and to 2 students for 4 months.

Outside Publications

Boyle, R.W.: The Occurrence and Geochemistry of Native Silver in the Lead-zinc-silver Lodes of the Keno Hill-Galena Hill area, Yukon, Canada; News Jahrbuch Mineralogie, Abh. 94, pp. 280-297, (Festband Ramdohr), 1960.

Jardine, M.A.: Rapid methods for the Determination of Trace Elements in Geological Samples (Abstract); Chemistry in Canada, vol. 12, No. 4, p. 51, 1960.

Kretz, R.: The Distribution of Certain Elements in Calcic Pyroxenes, Calcic Amphiboles, and Biotites in Skarns; Geochimica et Cosmochimica Acta, (in press).

Some Applications of Thermodynamics to Coexisting Minerals of Variable Composition, e.g. orthopyroxene, clinopyroxene, and orthopyroxene-garnet; Jour. Geol., (in press).

Washington, R.A.: List of Translations of Papers on Geochemistry Available from the Geological Survey of Canada Library, Geochemical News, August, 1960.

PLEISTOCENE GEOLOGY SECTION

V. K. Prest

General

The output of some 15 preliminary maps and reports, bulletins, and memoirs over the past year is one indication of the productivity of the Pleistocene Section. These reports pertain to widely dispersed areas reaching from the Atlantic to the Pacific and from the International Boundary to the Arctic Islands.

Over the past ten years the value of Pleistocene geological studies has become increasingly more evident, with a consequent demand for both regional and detailed work in many parts of the country. Also the need and opportunity for studies in the far north has become readily apparent. Some personnel have, therefore, been assigned at intervals to reconnaissance work in these remote regions. This has consequently drained staff from the more populated areas where work was earlier being conducted for more direct economic or applied purposes. The great increase in requests for services, and in the increased size of the area now to be covered, has had to be met without any addition in permanent staff personnel; in fact there has been a decrease. (Persons formerly on our Pleistocene staff or 'ear-marked' for such work as early as 1949 include Elson, Halstead, Hatfield, Gravenor, and Owen. Prest may be considered as a replacement for Deane.) To some extent the demand for Pleistocene surveys has

been met over the past decade by assigning areas to Ph.D. candidates in Pleistocene geology (Karrow, Mirynech, Scott, Fulton) and to outside professional men (Crowl, Frankel). Also the Pleistocene section head has endeavoured to handle three field assignments as well as technical and administrative work for Pleistocene, Engineering, and Ground Water purposes; and on one occasion the Pleistocene palynologist was assigned a map area. Also, to some extent, the demand or need for more Pleistocene information has been met by the encouragement given to other G.S.C. staff to produce maps or articles on Pleistocene geology or to elaborate this phase of geology in their regular reports; some notes, articles, and reports of merit have resulted.

It may also be mentioned here that we have endeavoured not to overlap on areas where physical geography or geomorphological studies were carried out by geographers, except insofar as some of our major helicopter operations may have necessarily overlapped. But all-in-all the lack of increase of Pleistocene field personnel over the past ten years, during a time of active G.S.C. and federal growth, is a most unhealthy situation. The recent addition of Mirynech to our permanent staff is most welcome. A second position, now vacant, is also welcome: it will be filled or 'tagged' as soon as applicants for the position, now being advertised, are on hand. Our failure to grow over the past decade has deterred Canadian students from specializing in this field, and those who have done so have obtained work with Provincial agencies or have left Canada.

It should be mentioned here, of course, that growth in the Pleistocene section at large did take place during the last decade in connection with the ground water and engineering unit. With the full weight of the present Director of the Survey, the ground water unit was able to expand in 1958, and recently an engineering geologist was taken on staff. This growth has taken care of some of the demands placed on the Pleistocene unit, but it has also pointed out the need for more mapping assignments. Growth of the Pleistocene unit per se may well be regarded as a necessary corollary of that of the ground water unit.

Development of our sedimentology and palynology services over the past decade constitutes most necessary and profitable progress. Both laboratories are working at peak production and need to be expanded to meet the demand for services.

(In view of the work of the Geographical Branch and similar interests in the far north, and our dearth of personnel to meet the demand for services in the south, and to carry out a regional mapping program, our position might well be appraised at a high level, and firm policy established. It may be said here, however, that neither our present northern workers nor I wish to forsake the north as we consider it an integral part of the overall Pleistocene geology of Canada).

Field and Office Activities

B.G. Craig participated in Operation Back River as the Pleistocene member of the party. He has provided additional important information on the history of deglaciation, and on the transgression and retreat of the Arctic Ocean waters in this region. Craig has now been a member of four helicopter-supported operations on the mainland of the N.W. Territories.

Geo. H. Crowl and L. Frankel have submitted maps and covering reports concerning the surficial geology of the eastern end of Prince Edward

Island. This will be of great interest to all disciples concerned with the soils of the Island. They have also submitted a paper to the Journal of Geology, concerning the submerged forests of eastern Prince Edward Island.

J.G. Fyles has continued his Pleistocene studies of the Arctic Islands by both field and air photo work. Progress has been made toward a better understanding of the diverse glacial movements on Victoria Island. The conclusion that all of Banks Island has been glaciated and that the previously indicated boundary of glaciation on this Island (Glacial Map of Canada) is actually the approximate limit of Wisconsin ice, is a matter of great scientific interest. Fyles' work has thrown new light on the early Pleistocene events in this remote region and is helping determine the true nature of the Beaufort Formation.

Fyles has given considerable time and effort to the filing and processing of organic samples for radiocarbon analyses pertinent to the work of the Pleistocene Section. Analyses (about 20) have been largely obtained through Isotopes Incorporated, but some have been procured through research organizations. In view of the development of the radiocarbon laboratory within the Survey, he has also spent considerable time on the organization of a C-14 committee to handle specimens, establish priorities, and ensure a ready supply of suitable samples for the laboratory.

N.R. Gadd completed his field work in the Chalk River Area, which work together with that in the Ottawa and Trois Rivieres region establishes him as the Canadian authority on the Surficial Geology and Pleistocene history of the region invaded by the Champlain Sea. During the summer he conducted a glacial geology field trip for employees of the Petawawa Forest Experiment Station, Chalk River, Ontario. He also delivered a lecture on the "Glacial Geology of the Deep River Area", to the Deep River Science Association on October 28th. About 200 persons attended the lecture which was followed by a lengthy discussion period.

E.P. Henderson spent considerable time on an air photo study of the eastern coastal regions of Newfoundland necessary to his field study of coastal uplift, carried out during the summer of 1960. Office work is being actively pursued on the Pleistocene geology of Avalon Peninsula for a forthcoming memoir on this region.

O.L. Hughes has directed a program of research on varved clays in the Matheson-Cochrane area of Northern Ontario. Drilling and shelby-tube sampling procedures were carried out in both the spring and early winter of this year, and study of the geology and engineering characteristics of the materials are currently taking place in the Dept. of Public Works Testing Laboratories. Special tests are also to be made at the Division of Building Research, N.R.C., and at the Dept. of Civil Engineering, Queen's University.

Hughes preliminary investigations in the placer mining district of the Yukon Territory offer much promise of being of direct aid to the future of the placer operations.

H.A. Lee attended the XXIst International Geological Congress in Copenhagen, Denmark, and participated in three field trips concerning Pleistocene geology and geography. He was also called on to prepare an abstract and deliver a half hour paper on "Method of deglaciation, age of submergence, and rate of uplift west and east of Hudson Bay, Canada." The presentation and discussion did much to focus attention on Canadian work in

northern Canada. The paper in currently "in press" for the Biuletyn Peryglacjalny, Lodz, Poland. Lee completed field work pertaining to his lengthy study of deglaciation in the Fredericton-Edmundston part of the St. John River Valley.

About 20% of Dr. Lee's office time is spent in connection with his supervisory work for the Sedimentology Laboratory.

E. Mirynech, a recent addition to our Pleistocene staff, has completed a study of the west half of the Kingston (4-mile) map-area, Ontario. This work provides new scientific information on deglacial events and glacial lake history in the Ontario basin including the establishment of Lake Ontario.

V.K. Prest prepared the introductory paper for the Royal Society Symposium volume on the Soils of Canada (Geological Pedological and Engineering) and presented the paper at the Annual Meeting of the Society.

Prest, Henderson, Mott, and Terasmae attended the 14th Canadian Soil Mechanics Conference held at Niagara Falls in October. This conference dealt with marine and lacustrine clays, and glacial tills. It served to bring soils engineers and geologists into closer association re Canadian Soil Problems.

Prest also participated in the Ontario Roads to Resources program in northwest Ontario, being responsible for the interpretation of the surficial geology of the area including the soil conditions and glacial history. The study holds much promise of throwing new light on glacial events in that area and, in particular, on the late history of glacial Lake Agassiz.

H.S. Scott concluded his Pleistocene studies in the area of the South Saskatchewan River Project thereby providing important data relevant to both the engineering and irrigation aspects of the project and with respect to the Pleistocene mapping program of the Saskatchewan Research Council.

A.M. Stalker attended the Rocky Mt. Section "Friends of the Pleistocene" field trip in Utah in September. This trip dealt with the glaciation of the Wasatch Mountains and history of Great Salt Lake. Stalker prepared the geological wording for several interpretive signs for Banff and Waterton National Parks and supplied information for several "nature trail" signs. Stalker also compiled the report of the Subcommittee on Pleistocene Geology, for the National Advisory Committee on Research in the Geological Sciences, and presented this report at the meeting in April.

An interesting side-light of Stalker's regional studies on the limits of glaciation in Alberta and Saskatchewan has been his deductions concerning the surface of the Laurentide ice sheet along the International Boundary. Dr. Stalker believes that the surface of the ice sheet was saucer-shaped rather than dome-shaped as generally assumed. "The maximum height of ice lowered some 2,000 feet from western Alberta to 106 degrees west longitude. The ice-sheet at its maximum may therefore have contained one-quarter less ice than generally estimated. General overall ice-movement in the southern part of the continental ice sheet was from the northwest and northeast towards the region of maximum drawdown in the Great Lakes region".

Increased attention has been given to the till itself in southwestern Alberta, as regards its composition and fabric. The stone orientation and their direction of dip were studied in the field and the data are now being analysed by Mr. P. Vernon, who had served as a senior assistant in the field work.

A radiocarbon date from the Crowsnest pass indicates that a glacier advance, probably the largest since the Cochrane substage, reached its maximum about 4,770 years ago.

Stalker has also submitted manuscripts, to the Survey, of considerable Pleistocene interest. These are entitled "Buried Valleys in Central and Southern Alberta", and "Quaternary Stratigraphy in Southern Alberta".

J. Terasmae completed the field work necessary for his research into the history of deglaciation of the area between Lake Erie and James Bay by palynological methods. This work has been accompanied by wide-spread study of the Pleistocene geology of the region, and involved close cooperation with other Pleistocene geologists, agronomists, and botanists. The results of this work, already covered in part by numerous short articles of merit, are widely sought after. Terasmae has also investigated the occurrence of spores and pollen in varved sediments. He attended a field conference with biologists from Queen's University to study new methods of sampling lake sediments. An effort is being made to develop a better sampler for our own palynological purposes. Terasmae delivered a lecture on Palynological methods to the Geology Discussion Group at the University of Toronto. He also attended the annual field conference of the Eastern Friends of the Pleistocene in the area immediately southeast of Lake Erie. He was accompanied by Drs. Fyles, Henderson, Prest, and Stalker. The work of the American Pleistocene geologists along the southern edge of the glaciated area is of prime concern to the Canadian program of study.

Pleistocene Palynology Laboratory Report

J. Terasmae

Most of the work has been devoted to palynological studies of Pleistocene deposits in Ontario in an effort to establish a chronology of post-glacial events (retreat of the Wisconsin ice) as interpreted from the history of the vegetation and palaeoclimatology. Correlation of the Great Lakes history with the events in the St. Lawrence lowlands has been established in some detail. This part of the study has been aided by several radiocarbon dates.

The following services were provided to geologists of the Geological Survey: (a), preliminary study of samples collected by J.G. Fyles from Banks Island and Victoria Island; (b), study of a pollen profile from Newfoundland for E.P. Henderson; (c), study of samples from the Coppermine River area Northwest Territories for B.G. Craig; (d), study of bog and lake sediments from northwest Ontario for V.K. Prest; (e), study of preliminary samples from Yukon, collected by O.L. Hughes; and (f), analyses of several samples for A.M. Stalker (Alberta) and H.A. Lee (New Brunswick).

The following services were provided to geologists outside the Geological Survey: (a), correlation of Pleistocene deposits at northern Ontario dam sites for the Ontario Hydro-Electric Power Commission; (b), study of samples submitted by P. Karrow for the Ontario Department of Mines;

(c), study of history of weed pollen for the Department of Agriculture, Ottawa; (d), correlation and age estimate of Pleistocene deposits for the Department of Public Works, Ottawa; and (e), study of late-glacial deposits for the Saskatchewan Research Council.

Other activities included: necessary basic research for identification and description of plant microfossils and Protozoa and Rotatoria; and study of pollen and spore assemblages in surface samples and their relation to modern vegetation - as basis for interpretation of fossil assemblages.

Sedimentology Laboratory Report

H. A. Lee

The Sedimentology Laboratory makes mechanical analyses of clastic sediments, mineral separations, and microscope mounts of the heavy minerals.

Results from the laboratory are being used as an aid to research carried out by geologists of the Geological Survey for improvement of classification and precision of nomenclature of clastic sediments, in correlation problems, and in basic research into the behaviour of sediments.

The procedures for mechanical analyses of a sediment include crushing, sieving, disaggregation, and pipette draw-offs of clay-size particles, computation of results, and plotting of graphs. Mineral separation is by heavy liquids.

In 1960, a total of 237 mechanical analyses of sediments were made; 90 of these were sieve analyses, and 147 were complete sieve and pipette analyses. In addition, 68 heavy mineral separations were made and 136 microscope mounts were prepared. The laboratory has also been used for the preparation of 32 samples for further palaeontological treatments. In addition during the year, a method to determine percentages of sand, silt, and clay suitable for field use was devised and tested in the laboratory. Over a month was spent in experimenting with methods suitable for mechanical analyses of extremely friable sandstone and shale from Prince Edward Island. Variable results were obtained but none proved satisfactory.

Open house was held in the laboratory in January for the purpose of acquainting the Geological Survey staff with the equipment, facilities, and services of the laboratory. An information brochure was distributed.

Changes in the technical staff took place with John Read, a seasonal employee, leaving on April 1st, and Ronald G. Kelly from the Department of Public Works Testing Laboratories joining the staff on September 1st to occupy a new position of Technician 1.

The laboratory unit reached the limit of its production ability this year with its existing staff, space, equipment, and present methods. An important part is being played in the Polar Continental Shelf program. This has resulted in an increased demand for the services of the Sedimentology

Laboratory, accounting for full utilization of the laboratory for 72 per cent of its time.

In an attempt to provide services for the exceptionally large demands, overtime work (twice a week) by the two technicians in the laboratory was begun in early December.

Membership on Committees

Fyles, J.G. - Commissioner, American Commission on Stratigraphic Nomenclature; Member, Pleistocene Committee of this Commission.
- Member, Committee on Stratigraphic Names, Geological Survey of Canada.

Gadd, N.R. - Consultant to A.E.C.L. on waste disposal problems (O.P. 83).

Prest, V.K. - Member, Associate Committee on Soil and Snow Mechanics; Member, Sub-committee on Soil-Mechanics, Nat. Research Council.

Terasmae, J. - Member, Advisory Committee on Geology, Toronto Rapid Transit Subway Extension.
- Member, Sub-committee on Muskeg Assoc. Committee on Soil and Snow Mechanics, N.R.C.

Outside Publications

Craig, B.G. and Fyles, J.G.: Pleistocene Geology of Arctic Canada (Abstract); Canadian Oil and Gas Industries, Dec. 1959.

Lee, H.A.: Late glacial and post glacial Hudson Bay Sea Episode; Science, vol. 131, No. 3413, pp. 1609-1611, 1960.

MacClintock, P. and Terasmae, J.: Glacial History of Covey Hill; Jour. Geol., vol. 68, No. 2, pp. 232-241, 1960.

Radforth, N.W. and Terasmae, J.: Palynological Study Relating to the Pleistocene Toronto Formation; Can. Jour. Bot., vol. 38, pp. 571-580, 1960.

Terasmae, J. and Hughes, Owen L.: Glacial Retreat in the North Bay Area, Ontario; Science, vol. 131, No. 3411, pp. 1444-1446, 1960.

ENGINEERING AND GROUND-WATER GEOLOGY SECTION

I. C. Brown

General

The Pleistocene, Engineering, and Ground Water Geology Section was divided into two sections, Pleistocene Geology Section, and Engineering and Ground-Water Geology Section in October 1960. This report covers the activities of those working in Engineering and Ground-Water Geology for the whole year.

Discussions with the Saskatchewan Research Council resulted in continued and increasing cooperation with Saskatchewan in mapping, drilling, and geophysics. Cooperation was maintained with Ontario Water Resources Commission particularly on work in the Ottawa area. A group visited the Carillon Power project of Quebec Hydro to observe a shear test of rock in place and inspected the whole site.

Meetings of the Section were held to report on field work, discuss form of publications, discuss ground-water problems and projects, and to discuss engineering geology problems. It was evident that there was no lack of problems and a file was set up to keep track of these for future planning. It is also apparent that the emphasis in ground-water work is changing from inventory to quantitative studies, and to support this an ever increasing research program is going to be needed.

More attention is being paid to the chemistry of water as an aid in solving problems, in addition to the obvious factor of potability, and cooperation is increasing with geochemists and the industrial water section of the Mines Branch.

Numerous requests are received and answered for ground water information from individuals, industries, drilling companies, and other government departments. More and more of these requests are for quantitative information.

Field and Office Activities

Field activities are covered in Information Circular No. 4 - Field Work, 1960. In addition to this the following activities are worth mentioning.

L.V. Brandon provided information in connection with the proposed Ottawa main collector sewer. In addition to the information given to Northern Affairs and National Resources and Indian Affairs on water possibilities at 7 northern localities, interesting problems concerning the chemistry of aquifers in the Great Slave Lake area were found and preliminary work was done on a quantitative study of ground-water in the Pine Point area. Some of these problems might be of interest to the Department of Fisheries. The RCMP were advised on water problems in Newfoundland and Nova Scotia and the

Department of National Defence (Army) were given advice on 6 different sites as well as some more general problems. Several thermal springs in the Northwest Territories were visited and the possibility of using these as sources of heat investigated.

P.A. Carr in cooperation with a geochemical party under A.Y. Smith, found some wells containing anomalously high values in copper, lead, and zinc in the Moncton area, N.B. Work in this area also introduces the problem of intrusion of sea water. Several towns wish to expand their water supply and more work is required to give quantitative data for this purpose.

J.E. Charron determined that considerable shallow ground-water is available from sands deposited in the meanders of abandoned streams. While much remains to be learned, work to date in southern Manitoba indicates that the recharge areas and movement of underground water in shallow and bedrock aquifers are probably entirely different and will have to be investigated for the solution of regional problems.

E. Hall gave advice to the RCMP, the Engineering Branch of the Department of Public Works and cooperatively to the Saskatchewan Research Council on water well problems. He also acted as consultant in arrangements with the Department of Public Works for our drilling program.

E.B. Owen has given advice on construction materials in Montreal, Cornwall, Ottawa, and Yukon areas and on the basis of past experiences advised on ground-water in the Maniwaki and Rigaud areas, Quebec, and at Alfred, Ontario.

R. Pearce, in addition to taking care of the ground-water files and other publications, has given answers to an average of 3 calls a week for ground-water information in the Ottawa area and has been reading water-level recorders in this area.

J.S. Scott was mostly concerned with Pleistocene geology but has also provided considerable engineering information in the south Saskatchewan dam area.

A.M. Stalker visited and reported on the water supply of the Peigan Indian Reserve, Alberta, at the request of the Dept. of Citizenship and Immigration, and answered other requests from Alberta.

A.M. Toth has provided information on ground-water to many residents in the Saskatoon area as well as the city of Saskatoon. He also has given to, and received much quantitative information on ground-water from large drilling companies, Potash Co. of America, Saskatchewan Research Council, and PFRA. In this area the method of doing a very rapid water inventory using students and a more detailed investigation of drilling in progress has been satisfactory and might be considered for future use in other areas.

J.J.L. Tremblay has been very successful in obtaining quantitative information from companies in the Vaudreuil area and such cooperative efforts can provide us with much useful information that could not be obtained by normal mapping methods.

E.C. Halstead and A. Treichel, both working from the Vancouver office, provided much advice on ground-water in the Vancouver and eastern

Vancouver Island areas and advised the Department of National Defence on a problem on Vancouver Island.

Continuous recording water level recorders are being maintained as follows: Northwest Territories (1), British Columbia (2), Saskatchewan (11), Manitoba (1), Ontario (4), and Quebec (4).

Membership on Committees

I.C. Brown
- Member, Geology Division Committee, C.I.M.
- Member, Salaries and Classification Committee, Professional Institute.
- Member, Committee on Scholarship and Research, National Advisory Committee on Research in the Geological Sciences.

L.V. Brandon
- Member, Subcommittee on Permafrost, NRC Committee on Geodesy and Geophysics.
- Member, Subcommittee on Hydrology, NRC Committee on Geodesy and Geophysics.

Membership in Societies

	C.I.M.	G.A.C.	P.I.	E.I.C.	G.S.A.
I.C. Brown	x	x	x		
J.E. Charron			x		
J.S. Scott					x
A.M. Toth				x	x
J.J.L. Tremblay	x				

GEOPHYSICS DIVISION

L.W. Morley, Chief

INTRODUCTION

The function of the Geophysics Division is to conduct and interpret geophysical surveys to aid in geological mapping and to conduct research on new methods and instruments for geophysical surveying and prospecting.

The regular yearly production of about 115 aeromagnetic maps by the Geological Survey was swelled enormously in 1960 by the publication of

160 aeromagnetic maps prepared by Spartan Air Services under the Ontario Department of Mines-Geological Survey of Canada "Road to Resources" aeromagnetic survey. These latter maps not only aided geological mapping by G.S.C. geologists but also undoubtedly stimulated prospecting considerably in northwestern Ontario. It is anticipated that a greatly increased rate of aeromagnetic surveying of the Canadian Shield will be effected on a similar Federal/Provincial sharing basis in the next few years.

The seismic unit made a useful contribution on the Polar Shelf Project by indicating a depth of the order of 28,000 feet for the Sverdrup Basin in the Arctic. They also made measurements on the depth of the Meighen Island ice cap and showed that the bottom of the permafrost could be mapped by the seismic method. Later in the year a buried river channel west of Montreal was delineated using the refraction method.

With a team of four members in the Palaeomagnetic Section, a record number of samples were collected, processed, and measured. These results are not only of interest locally but are published and used internationally to establish polar wandering curves and to shed light on theories of continental drift. When polar wandering curves have been verified by further data, the method can be used for age determinations more confidently.

The instrument development section managed to get C.G.S. "Baffin" and "Kapuskasing" equipped and operational with nuclear sea magnetometers in time for the 1960 field season with the result that about 17,000 line miles of data were obtained east and south of Nova Scotia. This project is part of the Oceanographic Institute field program.

Another important contribution has been nearly realized by the instrument section - the development of a long-wanted, light-weight airborne magnetometer which can be easily moved from one aircraft to another. This instrument is presently being flight tested.

In magnetic resonances research, 1960 has been a year of intensive construction. Two spectrometers and a magnetically shielded hut have been built. It is expected that interesting results will be forthcoming from these instruments in 1961.

Active research in the study of natural gamma radiation is being drawn to a close with the completion of reports on absorption studies in rock and air by A.F. Gregory.

Members of the division submitted during the year the following reports for publication:

Black, R.F.: Palaeomagnetism of the Belt Series of Southwestern Alberta and Southeastern British Columbia; submitted as bulletin to G.S.C.

Gregory, A.F., Bower, Margaret E., and Morley, L.W.: Geological Interpretation of Aerial Magnetic and Radiometric Profiles, Arctic Archipelago, N.W.T.; G.S.C. Bulletin 73 (in press).

- Airborne Geophysical Reconnaissance of the Canadian Arctic Archipelago - submitted to "Geophysics".

Larochelle, A.: Palaeomagnetism of the Monteregion Hills - Bulletin submitted to G.S.C.

- Design of a Curie Point Meter; G.S.C. Bulletin 69.

MacLaren, A.S.: Aeromagnetic Maps with Descriptive Notes on Interpretation: Beaver Hill Lake (75 I); Firedrake Lake (75 H); and Wholdaia Lake West Half (75 A).

Wesemeyer, H.: A Magnetically Shielded Room - submitted as a topical report G.S.C.

REPORTS ON SECTIONS

AEROMAGNETIC SURVEYS SECTION

Field and Office Activities

Aeromagnetic Surveys

(1)	Ontario-Quebec	23,445 line miles (½ mile spacing)
(2)	Coronation Mine area near Flin Flon	775 line miles (¼ mile spacing)
(3)	District of Mackenzie	43,240 line miles (½ mile spacing)
	Total	67,460 line miles (702 hours)

An Aero Commander 680 aircraft was leased from Commander Aviation Limited, fitted out with the Geological Survey's ASQ-3A airborne magnetometer and flown by Kenting Aviation Limited.

To complete the parts of Quebec and Ontario started last year, and lying between 78°45' and 80°15' West and 45°30' and 48°00 North, the aircraft was based at North Bay.

For the Coronation Mine area, the aircraft was based at Flin Flon. The area measures about 15 miles square. The terrain clearance was 500 feet and the line spacing 1/4 mile.

The main area for the season was in the District of Mackenzie, N.W.T., between latitudes 50°45' and 63°00 North and longitudes 107°30' and 112°00' West. The main base was at Uranium City, Saskatchewan with a refuelling stop at Fort Smith.

The party comprised the following Geological Survey personnel: K.H. Owens, party chief, F. Essex, J. Houlihan, J. Kempt, J. Lee, and D. Reveler.

The weather and aircraft serviceability were good and there were no major breakdowns of equipment during the season. However, more magnetic storms were encountered than anticipated, accounting for 27 of the 92 days operated out of Uranium City. This was the big factor in not completing the area assigned.

Aeromagnetic Compilation

A total of 115 maps were compiled and submitted for drafting during the year. These were all from the Maritime Provinces - Gulf of St. Lawrence area. This project, which was flown in 1958, is now complete.

The Northern Manitoba project with a total of 92 map sheets, which had been set aside for 3 years while waiting for better topographic maps, was resumed during the early part of May. First submission of manuscripts for this area should be about February 1, 1961.

In June 1960, compilation was started on the eastern part of the Ontario-Quebec area that was flown during the last two field seasons. This job comprises approximately 115 one-mile sheets. It will be at least one year before any of it is ready to submit for drafting.

N.W. Ontario 'Roads to Resources' Aeromagnetic Maps

This area lies between latitudes 50°30' to 53°00' N and longitudes 80°00' to 84°00' W. One hundred and sixty one-mile aeromagnetic map sheets were compiled, drafted, and delivered for checking to the Geological Survey by Spartan Air Services Limited. With the exception of 3 maps, which had to be recontoured, they were all acceptable and were mostly published before the end of the year.

These maps are being used by the G.S.C. mapping geologists to extrapolate the mapping of rock contacts under the overburden. Several large-scale features were outlined in this survey which will help considerably in delineating geologic structure.

SEA MAGNETOMETER SURVEYS

Two hydrographic ships, C.G.S. "Baffin" and C.G.S. "Kapuskasing", were equipped with proton free-precession magnetometers in time for the 1960 field season. This work is being undertaken on behalf of the Oceanographic Institute and will eventually be taken over by them. C.G.S. "Baffin" was used for surveying a small area south of Yarmouth, N.S., and the "Kapuskasing" for a larger area southeast of Cape Breton (see figure in pocket).

A Varian proton free-precession station magnetometer was set up and operated at Glace Bay, N.S., to act as a storm monitor for the sea magnetometer surveys.

The "Baffin" area was compiled and shows that certain rock formations in southern Nova Scotia extend south for considerable distances under the sea.

The "Kapuskasing" area has not been compiled except for one small area in which a large intense anomaly was observed.

At present, sea magnetometer compilation is at a stand-still owing to lack of staff.

INTERPRETATION SECTION

A.S. MacLaren continued geologic-aeromagnetic correlation in several areas. In the N.W. Territories, correlation with known geology and an interpretation of the magnetics were done for the Beaverhill Lake and Wholdaia Lake sheets. In the area between Georgian Bay and the Gatineau River, several unusual anomalies which had been examined and sampled last field season were reported on.

In the west half of the "Roads to Resources" area in N.W. Ontario, A.S. MacLaren prepared an interpretation of 8 two-mile sheets prior to field mapping by geologists in order to point out areas requiring greater attention than usual.

During the field season he examined the rocks underlying numerous anomalies in an effort to determine the cause of the anomalies.

A.F. Gregory completed the interpretation of the Arctic Island reconnaissance aeromagnetic data. The chief features of interest were the anomalies associated with the basic dykes and piercement domes in the Sverdrup Basin, the magnetic effect of a graben structure in Lancaster Sound, and the anomaly associated with the Boothia Arch.

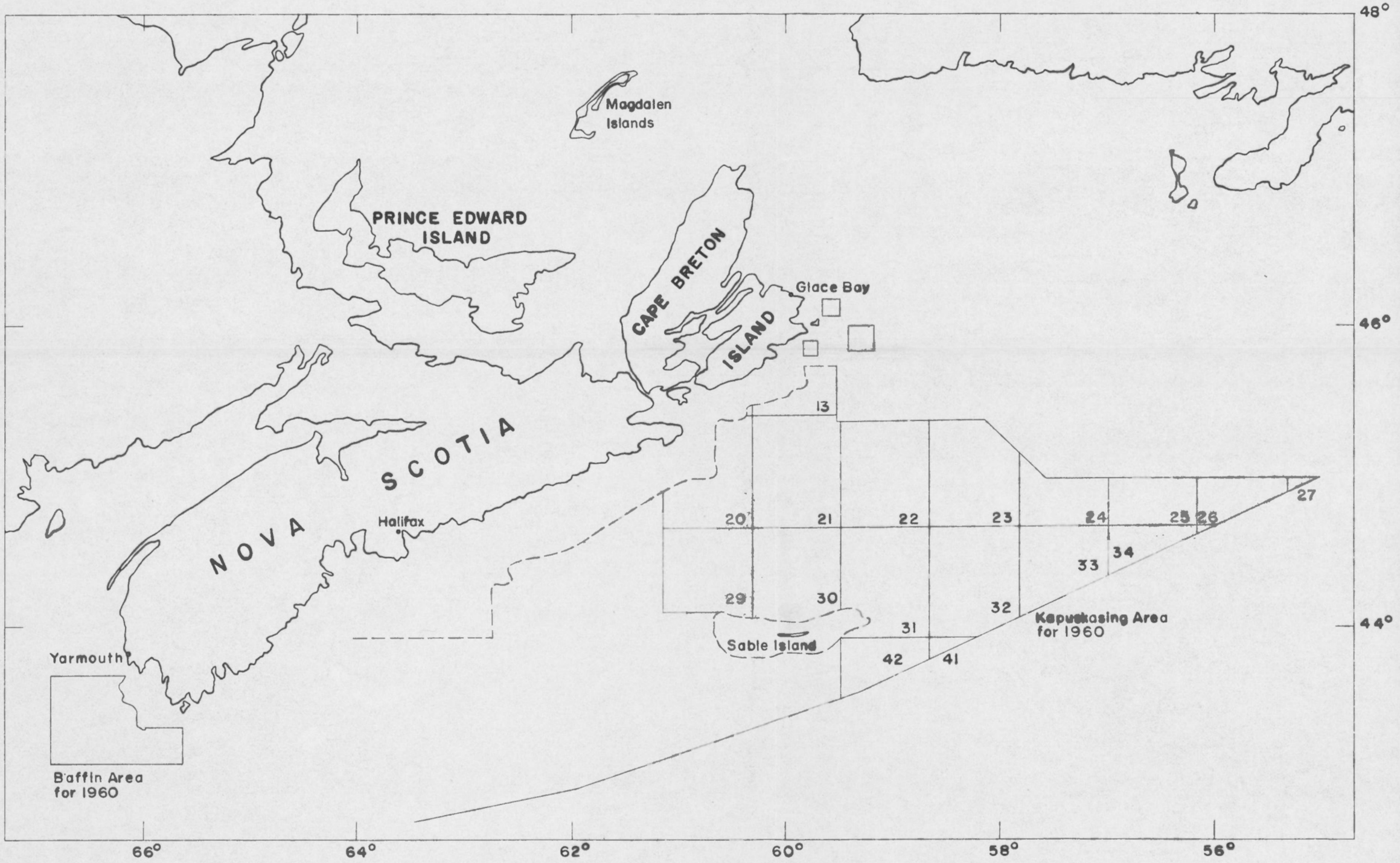
Miss Bower completed the interpretation of aeromagnetic profiles across Hudson Bay from Churchill to Coral Harbour and from Churchill to Great Whale River. This work showed that there is certainly no deep sedimentary basin in the Bay in the vicinity of these profiles. Maximum depths to basement were calculated to be of the order of from 1,150 feet just east of Churchill to 3,100 feet 40 miles off shore from the mouth of the Severn River.

Miss Bower also completed a compilation of the Marmora anomaly at different heights. From an analysis of the fall-off of the field with altitude it is apparent that the source of the anomaly is dipolar in nature - an indication that the orebody bottoms at a fairly shallow depth.

SEISMIC METHODS SECTION

All personnel of the Seismic Methods Section were attached to the Polar Continental Shelf Project in 1960. The crew was based at Isachsen, Ellef Ringnes Island from April 26th to August 7th.

It is hoped that the seismic technique will help to answer a few of the geological problems associated with the Sverdrup Basin within the next two years and in various other regions of the Canadian Arctic in succeeding years. Some of these problems are: the depth to basement; composition and configuration of the basement; the presence and configuration of Mesozoic and


48°
46°
44°
66°
64°
62°
60°
58°
56°
Magdalen Islands
PRINCE EDWARD ISLAND
CAPE BRETON ISLAND
Glace Bay
NOVA SCOTIA
Halifax
Yarmouth
Baffin Area for 1960
Sable Island
Kapuskasing Area for 1960
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Palaeozoic sediments; a correlation of lithologic types with seismic velocities; and the depth of the Mohorovicic discontinuity. All record interpretation is tentative at present, but indications are that there are more than 28,000 feet of sediments at the south end of Ellef Ringnes Island. This compares to about 7,000 feet at the north of Borden Island. The seismic velocities associated with various geological strata appear to be fairly consistent so that a correlation between certain lithologic types and seismic velocities should be possible.

A considerable amount of logistic information regarding seismic operations in the Arctic was accumulated which should be of value particularly to industry when intensive exploration for petroleum is started there.

There was not, as it was feared there might be, sufficient ice noise to interfere with seismic recording out on the Arctic ice. Another interesting by-product of the Arctic work was the discovery that the base of the permafrost can be mapped by reflection seismic techniques.

A seismic refraction survey was done near Vaudreuil immediately west of the city of Montreal for the purpose of delineating a buried river valley whose presence was postulated by Mr. J. Tremblay of the Groundwater Section. The buried channel was found to be about 200 feet deep and course westward from the town of Vaudreuil; it appears to source in the general region of Rigaud Mountain. Further work is planned in this area to delineate side channels and to trace the main channel farther.

PALAEOMAGNETISM SECTION

Two field projects were carried out in the summer of 1960. R.F. Black collected a total of 272 oriented specimens in Prince Edward Island to supplement the present palaeomagnetic results for Palaeozoic rocks from the Maritimes and Eastern Quebec. Sample preparation of these specimens is now completed and magnetization measurements are in progress. S.R. Sopher collected 240 oriented specimens in the Sudbury Basin area. This collection was supplemented by 27 oriented specimens collected underground by the staff of the International Nickel Company. The object of this project is to study the structural history of the Sudbury Basin from palaeomagnetic directions. So far, 225 of the above specimens have been prepared and measurements are in progress. The preliminary results in hand seem to indicate a substantial difference in palaeomagnetic orientations for rocks collected from the north and south limbs of the Basin respectively, thus implying a post-intrusive deformation of the igneous rocks forming the Basin.

Other laboratory activities included the completion of the project originated last year in the Purcell system in S.W. Alberta, Saskatchewan, and British Columbia. A total of 125 specimens were dealt with in this project. The results suggest a modification to the Polar Wandering Curve of North America for the Proterozoic.

Measurements were also carried through for 232 oriented specimens collected by different geologists in various parts of the country. On account of the extreme scattering the the magnetization directions within each of these groups of specimens, it does not seem possible to plan any publications of the results obtained. It is hoped, however, that possibly some of these groups of specimens may turn out to show a stable and consistent magnetization after magnetic washing.

Instrument development was an important item in laboratory activities. Mention will only be made of the adaptation of aircraft sun compasses for oriented specimen collection and that of a portable fluxgate magnetometer for improving on the field-nulling in the magnetic 'washing' apparatus. Development of the spinner-type, air driven magnetometer is nearing completion. This new magnetometer will speed up the measurement of rock samples several fold.

Dr. Larochelle, after attending the Helsinki meeting of the I.U.G.G., made visits to the palaeomagnetic laboratories in the Universities of Paris, London, Cambridge and Durham. These visits were of considerable help in planning future activities of the palaeomagnetic section.

INSTRUMENT RESEARCH AND DEVELOPMENT SECTION

L.S. Collett, S. Washkurak, P. Sawatzky, H. Knapp, and J. Stauffer designed and constructed two proton free-precession magnetometers and installed them in C.G.S. "Kapuskasing" and C.G.S. "Baffin" in time for the 1960 field season.

The magnetometers comprise a sensing head towed on a 400-foot cable, a main panel consisting of programming relays, power supply, receiver amplifier, a Berkeley digital counter, a digital to analog converter, and a pen recorder. Special electric reels for handling the cable were installed in the ships. Space was found in an existing cabin for housing the equipment in the Baffin, but a special hut had to be constructed with the help of the Navy in the case of the Kapuskasing.

During the course of the field season, a number of ideas for improvement became evident which will be incorporated in the instruments for next year.

H. Knapp continued work on a high gain narrow-band amplifier, high resolution phase comparator and power supply to be used in conjunction with the new air turbine remanent magnetometer.

H. Wesemeyer and R. Ahrens continued developmental research on the continuously recording paramagnetic resonance magnetometer. This project is turning out to be a great deal more difficult than originally supposed because of the necessity of conducting side experiments to get an understanding of the basic physics involved which has not been worked out in the physics literature.

S. Washkurak and P. Sawatzky have been working on the miniturization of a free-precession proton magnetometer for airborne use. It is hoped that the final weight will be less than 30 pounds and that the magnetometer will be good to $\pm$ 2 gammas. It is presently being tested for bird operation in cooperation with the Flight Research Section of the National Aeronautical Establishment, N.R.C.

Magnetic Resonances Research

For magnetic resonance absorption in rock samples, in particular, for the detection of trace elements by means of paramagnetic resonance, Dr. Wesemeyer built a K-band microwave spectrometer. Its main part is a reflection

type of cavity resonator which is mounted in one branch of a microwave bridge circuit. Preliminary results of rock sample analysis which Dr. Wesemeyer had previously done outside were reported on at an earlier date. Work on this instrument has been delayed until additional seasonal help can be obtained.

For magnetic resonance absorption at weak magnetic fields, a very sensitive radio frequency spectrometer was built to study paramagnetic and ferromagnetic rock samples. The complex phenomenon of magneto-absorption in rocks is of particular interest here. Absorption signals for a gabbro sample gave a signal to noise ratio of 50:1 at a field of 5 Oersted in a preliminary experiment.

A magnetically shielded room comprised of a double layer of co-netic shielding was constructed for magnetic resonance experiments for electromagnetic studies and for testing magnetometers.

Studies of the Natural Gamma Ray Spectra of Rocks

Dr. Gregory, in cooperation with J.L. Horwood of the Mineral Science Division, Mines Branch, continued the study of natural gamma radiation spectra emitted by sources of varying thicknesses of rocks and the extent to which these spectra become degraded after passing through 700 feet of air. The degraded spectra emitted by thick sources were found to contain features characteristic of the individual radio-elements present in the source, but the spectra vary with the thickness and density of the source.

The interpretation of the Arctic aeroradiometric data was completed. This study resulted in the formulation of a new method of interpreting integral count data by the "signal clearance" method. A bulletin has been published on this.

MEMBERSHIP ON COMMITTEES

L.S. Collett	- Departmental adviser on radio communications and equipment - Member, Ottawa Branch
A.F. Gregory	- Secretary, Ottawa Geophysical Discussion Group
A. Larochelle	- Secretary, Logan Club, G.S.C.
A.S. MacLaren	- Member, Library Committee, G.S.C.
L.W. Morley	- Member, N.R.C. Associate Committee on Geodesy and Geophysics - Member, Subcommittee on the Upper Mantle - Member, G.S.C. Committee on Absolute Age

MEMBERSHIP IN SOCIETIES

	I.R.E.	RASC	C.I.M.M.	C.A.P.	S.E.G.	A.G.U.	G.A.C.	M.S.C.	G.S.	R.C.G.S.	C.F.N.S.	Prof.Eng.	C.S.E.G.
Ahrens, R.H.	x											x	
Bower, Miss M.E.		x											
Collett, L.S.			x	x	x	x							
Gregory, A.F.							★					x	
Hobson, G.D.					x							x	
Larochelle, A.			x		x								
MacLaren, A.S.			x					x	x	x	x		
Morley, L.W.			x		x	x							
Sawatzky, P.	x											x	
Washkurak, S.	x												
Wesemeyer, H.				x									

★ indicates Fellow
x indicates Member

OUTSIDE PUBLICATIONS

Gregory, A.F., Bower, Margaret, E., and Morley, L.W.: Geological Interpretation of Aeromagnetic Profiles from the Canadian Arctic Archipelago; Proceedings of the First International Symposium on Arctic Geology (in press).

Gregory, A.F., and Fournier, A.L.: The Effect of Temperature on the Response of Scintillation Counters; Geophysics, vol. XXV, No. 6, pp. 1288-90, Dec. 1960.

Hobson, G.D., and Collett, L.S.: Some Observations with a Hammer Refraction Seismograph; Can. Min. and Met., Bull. vol. 53, No. 581, pp. 674-681, 1960; also Transactions C.I.M.M., Vol. LXII, pp. 448-455, 1960.

Hobson, G.D.: A Reconnaissance Seismic Refraction and Reflection Survey in Southwestern Ontario; Can. Min. Jour., vol. 81, No. 4, pp. 83-87, 1960.

- Seismic Survey in Ontario; Canadian Oil and Gas Industries, pp. 47-51, July, 1960.

Morley, L.W.: Prospecting for Massive Sulphides with Airborne E.M.; United Nations Seminar on Aerial Survey Methods and Equipment (E/CN.11/I & NR/AS/54).

OUTSIDE TALKS

A.F. Gregory presented different aspects of the Arctic Islands Airborne geophysical survey to (1) The First International Symposium on Arctic Geology, Calgary, Alberta, (2) The International Meeting of the Society of Exploration Geophysicists, Galveston, Texas, (3) The Logan Club, and (4) The Ottawa Geophysical Discussion Group. He also presented his paper on "Aeroradiometric Surveys as an Aid in Geological Mapping" to the Ottawa Geophysical Discussion Group.

G.D. Hobson presented his paper on "Seismic Surveying in S.W. Ontario" to the Prospectors and Developers Convention, Toronto, March 8th, and to the Ottawa Geophysics Discussion Group. He presented different aspects of the Polar Shelf seismic survey to (1) The International Society of Exploration Geophysicists, Galveston, Texas, (2) The Ottawa Geophysics Discussion Group, and (3) The Logan Club.

A. Larochelle presented his paper on "Palaeomagnetism of the Monteregion Hills" to the International Union of Geodesy and Geophysics, Helsinki, Finland, August, 1960.

L.W. Morley presented a paper on "Prospecting for Massive Sulphides with Airborne E.M." to the United Nations Seminar on Aerial Survey Methods and Equipment, Bangkok, Thailand, January, 1960. In this seminar he also acted as discussion leader on airborne geophysical methods.

PETROLOGICAL SCIENCES DIVISION

S. C. Robinson, Chief

INTRODUCTION

The Petrological Sciences Division comprises the Analytical Chemistry, Isotope Geology, Mineralogy, and Petrology Sections, all of which were part of the old Mineralogy Division in previous years. Reports of these sections and of the two major petrological studies on granites and ultrabasic rocks are appended.

The only major change in organization was in the Spectrograph Laboratory where responsibility for method development was vested in W.H. Champ and for sample analysis in W.F. White. This change has already improved output.

Laboratories of the division were opened to Public inspection at the official opening of the building. A surprisingly large number of visitors took advantage of this opportunity. Officers of the division, however, were even more delighted by the response of personnel of the Survey itself who took the opportunity to inspect each laboratory in large numbers as it was made ready for their inspection.

S.C. Robinson visited field parties in the Valhalla and Monashee Mountains, in the Tulameen Intrusive, and on the Muskox Complex in a four-week period in July and August.

Service Functions

The division has had a very productive year. The statistics, which are summarized below, indicate that the gross total of analyses and services in 1960 was 2.4 times as great as the total for the same services in 1959. At the same time it is apparent that the backlog of work outstanding at the end of 1960 in the Analytical Chemistry Section is more than twice as great as the backlog at the end of 1959, and amounts to 25 per cent of the annual output of the laboratories. For other sections, the backlog cannot be readily estimated because samples are submitted as priorities are established and as storage space permits. In Isotope Geology, however, the present backlog exceeds the annual production by a considerable margin.

In order to expedite work, an active programme of development of new methods and modification of old ones is maintained. The great advance in productivity this year is in large measure due to innovations and improvements developed in 1959. In 1960 new chemical methods for aluminum and magnesium were developed, a new vacuum X-ray spectrograph promises to lighten the load on the chemistry laboratories and has already made possible an increase in number and scope of X-ray diffractometer analyses, the solid source mass spectrometer has opened up new fields in isotope analysis, the new argon extraction lines coupled with introduction of an induction furnace have greatly improved and increased extraction of argon, improved flowsheets in the mineral crushing and separating laboratories have markedly increased their efficiency and productivity, the big increase in output of the spectrograph laboratory is due in part to reorganization and in part to introduction of new procedures, improvements have been made in methods of staining thin sections and of determining composition of plagioclase feldspars by the fusion technique, virtual completion of the radiocarbon laboratory ensures that this important new service will be providing dates early in 1961, development of procedures for generating a stable magnesium ion current have made possible isotope analyses of that element, and mass production methods in the preparation of mineral sets for the public have permitted reduction in staff.

PRODUCTION STATISTICS

MINERALOGY

X-ray Laboratory	1959	1960
Mineral Identifications	1320	1483
Determinations of unit cell constants	66	155
Diffractometer patterns	247	597
Reference patterns prepared	55	54
X-ray spectrographic analyses	99	116
Mineral Collections Sold		
Prospector's Collections	6506	5336
Mineral Industry Collections	32	50
Mineral Preparation & Separation		
Total mineral concentrates made	207	1206
Additional samples crushed and sized	178	515
Specimens examined for the Public	1647	2500
Letters written to Public	242	294

PETROLOGY

Services:	Staining feldspars		279
	Modal analyses		200
	Other (total)		58
	Meteorite Collection (additions)		8
	Specimens examined for the Public		4
	Thin section collections received		3 (300)
	Petrological collections received	22 (650)	7 (200)

ANALYTICAL CHEMISTRY

Samples received	1685	5127
Samples completed (Chemistry)	391	2013
Samples completed (Spectrographic)	509	2252
Backlog of samples (Chemistry)	343	544
Backlog of samples (Spectrographic)	409	999
Total, Chemical Determinations	3491	7489
Total, Spectrographic Exposures	1759	5650
Lead Tetramethyl Preparations	87	41

ISOTOPE & NUCLEAR GEOLOGY	1959	1960
Total argon extractions	91	202
Total argon isotope analyses		242
Total K/Ar ages reported		157
Total Pb/U and Pb-Th ages reported		11
Total stable isotope (Pb, S) analyses (gas source)		39
Total stable isotope (Mg) analyses (solid source)		36
Total SO_2 extractions		403

The increase in volume of services in 1960 was achieved with an increase of only two continuing positions and one borrowed position, which amounts to approximately 8% of the division's strength. Summer and winter seasonals were the same as in 1959 for the present four sections. It is apparent, therefore, that a very sharp increase in efficiency has been achieved. This increase is due to four main factors:

1. The incomparably improved facilities of the new building.

2. Improved methods and flowsheets.

3. The fact that last year a month to six weeks was taken up by the move.

4. The transfer of personnel on research projects to service work because of increase in service load.

Non-Service Functions

The non-service aspects of the work of this division have been reduced essentially to the projects on granites and ultrabasic rocks, and to some work on meteorites. As a result, publications emanating from the division are largely compilations of work done as services for others or joint authorship in projects initiated by others. This is an undesirable situation. There is urgent need for fundamental studies in other rock types such as anorthosites, diabases, alkaline rocks, and various sedimentary and metamorphic suites. There is also particular need for practical studies of the various families of rock-forming minerals if the Survey is to be able to use modern applications of quantitative mineralogy to petrological studies. If Geology is to make significant contributions to the search for new mineral deposits not exposed at the surface, continuous research in isotope geology, mineralogy, and petrology is essential. The field and laboratory facilities of the Geological Survey are ideally suited to this purpose.

Recommendations

It is apparent that despite the big increase is service productivity, the division is unable to meet the expanding requirements of the Branch as a whole. It is observed that the principal demand for services comes from officers employed on detailed mapping and special projects. As reconnaissance gives place to more detailed work the demand for services

will increase. It is anticipated therefore that a considerable increase in staff assigned to provision of services must be envisaged. Because much of the work requires experience to achieve adequate skill and efficiency, some increments of continuing staff should anticipate peak demand.

It was pointed out last year that if services for field and research projects are to be provided in the winter following collection of samples, it would be advisable to extend use of winter seasonals to include undergraduates and high school graduates as well as graduates. At present summer seasonal help is used principally to reduce existing backlogs. This means that some field men do not obtain results within a year of collecting samples. Use of seasonal assistants is an efficient and inexpensive means of providing services of a repetitive nature at peak periods, which in the laboratories occur in the fall and winter. It is also advisable to meet increases in demand first by seasonal personnel, in order to establish whether there is a necessity for additions to continuing staff.

An attempt was made last year to obtain an estimate of the demand for laboratory services in the hope of increasing efficiency. The results indicate that it is better to estimate this demand by applying a factor to the demand of the previous year. This allows greater flexibility and removes the imposition of more paper work from field and research officers.

REPORTS OF SECTIONS AND LABORATORIES

ANALYTICAL CHEMISTRY SECTION

J. A. Maxwell

General

Examination of the statistical section which follows will show that the Analytical Chemistry Section has had a very busy year. A very satisfactory increase over 1959 occurred in the number of analyses produced, but a similar large increase in the number of samples submitted for analysis has resulted in a large backlog of samples left undone.

One important development in the year has been the considerable increase in the demand for partial chemical analyses. The tendency of Survey geologists in past years has been to submit only those samples for which complete analyses were needed; these take longer to do and require experienced analysts. Partial analyses are more easily handled by less experienced personnel and it is in this type of analysis that we can make maximum use of summer assistants; the alkali project described in this report is a good example of this.

Of particular note is the very large increase in the number of quantitative spectrographic analyses made in 1960. This has been achieved by the more efficient use of personnel, permitting more time to be spent on the development of methods needed for sample analysis.

Method development continued in the chemical laboratories, as in the spectrographic laboratories, concomitant with sample analysis; particular mention is made in this report of the development of methods for aluminium and magnesium but several other methods in use underwent modifications as well.

Statistics

Samples Received and Completed

	Complete Chemical	Partial Chemical	Special Chemical	Spectrographic All types	Total
Samples on hand, January 1/60	112	103	91	426	732
Samples received, 1960	220	1887	195	2825	5127
	332	1990	286	3251	5859
Samples completed, 1960	211	1619	183	2252	4265
	121	371	103	999	1594
Samples withdrawn	1	39	11	--	51
Samples on hand, January 1/61	120	332	92	999	1543

Summary

		1959	1960
Samples received		1685	5127
Samples completed			
	Chemical analyses	391	2013
	Spectrographic analyses	509	2252
Backlog of samples, January 1st			
	Chemical analyses	343	544
	Spectrographic analyses	409	999
Complete analyses made			
	Regular	43	25
	Rapid	155	181

	1959	1960
Spectrographic analyses made		
Qualitative	48	101
Semiquantitative	402	950
Quantitative	59	1489
Total number of chemical determinations made, including checks and standards	3491	7489
Total number of spectrographic exposures made	1759	5650
Number of lead tetramethyl preparations made	87	41
Number of potassium determinations made for the argon-potassium age program	84	167

The record for 1960 is marked by very large increases in the number of analyses provided for Survey personnel. In particular, the spectrographic laboratory completed four times as many samples, involving over three times as many exposures, in 1960 as in 1959; the largest increase was in quantitative analysis. The chemical laboratories completed five times as many samples in 1960 as in 1959, the increase being largely due to the greater demand for partial analyses; the number of complete analyses done increased only slightly over that for 1959. The total number of chemical determinations made in 1960 was double those made in 1959. The number of samples submitted in 1960 was, however, over three times the number submitted in 1959, and the backlog of samples carried into 1961 is over twice that remaining at the end of 1959.

Personnel

The staff of the Analytical Chemistry Section during 1960 consisted of the following personnel, in addition to the writer:

Chemical Laboratories

Mr. Sydney Abbey, Mr. Serge Courville, Mrs. Marilyn Levine, Mr. G.P. Bender, Mr. K.G. Hoops, and Mr. W.U. ter haar Romeny.

Mr. R.P. Beaulne joined the staff in October. Mr. G.M. Bruce assisted in general laboratory work for about six weeks. Miss Margaret Tomilson left the Section in May after having brought the first phase of the project on the compilation of Canadian rock and mineral analyses to near completion.

During the summer months able assistance was rendered by Miss Dorothy Pocock and Miss Diane Tetreault in the Compilation project, and by Miss Janet McAlpine and Messrs. B. Robertson, W. Lalonde and A. Sweet who assisted in the work of the laboratories.

John Wallis was loaned to the Section by Dr. R.K. Wanless to assist in the conversion of sulphates to sulphides for the sulphur isotope program.

Spectrographic Laboratories

Mr. W.H. Champ, Mr. W.F. White, Mr. J.P. Malone, Miss Jocelyn Letang.

Mr. G.E. Pattenden returned to the laboratory for the summer months and will continue on a seasonal basis into 1961.

Visitors

The section also had several visitors who spent varying periods of time studying our analytical methods.

Mr. G.B. Mensah, a Colombo Plan trainee from Ghana, left the Section in January after three months of training in the Rapid Methods of Analysis.

Mr. A.M. MacKay, Mines Branch, Manitoba, spent one month studying our Rapid Methods of Analysis.

Ma Ma Lay, Colombo Plan trainee from Burma, spent two months in the Spectrographic Laboratories; she worked on the development of a new quantitative procedure.

Dr. A.W. Ruschil, Department of Geology, McMaster University, spent two months in the chemical laboratories studying our Rapid Methods of Analysis.

Mr. S.N. Puri, Colombo Plan trainee from India, spent one week in the spectrographic laboratory studying spectrographic procedures, and several days in the chemical laboratories studying our method for the determination of potassium in micas.

Mr. Anastopoulos, a geologist from Greece, spent several days in the spectrographic laboratory investigating the potentialities of spectrographic analysis.

Office and Laboratory Activities

(O.P. 121) Compilation of Geochemical Data (with K.R. Dawson)

The work of the past year has been concerned with the preparation of the manuscript on the first phase of this compilation project, that of gathering together those analyses of rocks, minerals, and ores first published by the Geological Survey of Canada, or present in Survey files as unpublished data, for the period 1845-1955. Miss Margaret Tomilson planned the form of the publication and prepared the geological descriptions that accompany the analyses; Miss Dorothy Pocock continued the organization of the manuscript and indexes, aided by Miss Diane Tetreault who also did much of the typing of the manuscript.

The proposed format consists of an introduction, followed by the main body of chemical analyses (with some spectrographic analyses also), together with geological and bibliographic data, and concluding with a name index, a geographic index, and a bibliography. The chemical and descriptive data are arranged in the following major categories: igneous intrusive rocks,

igneous extrusive rocks, metamorphic rocks, sedimentary rocks, and minerals and ores. The descriptive data include name, occurrence, location, analyst, National Topographic Index Number of the location, serial number, petrographic description, and reference.

There are 1,310 listed analyses, but the total number exceeds this because some analyses have as many as four parts.

Final checking of the manuscript will be done by Dr. K.R. Dawson and the writer and it is expected that it will be ready for submission in two or three months.

(O.P. 143) Comparison of methods for the determination of fluorine (with R.P. Hollingworth)

The determination of fluorine by the method used in our chemical laboratories was done by the writer on ten rock samples submitted by Mr. R.P. Hollingworth, University of Durham, England. Mr. Hollingworth will use these and other results in his Ph.D. thesis. The method used is that described by H.R. Shell and R.L. Craig in Report of Investigations 5158, U.S. Bureau of Mines, January, 1956. The sample is fused with sodium carbonate and the leached cake transferred to a distillation apparatus where distillation with perchloric acid, in the presence of silica, separates the fluorine from the sample as fluosilicic acid in the condensate. The final titration is done with standard thorium nitrate solution, using alizarin red S as indicator; the pH of the solution during titration is maintained at the optimum pH by continual adjustment, the changes in pH being followed by a pH meter.

Mr. Hollingworth will join the Section in January as a post-Doctorate Fellow and further work may be done in 1961 to improve the method now in use.

(O.P. 201) Mineralogical Abstracts

J.A. Maxwell assumed the responsibility for preparing abstracts of the Annual Reports of the Ontario Department of Mines, beginning with those publications from 1959, for Mineralogical Abstracts. He also continues as an abstractor for Section 8 (Mineralogical and Geological Chemistry) of Chemical Abstracts.

(O.P. 106) Magnesium Isotope Study (with C.H. Smith and R.K. Wanless)

Preliminary preparation of magnesium compounds were submitted for trial runs by the Isotopic and Nuclear Geology Section. After it was decided to use the oxide, a series of magnesium oxide preparations were made from selected minerals and rocks.

(O.P. 71) Petroleum Deposits Study (with R.K. Wanless and Helen R. Belyea)

No further analytical work has been done on this project.

Items of particular interest from the 1960 record of the Section Activity are as follows:

Polarographic Determination of Aluminium

The investigation of a polarographic method for the rapid determination of aluminium started by Mrs. M. Levine has continued throughout the year and will be terminated early in 1961. The object of the investigation was to find a method which, while utilizing the solution of the sample prepared as part of the rapid methods scheme of analysis, would be free of the uncertainties and errors inherent in the colorimetric method now in use.

After investigating several dyes which form reducible complexes with aluminium, Mrs. Levine settled her choice on Pontachrome Violet SW and attempted to work out a method based on its reaction with aluminium. Because of the low solubility of this dye, which required the use of very dilute solutions, large errors were experienced; in order to avoid these, Mrs. Levine synthesized a sulfonated analogue of Pontachrome Violet SW which is much more soluble in water than was the original dye, thus permitting the use of more concentrated solutions, and extending the range of aluminium concentrations to which the method is applicable. Experimental data confirm the existence of a linear relationship between the measured diffusion currents and varying aluminium concentrations, and the method is now being tested with a series of standard samples of varying aluminium content.

The Colorimetric Determination of magnesium

The determination of low concentrations of magnesium by EDTA titration in the presence of large amounts of calcium has not been satisfactory in our rapid methods scheme of analysis. Mr. Sydney Abbey investigated the possibility of adapting a colorimetric method to the conditions of the rapid methods scheme; one method in particular, that involving the formation of the Titan Yellow lake, seemed appropriate but on investigation it proved to be unsatisfactory. Mann and Yoe have described a method using a reagent known as "Magon" and this was also investigated. Modifications were necessary, particularly since confusion exists in the literature about the exact nature of the compound called "Magon", but the method as worked out by Mr. Abbey, which utilizes sample solutions prepared as part of the rapid analysis scheme, has given satisfactory results for magnesium concentrations of one per cent or less. A paper giving the details of the method is in preparation.

Summer Project, 1960

The chemical and spectrographic laboratories took on a major project for Drs. Cameron and Holman of the Geochemistry Section during the summer months. With the help of two summer assistants, the chemical laboratories completed 2,090 determinations of sodium and potassium in sandstones and igneous rocks. The spectrographic laboratories provided 1,684 determinations of barium and strontium on these samples, as well as 244 semi-quantitative analyses of about 20 elements each.

Development of Quantitative Procedures, Spectrographic Laboratory

Changes in the organization of the Spectrographic Laboratory resulted in the formation of two sections, the Development Section under Mr. W.H. Champ, and the Sample Analysis Section under Mr. W.F. White.

Considerable progress was made in the development of quantitative procedures. The quantitative method for barium and strontium was revised and extended to include Ag, B, Ba, Be, Co, Cr, Cu, Mn, Ni, Pb, Sr, Ti, V, and Zr in the range 0.002 to 2%. A quantitative method for the volatile elements, covering Ag, Cu, Ga, Ge, Pb, and Sn down to 0.0001%, has also been developed.

Open House

The Section held Open House to all Survey personnel on April 13. Displays and demonstrations were arranged to illustrate the various analytical services available and a very large number of people toured the laboratories of the Section and talked with staff members.

ISOTOPE AND NUCLEAR RESEARCH SECTION

R. K. Wanless

General

Studies have been continued in the fields of geological age measurement and stable isotope variations in natural processes. Increased emphasis has been placed on the determination of age based on the potassium-argon ratio found in micaceous minerals. During 1960, 157 such age determinations have been completed, the majority of which are to be used in the compilation of the tectonic map of Canada and to assist in the development of a time scale for the Precambrian regions of North America.

In order to carry forward existing projects and to provide facilities for the extension of the work to related fields, the personnel of the section have designed and assembled the necessary specialized high vacuum, electronic and mass spectrometric apparatus required. Included are: two new high vacuum lines for the extraction and purification of radiogenic argon released during the fusion of micaceous minerals; a new, 90 degree, 10-inch radius solid source mass spectrometer; and low-level radiocarbon counting, and sample preparation laboratories.

During 1960 the demand for isotopic analyses has steadily increased. At present, all projects requiring the isotopic analysis of sample materials in gaseous form have been dependent on the output of a single mass spectrometer. Consequently, projects with the highest priority only have been carried forward, thereby creating a large backlog of material awaiting analysis. This, is especially true of lead and sulphur isotope projects, which were considered to be of lower priority than the age work. In order to relieve this problem a second gas source mass spectrometer has been designed and construction has

commenced. The new instrument will take the major load developing from the K-Ar dating program and will thereby facilitate the resumption of lead and sulphur isotope research projects. In anticipation of this a large number of samples of lead and sulphur have been processed.

The new solid source mass spectrometer was completed during 1960 and was thoroughly tested. Particular emphasis has been given to the isotopic analysis of magnesium. Sample preparation techniques have been worked out and are being applied to the analysis of a representative suite of magnesium-bearing minerals.

All potassium-argon age calculations are now programmed through the electronic computer at Ottawa University, thereby reducing the time required for machine calculation in the laboratory. Other isotope calculations are to be similarly programmed next year.

A few members of the staff attended scientific meetings and visited various laboratories, as described below.

R.D. Stevens attended the technical sessions of the American Geophysical Union held in Washington, D.C., in May 1960. While in Washington he visited the geochronology laboratories of the U.S.G.S., The Department of Terrestrial Magnetism and the Geophysical Laboratory.

R.K. Wanless attended the conference on the Geochronology of Rock Systems sponsored by the New York Academy of Sciences, held in New York City in March, 1960.

R.K. Wanless attended the Gordon Research Conference symposium on the Chemistry and Physics of Isotopes held in New Hampton, New Hampshire, July 4 - 8, 1960.

R.K. Wanless, W. Dyck, and S. Abbey visited the Geochemistry Laboratory of the Lamont Geological Observatory, Columbia University, March 26, 1960. The application of the U-Rd method of age determination in geologic problems was discussed with Dr. W. Broecker.

Laboratory and Office Activities

Potassium-Argon Age Program

Two high vacuum lines embodying Alpert type metal value in place of conventional stopcocks have been built. The incorporation of the metal valves permits one to bake out the apparatus at elevated temperatures thereby obtaining a better vacuum. The micaceous samples are fused in alundum and molybdenum crucibles mounted in a water-cooled vacuum vessel placed within the work coil of a high frequency generator. Since the fusion may be carried in this way without the addition of a flux the probability of contamination of the radiogenic argon with atmospheric argon is greatly reduced.

A total of 157 age determinations (ranging from 11 m.y. to 2700 m.y.) have been processed with the new equipment. As mentioned above, the

majority of the samples were selected from Precambrian regions of Canada. The geographical distribution is as follows: British Columbia and Yukon Territory 34; Northwest Territories 33, Saskatchewan 8, Manitoba 18, Ontario 15, Quebec 32, New Brunswick 1, Newfoundland 16.

Whenever possible, materials for age measurement were selected to provide fundamental information as well as an indication of the age of the mineral. Specifically, biotite-muscovite pairs, assumed to be coeval, were selected in order to determine the relative argon retentivity of the mica structures. Since chloritization of a micaceous mineral could conceivably provide a process whereby argon could be lost during the lifetime of the mineral, specimens of fresh and chloritized biotite, and muscovite, were both processed and the ages calculated. Nine pairs of samples from the above listed categories have been studied this year. It is anticipated that this phase of the work will receive increased emphasis during the coming year.

Isotope dilution techniques are employed in the determination of the quantity of radiogenic argon released from the mica structure. In order to carry out this procedure a 'spike' sample of argon with an abnormal isotope ratio is required. A stock of argon gas containing 95% Ar-38 (normal Ar-38 abundance = 0.065%), sufficient for approximately 900 age determinations has been obtained from material irradiated in the Brookhaven reactor.

The Solid Source Mass Spectrometer

Our second mass spectrometer, a 90 degree, 10-inch radius instrument was completed during 1960. This unit is equipped with a solid sample source arrangement and an electron multiplier detection system. The analyser tube and magnet assembly were fabricated in the machine shops of the Mines Branch, while the electronic units were assembled by a commercial firm. All inter-connection of the electronic units, etc., was carried out by laboratory personnel.

To date, analyses have been restricted to a study of the isotopic distribution of the magnesium isotopes in nature. A great deal of difficulty was experienced in obtaining a sample material that would provide satisfactory ion currents in the mass spectrometer. Techniques have now been developed whereby stable ion currents may be obtained and isotope analyses may be carried out with excellent statistics. Magnesium isotope variations of less than 1% should now be detectable employing this method. A systematic study of a representative suite of magnesium-bearing minerals is now in progress.

Radiocarbon Dating Laboratory

In order to provide dates in the relatively recent past (0-35,000 years) a radiocarbon dating laboratory has been set up. This unit comprises a low-level counting laboratory, situated in the sub-basement in order to take advantage of the excellent shielding provided by the concrete floors of the building, and a sample preparation laboratory located on the fifth floor. Sample materials will be converted to CO_2 and the concentration of radiocarbon (C-14) will be determined in proportional counters. Two proportional counters (1 litre and 2 litre volumes) have been fabricated in the

G.S.C. instrument shop and have been extensively tested. The counters and associated ring of 22 geiger tubes connected in anticoincidence are positioned within a special castle having walls of iron 9" thick, a layer of paraffin 4" thick and a stainless steel vessel containing a layer of mercury 1" thick. When placed in the castle the background counts are 2.5 counts/minute for the 1 litre counter and 3.5 counts/minute for the 2 litre unit. An anticoincidence electronic circuit has been designed and assembled by laboratory personnel.

Extensive calibration tests have been carried out on CO_2 prepared from coal and from modern wood. During December a series of samples were converted to CO_2 in anticipation of the commencement of sample dating in the New Year.

Gas Source Mass Spectrometer Assembly

The expansion of the K-Ar dating program has resulted in an extremely heavy load being placed on the existing gas source mass spectrometer. As a result isotope projects requiring the analysis of gaseous materials, (lead, sulphur, and U-Pb and Th-Pb age measurements) have been severely restricted and large sample backlogs have developed. Since it is not essential to employ a high resolution mass spectrometer for argon analyses the design of a relatively low resolution (1 mass unit in 100) 90 degree, 6 inch radius, instrument was prepared. The construction of component parts of this unit has now been started. All machine work is to be carried out in the G.S.C. instrument shop and electronic units are to be assembled by laboratory personnel. It is anticipated that the unit will be ready for service late in the summer of 1961.

Office Projects

(O.P. 28) Age Determinations of Rocks and Minerals

This is a continuing project comprising K-Ar age determinations on micaceous minerals and U-Pb and Th-Pb determinations on uraniferous minerals.

During 1960 age measurements were completed on 157 micra concentrates and 11 uraninites.

During the year, one paper was published and two others were presented at geological meetings. The published paper, by J.A. Lowdon, was entitled "Age Determinations by the Geological Survey of Canada, Report I, Isotopic Ages", and is Paper 60-17 of the Survey. A jointly-authored paper by C.H. Stockwell and R.K. Wanless, entitled "Canadian Shield Age Program of the Geological Survey of Canada" was presented at the New York Academy of Sciences Symposium on the Geochronology of Rock Systems, New York City, March, 1960, and is to be published. Another paper, entitled "Geological Survey Age Program" was presented by A. Larochelle to a Symposium of the I.U.G.G. held in Helsinki, Finland, July, 1960. It also is to be published.

(O.P. 62) Isotope Chemistry of Sulphur in Rocks and Minerals

1. Yellowknife Region

The study of sulphur isotope distribution in the Yellowknife region is now complete. The final publication of this work appeared in Economic Geology as listed below.

R.K. Wanless, R.W. Boyle, and J.A. Lowdon: Sulphur Isotope Investigation of the Gold Quartz Deposits of the Yellowknife District; Econ. Geol., vol. 55, pp. 1591-1621, 1960.

2. Sullivan Mine, B.C.

A number of new samples from the Sullivan Mine and other deposits in the East Kootenay District have been selected with a view to rounding out the study. All of these have now been converted to sulphur dioxide, but no mass spectrometric analyses have been carried out.

3. Blind River

Initially, 23 sulphide samples were converted and analysed. In the light of these results an additional 67 specimens were selected for further study. The latter samples have been converted to sulphur dioxide and now await analysis.

4. Keno Hill

All samples selected for lead isotope study from this region have now been converted to sulphur dioxide and await mass spectrometric analysis. This study comprises 308 samples.

(O.P. 71) Isotope Studies of Sulphur from Canadian Petroleum Deposits

This project has remained dormant during 1960. Sixty SO_2 samples are ready for mass spectrometric analysis.

(O.P. 98) Isotopic Study of Canadian Ore Leads

1. Sullivan Mine, B.C.

A series of additional samples from deposits in the East Kootenay District of B.C. were selected to complete the isotope study of the Sullivan Mine and neighbouring deposits. All lead analyses are now complete. In addition K-Ar age measurements on biotite from the lamprophyre dykes in the mine and from a granitic stock at Hell Roaring Creek have been carried out.

A paper entitled "Lead Isotope Studies of Mineral Deposits and Potassium-Argon Measurements of Intrusive Bodies in the East Kootenay District of British Columbia", by R.K. Wanless and G.B. Leech, was presented at the C.I.M.M. meeting in Vancouver, October, 1960.

Final publication of the results will be in the form of an invited paper in the "Buddington Volume". The manuscript is to be submitted in January, 1961.

(O.P. 116) Magnesium Isotopes

Satisfactory techniques for the handling of magnesium samples in the solid source mass spectrometer have now been worked out. Thirty-six successful analyses have now been carried out on 16 representative samples from a suite of magnesium-bearing minerals. The project is to be evaluated in the light of the most recent results.

(O.P. 144) Lead and Sulphur Isotope Geology of Keno and Galena Hills, Yukon

Lead isotope analyses have been completed for 85 samples. Ninety-five samples await lead analysis, as well as 308 samples of sulphur dioxide that were prepared late in 1960. Publication of the results is scheduled for late 1961.

Statistics

Argon extractions (total including research, repeats, etc.)		202
Argon spike-calibrations		30
K-Ar. age measurements reported		157
Pb-U, Pb-Th age measurements reported		11
Magnesium samples analysed		16
Mass spectrometric analyses		
- extracted argon samples	172	
- argon spike calibrations	36	
- linde atmospheric argon	6	
- argon spike stock	38	
		252
- lead tetramethyl		35
- sulphur dioxide		4
- magnesium analyses ✱		36
Total		327

✱ Magnesium analyses are carried out on the solid source mass spectrometer and usually consist of three times as many mass scans per analysis as required for gaseous samples.

Sulphur dioxide production

Samples for	G. Gross	17
	S.C. Robinson	17
	S. Roscoe	68
	G.B. Leech	12
	R.W. Boyle	289
		403

Personnel

J.G. Hurley (Tech. 2) joined our staff on February 15, 1960. Mr. Hurley has rebuilt the sulphur dioxide conversion and purification line and has been responsible for the conversion of all sulphide minerals to sulphur dioxide for mass spectrometric analysis.

Personnel of the section are listed below.

	R. K. Wanless	- Physicist
	J. A. Lowdon	- Geologist
	R. D. Stevens	- Geologist
	W. Dyck	- Chemical Engineer
	W. D. Loveridge	- Physicist
	W. A. Smith	- Technician
	J. G. Hurley	- Technician
Summer Assistants	R. Sullivan	- C-14 Laboratory
	J. Woolsey	- Mass Spectrometer Laboratory
	P. Guthrie	- Mass Spectrometer Laboratory
	J. Wallis	- Mass Spectrometer Laboratory and Instrument Shop

MINERALOGY SECTION

R. J. Trail

General

This report summarizes the activities of the Mineralogy, X-ray, and Mineral Separation laboratories; progress of work on Canada's national collection of minerals and ores; the preparation of sets of minerals and rocks for sale to the public; and the identification of mineral and rock specimens as a public service.

Field and Laboratory Activities

During the 1960 field season Mr. Gauthier, accompanied by Mr. Turpin, collected more than 17 tons of bulk specimens needed for the preparation of mineral and rock sets. The specimens were collected from 32 localities in Ontario, Quebec, and Manitoba. We wish to acknowledge the kind cooperation received from the following persons and companies: Mr. J.B. Steele, Captain, Quartz Crystals Mine Ltd., who provided Mr. Gauthier with a beautiful display specimen of quartz crystals and 300 lbs. of loose crystals; Mr. D. Turner, Geologist, New Calumet Mines Ltd., for 500 lbs. of galena and 1000 lbs. of amphibolite; and the staff of Chemalloy Minerals Ltd., at Bernic Lake, for some 1200 lbs. of pollucite.

General Mineralogy

(a) Compilation of data on Canadian minerals

The major task of extracting pertinent data from geological literature covering the period from 1915 to mid-1960 was completed during the past year. All data have been recorded in card file form and chemical analyses have been checked with the original references. In addition, a considerable amount of reliable unpublished information provided by members of the Mineralogical Association of Canada and extracted from laboratory records of the Geological Survey of Canada has been incorporated into the compilation.

(b) Studies of micas

Dr. J. Rimsaite continues to make good progress on an extensive study of micas and mica-bearing rocks. A large amount of data on the properties of micas were obtained from microscopic and X-ray diffraction examination of several hundred thin sections and mica concentrates submitted for K-A age determinations. All concentrates were examined for impurities and alteration products which might affect the interpretation of the age values. In addition, the following information has been obtained and recorded:

1. X-ray properties. The positions, shapes, and intensities of the basal reflections of biotite, muscovite, and chlorite.

2. Optical properties. Textural features, colour, refractive index, optic angle.

3. Specific gravity. Determined by adjusting densities of liquids until mica is in suspension.

4. Chemical analyses. To assist with construction of X-ray determinative curves, 18 of the purest possible mica concentrates have been submitted for chemical analysis.

5. Petrology. Thin section studies with special emphasis on mineral assemblages, texture, paragenesis, metasomatism, and alteration. Characteristic or unusual features are recorded photographically.

On the basis of the thin section studies made on a wide variety of mica-bearing rocks it is concluded that only a small percentage of rocks contain a single homogeneous mica. Two-mica metamorphic rocks (e.g. biotite and, in general, paragenetically younger muscovite) are very common. In such rocks plagioclase is frequently sericitized and biotite altered in varying degrees to chlorite, colourless mica, and epidote. The biotite alteration may take place throughout the rock, just along fractures, or adjacent to microcline and muscovite. In basic rocks, Mg-rich biotite phenocrysts exhibit zoning and are frequently rimmed by almost black Fe-rich bands. A later biotite, perhaps deuteric, is similar in colour to the dark band in the earlier phenocrysts and contains 50 to 75 per cent more iron. Recrystallization of both muscovite and biotite is common in schists affected by regional metamorphism. A single rock may contain bands of coarse twisted micas exhibiting undulatory extinction and other bands in which the coarse micas have recrystallized into finer-grained aggregates. These preliminary studies show that mica is of considerable importance in petrological science for interpretation of rock history.

A good start has been made towards correlating petrology, X-ray and optical properties, specific gravity, and chemical composition.

(c) Other work

Sixty letters were written by Miss Sabina in reply to enquiries received from the public for information on mineral occurrences and general mineralogy.

Occurrences of Canadian minerals and rocks of particular interest to lapidarists and amateur mineral collectors have been compiled by Miss Sabina. This work will continue in 1961 and the data will be prepared for publication.

At the request of the Ottawa Valley Mineral Association a suite of minerals was assembled and displayed at a ten-day exhibition of minerals and gems at the Victoria Museum.

X-ray Diffraction

Mr. J. L. Jambor joined our staff on May 20, 1960, as a replacement for Mrs. J. Climo. The X-ray diffraction facilities were considerably improved in 1960 by purchase of a new X-ray spectrograph. This made it possible for our G.E. X-ray unit, previously used for both diffraction and spectrography, to be set-up permanently for use as a diffractometer. The result has been a marked increase in the use of the diffractometer for studies on such minerals as micas, chlorites, olivines, pyroxenes, feldspars, carbonates, and clay mineral groups.

A catalogue of X-ray diffraction patterns and specimen mounts on file at the Geological Survey of Canada up to April 1, 1959, was published as G.S.C. Paper 60-4. Work continued on the extension of this reference file with the addition of 54 new patterns during 1960. The specimens from which the new patterns were made were obtained from the G.S.C. mineral collections, the Royal Ontario Museum, the University of Ottawa and the University of British Columbia. One specimen was synthesized by J. L. Jambor.

Mr. Jambor studied the dehydration of melanterite ($FeSO_4.7H_2O$) and established beyond doubt that this mineral dehydrates directly to the tetrahydrate ($FeSO_4.4H_2O$) with no pentahydrate phase being formed in the process. This work suggests that the mineral siderotil, known to be a dehydration product of melanterite and considered to be the pentahydrate on the basis of an incomplete analysis made on a small amount of material, is in reality the tetrahydrate ($FeSO_4.4H_2O$). This work was discontinued following discovery of a paper published in a foreign journal in 1960, describing a similar study and proposing a new mineral name, rozinite, for the tetrahydrate ($FeSO_4.4H_2O$).

Preliminary studies were made on the application of X-ray diffraction determinative schemes for olivines, pyroxenes, and feldspars to the study of compositional variations within ultrabasic bodies. The results of this work were sufficiently encouraging to merit further extension of the study in 1961.

Several hundred X-ray diffractometer patterns of micas were made during the year. These patterns were used not only to check on the purity of mica concentrates prepared for K-A age determination, but also to supply research data for a continuing study of the mineralogy and petrology of micas and mica-bearing rocks.

A card file of literature references to X-ray diffraction data on minerals of all types has been started. This is a continuing project and should prove to be of considerable long-range value to the laboratory.

The analytical work of the laboratory during 1960 included: 1483 mineral identifications, 155 determinations of unit cell constants, 597 X-ray diffractometer patterns, and the preparation of 54 reference X-ray powder diffraction patterns.

X-ray Spectrography

The facilities for X-ray spectrography were expanded in June 1960 with the installation of a new Philips Universal Vacuum X-ray Spectrograph and the addition to our staff of Mr. G. R. Lachance. Work on the new instrument has been largely of a development nature and is summarized by Mr. Lachance as follows:

General

During the first six weeks, standards were prepared and analysed in order to determine the general sensitivity of the instrument and the effectiveness of the pulse height analyser. Investigations were also carried out on various fusion methods of sample preparation and on the direct determination of major, minor, and trace constituents in rocks and ores.

Results

(a) While it has not been possible to investigate every element from Mg (At. No. 12) to U (At. No. 92), which is the range of elements detectable with the instrument, results from work on some 20 elements indicate the following sensitivities: (i) All elements from K (At. No. 19) to U (At. No. 92) are detectable down to concentrations of 0.03%; (ii) all elements from Ti (At. No.22) to Nb (At. No. 41) and from Hg (At. No. 80) to U (At. No. 92) can be detected down to concentrations of 0.004%; (iii) Fe, Cu, Zn, Pb have been detected down to 10 p.p.m. (0.001%). Below K in the periodic table the sensitivity drops off sharply; the lowest concentration detectable for Al (At. No. 13) being in the order of 1-2%.

(b) Results indicate that pulse amplitude discrimination will be very useful in dealing with situations where a second order line interferes with the determination of the intensity of a first order line, and also for the detection of very low concentrations.

(c) Investigations were carried out on using borax, sodium carbonate, sodium pyrosulphate, and potassium pyrosulphate as fluxes for the determination of major constituents in various materials. The advantage of the fusion method is that it practically eliminates matrix and particle size effects. Results indicate that most elements in the concentration range 1 to 50% can be determined using this method.

(d) The direct determination of the elements present in similar materials has been under investigation. The main advantage of this method is the rapidity (i.e. 2 to 4 minutes per element) with which analyses can be made. Four types of materials have been analysed: (i) chromite concentrates for Cr, Fe, Ti, V, Ni, Mn, Si, Al, Ca; (ii) titaniferous magnetites for Fe, Ti, Ni, Co, V, Cr, Mn; (iii) Micas for K, Ti, Si, Al, Ca, Fe; and (iv) silicate and carbonate rocks for Si, Al, Fe, Ca, Ti, V, Mn, K, S, P.

The following numbers of analyses were made in 1960 for officers of the Geological Survey:

vanadium	5	lead	21
potassium	40	iron	4
uranium	20	copper	5
thorium	20	zinc	1

Mineral Preparation and Separation Laboratories

Mr. Paris reports that during 1960 his staff prepared 1,206 mineral concentrates and 515 samples for chemical analysis in the Rock Analysis Laboratory. These figures represent an increase in production of about 600 per cent over the 1959 figures. This increased output can be attributed to:

1. Improved laboratory space and better working conditions in the new Geological Survey building.

2. More experience gained by staff members.

3. Improved mineral separating techniques.

4. Over 200 hours of overtime worked by the permanent staff and a prevailing rate employee.

In spite of the increased production and from 40 - 50 hours of overtime per week the laboratory staff are unable to meet the demand for services, which continues to increase every year. The backlog of work at the end of this year is several times larger than it was at the same time last year. Although the need for additional personnel in these laboratories has been stressed annually since 1958 we have not been granted any new positions. The one new position which has been approved commencing April 1, 1961, will not be enough to make a serious dent in the backlog of work.

Geological Survey of Canada Collections of Minerals and Ores

H. R. Steacy joined the Mineralogy Section on April 1, 1960, as curator of the collections of minerals and ores. He reports as follows:

"Much progress has been made in re-housing the collections in our present building. Of the approximately 500 boxes of mineral and ore specimens shipped to the building from previously occupied quarters, 448, representing about 25 tons of material, have been carefully unpacked and their contents placed in metal storage cabinets. In addition, much of the collection of radioactive minerals has been re-sorted and catalogued. In order to avoid mixing of specimens and contamination by dust we have instituted the use of transparent plastic bags and we believe this constitutes a significant advance in storage of mineral specimens. During the year, the collections were improved by donations of mineral and ore specimens from Officers of the Geological Survey, notably R.W. Boyle, and by acquisitions obtained through personal collection and contact, and by letter. During the year I made four short collecting trips and familiarized myself with many of the nearly classic mineral localities. I also conducted Dr. George Bigotte of the Atomic Energy Commission of France to uranium mines and radioactive deposits in the Bancroft area. Other related activities included the preparation of a small ore display for an exposition in the U.S.A., and the designing of a bench, shelving and other working facilities for Room G-48. Much correspondence was entered into with others in my field".

Mr. Steacy was assisted by two summer students during the summer months. In October, Mr. Gauthier was assigned part-time duties in connection with the reorganization and re-housing of the mineral collections, and will continue to assist Mr. Steacy in 1961.

Preparation of mineral and rock sets

The sales of mineral and rock sets to the public declined from 6,506 in 1959 to 5,336 in 1960. Comparative figures for 1959 and 1960 by province are as follows:

Province	1959	1960
British Columbia	2,097	1,548
Ontario	1,651	1,373
Alberta	974	1,083
Quebec	404	338
Yukon	302	1
Manitoba	311	261
Saskatchewan	141	170
N.W.T., P.E.I., Nfld.	81	4
New Brunswick	70	37
Nova Scotia	43	77
Ottawa Office	432	398
Minister's Office	0	46
	6,506	5,336

In addition 50 collections of 120 specimens representing Canada's mineral industry were sold. Thirty-two of these collections were sold in 1959.

The quality of the prospectors set of rock chips was improved by changing some of the specimen material following suggestions made by Dr. K.R. Dawson. A committee composed of S.C. Robinson, R.J. Traill, H.R. Steacy, D.R.E. Whitmore, W.D. McCartney, and C.H.R. Gauthier gave active consideration to the question of revision and improvement of the collection of minerals representing the Canadian mineral industry. Plans for revision of the collection were drawn up and it is anticipated that the revision will take place in 1961.

Identification of specimens for the public

Mr. Fabry examined approximately 2,500 specimens submitted by the Canadian public. The results of the examinations were communicated to the senders in 294 letters. In addition, a number of people made personal calls and were provided with the information they sought. Several mineral collections belonging to institutions were examined and classified for educational purposes.

Office Projects

(O. P. 6) Distribution of Collections of Canadian Rocks, Minerals, Ores and Fuels (C.H.R. Gauthier)

Objective: To assist prospectors and to familiarize individuals and institutions associated with the mineral industry with Canadian rocks, minerals, ores, and fuels.

Progress: During the year, 5,336 sets of rocks and minerals containing 189,584 specimens and 50 collections representing Canada's mineral industry (6,000 specimens) were distributed throughout Canada.

(O. P. 7) Examination of Mineral and Rock Samples (R. J. Traill and R.J.C. Fabry)

Objectives: (1) Identification of minerals in specimens submitted by members of the Geological Survey.

(2) Examination and reports on mineral and rock samples and specimens sent in from all parts of Canada by the public.

Progress: (1) The results of 2,235 mineral identifications, cell-edge determinations, and diffractometer analyses were reported to Officers of the Geological Survey of Canada.

(2) Approximately 2,500 specimens were examined and the results communicated to the senders in 294 letters. In addition, a number of persons made personal calls and were given the information they sought. Several small mineral collections belonging to institutions were classified for educational purposes.

(O. P. 15) Reference Collection of X-ray Powder Photographs of Minerals (R.J. Traill and Ann P. Sabina)

Objective: To prepare a collection of X-ray powder diffraction patterns of minerals identified correctly by chemical or other means and to develop new techniques in powder diffraction.

Progress: A Catalogue of X-ray Diffraction Patterns and Specimen Mounts on File at the Geological Survey of Canada was published as G.S.C. Paper 60-4. During the year 54 new reference patterns were added to the collection.

(O. P. 28) Age Determinations of Rocks and Minerals (R.J. Traill, J. Rimsaite, and J.C. Paris)

Objective: To make concentrates of minerals from bulk samples of rocks and ores. To check these concentrates mineralogically before submission to the Isotope Geology Section.

Progress: 244 mica concentrates were prepared and studied microscopically and by X-ray diffraction. 159 concentrates were forwarded to the Isotope Geology Section.

(O. P. 101) G.S.C. Mineral and Ore Collections (R. J. Traill, H.R. Steacy, and C.H.R. Gauthier)

Objective: To reorganize, catalogue, index, and maintain the mineral and ore collections of the G.S.C.

Progress: During the year 448 out of a total of about 500 boxes of mineral and ore specimens were unpacked and their contents housed in steel cabinets. Work is proceeding on the resorting and cataloguing of these and other specimens.

(O. P. 160) Revision of Memoir 74, A List of Canadian Mineral Occurrences (R.J. Traill)

Objective: To compile and publish an up-to-date list of Canadian mineral occurrences, including all available analytical data.

Progress: A literature survey covering the past 45 years was completed this year. All data from the literature and additional unpublished data supplied by the Mineralogical Association of Canada and extracted from G.S.C. laboratory records have been entered in a card file. Preparation of the manuscript for publication is anticipated in 1961.

(O. P. 174) Preparation of Mineralogical Abstracts (R.J. Traill and S.C. Robinson)

Objective: To prepare abstracts of mineralogical data from Geological Survey of Canada publications for inclusion in Mineralogical Abstracts.

Progress: Seven abstracts were prepared in 1960 and forwarded to the Canadian editor, L.G. Berry.

Personnel

The following personnel were employed in the Mineralogy Section during 1960:

R.J. Traill,
H.R. Steacy (began April 1, 1960)
Miss J. Rimsaite,
G.R. Lachance (began June 1960)
Miss A.P. Sabina,
J.L. Jambor (began May 1960 in place of Mrs. J. Climo)
Mrs. J. Climo (resigned April 1960)
R.J.C. Fabry,
C.H.R. Gauthier,
J.C. Paris,
A.M. Vaux,
R. Cormier,
A. Lacroix,
J. Turpin

In addition to the continuing staff a total of 10 seasonal employees were employed in the section for periods ranging from 3 months to a full year. The total time worked by seasonal employees amounted to 44 months.

Membership in Societies

	M.A.C.	M.S.A.	C.I.M.M.	C.A.A.S.	A.S.P.G.
R.J. Traill	x	x			
H.R. Steacy	x		x		
J. Rimsaite	x			x	
A.P. Sabina	x				
C.H.R. Gauthier	x				
J.L. Jambor	x	x			x
G.R. Lachance	x		x	x	

PETROLOGY SECTION

K. R. Dawson

General

The 1960 operations of the Petrology Section have been characterized by a marked increase in the quantity of services supplied. The lack of a full time technical person still reduces the efficiency of the operation. The meteorite collection has experienced the greatest growth since the original purchase was made. Field activities have been more extensive than for several years and the comprehensive study of the Anstruther batholith has been started.

Field and Laboratory Activities

Field trips

Northwestern University	3 days
Anstruther, Ontario	35 "
Mecatin, P.Q.	5 "
Sault au Cochon, P.Q.	5 "
Gabriault & Nevers Quarry, Rowcliff, P.Q.	1 "

A visit was made, at the invitation of E.H.T. Whitten, to the campus of Northwestern University between April 26 and 28th. The purpose of the visit was to gather additional information regarding trend surface analyses being made at that place. The visit indicated that the method, which relies on electronic computing facilities, provides a refinement of facies and other maps on which data have been contoured. An impressive usage of the techniques is to be found in the development departments of large oil companies. The technique enables the operator to separate regional from local geological or geochemical effects and to estimate the efficiency of the calculated surface.

The Anstruther field operation took five weeks between May 30 and June 30th. Field work was done on 32 of the 35 days spent in the area. The principal objective was to sample the exposed rock types and to study the contact relationships exhibited by the batholith. Approximately 10 per cent of the area was mapped, and 162 specimens were collected including 32 bulks for geochemical research.

The work indicated the presence of four map units, a migmatitic-granite gneiss, a massive red granite, with related pegmatite and aplite, a fine-grained paragneiss, and a lime silicate-marble unit. In general, a circular outward dipping sill of red granite surrounds a coarse migmatite and is surrounded in turn by fine-grained schists and gneisses.

The Mecatina Crater, Quebec, field trip was made in the company of Dr. C.S. Beals, Director of the Dominion Observatory. Of the 5 days spent away from Ottawa, 2 were spent at the crater, which proved to be the product of foliation and jointing in the underlying coarse-grained porphyritic granite.

The Sault au Cochon Crater, Quebec, field trip took 5 days in September. The trip was made in the compnay of Mr. Peter Winter of the Dominion Observatory. A helicopter was used to facilitate the study of a circular structure at Lac Sault au Cochon. The structure proved to be the product of subsurface geology in the form of foliated and banded anorthosites.

A trip of one day's duration was made to the Gabreault and Nevers Quarry at Rowcliff, P.Q., in the company of Dr. J.A. Maxwell. This trip was made to collect specimens for the preparation of laboratory standards.

Laboratory Activities

The laboratory facilities continue to be used chiefly by the staff of the section and post-doctorate fellows. It is used to a limited extent by other officers of the Survey.

Progress has been made towards a more effective technique for staining potash feldspar by the utilization of a more precise control of the temperature for the HF etch. In addition, the actual staining has been improved by means of mechanical agitation of the stain solution.

The double variation apparatus is now operative on a single variation (temperature) basis and the prospects are good that the second variable (wave length of light) will be in operation next year.

The universal stage has been used extensively for the identification of pyroxene, olivine, and plagioclase. To facilitate these efforts a 26 page manual of techniques has been prepared by M. Dence.

The laboratory projects completed for the Dominion Observatory have included the study of a soil from a small crater in Alberta, the continuation of the study of rocks from the Holleford* and Brent craters, and an intensive search of those specimens for the high density form of quartz, Coesite.

Petrological Collections

Considerable activity has been stimulated in the field of meteorite studies in Canada by the fall of the Bruderheim chondrite near Edmonton, Alberta, on March 4th**. In addition, a great deal of interest is being shown in isotope studies of meteorites in laboratories in North America and Europe.

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* Dawson, K.R. (1961) The Origin of the Holleford Crater Breccia; Can. Min., in press.

** Dawson, K.R., Maxwell, J.A. and Parsons, D.E.: A description of the meteorite which fell near Abee, Alberta, Canada; Cosmochim. et Geochim. Acta, (in press).

The following additions have been made to the National Collection:

Bruderheim chondrite	886	gms.
Springwater pallasite	745	"
Selma chondrite	636	"
Plainview chondrite	63	"
Lake Brown chondrite	8	"
Odessa, Texas	208.5	"
Trenton, Ohio	171	"
Achilles, Kansas	30.0	"

The thin section collection continues to grow slowly. Lack of more rapid growth is attributed to the length of field projects and to the widespread aversion to the preparation of cards for cataloguing purposes. The lack of a suitable piece of office equipment for the card catalogue hampers the development of a cross-referencing scheme and the formulation of a regular policy for the recovery of suites on loan.

The petrological collections have grown slightly during the year and the growth of this collection faces the same problems as the thin section collection.

Statistics

Office Projects:	Geographical Branch	1
	Dominion Observatory	4
	Geological Survey	7
Services:	Potash feldspar stain	279
	Modal analyses	200
	Rock & mineral identifications	27
	Plagioclase fusions	26
	Universal stage determinations	5
Meteorite collection:		
	Specimens received for identification	4
	Exchanges and purchases	8
Thin section collection:		
	Collections received	3
	Thin sections received	300
Petrological collections:		
	Collections received	7
	Specimens received	200

Office Projects

(OP. 46) Trend Surface Study of Preissac-Lacorne Modal Analyses and Specific Gravity Determinations.

The draft mss. has been completed and presently is being studied by co-author Whitten.

(OP.203) A Petrographic Description of the Holleford Breccia.

This project has been completed and the mss is in the hands of the editor of the Canadian Mineralogist for publication.

(OP. 119) Studies of Canadian Meteorites and Petrographical study of the Holman Island and Benton meteorites.

Work on these meteorites has just commenced.

(OP. 197) Identification of Rocks and Minerals for B. Robitaille, Geographical Branch.

Project completed, and written report submitted.

(OP. 120) Petrological Collections.

Work continuing intermittently as collections are submitted.

Personnel

The following were employed as seasonal personnel:

M. Dence, January to September 1960
W. Nixon, May to September 1960
T. Roach, September to December 1960

The Petrology Section has operated this year with a technical officer, plus a survey assistant during the field season. It is emphasized however, that much more could have been accomplished with a full-time technical person. Messrs. M. Dence, W. Nixon, and T. Roach have given excellent service on a seasonal basis.

REPORT ON THE STUDY OF GRANITE IN CANADA

J.E. Reesor

General

As approximately 40 per cent of the area of Canada is underlain by granitic and gneissic rocks, it is clearly evident that increased understanding

of these rocks is closely interwoven with the developing understanding of geology in Canada as a whole. Therefore any specific study or mapping project involving granites or gneissic rocks is of value in the eventual development of this project. Such detailed studies as those of K.R. Dawson in Preissac-Lacorne or Anstruther batholith, or at the opposite end of the scale, plans of the Cordilleron Section (J.G. Souther, et al) for reconnaissance mapping of the Coast Range "Batholith" add data eventually to be used in any long range attempt to understand the origin and emplacement of granitic rocks.

For the present, the development of the "Study of Granite in Canada" is directed toward the understanding of the origin and emplacement of the granitic rocks in part of a single, well-defined orogenic unit in southern British Columbia. This orogen provides a great variety (virtually sampling all the granitic types found in any mountain belt) of well exposed relatively young granitic rocks. It consists of two well-defined belts lying within the Purcell, Selkirk, and Monashee Mountains mostly within the oval bounded by Kootenay and Columbia Rivers, but extending into the Monashee Mountains west of the Arrow Lakes. The total area embraces about 8 one-degree map-areas, all of which have been mapped or are currently being mapped on 4-mile reconnaissance.

The eastern part of this orogen in the Purcell and Northern Selkirk Mountains consists of a series of well-defined granitic plutons (Bayonne, White Creek, Fry Creek, Horsethief, Bugaboo, Battle, Adamant, and many other smaller ones) in a folded belt of low-grade regional metamorphism. Of these only White Creek has been studied in any detail. The western part of this orogen in southern Selkirk and Monashee Mountains consists of a complex of migmatites, gneisses, and granites commonly referred to as Shuswap Terrain. Most of this region has been mapped at 4-mile scale, but no detailed studies have been made in the past.

In this study critical localities have been selected for detailed work on the basis of the reconnaissance mapping. Valhalla Range and part of the Monashee Mountains southwest of Revelstoke were selected in the complex gneissic and migmatitic region as well as Adamant, one of the individual plutons of the eastern belt of the orogen. (White Creek batholith in this same belt has already been studied in some detail). Following the completion of these studies, or concurrently with them, some further reconnaissance is necessary to correlate associated, similar granitic terrain or other individual plutonic bodies. Once this stage has been reached certain further critical specific studies may be necessary.

A study of granitic rocks built up in this way, within a well-defined orogenic unit, allows interpretation and evaluation of the results of isolated, detailed, "sample" studies on the basis of their regional pattern and tectonic significance. It will eventually contribute to the general understanding of granitic rocks in mountain belts.

Field and Office Activities

The results obtained in a combined detailed and related regional study as outlined above could well provide a pattern for progressive geological work elsewhere in the Cordillera, or in Canada generally, once the overall initial reconnaissance mapping is completed a few years from now. Thus overall regional units could be selected on the basis of mapping available; within these units thorough detailed studies could be made, then followed up using these results for a reexamination of the region on a second reconnaissance, more thorough and perhaps

more productive than the initial preliminary work. The approach to the study of granitic rocks could well serve as a test of the effectiveness of this method for general use once the Survey's programme of initial reconnaissance is finished.

Status of Work to Date

Three detailed studies are currently in progress:

1. Valhalla Complex
2. Monashee Group southwest of Revelstoke
3. Adamant batholith

These projects have all been selected within the framework of the overall pattern of study as outlined above.

1. Valhalla Complex

Field work 1960 - About 2 months was spent in Valhalla Range with work aimed at further outlining and defining the Valhalla Dome. Much information was obtained relating to the structural evolution of this complex mass. Two short visits were made to D.B. Craig working in Monashee Group rocks southwest of Revelstoke.

Before conclusions on the petrologic study can be made the structural history must be understood at least in outline. Therefore my efforts are currently being directed toward compilation, synthesis, and preliminary publication of the structure of Valhalla Dome.

A thorough study of the petrology of Valhalla Complex is being carried out concurrently with the field and structural study. Study of variation in individual mineral species involves time-consuming effort in picking pure mineral samples. Progress is slow. Analyses (complete) of minerals once picked is also slow (2 years), though analyses of whole rock samples by the rapid method is much quicker. Many further analyses both chemical and instrumental will be required during the coming year, as we trace the variations and evolution of garnet, potash feldspar, biotite, and hornblende. On much of this work we learn as we go along, the best method of study or separation, the most successful line of attack, or an unproductive line of attack, so that progress though thorough, is not spectacular. In the petrologic study Dr. H.H. Bostock is invaluable, as he is thorough and painstaking in all he does.

2. Shuswap Terrain - Monashee Group, Revelstoke Area (D.B. Craig)

One summer's field season (1960) has been spent on this study. It involves a careful detailed study of minor structural features in an attempt to unravel the overall structural character of this well-defined tectonic unit in the western part of the orogen. Concurrently the relation of associated migmatites, granitic bodies, and high grade metamorphic rocks are being studied. It has been found that lenses and layers of competent quartzite and schist, gneiss and granitic material are interlayered. Concentrations of lineation and minor recumbent folds are found in the schist and gneiss at the base of quartzite members. This entire study is based on the premise that this belt is genetically

related to, and is therefore part of the Mesozoic mountain belt, not an older unrelated mass. This study will continue during the coming field season with concurrent laboratory and office work at the University of Wisconsin.

3. Adamant Batholith (P.E. Fox)

This is a projected study for the coming field season in a well defined batholith in the northern Selkirks, part of the belt of distinct granitic plutons along the eastern border of the orogen.

Mr. Fox has worked the past two season as Dr. Wheeler's assistant in the surrounding region. As opportunity presented itself he has studied a part of this batholith and collected specimens. The work so far done formed the basis of his M.Sc. Thesis at Queen's University. He expects to continue the study for his Ph.D. Thesis at Johns Hopkins.

Plans for Future Work[1].

1. Season of 1961. J.E. Reesor plans to work with D.B. Craig for three weeks to visit P.E. Fox and to use helicopter for examination of country between Monashee Group and Valhalla Complex. He also plans to sample White Creek batholith for further research on significance of age determinations.

2. Study of synclinal culmination north of Valhalla Dome. This would be expected to accomplish some or all of the following:

   (a) to determine structural involvement of these rocks in formation of the gneissic complex to the south (Valhalla); and

   (b) to study discrete bodies of granitic rock apparently intruded into the overlying sedimentary rocks. (Has their source been the underlying complex, or was the leucocratic material in both cases derived from the same source, deeper in the earth's crust?). (Thesis study)

3. Petrological study of granitization in western part of Valhalla Dome. (Thesis study)

4. Chemical petrology and Trace element study in White Creek batholith, with associated study of age relations.

5. Study of relations of Coryell intrusion to the surrounding gneissic terrain as well as study of its internal chemical and mineralogical variations. (Thesis study)

6. Critical compilation of all available data on granitic rocks of this region from published and unpublished sources as well as original notebooks. (Summer assistant)

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[1] Most of these projects could be done by either Ph.D. Thesis candidates or by continuing staff.

Age Determinations in the Granite Study

In any reconnaissance study, whether it be in the laboratory or in the field, it is only too easy to impress personal ideas or currently popular geological thought on the scattered and scanty data available.

The use of K-A age determinations on biotite in the study of granite was therefore designed for two purposes:

1. To critically test the reliability and usefulness of such age determinations where a reasonable amount of geological data were available.

2. Assuming the method to be accurate and reliable with a maximum error of 4 or 5 million years (± 8%) in these young rocks, it was expected they would yield evidence leading to an understanding of the temporal emplacement history within one place and from place to place in an orogen.

This hope has not been borne out by the results and rocks that are clearly contemporaneous come out 30 m.y. apart. One biotite-muscovite pair with biotite clearly the earlier shows muscovite nearly 20 m.y. older, far greater than the error in the physical method. Furthermore, the youngest age obtained in Valhalla Complex of 11 m.y. hardly leaves time for erosion of 30,000 ft. of high grade metamorphic rocks.

In White Creek batholith although geological evidence shows development and cooling over a long period of time, age determinations show a spread of 60 m.y. with 18 m.y. remaining for uncovering several miles of sedimentary cover.

Clear evidence of such a systematic error in K-A age determinations surely cannot be ignored or suppressed. It is imperative that checks be made by perhaps Rubidium-Strontium or other independent methods of age determination.

A short report outlining the specific results on age determinations to date will be published in the forthcoming issue of "Age Determinations of the Geological Survey of Canada, Pt. II" (G.S.C. Paper 61-17).

International Geological Congress

About two months during the past summer were spent in attendance at the International Geological Congress at Copenhagen. About 11 days were spent on a field trip in Norway, about two weeks in Southern Sweden and about two weeks in the Swiss Alps, mainly in the Pennine Region.

(a) West Central Norway

This field trip involved a detailed study of lineation in Caledonian metamorphic rocks. In particular, the trip concentrated on a study of the relation of lineation to movement on nappe-type thrusts with resulting lineation in the direction of tectonic transport as well as perpendicular to tectonic transport. The patterns resulting from this study as well as the methods used are directly applicable to the study of Shuswap terrane and Wolverine Complex in Central British Columbia.

Many similar patterns elsewhere in the world were discussed with other members of the field trip, in particular the origin of conflicting patterns of lineation and folding in metamorphic terrains in a single mountain belt. We have largely ignored these relations, leading, in my view, to a completely incorrect interpretation of the relationship of such metamorphic complexes as the Shuswap to the Mesozoic mountain building in the Cordillera.

(b) Southern Sweden

This field trip was mainly concerned with the study of the Precambrian Fennoscandian Shield in this part of Sweden. The relation between Tectonics and granitization was particularly emphasized with concentrated study of localities in the Vestervik area that show remarkable preservation of primary sedimentary features in a metamorphic terrain as well as a remarkable relation of intensity of granitization to intensity of deformation.

Again in conversation with members of the field trip, not only on the geology of Sweden, but in other parts of the world, I gain the impression the classical "model" of granitization in situ without reference to structural influences is giving way to a more realistic "model" in which structure plays a major role in the actual granitization process.

(c) Pennine Region of the Swiss Alps

This is a well exposed and extremely well studied region of major thrusts of gneissic and metamorphic rocks into higher levels of the earth's crust. An examination, on the ground, emphasized the possible complexity of apparently flat-lying or gently dipping gneissic terrain as well as the rather narrow zones of deformation at the base of nappes and the remarkable complexity possible near the forward limits of the thrusts. Thorough detailed work representing many lifetimes of effort has been necessary to solve some of the geology of this complex terrain. One Swiss geologist estimates that four years are necessary to study properly a 15 minute quadrangle and that the resulting map will be out of date within 25 years. Yet they are at the same time able to relate such work to the regional pattern. The effort required and the approach to the solution of geological problems in the Pennine Alps provides a marked contrast to our approach to equally complex problems.

REPORT ON THE STUDY OF CANADIAN ULTRABASIC ROCKS

C. H. Smith

General

The ultrabasic study was represented by three parties in 1960, one under Dr. Smith, assisted by Dr. Kapp, in the Muskox Complex on the Coppermine River, a second under Ph.D. candidate D.C. Findlay in the Tulameen intrusion of British Columbia. The third party, under seasonal employee R.F.C. Scoates, made a preliminary study of ultrabasic rocks associated with nickel deposits in the Werner Lake area, Ontario. Field work on Muskox, now completed, has revealed the most complete, layered ultrabasic body known in Canada. Work on the Tulameen intrusion indicates that it is a complex differentiated body that requires one additional season of study in the field. The preliminary study underground at Werner Lake indicates that the ore bodies are genetically associated

with ultrabasic rocks in a fault zone. This association should be fully studied.

Field and Office Activities

The highlights of the past year have been the progress made in the studies of the Mount Albert pluton, Gaspe, and the Muskox Complex, Northwest Territories. The former is now nearing completion and the results form a valuable guide for newer projects, e.g., the current study of the Tulameen Complex in southern British Columbia. It is expected that the studies of these 3 contrasting plutons will provide a basis for a general interpretation of the primary features of Canadian ultrabasic intrusions.

The next stage in a study of ultrabasic rocks is to determine the effect of serpentinization and later metamorphism in modifying the mineralogy and geochemistry of the intrusions and causing the formation of economic mineral concentrations (asbestos and nickel). Two projects are proposed as a beginning on this phase of the ultrabasic study, one on the metamorphism of ultrabasic rocks related to granite intrusion in the Jennings River area, B.C., and the other a study of the Gordon Lake nickel deposits, Ontario.

There still is a great need to set up methods that will put quantitative mineralogy on a production basis. Studies on igneous rocks cannot proceed quickly until mineral compositions can be determined accurately and in quantity. Current optical determinative methods are slow and subject to personal error. During the summer of 1959, R.F.J. Scoates, a summer student, worked on X-ray methods of mineral determinations. Using material from the Muskox Complex single runs were made on mixtures of olivine, orthopyroxene, and clinopyroxene. Characteristic spacings for each mineral were measured, and the results interpreted in terms of known data relating cell spacings and chemical composition. The results show a poor correlation between published X-ray and compositional data in the pyroxene group. Before this approach can be used as a tool, further research is required into the X-ray properties of the pyroxene group of minerals. It is difficult for a project leader to conduct field research and mineralogical research simultaneously, and the situation to date indicates the need for a research mineralogist to carry out studies of rock-forming minerals with the aim of improving our output of quantitative mineral determinations. These studies should be carried out in preparation for future regional petrologic studies.

The following is a summary of current work being conducted under this project:

(O. P. 127) Study of Mt. Albert Ultrabasic Pluton, Gaspé

Petrographic study of the intrusion was carried out by I.D. MacGregor last winter and the results are now ready to be written up as a Bulletin.

The study has indicated the effect that water, incorporated into an ultrabasic magma during intrusion, has on the composition of mineral phases. The Mt. Albert intrusion is essentially a homogeneous, undifferentiated ultrabasic pluton but where its water content is highest, the coexisting olivine and pyroxenes have a lower Fe^{2+} content. This is interpreted as due to the oxidation of Fe^{2+} to Fe^{3+} in the presence of water vapor, thus effectively preventing its entry into the silicate phase. The important feature of this study is its

indication of the presence, and influence of water in an ultrabasic magma at high temperatures, a feature which has been disputed by geologists in the past.

A paper entitled "Ultrabasic Intrusive Conditions Illustrated by the Mount Albert Ultrabasic Pluton, Gaspe, Quebec", was presented at the Geological Society of America meeting in Denver, Colo. It was one of six selected from over 400 for inclusion in the principal symposium on geologic concepts at this meeting.

(O. P. 106) Study of Magnesium Isotope (with R.K. Wanless and J.A. Maxwell)

This study is being made to determine (a) if a fractionation of Mg isotope takes place in nature and if so (b) whether different Mg isotope abundances are indicative of distinctive geologic environments.

Problems related to the development of measurement techniques are discussed in the report of the Isotope and Nuclear Geology Section.

Measurements to date have not indicated the presence of significant fractionation, but definite conclusions cannot be drawn on the basis of the data in hand.

Study of Muskox Complex, N.W.T. (with Dr. H.E. Kapp)

The Muskox Complex is a layered basic-ultrabasic intrusion, 75 miles long, containing layers ranging in composition from dunite to granophyre. It has been mapped and sampled on a scale of 1 inch to 1,000 ft. Petrographic examination is now underway and it is planned to publish a preliminary report in 1961.

The succeeding phases of this study will include (a) quantitative mineralogical study (b) quantitative chemical study and (c) possible isotopic study. The problems involved in the quantitative mineralogical study are outlined in a previous paragraph.

H. E. Kapp, a Swiss post-doctoral fellow, has been engaged in the petrographic study and field mapping of this Complex. He is returning to Europe in January, 1961.

Study of the Tulameen Ultrabasic Complex, British Columbia

The Tulameen ultrabasic complex has an elongated core of dunite and peridotite surrounded by various types of pyroxenite and gabbro. It contains titaniferous magnetite concentrations and is a source for placer platinum.

A quantitative mineralogical and petrographic study of the complex was commenced by O. C. Findlay as a Ph.D. study at Queen's University. The body is about 1/2 mapped and field work will be completed in 1961.

Compilation of ultrabasic occurrences in Canada

This compilation was completed on a scale of 1 inch to 120 miles, but needs to be checked and edited before being considered for publication.

Study of Gordon Lake Nickel Deposit, Kenora District, Ontario.

At the request of the resident manager of the Gordon Lake deposit of Nickel Mining and Smelting Corporation, sampling of the lower levels was undertaken by R.F.J. Scoates prior to their flooding. The purpose of this study was to extend the observations made by E.R. Rose in 1956 and to provide further data on the geology of the deposit.

A petrographic examination of this material is now underway with a view to recommending the course of future research on the origin of the deposit.

MEMBERSHIP ON COMMITTEES

S. Abbey - Immediate Past Chairman, Chemists Group, Prof. Inst.
Chairman, Nominations Committee, Professional Institute

W.H. Champ - Member, Standards Committee, Can. Assoc. for Applied Spectroscopy

K.R. Dawson - Member, A.A.P.G. Famous Lecture Series Committee
Member, Canadian Committee on Meteorites
Member, Departmental Committee on Electronic Computors

J.A. Maxwell - Member, Library Committee, Geological Survey
Chairman, Subcommittee of Departmental Scientific Appraisal Committee
Member, Standards Committee, Geochemical Society
Member, Nominations Committee, Analytical Chemistry Division, Chemical Institute of Canada
Member, Program Committee, 18th Congress International Union of Pure and Applied Chemistry, Montreal, August, 1961

S.C. Robinson - Chairman, N.R.C. Associate Committee on Meteorites
Honorary Curator of Mineralogy, National Museum of Canada
Associate Secretary and member, Executive Committee and Council, Royal Society of Canada
Member, Subcommittee on Mineralogy, Petrology and Geochemistry, National Advisory Committee on Research in the Geological Sciences
Member, Departmental Committee on Map Exhibits
Chairman, Committee on Exhibits, Geological Survey
Member, Publications Committee, Geochemical Society
Member, Committee on Absolute Age, Geological Survey

H.R. Steacy - Member, Committee on Exhibits, Geological Survey
Treasurer, Mineralogical Association of Canada
Secretary-Treasurer, Ottawa Branch, C.I.M.M.
Liaison Officer, Public Service Division, Ottawa Community Chest (1960)

C.H. Smith - Secretary, Committee on Stable Isotopes, Geological Survey
Auditor, Ottawa Branch, C.I.M.M.

R.J. Traill - Secretary, Committee on Absolute Age, Geological Survey
Member, Executive Committee, Mineralogical Association of Canada
Member, Commission on New Minerals and Mineral Names, International Mineralogical Association

R.K. Wanless - Member, Committee on Stable Isotopes, Geological Survey
Member, Committee on Absolute Age, Geological Survey
Member, Editorial Advisory Board, (proposed) Journal of Isotope Geology, North Holland Pub. Co.
Chairman, Physicist Group, Prof. Inst.

OUTSIDE PUBLICATIONS

Abbey, S., and Maxwell, J.A. (1960): Determination of potassium in micas; a flame photometric study, Chemistry in Canada, vol. 12, No. 9, pp. 37-41.

Dawson, K.R.: The Origin of the Holleford Crater Breccia; Can. Min., vol. 6, Pt. 5, (in press).

Dawson, K.R., Maxwell, J.A., and Parsons, D.E.: A Description of the meteorite which fell near Abee, Alberta, Canada, Geochimica et Cosmochimica Acta, (in press).

Jambor, J.L. (1960): Vanadium-bearing interlava sediment from the Campbell River area, British Columbia, Can. Min. Jour., vol. 81, p. 133, 1960.

Maxwell, J.A.: Chemistry in the Geological Survey, Chemistry in Canada, vol. 12, No. 5, pp. 64-66, 1960.

Nickel, E.H., Karpoff, B.S., Maxwell, J.A., and Rowland, J.F.: Holmquistite from Barraute, Quebec, Can. Min., vol. 6, Pt. 4, pp. 504-512, 1960.

Robinson, S.C.: Economic Uranium Deposits in Granite Dykes, Bancroft District, Bancroft, Ontario, Can. Min., vol. 6, Pt. 4, pp. 513-521, 1960.

Smith, C.H.: Diamonds in the Great Lakes Area -- A geological Enigma; Can. Min. Jour., vol. 81, pp. 51-50, 1960.

Smith, C.H., and MacGregor, I.D.: Ultrabasic intrusive conditions illustrated by the Mount Albert ultrabasic pluton, Gaspe, Quebec; (Abstract), Bull. Geol. Soc., Amer., vol. 71, p. 1978, 1960.

Wanless, R.K., Bouele, R.W., and Lowdon, J.A.: Sulphur Isotope Investigation of the Gold Quartz Deposit of the Yellowknife District, Econ. Geol., vol. 55, No. 8, pp. 1591-1621, 1960.

SPECIAL PROJECTS

REPORT ON ACTIVITIES

C.H. Stockwell

(O. P. 153) Lexicon of Stratigraphic Names Used in Canada

This is being compiled by T.E. Bolton, assisted by Miss F.J.E. Wagner (C.H. Stockwell in nominal charge and liaison with the G.S.C. Committee on Stratigraphic Nomenclature). Up to the end of 1960 a card index of over 4,000 names has been prepared and about 590 names have been written up. It is expected that the Lexicon will be published by the Geological Survey of Canada in three parts.

(O. P. 154) Tectonic Map of Canada

The purpose is to prepare a Tectonic Map of Canada for publication by the G.S.C. and form part of a world tectonic map for the International Geological Congress. The map of Canada is being prepared jointly by the Geological Survey of Canada, the Geological Association of Canada, and the Alberta Society of Petroleum Geologists, under the overall chairmanship of C.H. Stockwell. Various committees and subcommittees have been formed and altogether, at least 25 people are actively engaged in the project.

Up to the end of 1960 much basic information has been compiled by the various people involved and it is expected that this will be assembled and correlated during 1961, when, it is expected, an overall legend will be agreed upon. It has been decided that the Tectonic Map of Canada will be published on a scale of 1:5,000,000.

Up to the end of 1960 some 215 potassium-argon age determinations have been completed and most of them are for the determination of age and extent of various orogenic belts. This work will be continued in 1961. The first of a proposed series of annual publications of geological age determinations carried out in the laboratories of the Geological Survey of Canada was published in 1960 and the second annual publication is being prepared.

The Tectonic Map of Canada is to be published by the Geological Survey of Canada, probably before 1964. Tectonic maps of certain provinces possibly may be published by the Geological Survey of Canada. The World Tectonic Map will be published by the International Geological Congress.

(O. P. 162) Geological Map of the World

The purpose is to prepare a geological map of Canada as part of the World Geological Map of the International Geological Congress. Vice-President for North and Central America is W.D. Johnston Jr. of the U.S.G.S. The G.S.C. has submitted its final version of the geology of Canada to the G.S.A. committee for the map of North America and our task, therefore, is completed, except for revisions of the legend to fit the legend for the world map. The map of North America will be published by the G.S.A. on a scale of 1:5,000,000 probably in 1961.

The world map will be published by the International Geological Congress, probably on a scale of 1:10,000,000.

American Commission on Stratigraphic Nomenclature

The Commission has, for several years, been working toward the publication of a new stratigraphic code. At a meeting of the Commission on November 2, 1960 the new code was approved and will be published in 1961. The sub-Committee on Problems of the Precambrian and Igneous and Metamorphic Rocks was dissolved.

G.S.C.Committee on Absolute Age

The committee was formed on October 21, 1958 and now consists of C.H. Stockwell, Chairman, R.J. Traill, secretary, S.C. Robinson, R.K. Wanless, Y.O. Fortier, L.W. Morley, G.B. Leech, E.R.W. Neale, G.M. Wright, W.F. Fahrig, and R.J.W. Douglas. Main matters dealt with include priorities, preparation of annual publication of results with descriptive material and interpretation, preparation of a punch card index of all published dates in Canada, plans for future field work and fundamental research.

MEMBERSHIP ON COMMITTEES

Member, American Commission on Stratigraphic Nomenclature.

Chairman, Sub-Committee on Problems of the Precambrian and Igneous and Metamorphic Rocks, American Commission on Stratigraphic Nomenclature.

Member, Committee on Stratigraphic Nomenclature, Geological Survey of Canada.

Chairman, Committee on Absolute Age, Geological Survey of Canada.

Representative of the Geological Survey of Canada on the International Geological Congress Commission on the Geological Map of the World.

Representative of the Geological Survey of Canada on the International Geological Congress Commission for the Tectonic Map of the World.

Chairman, Committee on the Tectonic Map of Canada.

OUTSIDE PUBLICATIONS

Stockwell, C.H., and Wanless, R.K.: Canadian Shield Age Program of the Geological Survey of Canada; N.Y. Acad. Sciences (in press).

REPORT ON ACTIVITIES

A.H. Lang

(O. P. 125) Metallogenic Map of Canada

The main work of the year was completing, temporarily, the compilation of a series of metallogenic maps of Canada. This involved finishing, after Dr. McCartney left for the field, the compilation of a map showing producing mines, classified geologically; drafting this for display as a MSS. map at the International Geological Congress; compiling two preliminary 'composite' metallogenic maps showing concentrations of major and minor metals; compiling an accompanying map showing geological provinces and subprovinces; and writing a report to accompany these, entitled "A Preliminary Study of Canadian Metallogenic Provinces".

Map Exhibit

An exhibit of maps of the G.S.C. and G.A.C. for the International Geological Congress was prepared with assistance from the Geological Cartography Section. An article on "The Geology of Canada" was prepared at the request of the Dominion Bureau of Statistics for the Canada Year Book 1961 (O.P. 46). Late in the year compilation of a geological map of Carrot River area was begun (O.P. 232). This area contains the deposit being investigated as the 'comprehensive study of an orebody'.

OUTSIDE PUBLICATIONS

Lang, A.H.: Surveying and Evaluating Radioactive Deposits; International Atomic Energy Agency, Vienna, Review Series No. 1, 1960.

BRITISH COLUMBIA OFFICE REPORT

J. E. Armstrong

General

A number of short term field projects are carried out each year by the geologists in the office, mainly at the request of other Government Departments. These consist largely of engineering and ground-water investigations.

1960 was the busiest year ever recorded in the B.C. office. 8,650 visitors registered and 21,391 publications of various kinds were distributed. 1,190 collections of rocks and minerals were sold. The total cash sales amounted to $7,422.05 exclusive of British Columbia Department of Mines publications. The four geologists in the office interviewed approximately 4,529 people and identified about 655 rock and mineral specimens. Approximately 1,170 letters were answered.

A complete stock of Geological Survey publications and topographic maps relating to Western Canada is maintained for sale and reference. The

British Columbia Department of Mines and the Federal Mines Branch publications are also stocked for sale and reference. In addition, a library and reading room are maintained for the use of the public.

The B.C. Office of the Geological Survey provides space, telephone services, and secretarial services for the Federal Explosives Inspector for Western Canada, and a Surveyor of the Legal Survey. The office also works in close co-operation with the B.C. Dept. of Mines, who maintain an office adjoining our own, staffed by a personnel of six.

Approximately 50 requests dealing with ground-water development for domestic, farm and irrigation use were received during the year.

A record is kept and filed on all wells drilled in Fraser Valley and Vancouver Island. During the winter months field work consists of visiting drillers, collecting records, locating new wells and observing drilling programs.

During the past summer two water-level recorders have been set up for continuous use recording the performance of water levels in aquifers used for municipal and industrial supplies. One is used on an observation well set up by the City of Langley to record long-term fluctuations of the water-table in an unconfined aquifer covering some 12 square miles from which the city obtains its water supply. The other recorder, set up in December, will record water-table fluctuations in an aquifer that is to be fully developed to supply water for an industrial development in Langley Municipality.

FIELD AND OFFICE ACTIVITIES

J. E. Armstrong spent five days in the field in the Fraser Valley area in co-operation with the Provincial (B.C.) Soils survey. Five days were spent in the field in the Howe Sound area preparing a road log for a geological field trip conducted by Dr. Armstrong during the Annual Meeting of the Cordilleran Section of the G.S.A. in Vancouver in May 1960. Dr. Armstrong also undertook about ten days field work in the Lower Fraser Valley area, never more than a day on any occasion, in order to gain additional information for the final manuscript to be submitted on the Surficial Geology.

Dr. Armstrong attended the International Geological Congress, Copenhagen, August 1960, the Cordilleran Section Meeting of the G.S.A. in Vancouver in May, and the Annual Western meeting of C.I.M.M. in Vancouver in October. He also conducted 3 one-day geological field trips (Saturdays and Sundays) for the Vancouver Natural History Society.

E. C. Halstead conducted a ground-water investigation on Vancouver Island between Courtenay and Campbell River including Quadra Island. Upon completion of this project he continued similar field work until the close of the field season in an area south of Nanaimo including Gabriola Island. Ground water for domestic, farm, irrigation, industrial and municipal use is available from permeable surficial deposits throughout most of the area investigated. Where these deposits are lacking or clays and till exist water is obtained from wells dug or drilled into the bedrock. Water from the bedrock is not abundant and is of poor quality.

Following a request of the village of Abbotsford for assistance in the development of ground water for a village supply, Mr. Halstead outlined a

drilling program at a meeting of the village council. The first test hole indicated a potential water supply of 1,000 gallons a minute, hence the test hole was developed into a producing well yielding sufficient water to meet the requirements for some years to come.

Following a request from Courtenay School District No. 71, regarding water supply for Tsolum Schools, Vancouver Island, Mr. Halstead investigated the area during the first two weeks of the field season and forwarded a report to the school board. In August a successful flowing artesian well was drilled on the school property.

At the request of the community of Sandwyck on Vancouver Island regarding a ground-water supply, the area was included in last season's field area and a report was forwarded at the close of the field season as to the possibilities of further ground-water development.

Department of Agriculture asked for assistance with a drilling program to develop irrigation water on section 4, township 10 Langley Municipality. All available data plus published report were forwarded and drilling is to follow.

Complete co-operation was given to a drilling program, well development, and test pumping of wells for Project Bridge, Vancouver Island.

S. F. Leaming did 31 days field work in 1960. On approximately 10 of these days he accompanied J.E. Armstrong in surficial geology field work in the Lower Fraser Valley. On the remaining 21 days he did surficial geology, primarily concerned with bringing information on gravel deposits up to date. He also visited on the average of once every 10 days the major sewage tunnel being constructed across Burrard Peninsula, Vancouver. This project will not be completed until 1962. As a result of Leaming's visits (average 2 hours) we will obtain a complete geological section of the surficial deposits for a length of 3.2 miles. In addition to the tunnel drill holes had been or will be completed approximately every 200 feet. We have been supplied geological logs of all the holes.

Leaming has been an invaluable addition to the B.C. office. In the period of about 9 months he has interviewed approximately 1,900 visitors and identified approximately 300 rock and mineral specimens. In addition he has handled some of the correspondence seeking geological information, and supervised the rearrangement of the supplies of publications, maps and library in the renovated office.

B. Treichel joined the Engineering Geology and Groundwater Section on April 1, 1960, worked for a brief period under the supervision of Dr. V.K. Prest in Ottawa, then transferred to the B.C. Office where he spent the field season on ground-water investigations on Vancouver Island under the supervision of E.C. Halstead.

Mr. Treichel spent the rest of the year assisting E.C. Halstead on special projects, compiling ground-water data accumulated from field work on Vancouver Island, and helping to supervise pumping tests for the Department of National Defence on Vancouver Island.

MEMBERSHIP ON COMMITTEES

J. E. Armstrong - Treasurer, B.C. section of C.I.M.M.
Executive of Geology Division, C.I.M.M.
Chairman, Finance Committee, Ann. West. Meeting, C.I.M.M., Vancouver, 1960
Treasurer, Vancouver group, Cordilleran Section, Geol. Soc. America (terminated in November, 1960)
Member, Program Committee, Cordilleran Section, Geol. Soc. America (terminated in May, 1960)
Member of Executive and Chairman of Geology Division, Vancouver Natural History Society
Member, Board of Directors, Vancouver Art, Historical, and Scientific Society
Chairman and Treasurer, Vancouver Geological Discussion Club
Member of Honorary Advisory Board, B.C. and Yukon Chamber of Mines

MEMBERSHIP IN SOCIETIES

J. E. Armstrong - Fellow, Royal Society of Canada
Fellow, Geological Society of America
Member, C.I.M.M.
Member, Geochemical Society
Member, Professional Institute
Member, Vancouver Natural History Society
Member, Art, Historical, and Scientific Society of Vancouver
Member, Vancouver Geological Discussion Club
Member, Vancouver Soils Group

E. C. Halstead - Member, Professional Institute

B. Treichel - Member, Assoc. Professional Engineers of Ontario

OUTSIDE PUBLICATIONS

Armstrong, J.E.: Geology of Proposed Columbia River Dam Sites, British Columbia, Abstract, Bull. Geol. Soc. Am., Vol. 71 No. 12, Pt. 2.

Field Trip to Illustrate Geology of Coast Mountains, North Vancouver, B.C.; Guidebook for Geological Field Trips in Southwestern British Columbia. Prepared by Geological Discussion Club, Vancouver, B.C. for meeting of the Cordilleran Section of the Geol. Soc. Am; pp. 15-25, March, 1960.

Soils of the Coastal Area of Southwest British Columbia; To be published by the University of Toronto Press in Special Publication, No. 3 of the Royal Society of Canada (in press) 15 pp. mss.

OUTSIDE TALKS

During the year, Dr. J.E. Armstrong gave the following talks: "Geology of Vancouver Area" to the Vancouver Museum Society; "Geology of Columbia Basin Dam Sites, British Columbia" to the Annual Meeting of the Cordilleran Section of the Geological Society of Ameria; " A Geologists Wanderings in Great Britain" to the Vancouver Natural History Society; and "Geology of Oslo Basin" to the Vancouver Geological Discussion Club.

WHITEHORSE OFFICE REPORT

Ralph Skinner

The Whitehorse Office of the Geological Survey is staffed by a Resident Geologist and a clerk who provide geological and geographical information and advice to prospectors, exploration companies, government departments, and the general public. The office maintains a complete stock of geological and topographical publications on the Yukon, northern British Columbia, and western Northwest Territories. During 1960 it distributed 772 geological publications and 5,039 topographical maps. A geological library that includes out-of-print Geological Survey reports and British Columbia Department of Mines reports and bulletins is provided for use by the public. The total number of visitors registered in the office during 1960 was 2,086.

The Resident Geologist keeps in touch with mining and exploration companies and prospectors and during the field season visits operating mines and important prospects that are being explored and reports his findings to the Chief Geologist. He identifies many mineral and rock specimens brought in by prospectors and others and sends some specimens to the Geological Survey laboratories in Ottawa for identification by X-ray diffraction or spectrographic analysis. The Resident Geologist organizes the Yukon Chamber of Mines prospecting classes, which are given in February or March, and gives most of the lectures. He also expedites as far as practicable the servicing of isolated departmental survey parties.

The mining activity in the Yukon during 1960 was about the same as in the previous year. United Keno Hill, the chief producer, operated its Hector-Calumet and Elsa mines on Galena Hill, Elsa, Y.T. totalling about 500 tons of ore per day and producing about 12 million dollars worth of silver, lead, and zinc, during the year. Yukon Consolidated Gold Corporation, the second largest producer, operated six dredges, an hydraulic and a bull-dozer placer plant in the Klondike area, Dawson producing about 2 million dollars worth of gold for the year. There are several small scale, mainly private, placer operations in the Yukon: twelve in the Klondike, a dredge and two in the Sixty-mile area, one on Kirkman Creek, five in the Haggart-Highet Creek area, three in the Kluane Lakes area, and one in the Dezadeash area. Johobo Mines Ltd. mined about 1,000 tons of high grade copper ore from the Bornite Creek deposit near Sockeye Lake in the Dezadeash area, and Barry O'Neil and Rae McKame of Mayo mined about 120 tons of high grade silver-lead-zinc ore from the old Comstock property on Keno Hill.

As usual most of the exploration was done by large companies. Canada Tungsten Corporation completed drilling its property on Flat River, N.W.T. and

outlined 1.32 million tons of 2.51% WO_3. Mackenzie Syndicate continued prospecting and exploring in the Flat River area, N.W.T. and Canadian Exploration Ltd. prospected and discovered a tungsten deposit in the Selwyn Mountains, N.W.T. Southwest Potash Corporation prospected the St. Elias Mountains; Frobisher Ltd. prospected the western Dezadeash area and northwestern British Columbia; Phelps Dodge Corporation prospected the Logan Mountains; and Cassiar Asbestos Corporation prospected the Pelly Mountains east of the Canol Road and started a staking rush in the Finlayson Lake map-area. Conwest Exploration Company had prospecting parties that operated in various parts of the territory, northern British Columbia and western Northwest Territories and 4 or 5 field scouts. Consolidated Mining and Smelting Company, American Smelting and Refining Company, and one or two others had field scouts in the Yukon examining old properties during 1960.

YELLOWKNIFE OFFICE REPORT

W.R.A. Baragar

During 1960 the Yellowknife Office through its sale of Departmental publications, its library and laboratory facilities, and its limited consulting services continued to act as a source of geological information for the public. Over 250 Departmental publications and a number of rock and mineral sets were sold during the period. Local prospectors and non-resident exploration geologists and engineers made frequent calls at the office for geological data and to exchange information and ideas. During the field season Departmental personnel on field assignments made use of the office as a secondary headquarters.

The Yellowknife office continued to function through the year as a repository of geological data collected in the Northwest Territories. Geological and geophysical maps and reports and drill log data are filed in the Yellowknife Office and when the properties concerned are relinquished by the owners the data is made available to the public. Several calls were made on such data during the year and in at least one case drill log data on file proved of considerable value to the new tenants of a property.

The Resident Geologist attempted to keep abreast of mining and exploration activities in the Northwest Territories during the year and through monthly and bi-monthly reports to keep headquarters informed of such activity. The first annual report on the mineral industry of the District of MacKenzie was compiled after the field season and submitted for publication.

During the field season the Resident Geologist examined and reported on 11 mining properties and made several other visits to private prospecting parties and Geological Survey field parties. Visits to each of the producing mines were made at fairly regular intervals.

The Geological Survey, through the Resident Geologist, continued its cooperation with the Department of Northern Affairs and Natural Resources in reviewing and approving of geological and geophysical work submitted as representation work on mining claims.

Other office activities included the identification of minerals and rocks submitted by prospectors, the examination of thin sections of rocks from

the mines, and the classification and cataloguing of rocks and minerals from the Northwest Territories for the Yellowknife Office petrological collection.

In addition to activities related to the Yellowknife Office the Resident Geologist spent as much office time as could be afforded on study of the Wakuach Lake map-area, Quebec-Labrador.

GEOLOGICAL MANUSCRIPTS UNIT

H. M. A. Rice

All manuscripts published by the Geological Survey of Canada, whether maps or reports, are processed by the Geological Manuscripts Unit. It is the responsibility of the unit to ensure that all publications conform to Geological Survey standards and to help the author to produce an accurate, logical, unambiguous report and map. The duties of the unit include the transmission of reports to the Departmental Editorial Division and maps to the Cartography Unit.

STATUS OF GEOLOGICAL MANUSCRIPTS WITH COMPARABLE FIGURES FOR 1958 and 1959 (Dec. 15, 1960)

Type of Report	Being processed by Divisions			Being processed by G.M. Unit			Being processed after leaving unit			Published during year		
	1960	1959	1958	1960	1959	1958	1960	1959	1958	1960	1959	1958
Memoirs	5	8	6	9	11	4	15	15	6	7	8	5
Bulletins	6	5	1	7	6	3	20	15	7	10	6	7
Econ. Geol. Ser.	0	0	1	1	3	0	2	1	1	1	1	1
Multicolour Maps[1]	4	3	1	0	2	0	36	32	25	9	9	10
P.S.Papers	2	4	0	4	4	0	18	9	5	27	10	11
P.S.Maps	4	5	2	1	5	0	13	20	7	34	39	18
Topical Reports	0	0	0	0	0	0	0	0	0	10	5	-

[1] This does not include multicolour maps to illustrate Memoirs and Bulletins.

Sixty-three P.S. publications were forwarded during the year. This is five less than were forwarded last year but it is interesting to note that last year sixteen of them were papers and this year thirty-three are papers. This great increase in the proportion of papers, and many of them were complex reports illustrated with several figures, reflects a trend among the staff to loose sight of the true preliminary nature of Preliminary Series reports. It is the simple nature of these reports that permits rapid publication, an increase in length and complexity above what is strictly necessary will defeat the whole purpose.

During the year Stuart Jenness joined the unit from the Regional Geology Division. Ira Brown was transferred to the Economic Geology Division as acting head of the Engineering Geology and Ground-water Section. Miss M. Stewart was attached to the unit for the winter, and among many other duties is responsible for preparing abstracts for GeoScience Abstracts.

Spartan Air Services under contract compiled and has nearly completed drafting a series of index maps on a scale of 1 to 1,000,000 of published maps of the G.S.C. These will be printed by the Surveys and Mapping Branch and should be ready in 1961.

AREA OF CANADA MAPPED

The following is an estimate of the area of Canada covered by geological maps published by the Geological Survey of Canada to December 31, 1960.

Province of Territory	Total area in sq. m.	Area in sq. m. Published	Per cent
Newfoundland (Island)	43,359	23,664	48.0
Newfoundland (Labrador)	112,826	31,685	28.1
Nova Scotia	21,425	21,425	100
New Brunswick	28,354	28,354	100
Prince Edward Island	2,184	2,184	100
Quebec	594,860	230,798	38.8
Ontario	398,524	128,485	32.2
Manitoba	248,125	148,601	59.8
Saskatchewan	251,396	205,731	81.8
Alberta	255,285	106,148	41.5
British Columbia	366,255	187,151	51.0
Yukon Territory	207,076	97,351	47.0
District of Mackenzie	520,933	320,765	61.5
District of Keewatin	228,160	123,361	54.0
District of Franklin	549,253	145,849	26.5
TOTAL	3,831,016	1,800,826	47.0

Large areas included as geologically mapped in estimates prepared prior to 1950 were covered only be reconnaissance surveys; in the estimates since 1955 only the part of these areas within 2 or 3 miles on either side of the route of travel is included as geologically mapped. The present aim is to hold the standard of geological mapping to that of 4-mile or better grade, although field work published on 1-inch to 8 miles is included where aerial photographs were used and the geology is projected only a few miles from points of observation. Other large areas in Manitoba, Saskatchewan and Alberta, probably underlain by nearly horizontal beds of Palaeozoic and younger strata are not included in recent estimates, although this omission might be questionable for such areas are so heavily drift-covered that 4-mile or more detailed mapping may not be justified in the near future.

SEASONAL EMPLOYEES

(By I. C. Brown)

The employment situation has remained much the same for the last three years. The total number of applications is not known as the rejects and first year students were not counted by the Civil Service Commission. The number of applications received was much the same as last year and the only really noticeable change was a 10 per cent increase in acceptances in the T.O. classification. This increase together with the increased establishment has given us a larger number of well trained T.O's to work with and for the first time we do not have to use senior students in T.O. positions. Despite this increase we still need a considerable number of well qualified T.O's and this is still our most important class for recruiting purposes.

For the first time a recruiting tour was made of the western Canadian universities and Table 6 shows that we have had a slight increase in Technical Officer acceptances from Saskatchewan west. It is questionable how much of this increase is due to the recruiting programme but the increase would have been considerably larger if we had been able to provide thesis problems for a number of western students who requested them. We were unable to because of the large number of requests for problems in the Cordillera.

Salaries were competitive in all classes. The average for T.O's was $410.00 per month and for students was $272.00 per month.

The following Tables summarize the status of student applicants for the field seasons of 1954 to 1960 inclusive.

Table I

Recruiting of Geology Students

		1960	1959	1958	1957	1956	1955	1954
T.O. 3	Appln	50						
	Offer	50						
	Accept	33						
	% "	66						

Table I (contd)

		1960	1959	1958	1957	1956	1955	1954
T.O. 2	Appln	82						
	Offer	64						
	Accept	36						
	% "	56						
T.O. 1	Appln	34						
	Offer	5						
	Accept	4						
	% "	73						
Total	Appln	166	172	85	81	69	94	108
	Offer	119	155	71	66	69	86	93
	Accept	73	80	56	47	41	37	47
	% "	61	52	79	71	60	43	51
S. A.3rd year	Appln	144	171	169				
	Offer	135	133	144				
	Accept	75	89	96				
	% "	56	67	67				
S.A. 2nd year	Appln	170	210	178				
	Offer	120	67	82				
	Accept	67	28	39				
	% "	56	44	48				
Total S.A.	Appln	314	381	347	394	392	316	286
	Offer	255	200	226	191	273	212	179
	Accept	142	117	135	110	112	108	113
	% "	56	59	60	58	41	51	63

NOTE: Table I includes only geology students recruited on the 1960 geology competition and does not include T.O's extended from winter employment, special cases, and non geologists. Details of previous years are in previous reports.

Table 2

Resignations after assignment to party 1954-60

	1960	1959	1958	1957	1956	1955	1954
T. O.	2	1	1	1	1	4	3
3rd yr.	2	3	2	1	3	3	5
2nd yr.	7	2	0	1	5	9	6
1st yr.	-	-	-	0	1	2	0
Total	11	6	3	3	10	18	14

Table 3

Actual Employment 1960

	Office	Field	Total	Establishment	Req'd Office	Req'd Field
T.O.3-10	4	42	46			
T.O.2	8	38	46			
T.O.1	8	1	9			
Total T.O.	20	81	101	100	23	85
					Total 108	
3rd yr.	8	71	79			
2nd yr.	16	56	72			
					26	130
Total S.A.	24	127	151	153	Total 156	

NOTE: This table includes the following personnel not included in Table 1:

4 T.O. from chemistry competition
6 S.A. " " "
1 S.A. " physics "
1 S.A. " radio operator "
5 senior T.O's from university staff

The column marked Req'd shows the numbers required to fully staff the field and office programs if positions and personnel had been available.

Table 4

Students employed in offices 1954-60

	1960	1959	1958	1957	1956	1955	1954
T.O.	20-	16-24	14-15	4- 7	3- 3	4- 4	- 1
S.A.	24-	15-	23-	19- 6	17- 5	10- 1	4- 3
Total	44	31-24	37-15	23-13	20- 8	14- 5	4- 4

NOTE: 1st figure is summer employment and 2nd is following winter.

Table 5

Students per field party 1954-60

Year	No. of Parties	No. of T.O's	T.O's per Party	No. of S.A's	S.A's per Party
1960	88	81	.92	127	1.44
1959	77	69	.90	107	1.39
1958	70	59	.84	95	1.36
1957	72	43	.60	91	1.26
1956	73	38	.52	95	1.30
1955	70	33	.47	98	1.40
1954	87	47	.54	109	1.25

Table 6

Distribution of Students 1959-60

University	T. O. 60	T. O. 59	S. A. 60	S. A. 59
Memorial	-	-	-	3
Dalhousie	-	-	2	1
St. Francis Xavier	2	4	6	6
Acadia	-	1	3	4
U. N. B.	5	5	3	11
Mount Allison	-	1	2	3
Sherbrooke Col.	-	-	1	-
Laval	-	-	1	-
U. of Montreal (E.P.)	-	-	3	-
McGill	7	3	5	7
Ottawa	-	-	1	-
Carleton	6	3	16	8
Queen's	8	5	10	7
Toronto	10	7	14	16
McMaster	4	5	11	4
Western	3	-	12	12
U. of Manitoba	3	6	5	2
Brandon College	-	1	2	4
U. of Saskatchewan	3	1	17	11
U. of Alberta	2	2	10	6
U. B. C.	10	8	18	13
U. S. Schools	10	15	3	1

Recruiting

During the year information and liaison visits were made to all Ontario and Quebec Universities. Dr. Gadd visited the Quebec Universities, and Dr. Brown visited the Ontario Universities in January. Dr. Neale visited the Montreal Universities in December. Technical talks and interviews were given all universities. Changes in duties and lack of travelling funds cancelled a tour of the Maritime Universities during the fall.

MEMBERSHIP ON COMMITTEES

P. Harker	-	Chairman Member	Library Committee, Geological Survey American Commission on Stratigraphic Nomenclature Exhibits Committee, Geological Survey
J.F. Wright	-	Secretary	Committee on Stratigraphic Nomenclature, Geological Survey

MEMBERSHIP IN SOCIETIES

	PA	MAC	MSA	CIMM	GSA	GAC	RSC	ESC	PI	GSL	Sigma Xi
Rice, H.M.A.					★	★	★	x			
Brown, I.C.				x		★			x		
Harker Peter	x						★		x	★	
Wright, J.F.				x	★		★				
Jenness, S.E.		x	x	x	x				x		x

★ indicates Fellow
x indicates Member

GEOLOGICAL CARTOGRAPHY

G.S. Daughtry

GENERAL

In an effort to increase the production of geological maps, the Cartography Unit has introduced the scribing process on a limited scale, which will be gradually increased as more draftsmen are trained in the technique. It is hoped that drafting time on Preliminary Series maps will be reduced by the introduction of a new type of map, the first of which, "St. Ann's, Nova Scotia", was printed in December. The re-drafting of base-maps will be avoided whenever practicable by the printing of an existing topographic base in grey, with the geological information overprinted in black.

Due to a considerable increase in manuscripts received, the backlog of figure illustrations is larger than a year ago, but with a reduction in incoming aeromagnetic work a number of draftsmen have been diverted to figure drawing.

The revised geological map of British Columbia has occupied the time of a senior draftsman for the greater part of the year, but is now near completion.

Three maps were prepared under contract by the Hunting Survey Corporation, and two more have been submitted for tender. A number of figure illustrations have also been submitted for drafting under contract.

The inter-departmental committee on mapping techniques held several meetings during the year, and provides an excellent opportunity for the exchange of ideas and information on new materials.

The display map in the foyer was completed and installed, and the Cartography Unit is engaged in adding up-to-date information. Work is continuing on the preparation of Logan Hall exhibits. Display of maps and photographs were prepared for various conventions, and the use of these panels has been extended to high schools.

PRODUCTION DATA

Maps and figure illustrations prepared by the Geological Cartography Unit and printed during 1960 comprised the following:

Multicoloured geological maps .....21 (including 4 reprints)

Preliminary geological maps.....52

Aeromagnetic maps.....115

Figure illustrations (lithographed).....52

Figure illustrations (zinc cut).....146

Maps for Water Supply Papers.....2

Miscellaneous drafting consisted of 136 items, comprising 435 pieces, including drafting illustrations for scientific papers, colouring lantern slides, map mounting and other general drafting services.

At the end of the year 4 multicoloured geological maps were in the hands of the Queen's Printer for lithography; 3 multicoloured geological maps, 5 preliminary geological maps, and 5 figure illustrations were at the Surveys and Mapping Branch for lithography.

Work was in progress on 16 multicoloured geological maps, 8 preliminary geological maps, 1 map to accompany a Water Supply Paper, and 356 figure illustrations.

The following work was completed in the photo-mechanical section.

Mapping camera

Film negatives (up to 40" x 48") 2,150

Contact processes

Films	683
Ferro-prussiate blue-line impressions	236
Vandyke prints	4,039
Copyflex prints	3,470
Blue-line map prints	45,936
Photostat impressions	10,808
Mimeograph impressions	334,868

Negative retouching

Film negatives	1,213
Artificial negatives	200
Paper negatives	30

Typesetting

Map names, titles, etc. were set-up and printed for all maps and figure illustrations being drafted. Postcards, envelopes, etc. printed totalled 7,925 impressions of 74 items.

Manuscripts received

Multicoloured geological maps	26
Preliminary geological maps	49
Aeromagnetic maps	88
Figure illustrations	545
Maps for Water Supply Paper	1

Backlog of maps and illustrations in Cartography Unit

	Dec. 31, 1960	Dec. 31, 1959
Multicoloured geological maps	28	26
Preliminary geological maps	6	8
Aeromagnetic maps	0	8
Figure illustrations	221	147

PERSONNEL

During 1960, seven persons joined the staff of the Cartography Unit, comprising five Draftsmen 2, one Student Draftsman, and one Duplicating Equipment Operator 1. Separations during the year included H. Sproule and R. Eaton, Draftsmen 2, and G. Latreille, a Duplicating Equipment Operator 1. At the end of the year the strength of the Unit was fifty-six, including one vacant position.

MAPS PRINTED FROM JANUARY 1, 1960, to DECEMBER 31, 1960

Geological ("A") Series (Multicolour)
Preliminary Geological Series (P.S.)
Aeromagnetic ("G") Series; scale, 1 inch to 1 mile unless otherwise indicated
Water Supply Papers (W.S.P.)

CANADA

900A — Canada, Principal Mineral Areas (tenth edition); in cooperation with the Mineral Resources Division; 1 inch to 120 miles.....For separate distribution

1045A-M2 (Reprint) — Metallogenic Map, Beryllium in Canada; 1 inch to 120 miles.....For separate distribution

NORTHWEST TERRITORIES - DISTRICT OF FRANKLIN

55-1959 (P.S.) — Hobart Island (35P, 36A, parts of); Baffin Island; 1 inch to 4 miles.....For separate distribution

NORTHWEST TERRITORIES - DISTRICT OF MACKENZIE

1080A — Wholdaia Lake East (65D); (Aeromagnetic); 1 inch to 4 miles.....For separate distribution

48-1959 (P.S.) — Horn River (85NE, 85NW, 95NE, parts of); 1 inch to 8 miles.....Paper 59-11

18-1960 (P.S.) — North Central District of Mackenzie (86,87,96,97, parts of); (2 sheets); 1 inch to 8 miles.....For separate distribution

22-1960 (P.S.) — Virginia Falls (95F); 1 inch to 4 miles.....Paper 60-19

23-1960 (P.S.) — Sibbeston Lake (95G); 1 inch to 4 miles.....Paper 60-19

24-1960 (P.S.) — North-Central District of Mackenzie (86,87,96,97, parts of); (surficial geology) 1 inch to 16 miles.....For separate distribution

YUKON TERRITORY

372A (Reprint) — Laberge (105E) 1 inch to 4 miles.....For Memoir 217 and separate distribution

7-1960 (P.S.) — Quiet Lake (105F); 1 inch to 4 miles.....For separate distribution

8-1960 (P.S.) — Finlayson Lake (105G); 1 inch to 4 miles.....For separate distribution

10-1960 (P.S.) — Wolf Lake (105B); 1 inch to 4 miles.....For separate distribution

25-1960 (P.S.) — Glenlyon (105L); 1 inch to 4 miles.....For separate distribution

BRITISH COLUMBIA

888A (Reprint) — Princeton (92H, E.1/2), Yale, Kamloops, Similkameen Districts; (Geology) 1 inch to 4 miles.....For Memoir 243 and separate distribution

889A (Reprint) — Princeton (92H, E.1/2), Yale, Kamloops, Similkameen Districts; (Mining Properties) 1 inch to 4 miles.....For Memoir 243 and Separate distribution

1059A — Vernon (82L); Kamloops, Osoyoos and Kootenay Districts, 1 inch to 4 miles.....For Memoir 296 and separate distribution

1082A — Atlin (104N); Cassiar District,
1 inch to 4 miles.....For Memoir 307 and separate distribution

44-1959 (P.S.) — Sumas (92 G/1)
New Westminster District;
(surficial geology);
1 inch to 1 mile.....Paper 59-9

49-1959 (P.S.) — Oyster River (92 F/14);
Comox, Nanaimo, And Sayward Districts;
(surficial geology);
1 inch to 1 mile.....For separate distribution

53-1959 (P.S.) — Chilliwack, West Half (92 H/4, W.1/2);
New Westminster and Yale Districts;
(surficial geology);
1 inch to 1 mile.....For separate distribution

57-1959 (P.S.) — Kechika (94L);
Cassiar District;
1 inch to 4 miles.....For separate distribution

59-1959 (P.S.) — Quesnel Lake, West Half (93A, W.1/2);
Cariboo District;
1 inch to 4 miles.....For separate distribution

6-1960 (P.S.) — Tulsequah (104K);
Cassiar District;
1 inch to 4 miles.....For separate distribution

11-1960 (P.S.) — Fernie, West Half (82 G/NW, SW);
Kootenay District;
1 inch to 2 miles.....For separate distribution

32-1960 (P.S.) — Courtenay (92 F/11, E.1/2, 92 F/10, W. 1/2);
Comox, Nelson, Nanaimo, and
Newcastle Districts, Vancouver Island;
(surficial geology);
1 inch to 1 mile.....For separate distribution

W.S.P. — Matsqui Municipality (92 G/1, part of)
New Westminster District (2 maps)
1 inch to 1/2 mile

BRITISH COLUMBIA AND ALBERTA

51-1959 (P.S.) — Distribution of Reefs and Banks of the Upper Devonian Woodbend and Fairholme Groups; 1 inch to 20 miles.....Paper 59-15

21-1960 (P.S.) — Cretaceous Rocks of Smoky and Pine Rivers Area, Rocky Mountain Foothills; 1 inch to 4 miles.....Paper 60-16

ALBERTA

1077A — Sturgeon Lake (83N); West of Fifth Meridian; (surficial geology); 1 inch to 4 miles.....For Memoir 303 and separate distribution

1081A — Red Deer-Stettler (83A); West of Fourth Meridian; (surficial geology); 1 inch to 4 miles.....For Memoir 306 and separate distribution

40-1959 (P.S.) — Miette (83 F/4); West of 5th Meridian; 1 inch to 1 mile.....For separate distribution

12-1960 (P.S.) — Fort Fitzgerald (74M, 74L, part of); 1 inch to 4 miles.....For separate distribution

SASKATCHEWAN

1095A — Crackingstone (74 N/7, W.1/2); 1 inch to 1 mile.....For separate distribution

38-1959 (P.S.) — Milliken Lake (sheet 1) (74 N/7, part of); 1 inch to 800 feet.....For separate distribution

5-1960 (P.S.) — Phelps Lake (64M); 1 inch to 4 miles.....For separate distribution

MANITOBA AND SASKATCHEWAN

1078A — Flin Flon-Mandy (63 K/12, 13, parts of);
1 inch to 1,000 feet.....For separate distribution

1066A — Brandon (62G);
West of Principal Meridian;
(Bedrock and Aquifers);
1 inch to 4 miles.....For Memoir 300

1067A — Brandon (62G);
West of Principal Meridian;
(surficial geology);
1 inch to 4 miles.....For Memoir 300

45-1959 (P.S.) — Big Sand Lake (64G);
1 inch to 4 miles.....For separate distribution

27-1960 (P.S.) — Chisel Lake (63 K/16, part of);
1 inch to 1,000 feet.....For separate distribution

ONTARIO

39-1959 (P.S.) — City of Ottawa (31 G/5, part of);
Carleton County (drift-thickness contours);
1 inch to 1,200 feet.....For separate distribution

46-1959 (P.S.) — Iroquois Falls (42 A/NE);
Cochrane District
(surficial geology);
1 inch to 2 miles.....For separate distribution

58-1959 (P.S.) — Trout Lake (52N);
Kenora District;
1 inch to 4 miles.....For separate distribution

1-1960 (P.S.) — Kirkland Lake (42 A/SE);
Timiskaming and Cochrane Districts;
(surficial geology);
1 inch to 2 miles.....For separate distribution

3-1960 (P.S.) — Wakwekobi Lake (41 J/6);
Algoma District;
1 inch to 1 mile.....For separate distribution

16-1960 (P.S.) Rice Lake-Port Hope (31 D/1, 30 M/16, part of); Peterborough, Northumberland, and Durham Counties; 1 inch to 1 mile.....Paper 60-14

17-1960 (P.S.) Trenton (31 C/4, 30 N/13, part of); Northumberland, Hastings, and Prince Edward Counties; 1 inch to 1 mile.....Paper 60-14

ONTARIO - QUEBEC

4-1960 (P.S.) Cornwall (31 G/2); Stormont, Glengarry, and Huntingdon Counties, (surficial geology) 1 inch to 1 mile.....Paper 60-28

QUEBEC

41-1959 (P.S.) Grondines (31 I/9); Champlain, Portneuf, Lotbiniere and Nicolet Counties (surficial geology) 1 inch to 1 mile.....For separate distribution

42-1959 (P.S.) Becancour (31 I/8); Nicolet, Champlain, Lotbiniere, and Arthabaska Counties, (surficial geology); 1 inch to 1 mile.....Paper 59-8

43-1959 (P.S.) Yamaska (31 I/2); Yamaska, Nicolet, Maskinonge, Richelieu, Berthier, and St. Maurice Counties; (surficial geology); 1 inch to 1 mile.....For separate distribution

49-1959 (P.S.) Aston (31 I/1); Nicolet, Arthabaska, and Drummond Counties; (surficial geology); 1 inch to 1 mile.....For separate distribution

52-1959 (P.S.) Sakami Lake (33, part of); Fort George-Great Whale District, New Quebec, (surficial geology); 1 inch to 8 miles.....For separate distribution

54-1959 (P.S.) Trois-Rivieres (31 I/7); St. Maurice, Champlain, Maskinonge, and Nicolet Counties, (surficial geology); 1 inch to 1 mile.....For separate distribution

56-1959 (P.S.) Nichicun-Kaniapiskau (23 SW, NW);
1 inch to 8 miles.....For separate distribution

13-1960 (P.S.) Geological Observations,
Northern Quebec (34, 35, parts of);
1 inch to 16 miles.....Paper 60-12

15-1960 (P.S.) Upton (31 H/15); Yamaska, Drummond,
Richelieu, Bagot, St. Hyacinthe, and
Nicolet Counties
(surficial geology);
1 inch to 1 mile.....Paper 60-27

QUEBEC - NEWFOUNDLAND

2-1960 (P.S.) Michikamau Lake, West Half (23 I, W.1/2);
1 inch to 4 miles.....For separate distribution

9-1960 (P.S.) Shabogamo Lake (23G, E.1/2);
1 inch to 4 miles.....Paper 60-9

NEW BRUNSWICK

1094A St. George (21 G/2);
Charlotte County;
1 inch to 1 mile.....For separate distribution

1096A St. Stephen (21 G/3);
Charlotte County;
1 inch to 1 mile.....For separate distribution

1097A Rolling Dam (21 G/6);
Charlotte County;
1 inch to 1 mile.....For separate distribution

37-1959 (P.S.) Woodstock-Fredericton (21G, 21J, parts of);
York, Carleton, Sunbury, and
Northumberland Counties;
1 inch to 2 miles.....For separate distribution

19-1960 (P.S.) Hayesville (21 J/10); York,
Northumberland, Carleton and
Victoria Counties;
1 inch to 1 mile.....Paper 60-15

20-1960 (P.S.) McNamee (21 J/9, W. 1/2);
Northumberland and York Counties;
1 inch to 1 mile.....Paper 60-15

592G — Musquash (21 G/1); Saint John, Charlotte, and Kings Counties (revised)

596G — St. George (21 G/2); Charlotte County (revised)

764G — Harcourt (21 I/6); Kent and Westmorland Counties

765G — Grand Manan (21 B/10); Charlotte County

767G — Salisbury (21 I/3); Westmorland, Queens, and Kings Counties

768G — Rogersville (21 I/11); Kent County

769G — Petitcodiac (21 H/14); Kings, Westmorland, and Albert Counties

773G — Campobello (21 B/15); Charlotte County

775G — Cape Spencer (21 H/4); Saint John County

776G — Loch Lomond (21 H/5); Saint John and Kings Counties

777G — Salmon River (21 H/6); Saint John County

778G — Waterford (21 H/11); Kings, Saint John,and Albert Counties

803G — Hillsborough (21 H/15); Albert and Westmorland Counties

804G — Kouchibouguac (21 I/14); Northumberland and Kent Counties

805G — Chatham (21 P/3); Northumberland County

806G — Tabusintac River (21 P/6); Gloucester and Northumberland Counties

807G — Burnsville (21 P/11); Gloucester County

808G — Grande-Anse (21 P/14); Gloucester County

809G — Moncton (21 I/2); Westmorland and Albert Counties

810G — Buctouche (21 I/7);
Kent and Westmorland Counties

811G — Richibucto (21 I/10);
Kent County

812G — Point Sapin (21 I/15);
Kent and Northumberland Counties

813G — Point Escuminac (21 P/2);
Northumberland and Kent Counties

814G — Wishart Point (21 P/7);
Northumberland and Gloucester Counties

815G — Tracadie (21 P/10);
Gloucester County

816G — Caraquet (21 P/15);
Gloucester County

817G — Port Elgin (21 I/1);
Westmorland County

824G — Miscou Island (21 P/16);
Gloucester County

NEW BRUNSWICK - NOVA SCOTIA

797G — Amherst (21 H/16);
Colchester and Westmorland Counties

802G — Alma (21 H/10);
Cumberland, Westmorland, and Albert Counties

NEW BRUNSWICK - PRINCE EDWARD ISLAND

826G — Cape Tormentine (11 L/4);
Westmorland and Prince Counties

NOVA SCOTIA

1074A — Cape Canso (11 F/7, W. 1/2);
Guysborough and Richmond Counties;
1 inch to 1 mile.....For separate distribution

1075A — Kennetcook (11 E/4);
Hants County;
1 inch to 1 mile.....For Memoir 302 and separate distribution

1076A — Shubenacadie (11 E/3);
Colchester, Halifax, and Hants Counties;
1 inch to 1 mile.....For Memoir 302 and separate distribution

1088A — Louisburg (11 G/13);
Cape Breton County;
1 inch to 1 mile.....For separate distribution

14-1960 (P.S.) — Nictaux-Torbrook (21 A/14, E,1/2, 21 A/15, W.1/2);
Annapolis and Kings Counties;
1 inch to 1 mile.....Paper 60-13

38-1960 (P.S.) — St. Ann's (11 K/7);
Victoria and Inverness Counties;
1 inch to 1 mile.....For separate distribution

230G — Cape George (11 F/13);
Antigonish and Inverness Counties (revised)

240G — Antigonish (11 F/12);
Antigonish and Guysborough Counties (revised)

610G — Meteghan (21 B/1);
Digby and Yarmouth Counties (revised)

611G — Church Point (21 B/8);
Digby County (revised)

759G — Ecum Secum (11 D/16);
Halifax and Guysborough Counties

762G — Hopewell (11 E/7); Pictou, Colchester,
Guysborough, and Halifax Counties

763G — New Glasgow (11 E/10);
Pictou County (advance edition)

763G — New Glasgow (11 E/10);
Pictou County (revised)

770G — Granville Ferry (21 A/13);
Annapolis County

771G — Digby (21 A/12);
Digby and Annapolis Counties

772G — Centreville (21 B/9);
Digby County

774G — Sambro (11 D/5);
Halifax County

779G Owls Head (11 D/10);
Halifax County

780G Tangier (11 D/15);
Halifax County

781G Upper Musquodoboit (11 E/2);
Halifax, Colchester, and Guysborough Counties

782G Bridgetown (21 A/14);
Annapolis and Kings Counties

783G Margaretsville (21 H/3);
Annapolis County

784G Chezzetcook (11 D/11);
Halifax County

785G Musquodoboit (11 D/14);
Halifax County

786G Shubenacadie (11 E/3);
Colchester, Halifax, and Hants Counties

787G Truro (11 E/6);
Colchester and Hants Counties

788G Tatamagouche (11 E/11);
Colchester, Pictou, and Cumberland Counties

789G Halifax (11 D/12);
Halifax County

790G Uniacke (11 D/13);
Halifax and Hants Counties

791G Kennetcook (11 E/4);
Hants County

792G Bass River (11 E/5);
Colchester and Hants Counties

793G Oxford (11 E/12);
Cumberland and Colchester Counties

794G Wolfville (21 H/1);
Kings and Hants Counties

795G Parrsboro (21 H/8);
Cumberland, Colchester, and Kings Counties

796G Springhill (21 H/9);
Cumberland and Colchester Counties

798G New Germany (21 A/10);
Lunenburg, Annapolis, and Kings Counties

799G — Gaspereau Lake (21 A/15);
Kings, Annapolis and Lunenburg Counties

800G — Berwick (21 H/2);
Kings County

801G — Cape Chignecto (21 H/7);
Cumberland County

825G — Pugwash (11 E/13);
Cumberland County

830G — Malagash (11 E/14);
Cumberland, Pictou, and Colchester Counties

840G — Merigomish (11 E/9);
Pictou, and Antigonish Counties

846G — Port Hood (11 K/4);
Inverness County

1010G — Margaree (11 K/6);
Inverness County

1011G — Cheticamp (11 K/11);
Inverness County

1013G — Pleasant Bay (11 K/15);
Inverness and Victoria Counties

1014G — Dingwall (11 K/16);
Victoria County

1025G — Cheticamp River (11 K/10);
Inverness and Victoria Counties

1026G — Lake Ainslie (11 K/3);
Inverness and Victoria Counties

NOVA SCOTIA - PRINCE EDWARD ISLAND

835G — Pictou Island (11 E/15);
Queens, Kings, and Pictou Counties

841G — Malignant Cove (11 E/16);
Antigonish and Kings Counties

PRINCE EDWARD ISLAND

818G — Cape Egmont (21 I/8);
Prince County

819G — O'Leary (21 I/9);
Prince County

820G — Tignish (21 I/16);
Prince County

821G — North Point (21 P/1);
Prince County

827G — Summerside (11 L/5);
Prince and Queens Counties

828G — Malpeque (11 L/12);
Prince and Queens Counties

831G — Charlottetown (11 L/3);
Queens County

832G — Rustico (11 L/6);
Queens County

836G — Montague (11 L/2);
Queens and Kings Counties

837G — Mount Stewart (11 L/7);
Kings and Queens Counties

842G — Boughton Island (11 L/1);
Kings County

843G — Souris (11 L/8);
Kings County

NEWFOUNDLAND

1086A — Trout River (12 G/1, 12 G/8, parts of);
Island of Newfoundland;
1 inch to 1 mile.....For separate distribution

35-1959 (P.S.) — St. John's (1 N);
Island of Newfoundland;
(surficial geology);
1 inch to 4 miles.....For separate distribution

47-1959 (P.S.) — Sandy Lake (12 H, W, 1/2);
Island of Newfoundland;
1 inch to 4 miles.....For separate distribution

GULF OF ST. LAWRENCE

822G — Sheet 21 P/8

823G — Sheet 21 P/9

829G — Sheet 11 L/13

833G	Sheet 11 L/11
834G	Sheet 11 L/14
838G	Sheet 11 L/10
839G	Sheet 11 L/15
844G	Sheet 11 L/9
845G	Sheet 11 L/16
847G	Sheet 11 K/5
848G	Sheet 11 K/12
849G	Sheet 11 K/13
1012G	Sheet 11 K/14
1015G	Sheet 11 M/SW 1 inch to 2 miles
1016G	Sheet 11 M/NW 1 inch to 2 miles
1017G	Sheet 11 M/SE 1 inch to 2 miles
1018G	Sheet 11 M/NE 1 inch to 2 miles
1019G	Sheet 11 N/SW 1 inch to 2 miles
1020G	Sheet 11 N/NW 1 inch to 2 miles
1021G	Sheet 11 N/SE 1 inch to 2 miles
1022G	Sheet 11 N/NE 1 inch to 2 miles
1023G	Sheet 11 O/SW 1 inch to 2 miles
1024G	Sheet 11 O/NW 1 inch to 2 miles

BAY OF FUNDY

760G	Sheet 21 B/2
761G	Sheet 21 B/7
766G	Sheet 21 B/16

ADMINISTRATIVE SERVICES

LIBRARY

Mrs. N.I. Kummermann

The library has now settled down in the new building but there are still some improvements to be made. These include completing the cards indicating the material shelved in each stack, the shifting of the map library to make use of the vacant drawers made available by the transfer of a large number of United States topographical maps to the library of the Geographical Branch, and the sorting and disposal of duplicate or obsolete material now stored in the basement. It is hoped that these projects will be completed in 1961. The removal, from the catalogue, of cards for discarded material has also now been finally completed. The use of a wheel to indicate the location of periodicals and serials has proved to be a valuable time saver. It was made possible to set this up by the loan of Mrs. Shields.

The library is still plagued by a shortage of staff. However, it is expected that a replacement will shortly be made for Mr. R. Shanks, who resigned July 31st to take up a more remunerative position. The library is also to have an additional technical officer 1 on the first of April 1961. It is expected that this appointment will relieve the head librarian of much detail and routing checking. It has been found that university graduates who are not librarians and are classed as technical officers, tend to stay longer and to be more cooperative in sharing the work load.

Library statistics for the year are as follows:

Acquisitions:

Books and pamphlets acquired by purchase	649
Canadian periodicals	1,668
Canadian government publications	4,842
Proceedings, transactions and bulletins of societies.	4,335
British and foreign government publications	4,607
British and foreign periodicals	7,550
Total	23,651

Other data:

Recorded loans, books, pamphlets and periodicals	45,256
Interlibrary and occasional loans	3,894
Publications borrowed from other libraries	526
Maps and charts received before sorting for disposal	1,421
Maps and charts loaned	782
Cards added to general catalogue	23,871
Items catalogued including books, pamphlets, microfilms, monographs and analytical entries	6,584
Volumes bound	650
Scientific books purchased for personal use of staff members at their expense	102

PUBLICATION DISTRIBUTION OFFICE

L. Touchette

The distribution of geological reports and maps in 1960 increased by some 5,000 publications in spite of the fact that total incoming requests were slightly below 1959 figures. Decrease of incoming requests is due - principally - to less demand from "junior" students.

Our Information Office (suitably located at the main entrance) has been quite active in answering all types of queries from numerous visitors to this building.

During the year all files for completed requests for maps and reports from the general public and G.S.C. were taken over by this unit; these were previously under "Administrative Files".

In addition to regular duties, a number of listings of geological publications were revised and made available for general distribution; work of similar nature is planned for 1961. Facilities and assistance were provided Mr. P. E. Palmer in his compilation of an index to G.S.C. maps.

Displays of geological publications were presented at the Prospectors and Developers Association convention in Toronto, and the C.I.M.M. convention in Montreal.

During the year the following publications were received and made available for distribution.

Memoirs	7
Memoirs (reprint)	2
Geol. Survey Bulletins	10
Economic Geol. Series	2
Preliminary papers	29
Preliminary papers (reprint)	16
Preliminary Geol. maps	34
Final Geol. maps	14
Final Geol. maps (reprint)	6
Mineral map of Canada (revision)	1
Aeromagnetic maps (new & revised)	235
Aeromagnetic maps (reprint)	6
Reprint series	17
Water Supply Papers	1
Water Supply Papers (reprint)	4
Miscellaneous reports	6
Departmental Annual Report	1
Notice Lists	46

Publications sent out from this office in answer to 15,524 requests were as follows:

Maps	91,038
Other Publications	69,129
Total	160,167

Visitors (cash sales only)..... 562

Acknowledgements.....3,431

PHOTOGRAPHIC SECTION

E.C. Elliott

In reporting photographic activities for the year 1960, we are happy to say that a further increase in production, in some segments of our work, has been very gratifying. Negative making has increased, this has been accomplished by Mr. Thorpe who now devotes his full time to the photographing of fossils.

The overall production has declined from last years record by some 6,014 pieces of completed work. This can be traced to the fact that for the past year we have had a position vacant.

In previous years we have been able to show an increase in production but, alas, there comes a time when the capacity of work from a staff must reach its peak and it would now seem that the peak has been reached and that any increase in the future must come from additional staff.

Since moving into the new building we have had to take on additional commitments from other branches. These include the Continental Polar Shelf Project, which has a very large volume of work, the Mineral Resources Branch for which we have just completed processing 640 color transparencies. We also have been asked to assist other branches from time to time. The Geographical Branch requested that one of the staff address a field officers group on the proper use of hand cameras. The Mines Branch requested our advice on photographic problems and the Editorial and Information Division asked for assistance in photo productions. We have had to supply personnel for the Logan Club meetings. While these requests are minor they are also time consuming. I might also mention that we have assisted in the editing and putting into continuity of movie film taken in the field on geological operations. At the present time party chiefs are asked to perform these duties. Their complaint is that they are not qualified and are too busy to undertake this task. If a film record is to be kept, it may be advantageous to have a photographer do the work and he should be supplied with proper camera equipment.

We are still without our negative filing cabinets which are at the Museum Building. This collection dates back to the year 1862 and it is believed to be the oldest photographic record on the North American Continent. It also contains historical records of the developments of events in Canada. Great care has been taken in the past to protect it throughout the years and it only seems logical that it should be properly stored in steel negative cabinets similar to the ones in which it is now stored.

Production Report, 1960

Continental Polar Shelf Project

Contact prints	658
Bromide enlargements	2966
Photo negatives	58
Lantern slices made	39
Lantern slides bound	39

Continental Polar Shelf Project (contd)

Photos dry mounted		54
Aero film print		100
Exposures developed	Fieldwork	575
	Total	4,489

Mineral Processing Division

Contact prints	2
Bromide enlargements	6
Photo negatives made	3
Color transparencies processed	640
Total	651

Photographic Section Annual Report 1960

Contact prints	17,488
Bromide enlargements	4,400
Photo negatives made	3,357
Photo negatives opaqued	1,860
Photo negatives retouched	15
Photos dry mounted	1,016
Lantern slides made	189
Lantern slides bound	201
Color transparencies made	87
Color transparencies processed	1,240
Color transparencies mounted	370
Photomicrographs made	536
Autoradiographs	11
Exposures developed Fieldwork	4,898
Magnetometer film processed	28,806
Magnetometer print made	100
Total	64,574

10 Days, two men filing, indexing, and sorting photo plates and halftone blocks.
8 Half days, Logan Club meetings

LAPIDARY SECTION

H.W. Hay

Work done in the lapidary section from January 1960 to December 1960 was as follows:

Thin sections	4,261
Large polished sections	99
Mounted polished sections	202
Cut and levelled specimens	199
Slide's frosted	5,000

RESEARCH GRANTS TO CANADIAN UNIVERSITIES

J. F. Henderson

The grants were initiated in 1951 on the recommendation of the National Advisory Committee on Research in the Geological Sciences to stimulate and support geological research in Canadian universities. Applications are received from members of university staffs and are submitted to the Director, Geological Survey of Canada. They are reviewed by the National Advisory Committee on Research in the Geological Sciences and the grants are awarded by the Survey on the basis of the resulting recommendations.

For 1960-61, thirty six applications were received and the total of the grants applied for was $102,677. Of the 36 applications, 18 amounting in the aggregate to $63,005 were for the support of projects supported previously. The remaining 18 applications aggregating $39,672 were for support of new projects. Grants totalling $50,000 were awarded to 13 universities in support of 12 new projects and 17 continuing studies. For the amounts of the individual grants and descriptions of the projects they support, the reader is referred to Appendix II in the Tenth Annual Report of the National Advisory Committee on Research in the Geological Sciences.

Since 1951 when the grants were initiated, 40 projects have been completed and a total of 43 others are presently under way in 15 Universities. Some 117 papers have been published in scientific periodicals; 29 of these have appeared in the past year. Fifty-four of these papers were published in Canada, 43 in the United States, 13 in Great Britain and 7 elsewhere. In addition, results of the research have been incorporated in 36 M.Sc. and 19 Ph.D. theses. Summary reports on projects completed and reporting progress of interest in 1959-60 may be found in the Tenth Annual Report of the National Advisory Committee on Research in the Geological Sciences, Appendix I.

The National Research Council of Canada is now awarding grants-in-aid to geology departments of Canadian universities on a substantial scale and in 1959-60 awarded a total of $333,768 in grants-in-aid in the Earth Sciences. Of this sum about $150,000 was in support of geological projects, including geophysical projects concerned with geological problems.

Applications for National Research Council grants are received up to February 1st of each year and reviewed in March by a Grant Application Screening Committee established in 1959 to review applications in the Earth Sciences. Applications for Geological Survey of Canada grants are received up to May 1st. The Projects Sub-committee of the National Advisory Committee reviews the applications in June and at that time has full knowledge of grants in the geological sciences awarded in March by the National Research Council. In addition, one or more of its members are also members of the National Research Council Grant Application Screening Committee. In this way the grants-in-aid of research in the geological sciences by both organizations are fully co-ordinated.

COMPREHENSIVE STUDY OF A CANADIAN ORE DEPOSIT

J. F. Henderson

This project as originally envisaged and recommended in 1957 by the National Advisory Committee on Research in the Geological Sciences (Annual Report, 1956-57) was to be a cooperative comprehensive study, or series of studies, carried out by geologists, geochemists, geophysicists, and mineralogists in which the staff of the mine selected, the Geological Survey of Canada, the Department of Mines and the Research Council or Foundation of the Province concerned, and the Universities would participate. In recommending this major project the committee felt that although many geological studies of mining districts and of orebodies in these districts have provided much information, the results, on the whole, have been far below expectations largely because such studies have been too narrow in scope and have dealt with but one or two of the many facets of a truly comprehensive study. What is needed are investigations having a much wider range, concentrated on certain deposits and carried out by groups of scientists with diverse training and experience. Such integrated comprehensive investigations should result in much more rapid advance in our knowledge of fundamental geological processes including the source of the metals, and of how the orebodies attained their present position and form. The National Advisory Committee recommended that the Geological Survey sponsor such a project and have over all a responsibility for carrying it through.

Progress in initiating this project has been slow. After several unsuccessful attempts the National Advisory Committee, at the 1959 Annual Meeting, appointed a Sub-committee under the chairmanship of Dr. H.D.B.Wilson to select a suitable orebody and to carry out negotiations with the mining company for its use for the study. Late in 1959 the Hudson Bay Mining and Smelting Company was approached to permit such a study of the Coronation Mine. The Company agreed, and the project which was launched early in 1960, is now well under way. Dr. D.R.E. Whitmore of the Geological Survey of Canada has been appointed co-ordinator of the project. A summary report by Dr. Whitmore on progress up to October 1960 is contained in the Tenth Annual Report for 1959-60 of the National Advisory Committee on Research in the Geological Sciences.

ANNUAL REPORT, NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

J. F. Henderson

On behalf of the National Advisory Committee on Research in the Geological Sciences the Geological Survey continues to publish the Annual Report of the Committee. The Annual Report for 1958-59 was published and distributed in February 1960. Some 800 copies were prepared and as of November 1960 over 700 copies had been distributed. The report of the previous year (1957-58) and of most of the earlier Annual Reports are out of print; most of them being so before the subsequent report appeared. The report for 1959-60 will be ready for distribution early in 1961.

APPENDIX I

STAFF LIST

Geological Survey of Canada

Director's Office

1 Director
Harrison, J.M.

1 Admin. Off. 6
Pollitt, E.I.K.

1 Secretary to Executive
Arscott, Mrs. M.M.

1 Chief Geologist
Lord, C.S.

1 Clerk 4
Derry, Miss G.E.

1 Tech. Off. 5
Steeves, S.M.

1 Typist 1
Rozon, R.

Special Projects
2 Chief of Division
Lang, A.H.
Stockwell, C.H.

1 Clerk 3
Wragg, Miss C.E.

Secretary, Nat. Adv. Comm.
1 Sr. Geologist
Henderson, J.F.

British Columbia Office

1 Sr. Geologist
Armstrong, J.E.

1 Sr. Sc. Off. 1
Halstead, E.C.

2 Sc. Off. 1
Leaming, S.F.
Treichel, A.

British Columbia Office (cont'd)

1 Stenographer 3
Marble, Mrs. A.

1 Clerk 2
Lee, Mrs. E.K.

Whitehorse Office

1 Geologist 3
Skinner, R.

Yellowknife Office

1 Geologist 3
Baragar, W.R.A.

1 Clerk 2
Halliday, Miss S.R.

Geological Manuscripts

1 Sr. Geologist
Rice, H.M.A.

1 Geologist 4
Harker, P.

2 Geologist 3
Jenness, S.E.
Wright, J.F.

1 Clerk 3
Mahoney, Mrs. L.R.

Accounts

1 Admin. Off. 1
Besserer, L.E.

1 Principal Clerk
Raymond, J.E.

Accounts cont'd

3 Clerk 2
McNabb, Mrs. S.W.A.
McNaught, Mrs. M.E.I.
Moreau, V.

Files and Messenger Service

1 Clerk 3
Gooch, W.B.

1 Clerk 1
Olivier, Mrs. L.J.

3 Clerical Asst.
Bissonnette, Miss M.C.
Challice, Miss D.K.
Jean, Miss R.

Geological Information

1 Supervising Clerk
Touchette, L.J.L.

1 Clerk 4
Letang, J.E.Y.G.

2 Clerk 3
Coutu, F.V.
Lortie, L.H.

1 Clerk 2
Higgs, Mrs. M.M.

1 Clerk 1
Clarke, C.R.

1 Typist 1
Hayes, Mrs. B.E.

Stationery and Supplies

1 Clerk 4
Smith, D.D.

2 Storeman 1
Charlebois, G.J.
Levesque, R.

1 Clerk 2
Henderson, Mrs. M.V.

1 Typist 1
Richer, J.P.

1 Labourer
Cayer, H.H.

Photographic

1 Tech. 4
Elliott, E.C.

1 Photographer 3
Cooke, F.J.

3 Tech. 1
Kempt, J.W.
Stafford, W.G.
Thorpe, E.

1 Asst. Tech. 3
White, Miss J.I.

Library

1 Libr. 5
Kummermann, Mrs. N.I.

2 Libr. 2
Hudak, Dr. L.
Whitney, Mrs. L.E.

1 Tech. Off. 1
Lindsay, Miss L.E.

1 Asst. Tech. 3
Fisher, A.

1 Clerk 3
Stewart, Miss T.G.

1 Clerk 2
Patterson, Miss E.L.

1 Typist 1
Monette, Miss P.M.

Stenographic Pool

1 Clerk 4
Shanks, Mrs. M.A.

1 Clerk 3
Partington, Mrs. G.

4 Typist 3
Casey, Mrs. M.
Cross, Miss J.D.
Millar, Miss M.
Thomas, Mrs. F.C.

1 Steno. 2
Gravelle, Mrs. M.E.A.

Stenographic Pool cont'd

5 Typist 1
Baker, Mrs. V.D.
Dorazio, Mrs. L.M.
Jackson, Miss F.A.
Kiefl, Miss M.C.
Lessard, Miss J.M.

Technical Services

1 Tech. Off.4
Jones, F.W.

Instrument Shop

1 Technician 4
Meilleur, A.G.

Lapidary

1 Tech. 2
Hay, H.W.

1 Tech. 1
Whitehead, A.E.

1 Asst. Tech. 3
McEwan, W.O.

1 Asst. Tech. 2
Lacoste, F.

Carpenter Shop

1 Carpenter
Carey, E.L.

GEOLOGICAL CARTOGRAPHY

1 Tech. Off. 7
Daughtry, G.S.

1 Clerk 3
Nakomoto, Mrs. S.

Map Editing & Work Planning

2 Tech. Off. 5
McNeil, C.E.
Williams, L.A.

Stand. & Prel. Geol. Maps

1 Super. Drafts. 3
Nunn, E.P.

Stand. & Prel. Geol. Maps cont'd

2 Super. Drafts. 2
Debain, P.C.J.B.
Dumbrell, E.A.

11 Drafts. 3
Barbary, G.J.
Bernard, M.
Daugherty, R.F.
Edwards, B.
Finn, H.J.
Gagnon, J.G.E.
Guibord, J.L.
Howe, K.G.
Mainville, B.
Raddatz, Miss M.A.
Rockburne, K.G.

5 Drafts. 2
Babey, N.B.
Bencik, K.
Hayne, M.F.
Kovachic, Mrs. H.
Romhild, R.C.

Geophysical Maps, Figure illustrations, Special Map Projects

1 Super. Drafts. 3
Gardham, F.J.

2 Super. Drafts. 2
Babcock, L.W.
Leader, R.E.

4 Drafts. 3
Heyendal, H.A.
Hill, R.
Lavigne, G.H.
Walter, D.J.

4 Drafts. 2
Cooke, Miss B.J.
Gottinger, R.
MacLachlan, L.A.
Thomson, J.W.

7 Drafts. 1
Bartlett, E.G.
Bergeron, J.J.
Heney, F.J.
King, J.A.
Nichol, H.S.
Vermette, W.P.
Whitman, G.S.

Geophysical Maps, Figure Illustrations, Special Map Projects(cont'd)

3 Stud. Drafts.
Auger, M.R.
Corriveau, J.P.
Sutcliffe, W.J.

1 Technician 1
McCracken, J.N.

Photo Mechanical Units

1 Tech. 2
Connell, C.

Map Photography

2 Tech. 2
Buck, N.E.
Williams, J.B.F.

3 Learner (Litho or Photo)
Daley, L.A.
Fairfield, R.D.J.
Papps, T.L.

1 Asst. Tech. 3
Sidock, K.S.

Printing

2 Asst. (Litho or Photo) 2
Foshay, G.N.
Major, A.C.

1 Dup. Eq. Oper. 1
MacKenzie, R.J.G.

REGIONAL GEOLOGY DIVISION

1 Chief of Division
Weeks, L.J.

1 Clerk 3
Paquette, Mrs. A.M.

Appalachian

1 Geologist 4
Neale, E.R.W.

4 Geologist 3
Anderson, F.D.
Kelley, D.G.
Poole, W.H.
Taylor, F.C.

Appalachian (cont'd)

1 Geologist 2
Benson, D.G.

Eastern Shield

1 Sr. Geologist
Duffell, S.

3 Geologist 4
Eade, K.E.
Fahrig, W.F.
Stevenson, I.M.

1 Geologist 3
Frarey, M.J.

1 Geologist 2
Donaldson, J.A.

2 Tech. Off. 3
Emslie, R.F.
Jackson, G.D.

Western Shield

1 Sr. Geologist
Wright, G.M.

2 Geologist 4
McGlynn, J.C.
Tremblay, L.P.

3 Geologist 3
Bell, C.K.
Fraser, J.A.
Heywood, W.W.

2 Geologist 2
Currie, K.L.
Tremblay, M.

1 Sc. Off. 3
Davison, W.L.

Cordilleran

1 Sr. Geologist
Bostock, H.S.

4 Geologist 4
Green, L.H.
Leech, G.B.
Little, H.W.
Muller, J.E.

Cordilleran (contd)

6 Geologist 3
Campbell, R.B.
Gabrielse, H.
Roddick, J.A.
Souther, J.G.
Tipper, H.W.
Wheeler, J.O.

FUELS AND STRATIGRAPHY DIVISION

1 Chief of Division
Caley, J.F.

1 Clerk 3
Riddell, Mrs. N.H.

1 Sc. Off. 2
Howie, R.D.

1 Clerk 3
Dougherty, Miss H.M.

Petroleum Geology

1 Sr. Geologist
Douglas, R.J.W.

2 Geologist 4
Irish, E.J.W.
Norris, D.K.

4 Geologist 3
Liberty, B.A.
Pelletier, B.R.
Price, R.A.
Stott, D.F.

2 Geologist 2
Mountjoy, E.W.
Taylor, G.C.

2 Sr. Sc. Off. 1
Latour, B.A.
Sanford, B.V.

2 Sc. Off. 2
Herr, R.L.
MacLean, B.

1 Tech. 2
Lalonde, J.M.A.

Petroleum Geology (contd)

3 Asst. Tech. 2
Bova, P.
Larose, J.M.
Seguin, R.J.G.

1 Asst. Tech. 1
Remillard, G.

Arctic Islands

2 Geologist 4
Blackadar, R.G.
Thorsteinsson, R.

1 Geologist 3
Christie, R.L.

Stratigraphic Palaeontology

4 Geologist 4
McLaren, D.J.
Jeletzky, J.A.
Sinclair, G.W.
Tozer, E.T.

6 Geologist 3
Bolton, T.E.
Copeland, M.J.
Cumming, L.M.
McGregor, D.C.
Norris, A.W.
Wagner, F.J.E.

1 Geologist 2
Norford, B.S.

1 Sc. Off. 1
Uyeno, T.T.

1 Tech. 2
Botte, B.J.

1 Tech. 1
Callahan, J.J.

1 Asst. Tech. 2
Matte, J.E.A.

1 Asst. Tech. 1
Shea, R.

1 Clerk 3
Lemoine, Mrs. A.M.

Stratigraphic Palaeontology (cont'd)

1 Typist 3
Shields, Mrs. L.

Senior Research Palaeontologist

1 Sr. Geologist
Frebold, H.W.

Coal Research

1 Sr. Geologist
Hacquebard, P.A.

1 Tech. Off. 3
Cameron, A.R.

2 Sc. Off. 2
Birmingham, T.F.
Donaldson, J.R.

1 Technician 3
Barss, M.S.

Western Plains Office

2 Sr. Geologist
Wickenden, R.T.D.
Belyea, Miss H.R.

1 Geologist 4
Aitken, J.D.

3 Geologist 2
Burk, C.F.
Procter, R.M.
Pugh, D.C.

1 Sr. Sc. Off. 1
Price, L.L.

1 Asst. Tech. 3
Balfour, A.F.

1 Asst. Tech. 1
Abbott, G.H.

1 Clerk 3
Lawson, Miss H.F.

1 Typist 1
George, Mrs. M.E.

ECONOMIC GEOLOGY DIVISION

1 Chief of Division
Fortier, Y.O.

1 Clerk 3
Burns, Miss E.M.

1 Sc. Off. 1
Johnston, A.G.

1 Typist 3
Shurben, Mrs. P.A.

Geology of Mineral Deposits

1 Sr. Geologist
Kindle, E.D.

3 Geologist 4
Mulligan, R.
Roscoe, S.M.
Whitmore, D.R.E.

4 Geologist 3
Chamberlain, J.A.
Gross, G.A.
McCartney, W.D.
Rose, E.R.

1 Sc. Off. 2
McLeod, C.R.

Geochemistry

1 Sr. Geologist
Boyle, R.W.

3 Geologist 3
Cameron, E.M.
Holman, R.H.C.
Kretz, R.

1 Sc. Off. 3
Jardine, Mrs. M.A.

1 Sc. Off. 2
Washington, R.A.

1 Technician 1
Mihailov, G.

1 Asst. Tech. 3
Lavergne, P.J.

Pleistocene Geology

1 Sr. Geologist
Prest, V.K.

3 Geologist 4
Henderson, E.P.
Lee, H.A.
Stalker, A.M.

5 Geologist 3
Craig, B.G.
Gadd, N.R.
Fyles, J.G.
Hughes, O.L.
Terasmae, J.

1 Tech. Off. 3
Mirynech, E.

2 Technician 2
Field, D.E.
Mott, R.J.

1 Technician 1
Kelley, R.G.

Engineering and Ground-water Geology

1 Geologist 4
Brown, I.C.

3 Sr. Sc. Off. 1
Hall, E.
Halstead, E.C. -(Vanc. Off.)
Owen, E.B.

1 Geologist 2
Scott, J.S.

1 Sc. Off. 3
Brandon, L.V.

5 Sc. Off. 1
Carr, P.A.
Charron, J.E.
Toth, A.M.
(Treichel, A. - Vanc. Office)
Tremblay, J.J.L.

1 Technician 1
Pearce, R.G.

PETROLOGICAL SCIENCES DIVISION

1 Chief of Division
Robinson, S.C.

1 Clerk 3
Britt, Mrs. M.G.

Analytical Chemistry

1 Geologist 4
Maxwell, J.A.

1 Sr. Sc. Off. 1
Abbey, S.

1 Sc. Off. 3
Champ, W.H.

1 Sc. Off. 2
Courville, S.

1 Sc. Off. 1
Beaulne, R.P.

1 Technician 3
White, W.F.

3 Technician 1
Bender, G.
Hoops, K.G.
Ter Haar Romeny, W.U.

1 Asst. Tech. 3
Malone, J.P.

1 Asst. Tech. 1
Letang, Miss M.N.F.J.

Isotope and Nuclear Research

1 Sr. Sc. Off. 2
Wanless, R.K.

3 Sc. Off. 2
Dyck, W.
Lowdon, J.A.
Stevens, R.D.

1 Sc. Off. 1
Loveridge, W.D.

1 Technician 3
Smith, W.A.

1 Technician 2
Hurley, J.G.

Mineralogy

1 Geologist 4
Traill, R.J.

1 Sr. Sc. Off. 1
Steacy, H.R.

2 Sc. Off. 3
Lachance, G.R.
Rimsaite, Miss J.

2 Sc. Off. 2
Jambor, J.L.
Sabina, Miss A.P.

1 Tech. Off. 4
Fabry, R.J.C.

1 Technician 2
Gauthier, C.H.R.

1 Technician 1
Paris, J.C.

1 Asst. Tech. 3
Vaux, A.M.

3 Asst. Tech. 2
Cormier, R.
Lacroix, A.
Turpin, J.

Petrology

3 Geologist 4
Dawson, K.R.
Reesor, J.E.
Smith, C.H.

GEOPHYSICS DIVISION

1 Chief of Division
Morley, L.W.

1 Clerk 3
Purkiss, Miss B.F.

Interpretation

1 Geologist 4
MacLaren, A.S.

1 Geologist 3
Gregory, A.F.

Interpretation (cont'd)

1 Sc. Off. 3
Bower, Miss M.E.

Aeromagnetic Surveys

1 Tech. Off. 4
Owens, K.H.

1 Technician 2
Essex, F.

1 Technician 1
Pott, H.H.

1 Asst. Tech. 3
Reveler, D.A.

Compilation

1 Technician 3
Ready, E.E.

1 Technician 2
Houlihan, J.P.

1 Asst. Tech. 3
Leblanc, Mrs. M.K.

1 Map Comp. & Comp. 4
Langlois, R.J.

2 Map Comp. & Comp. 3
Chretien, Miss M.B.
Derouin, E.J.

4 Map Comp. & Comp. 2
Dods, S.D.
Dregas, Miss T.C.M.
Haley, E.L.
Zieman, F.W.

1 Map Comp. & Comp. 1
Zebarth, A.L.

Palaeomagnetism

1 Geologist 3
Larochelle, A.

1 Technician 1
Black, R.F.

1 Asst. Tech. 1
Freda, G.N.

Seismic Methods

1 Sr. Sc. Off. 1
Hobson, G.D.

1 Technician 3
MacAulay, H.A.

1 Technician 1
Gauvreau, G.

Instrument Research and Development

1 Sr. Sc. Off. 1
Collett, L. S.

1 Sc. Off. 3
Lattacharyya, B.K.

1 Tech. Off. 4
Washkurak, S.

1 Sc. Off. 2
Sawatzky, P.

1 Technician 3
Knapp, H.W.C.

Magnetic Resonances

1 Sr. Sc. Off. 1
Wesemeyer, H.

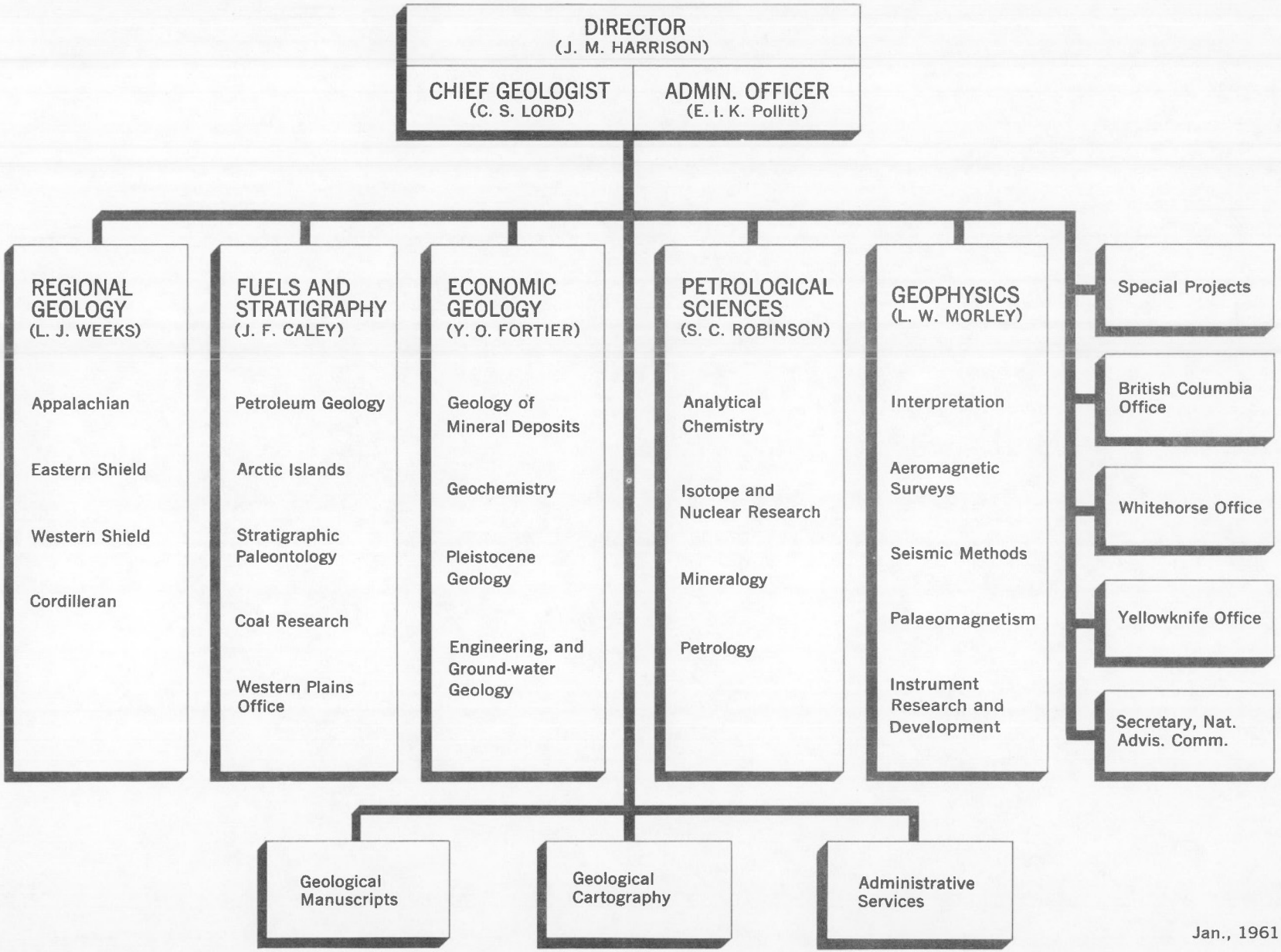
1 Sc. Off. 2
Ahrens, R.H.

APPENDIX IV

ABBREVIATIONS OF SOCIETY NAMES

A.A.P.G.:	American Association of Petroleum Geologists
A.E.C.L.:	Atomic Energy of Canada Limited
A.I.N.A.:	Arctic Institute of North America
A.G.U. :	American Geophysical Union
A.P.E. :	Association of Professional Engineers
A.S.P.G.:	Alberta Society of Petroleum Geologists
B.C.P.E.:	British Columbia Professional Engineers
B.S.A. :	Botanical Society of America
C.A.A.S.:	Canadian Association for Applied Spectroscopy
C.A.P. :	Canadian Association of Physicists
C.F.M.S.:	Canadian Field Naturalist Society
C.G.S. :	Canadian Geographical Society
C.S.E.G.:	Canadian Society of Exploration Geophysicists
C.I.C. :	Chemical Institute of Canada
C.I.M.M.:	Canadian Institute of Mining and Metallurgy
D.G.S. :	Danish Geological Society
E.C.A. :	Ecological Society of America
E.I.C. .:	Engineering Institute of Canada
E.S.C. :	Entomological Society of Canada
G.A.C. :	Geological Association of Canada
G.G.S. :	German Geological Society
G.S. :	Geochemical Society
G.S.A. :	Geological Society of America
G.S.F. :	Geological Society of France
G.S.L. :	Geological Society of London
G.S.S.A.:	Geological Society of South Africa
G.V.B. :	Geologische Vereinigung Bonn
I.M.M. :	Institute of Mining and Metallurgy
I.R.E. :	Institute of Radio Engineers
I.P.U. :	International Palaeontological Union
M.A.C. :	Mineralogical Association of Canada
M.B.G.S.:	Michigan Basin Geological Society
M.S.A. :	Mineralogical Society of America
M.S.C. :	Mineralogical Society of Canada
O.A.S. :	Ohio Academy of Science
P.A. :	Palaeontological Association
P.D.A. :	Prospectors and Developers Association
P.S. :	Palaeontological Society
Pg.S. :	Palaeontographical Society
P.S.G. :	Palaeontological Society of Germany
P.S.J. :	Palaeontological Society of Japan
P.I. :	Professional Institute
R.A.S.C.:	Royal Astronomical Society of Canada
R.C.G.S.:	Royal Canadian Geographical Society
R.S.C. :	Royal Society of Canada
S.E.G. :	Society of Economic Geologists
S.Ex.G. :	Society of Exploration Geophysicists
S.E.P.M.:	Society of Economic Palaeontologists and Mineralogists
S.E.S.A.:	Society of Experimental Stress Analysis
S.S.Z. :	Society of Systematic Zoology
S.Xi. :	Sigma Xi

GEOLOGICAL SURVEY OF CANADA



Jan., 1961