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CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

ANNUAL REPORT

CALENDAR YEAR 1965

FOR GEOLOGICAL SURVEY USE ONLY

OTTAWA

1966

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ANNUAL REPORT - CALENDAR YEAR 1965

Note - The enclosed data are those submitted for the 1965 Departmental Annual Report. They have been re-arranged somewhat for ready reference, but have not been carefully edited. They are intended only for Geological Survey office use and record.

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15 April, 1966

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ANNUAL REPORT - CALENDAR YEAR 1965

GEOLOGICAL SURVEY OF CANADA

INTRODUCTION

by

Y.O. Fortier, Director

The Geological Survey of Canada carries out systematic geological investigations in Canada and compiles and publishes such information in the form of reports, maps, and other graphic representations. The scope of its activities extends into many aspects of the geological sciences, including geochemistry, geophysics, geomorphology, mineralogy, palaeontology, petrology, surficial and bedrock geology, and petroleum geology. The Survey's objectives are fourfold: (1) to systematically investigate, describe, and explain the geology of Canada in order to determine the nation's potential mineral resources, and to provide data to industry and others to aid in the discovery, exploration, and development of these and other resources; (2) to carry on other research that will contribute to our knowledge of the origin of rocks and minerals, thereby expanding the potentials of the science and enabling geologists to investigate and explain the geology of Canada more effectively; (3) to develop new instruments and methods as aids to geological investigations and to the search for mineral deposits; and (4) to assist in the scientific training of young Canadians to meet the requirements of science and the nation's economy for qualified manpower.

The Geological Survey conducts a broad category of investigations of a regional nature in the Canadian Shield, in the Appalachian and Cordilleran geosynclinal belts, in the sedimentary basins of the mainland Arctic Archipelago, and in the unconsolidated Quaternary deposits. In addition, it undertakes activities directed towards the investigation of specific topics, interest in which often arises from the broader regional studies.

In 1965 the Geological Survey sent out 110 full-time field parties and 36 short-term field parties. Of the former, field investigations were made up as follows: bedrock geology, 38; surficial, engineering, and groundwater geology, 25; stratigraphy and palaeontology, 15;

mineral deposits, mineralogy, and petrology, 18; geophysics, 9; and geochemical, structural, or other geological studies, 5. Brief reports of these investigations were published in G.S.C. Paper 66-1 early in January, 1966.

Several helicopter-supported large-scale reconnaissance operations were carried out. Operation Amadjuak completed in one field season the initial study of southern Baffin Island, an area of about 50,000 square miles. Operation Grant Land completed half of a two-year investigation of some 30,000 square miles in northeastern Ellesmere Island. Operation Liard, a three-year investigation of about 30,000 square miles of the northern Rocky Mountains and neighbouring plains, was completed during the year, as was Operation Nahanni, a reconnaissance of about 12,500 square miles in Logan and Mackenzie Mountains of Yukon Territory and the adjoining District of Mackenzie. Operation Selwyn, a three-year reconnaissance covering a 26,000-square-mile area south and west of the area covered by Operation Nahanni, was commenced during the field season. Farther south, reconnaissance studies of some 20,000 square miles of the British Columbia coast mountains were completed, and half of Operation Bow-Athabasca, astride the British Columbia and Alberta provincial boundary, was completed. In eastern Canada, an operation covering about 14,000 square miles of southern Labrador was undertaken and completed. These are but a few of the many large-scale helicopter-supported operations undertaken by the Geological Survey in recent years, which collectively have speeded up the geological reconnaissance of Canada by decades, and assure the completion of initial-stage reconnaissance of the country within the next several years.

On a more detailed and topical scale, Geological Survey activities encompassed a broad spectrum of projects, ranging from the study of trace elements in certain base-metal deposits to petrological studies of ultramafic rocks in north-central British Columbia; from vertebrate palaeontology on Somerset Island in Canada's Arctic to geophysical surveys for water in Saskatchewan; from stratigraphic studies of Precambrian sediments in the District of Mackenzie to geomorphological studies in northern Alberta; from crater investigations in Quebec to studies of granitic rocks in British Columbia; from biochemical investigations in Ontario to dam-site investigations in the Yukon River area; from palaeomagnetic studies in western Quebec to the study of microfossils in Precambrian iron-formations; and from mineral localities for amateur collectors to studies of saltwater intrusion in Prince Edward Island. Many of these activities have been reported on briefly in G.S.C. Papers 66-1 and 65-2.

The successful operation of a modern geological organization requires the availability of a wide variety of electronic and other equipment and the skilled staff to operate and maintain such equipment,

to provide services for the field personnel and to carry out theoretical and applied research in the various geological disciplines. Laboratory studies ranged from the development of a continuously recording magnetometer, groundwater-pressure equipment, and radiocarbon-analysis equipment, to the interpretation of aeromagnetic data and the identification and interpretation of mineral and fossil collections.

To stimulate geological research at Canadian universities, the Survey awarded 74 grants amounting to $150,000 to 19 universities. Requests for grants totalled $264,263 (up $58,000 from 1964), and 18 applications could not be accommodated. Support was provided for 17 Ph.D. thesis projects, and staff members presented lectures and conducted guided tours for numerous university groups. A staff geologist returned to the Survey in September after completing a two-year assignment as Commonwealth Geological Liaison Officer in London, England.

The Survey regularly publishes the results of its scientific activities in the form of memoirs, bulletins, papers, and geological maps. During the year the following publications were made available to the public: two memoirs, two economic geology series reports, ten bulletins, 45 paper series reports, two miscellaneous series reports, 39 geological maps, and 707 aeromagnetic maps. Approximately 310,000 copies of maps and reports were distributed in response to 20,025 requests. Staff members presented more than 100 papers at meetings of national and international societies, many of which were or are being published in outside scientific journals. One of the Survey's economic geologists received the Leonard Medal from the Engineering Institute of Canada during the year for the best paper published by the Canadian Institute of Mining and Metallurgy or the Engineering Institute of Canada on a mining subject.

In addition to its Ottawa headquarters, the Geological Survey maintains offices in Calgary, Vancouver, Yellowknife, and Whitehorse, and has staff at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. The Branch has a continuing staff of 445 (of whom 200 are scientists), and provided summer employment and training for 128 graduate and 186 undergraduate university students.

A contract for the construction of a new two-million dollar Geological Survey building in Calgary was let during the year, and construction began in November. The building is expected to be ready for occupancy in November 1966.

DISTRIBUTION OF PARTIES BY AREA AND FUNCTION

Province or District	Bedrock Mapping	Surficial Mapping	Groundwater & Engineering	Geophysics	Geochemistry	Stratigraphy & Palaeontology	Structure	Mineral Deposits, Mineralogy, Petrology	Others	Totals
Franklin	2					4		1		7
Keewatin	1			2						3
Keewatin and Mackenzie	1									1
Mackenzie	5									5
Mackenzie, Yukon and B.C.	1	1	1					1		4
Yukon	1	1								2
British Columbia	11	2	1		1	1		5		21
B.C. and Alberta	1				1	4				6
Alberta		2				3				5
Alberta and Sask.			1			1				2
Saskatchewan			2	1						3
Sask. and Manitoba		1		1						2
Manitoba	2	1	2			1				6
Ontario	4	3		2						9
Ontario and Quebec	1			1				3		5
Quebec	1	2					1			4
Newfoundland (Labrador)	1							1		2
New Brunswick					1			1		2
Nova Scotia	2									2
Newfoundland (Island)	3			1				1		5
General	1	3	2	1		1		5	1	14
Totals	38	16	9	9	3	15	1	18	1	110

REGIONAL GEOLOGY DIVISION

R. J. W. Douglas, Chief

S. Duffell, Acting Chief

INTRODUCTION

The division is responsible for geological investigations of the orogenically disturbed regions of Canada, viz. the Cordilleran and Appalachian Regions and Precambrian Shield. These investigations are directed primarily to studies of the processes and effects of metamorphism, plutonism, volcanism, deformation, sedimentation and ore deposition and contribute to the assessment of the mineral potential of the various regions and the exploration for minerals therein by industry.

In 1965 to carry out these responsibilities there were in the Division 41 staff geologists, to which was added during the field season a complement of 3 university professors, 1 Post Doctorate Fellow, and 8 graduate students engaged in Ph. D. thesis projects. A total of 41 geologists were engaged in field research on 40 projects distributed as follows: 14 Cordilleran Section, 9 Western Shield Section, 11 Eastern Shield Section, and 5 Appalachian Section. During the winter months the officers concentrated on the office and laboratory phases of their projects. Many officers of the Division actively participated in the programs of various technical and scientific organizations by presentation of papers and service on committees.

In addition to the reports on the past seasons field work contained in G. S. C. Paper 66-1, many of which are in effect preliminary reports, there was submitted for publication a total of 40 manuscripts of all types. These were divided as follows: 2 Memoirs; 2 Bulletins; 4 Papers; 20 maps and 12 papers for outside publication. Actual publications by members of the division during the year were 34, represented as follows: 1 Memoir, 8 Papers, 12 Maps; and 13 Papers by other organizations.

Much time and effort was expended by the Chief of Division and Section Heads in the reclassification of personnel of the Division to the new Research Scientist class, the whole operation taking approximately a month.

For a period of approximately 3 months between July and October, Dr. G. M. Wright carried on the duties of Chief Geologist in the absence of Dr. C. S. Lord.

In December Dr. R. J. W. Douglas was transferred to Special Projects to edit the 5th edition of Geology and Economic Minerals of Canada and S. Duffell was appointed Acting Division Chief.

Committees - R.J.W. Douglas

Member, N.A.C. Subcommittee, on Structural Geology

Member, Geology Advisory Committee, Alberta Research Council

Member, Publications Committee, Geological Society of America, 1965-1967

REPORTS ON SECTIONS

CORDILLERAN SECTION

H.W. Little

Geological investigations of the Canadian Cordillera in British Columbia and Yukon Territory are the responsibility of the Cordilleran Section. These activities commonly supplement or are supplemented by similar or related investigations by geologists of other divisions of the Geological Survey of Canada and the British Columbia Department of Mines. Current activities are directed mainly toward the study and integration of data and conclusions on the stratigraphy, structure, volcanism, plutonism, metamorphism, and mineral deposits of the region.

The separation of the section into two parts based in Vancouver and Ottawa hinders the easy exchange of data and ideas enjoyed by most other sections.

Field investigations were undertaken by all members of the section, although field activities of two were limited to two months. Operation Nahanni, District of Mackenzie, was completed, as was the north part of Operation Coast Mountains, B.C., and investigations were completed on 8 one-degree quadrangles in central and southern British Columbia. Operation Selwyn, a 3-year project embracing 5 one-by-two degree quadrangles in Yukon, Mackenzie, and northern British Columbia, was begun. Investigations on a similar scale were continued on Vancouver Island, and begun in Lardeau area. The more detailed study of Greenwood area was completed. A volcanological study of Tertiary and later volcanoes was begun.

Detailed structural studies in southern B.C., directly or or indirectly connected with the Southern Cordillera Structure Project of N.A.C., were initiated or continued by 3 graduate students and a university professor, and another professor completed similar investigations. Detailed structural studies undertaken by another Ph.D. candidate in northern Yukon were completed.

During the year officers of the Cordilleran Section had published 4 preliminary maps, 1 final map, 1 memoir and 2 papers by the G.S.C., and 3 papers by other organizations. They also submitted for publication 1 paper, 3 preliminary maps, and 1 final map. In addition 5 papers were submitted for outside publication.

Activities

A.J. Baer: concluded studies of the stratigraphic, plutonic, metamorphic, and structural development of the Bella Coola area and with W.W. Hutchison completed Operation Coast Mountains, north part, under supervision of J.A. Roddick. Dr. Baer submitted for publication a preliminary map of Bella Coola area.

S.L. Blusson: with H. Gabrielse completed the reconnaissance mapping of Wrigley Lake (95M) and Glacier Lake (95L), N.W.T., thus completing Operation Nahanni. He commenced the investigation of Sekwi Mountain (105P), Frances Lake (105H), and part of Nahanni (105I), Y.T. and N.W.T. in the initial phase of Operation Selwyn. Stratigraphy and structure of Proterozoic and Palaeozoic miogeosynclinal rocks, and intrusive rocks with attendant metamorphism were studied. Dr. Blusson also assisted Dr. Gabrielse in the initial reconnaissance of Jennings River area (104 O), B.C. He prepared a preliminary map of Frances Lake area, Y.T.

R.B. Campbell: completed the study of Canoe River (83D), B.C. west of Rocky Mountain Trench in cooperation with R.A. Price and E.W. Mountjoy of the Fuels and Stratigraphy Division, who mapped the part east of the Trench. The primary problem investigated was the relationship of Shuswap rocks to Proterozoic and Palaeozoic strata. With H.W. Tipper he completed Bonaparte River east half (92 P E 1/2), B.C., which involved the stratigraphy and structure of Palaeozoic to Tertiary rocks of sedimentary and volcanic origin and intrusive rocks of Cretaceous and Tertiary age. Dr. Campbell completed for publication a paper on the tectonics of south-central B.C., and prepared reports on Canoe River and Bonaparte River areas for publication in G.S.C. Papers 65-2 and 66-1.

H. Gabrielse: completed the two remaining areas of Operation Nahanni, Wrigley Lake (95M), and Glacier Lake (95L), and commenced Operation Selwyn, which includes Jennings River (104 O), B.C., and Watson Lake (105A), Nahanni (105I), Frances Lake (105H) and Sekwi Mountain (105P),

Y.T. and N.W.T., with S.L. Blusson. In the Jennings River and Watson Lake areas, investigations revealed a sedimentary succession ranging in age from Proterozoic to Mississippian with volcanic members in the upper part. Granitic plutons and smaller bodies intrude these rocks. Dr. Gabrielse submitted a paper on "Tectonic Evolution of the Northern Canadian Cordillera" for publication by the Royal Society of Canada. With J.A. Roddick and S.L. Blusson he published "Flat River, Glacier Lake and Wrigley Lake, District of Mackenzie and Yukon Territory"; Geol. Surv. Can., Paper 64-52.

W.W. Hutchison: continued investigations into the stratigraphic, plutonic, metamorphic, and structural history of the Prince Rupert-Skeena area and with A.J. Baer completed Operation Coast Mountains, north part, under the supervision of J.A. Roddick. (see Roddick). Dr. Hutchison prepared a map of Prince Rupert-Skeena area and parts of the northern Coast Mountains, which was published as G.S.C. Map 3-1965.

G.B. Leech: completed the reconnaissance examination of Kananaskis Lakes, west half (82J W 1/2), B.C. and Alta. The study was directed mainly towards an understanding of the structure in the vicinity of Rocky Mountain Trench. Large bodies of magnesite were discovered during the course of the work in the Middle Cambrian Cathedral Formation. Dr. Leech prepared maps and reports on this and other projects. He published in the Canadian Journal of Earth Sciences, Vol. 2, No. 4 a short paper entitled Discussion of The Rocky Mountain Trench - A Problem.

H.W. Little: in addition to duties as section head, completed the mapping of Greenwood area (82 E/2), B.C. The season was devoted mainly to a study of faulting for the most part revealed by unravelling the succession of lavas of Early Tertiary age. Preparation of a section on mineral deposits exclusive of fuels, of the Cordillera and Plains for the revision of Geology and Economic Minerals of Canada took up most of the remaining time. He published a final map "Salmo, British Columbia", Geol. Surv. Can., Map 1145A.

J.E. Muller: continued the investigation of the geology of Vancouver Island and Gulf Islands (parts of 92F, 92G, and 92K), B.C. Knowledge of the stratigraphy, structure, petrography, and metamorphism of sedimentary and igneous rocks ranging in age from Permian to Upper Cretaceous was considerably advanced in this area. A preliminary map of Comox Lake area was submitted and was published as G.S.C. Map 2-1965.

J.G. Souther: began a program of volcanological study in the Cordillera. Initial work was on certain coastal islands where post-Pleistocene volcanoes were examined and the remainder of the season was devoted

to investigation of the Mount Edziza volcanic complex in part of Telegraph Creek area (104G), B.C. Dr. Souther submitted a map and manuscript on Tulsequah area, and prepared a paper on "Acid Volcanism and its Relationship to the Tectonic History of British Columbia".

J.A. Roddick: was coordinator of the Coast Mountains project, which he carried out with W.W. Hutchison and A.J. Baer. The north part (between 52° and 55° N latitude) was completed. The area includes the central part of what has long been termed the "Coast Range batholith". Within this region are roughly 20-25% gneisses, 15% metasedimentary rocks, and the balance almost entirely granitic rocks. The relationships between the granitic rocks and gneisses vary from place to place, but the gneisses are regarded as the oldest rocks in the region.

He prepared a preliminary map and report on northern Coast Mountains, and a paper on the tectonics of the region to be published in a symposium volume by the C.I.M.M. His memoir entitled Vancouver North, Coquitlam, and Pitt Lake Map-area, British Columbia, with Special Emphasis on the Evolution of the Plutonic Rocks was published in December as G.S.C. Memoir 335.

H.W. Tipper: completed the investigation of Bonaparte River (92P), B.C., the eastern half jointly with R.B. Campbell. He also investigated certain problems in Quesnel (93B) and Prince George (93G) areas. In Bonaparte River the tectonic history of the Late Palaeozoic rocks in particular was under study. Dr. Tipper submitted for publication the manuscript for a joint paper with J.A. Jeletzky on the Upper Jurassic and Cretaceous stratigraphy of southwestern B.C.

J.O. Wheeler: began the study of Lardeau west half (82K W 1/2) B.C., which comprised the investigation of the stratigraphy and structure of Late Proterozoic to Early Mesozoic strata, and the petrology and mode of emplacement of Mesozoic and (?) later intrusions. Dr. Wheeler submitted for publication a paper on "Eastern Tectonic Belt of Western Canadian Cordillera". He also continued as coordinator of the Southern Cordillera Structure Project of the National Advisory Committee for Research in the Geological Sciences. He published in the Canadian Geophysical Bulletin, Vol. 17, a short paper entitled "Selkirk and Monoshee Mountains Recent Glacier Fluctuations" and in addition Geol. Surv. Can., Paper 64-32 entitled "Big Bend Map-area, British Columbia".

W.K. Fyson: a professor at the University of Ottawa, carried out structural studies in the Mount Ida, Cache Creek, and Monashee Groups near Shuswap Lake, B.C. to determine the relationships of first and second phase folds within each group, and to the folds of the other groups.

J.V. Ross: a professor at the University of British Columbia, completed his detailed investigation of the easternmost part of the Shuswap metamorphic complex near Revelstoke, B.C., and established that these rocks are more highly metamorphosed equivalents of adjacent Milford and Lardeau Groups.

W.J. McMillan: a graduate student at the University of British Columbia, commenced the examination in detail of the structure of the Shuswap rocks in the vicinity of Ratchford Creek, north of Revelstoke to determine the succession of folding.

V.A. Preto: a Ph.D. candidate at McGill University, began the study of deformation of the Grand Forks Group in Grand Forks area, west half (82E/1 W 1/2) B.C. Despite a late start due to an injury, he has uncovered indications of large scale folding about axes plunging west-northwesterly.

D. Tempelman-Kluit: a Ph.D. candidate at McGill University, completed an investigation of the structure and stratigraphy of Palaeozoic and Mesozoic rocks of Tombstone area (116B/7), Y.T., and part of the adjacent area to the east. He has worked out the structure and established Permian, Middle Jurassic, and Early Cretaceous ages for some units.

J.A. Coates: a Ph.D. candidate at the University of British Columbia, continued the study of the structure and stratigraphy of the Dewdney Creek and Pasayten Groups in Manning Park, B.C. Complex fold and fault patterns have been worked out and numerous fossil collections, when identified and dated, will add much to the knowledge of the stratigraphy.

Personnel Notes

A.J. Baer: was transferred to the Western Shield Section in Ottawa in November.

S.L. Blusson: joined the Cordilleran Section in the spring. He visited the Vancouver office in May for consultations.

R.B. Campbell: during the field season visited W.K. Fyson at Shuswap Lake, was visited by G.B. Leech, and worked with R.A. Price, E.W. Mountjoy and J.O. Wheeler for one week from a common base.

H. Gabrielse: addressed the Royal Society of Canada in Vancouver in June and the Logan Club, Ottawa on "Tectonic Evolution of the Northern Canadian Cordillera". He also attended the Annual Meeting of the Geological Society of America in Kansas City, Mo. in November.

W.W. Hutchison: attended the Geological Society of America meeting in Kansas City.

G.B. Leech: participated in the International Upper Mantle Committee's symposium on World Rift Systems, in Ottawa in September and presented a paper on the Rocky Mountain Trench.

H.W. Little: was visited in the field by R.C. Pearson of the U.S. Geological Survey. He supervised V.A. Preto's work in Grand Forks area. In February he visited Ottawa for consultations, and in June attended the Royal Society Meeting in Vancouver.

J.E. Muller: visited marine laboratories in Nanaimo and Victoria and marine exploration vessels of an oil company operating on the Pacific continental shelf.

J.G. Souther: joined the Coast Mountains project for one week to investigate post-glacial volcanoes on certain islands. He was visited in the field by Professor Kuno of Japan. In November he attended the International Symposium on Volcanology in New Zealand, where he presented a paper on "Acid Volcanism and its Relationship to the Tectonic History of British Columbia".

J.A. Roddick: visited Ottawa in April for a week of consultations.

J.O. Wheeler: visited Ottawa in February for consultations and participated in the Upper Mantle Workshop. He attended the Royal Society Meeting in Vancouver and presented a paper on "Tectonic Evolution of Southern Canadian Cordillera".

Membership on Committees

H. Gabrielse - Member, G.S.C. Exhibits Committee

Member, G.S.C. Age Determinations Committee

Member, G.S.C. Committee on Stratigraphic Nomenclature

Commissioner to American Committee of Stratigraphic Nomenclature

G.B. Leech - Member, Committee on Geological Survey of Canada History

Member, Standing Committee on Geology and Geophysics, Pacific Science Association

Member, ad hoc Director's Committee on working relationships between G.S.C. and National Museum

H.W. Tipper - Member, G.S.C. Equipment Committee

J.O. Wheeler - Member, N.A.C. Subcommittee on Structural Geology

Member, Canadian Scientific Committee for Upper Mantle Project

WESTERN SHIELD SECTION

G.M. Wright

The Western Shield section is responsible for geological investigations in those parts of the Canadian Shield lying west and north of the Ontario-Manitoba border. Of the 9 field projects carried out in 1965, 5 were in District of Mackenzie, 2 in District of Keewatin, and 2 in Manitoba; this continues the trend in recent years of heavy commitment of personnel to projects in the Northwest Territories.

The use of helicopters in the Western Shield, heavy for some years, continues, but with a different approach. Instead of being concentrated under one party in regional studies as during the reconnaissance stage of the last dozen years, helicopters are now used as geological "taxi-cabs", proceeding from one party to another over distances of hundreds of miles according to geological needs and operational factors such as break-up. This application of helciopters is made possible by their greatly increased efficiency and reliability. In this manner one helicopter (under contract to Arctic Islands Section) assisted Reinhardt, Hoffman, Fraser, Tremblay, and Bostock in the Yellowknife region while en route to Ellesmere Island, and another was used by Davison, Eade, Donaldson, and Bell in Manitoba and District of Keewatin.

The essential completion of reconnaissance studies in the Western Shield by 1964 has resulted, as anticipated, in the assignment of

most available staff to areas and problems of significance to geological theory and/or of importance in mineral exploration in northern Canada. The field projects of individual officers, outlined below, clearly show this trend. Nor are these studies unrelated; two major, coordinated studies are now underway. The first of these is in the Tazin Arc, with P.F. Hoffman, E.W. Reinhardt, and J.C. McGlynn, commencing separate but mutually related projects. The second involved K.E. Eade and W.L. Davison in projects that are parts of a proposed multi-disciplinary study in the Ennadai orogenic belt, designed to provide a thorough understanding of the geology and evolution of this major, economically interesting, sedimentary-volcanic-gneissic complex. Other officers and their projects included L.P. Tremblay and H.H. Bostock, who completed and continued respectively investigations in the Contwoyto Lake area; J.A. Fraser, who continued his stratigraphic and structural studies of the Epworth Group at Rocknest Lake; J.A. Donaldson, who carried on his investigations of the stratigraphy and sedimentology of the Dubawnt Group; and C.K. Bell, who spent one month with a helicopter on key aspects of the Churchill-Superior boundary zone in central Manitoba.

Summaries of the results of 1965 field work, in some cases expanded and substituting for reports in the Paper Series, are contained in Geol. Surv. Can., Paper 66-1.

In general, these projects involved each of the geologists concerned in several weeks of pre-season scientific studies and operational planning, and in several weeks preparing preliminary reports for early publication of results. The remainder of the year was occupied by research leading to final publications and maps on current and previous assignments, and by other duties such as service on committees, preparing papers for oral presentation at conventions and meetings, and consultations with other scientists in government and industry.

During 1965, officers of the Western Shield section published or submitted for publication 1 bulletin and 7 papers by the Geological Survey and 5 papers in outside journals.

Activities

A.J. Baer: was transferred in November from Cordilleran section in Vancouver to Western Shield section in Ottawa. An account of his activities during 1965 is given under Cordilleran section.

C.K. Bell: spent most of the year in Ottawa, mainly on preparation of his report on Wekusko map-area (63 J), which is one of four 4-mile areas involved in the Upper Nelson River project. Late in the summer

he spent one month with a helicopter and light fixed-wing aircraft in his project area, examining critical areas and correlating geological and aeromagnetic data. He also checked the extension of the Churchill-Superior boundary to the east. In certain phases he worked closely with officers of I.N.C.O. and the Manitoba Mines Branch. In October, Dr. Bell participated in a two-day field trip, examining three levels of the crust in the Red Lake District of Ontario.

Dr. Bell submitted a manuscript on the Configuration of the Churchill-Superior boundary in Manitoba for publication in the C.I.M.M. Bulletin.

H.H. Bostock: continued his work in the Point Lake-Contwoyto Lake area (76 E/W and 86 H/E), where interesting gold deposits are known in amphibolites of the Yellowknife Group.

Dr. Bostock continues to take an active interest in cryptoexplosion structures. In the spring, while on leave in Germany, he spent ten days examining and sampling the Ries Kessel structure, and in November he made an eight-day trip with K.L. Currie examining eight cryptoexplosion structures in the central United States. Topical reports were submitted on both these trips. During the year, Dr. Bostock published a paper (G.S.C. Paper 64-45) and submitted a bulletin on the Clearwater Complex of New Quebec.

W.L. Davison: spent the 1965 field season on final correlation and synthesis of the geology of northeastern Manitoba (64 NE), before writing a memoir on the problems of metasediments, gneisses, and granulites of the area. Assisted by W.W. Heywood, Mr. Davison used a helicopter (ex Donaldson) for three weeks to gain access to otherwise inaccessible parts of the area. The results of his work should be of assistance in Eade's study of Hurwitz sediments and their granitization in southern District of Keewatin. Mr. Davison submitted in 1965 a map and paper on the Caribou River area (54 M) in northeastern Manitoba.

J.A. Donaldson: carried his study of the sedimentation and stratigraphy of the Dubawnt Group into the Schultz Lake region of the central barren grounds, with helicopter traverses extending much farther west. In addition to major subdivision of the Dubawnt Group, Dr. Donaldson has turned up evidence of a widespread regolith beneath the main sandstone formation, the possibility of Phanerozoic clastic rocks north of Aberdeen Lake, and the presence of block faulting as a pronounced structural feature.

During the helicopter phase of his work Dr. Donaldson carried out an experiment in 4-mile mapping (66 A) with the hope of producing high-quality results in a fraction of the time taken by normal methods. The experiment was an unqualified success, and it is hoped

that the completion of the Dubawnt project will provide, almost as a bonus, a strip of high quality 4-mile maps from Baker Lake westward through the Dubawnt plain.

Dr. Donaldson with G.D. Jackson submitted for publication in the Canadian Journal of Earth Sciences a paper on the Archaean Sedimentary Rocks of North Spirit Lake Area.

K.E. Eade: spent two weeks in the Kognak River area (65 G/E, H/W) of southern District of Keewatin in the final stages of his study of the stratigraphy and structure of the Hurwitz Group. The results of this research will be used as standards for further studies throughout the Ennadai orogenic belt. In 1965 he published G.S.C. Paper 65-8 on the Kognak River, West Half. Dr. Eade continued his investigations, with W.F. Fahrig and J.A. Maxwell, on the relative abundances of the constituent elements of the Canadian Shield.

Dr. Eade has been selected as the G.S.C.'s exchange officer with our Australian equivalent, and preliminary indications are that his year in Australia should be a rewarding experience in Precambrian geology. The exchange was arranged in the belief that it would be advantageous for both governments to have an experienced geologist in its employ spend a year with the other to learn their procedures and to give advice on those followed in his own country.

J.A. Fraser: essentially completed his studies of the stratigraphy and structure of the Epworth Group in the Rocknest Lake area, District of Mackenzie, some 300 miles north of Yellowknife. The possible correlation of the Epworth and Goulburn Groups was one of the interesting problems pursued. The presence of abundant and varied stromatolites in the Epworth dolomitic rocks presents a good opportunity for an investigation of their usefulness in stratigraphic correlation within a restricted basin; if they prove to be useful here, the next step will be to attempt to use them for regional correlation. It is hoped that further work on these stromatolites will be undertaken in 1966. During 1965, Dr. Fraser presented data for a final map on the Kasmere Lake area of Manitoba, and continued work on his memoir from Operation Coppermine.

W.W. Heywood: spent most of the year in Ottawa preparing a map and report on Operation Wager, which he submitted in November. He also submitted a short paper on the results of Operation Wager to the Polar Record. For four weeks Dr. Heywood assisted W.L. Davison on the helicopter phase of his studies in northeastern Manitoba.

P.F. Hoffman: a Ph.D. student at Johns Hopkins, was attached to J.C. McGlynn's field party in the Nonacho Lake area. Before break-up, he carried out a five-day helicopter reconnaissance and assessment of his thesis project - the stratigraphy and sedimentology of the Proterozoic rocks in the East Arm of Great Slave Lake.

J.C. McGlynn: in the area south of the East Arm of Great Slave Lake, commenced an investigation of the stratigraphy of the Nonacho sediments and their relationships to granitic rocks and Tazin gneisses. This study is part of a larger project, involving also P.F. Hoffman and E.W. Reinhardt, designed to elucidate the tectonic history of the large area between the East Arm and Lake Athabasca. Dr. McGlynn is supervising the Ph.D. projects of P.F. Hoffman, and also that of Peter Smith on the Basler Lake granites.

Dr. McGlynn devoted much of his time in 1965 to preparing the section on Precambrian geology for the new edition of Geology and Economic Minerals of Canada. Together with J.V. Ross he published a paper in the Canadian Journal of Earth Sciences on Snare-Yellowknife Relations, District of Mackenzie, N.W.T., Canada.

E.W. Reinhardt: commenced an investigation of the nature and origin of the gneissic and mylonitic rocks in the area between the MacDonald Fault and the Nonacho basin, south of the East Arm of Great Slave Lake. The project also includes studies of the pattern and movement of the major faults of the area. In the pre-break-up stage Dr. Reinhardt shared a helicopter for one week with P.F. Hoffman. While in the Yellowknife area, he collected specimens of cordierite-bearing gneisses for comparison with those of the Gananoque area, Ontario, which had been the subject of his Ph.D. dissertation.

Dr. Reinhardt presented a paper to the Canadian Journal of Earth Sciences on Phase Relations in Cordierite-bearing Gneisses.

L.P. Tremblay: completed his detailed studies of the Contwoyto Lake area (76 D/14), with special attention in 1965 to the stratigraphy of the Goulburn Group and the impressive display of diabase dykes and sills in the area. He detached a two-man team for ten days study in the Beechey Lake area to the east. Dr. Tremblay completed his memoir on the Beaverlodge area, and the final map of the Beechey Lake area, and continued his research on the source rock for uranium at Beaverlodge. He also submitted for publication a G.S.C. paper and map on the first stage of his work on the Contwoyto Lake area.

G.M. Wright: as head of the Western Shield section, prepared the 1965 and 1966 field programs for the section and requests for air photography and base maps, advised and consulted with field officers on progress in current scientific projects, critically read manuscripts submitted on the geology of the Western Shield, and acted as scientific adviser to the Division Chief on matters pertaining to that region. Preparation of dossiers in anticipation of the introduction of the Research Scientist classification occupied much of February and March.

Some weeks were spent on discussions and preparation of a detailed proposal for a 7-10 year, two-phase, multi-disciplinary investigation of the Ennadai orogenic belt.

In July, Dr. Wright carried out a three-week inspection of parties operating out of Yellowknife and lead by J.C. McGlynn, E.W. Reinhardt, J.A. Fraser, and L.P. Tremblay. All were involved in most interesting studies of key problems and areas. Dr. H.H. Bostock had been injured and spent a few days recuperating in Yellowknife, where the geological problems of his area were discussed. In Edmonton, talks were held with Dr. E.E.N. Smith of Eldorado Mining and Refining on the geology between Great Slave Lake and Lake Athabasca. Problems of aircraft and their availability were discussed with officers of Wardair and Associated Helicopters, particularly that of positioning helicopters at Yellowknife for casual hire.

On his return to Ottawa, Dr. Wright was directed to carry out the functions of Chief Geologist for three months while Dr. Lord was on sick leave. The major task in this period was the preparation, in its new format, of the Preliminary Field Program for 1966.

Personnel Notes

A.J. Baer: in December gave an illustrated talk to the Logan Club on the accomplishments of the Coast Range Project over the last four years.

H.H. Bostock: attended the G.S.A. meetings at Kansas City in November, and presented a paper on the Clearwater Complex.

C.K. Bell: attended the combined C.I.M.M. (Western)-G.A.C. meetings in Winnipeg in October, where he presented a paper on the Churchill-Superior boundary zone. He also attended the C.I.M.M. annual meeting in Toronto. He spoke to the Upper Mantle Workshop on the geology of central Manitoba and to the Weston Club on Selenology.

J.A. Donaldson: attended the meetings of the Society of Economic Palaeontologists and Mineralogists at New Orleans in April. He acted for most of 1965 as Secretary of the Logan Club.

W.W. Heywood: attended the combined C.I.M.M. (Western)-G.A.C. meetings in Winnipeg in October and presented a paper on Operation Wager. While there, he participated in a two-day field trip to the Red Lake area in Ontario.

J.C. McGlynn: attended the meetings of the G.S.A. in Kansas City in November.

E.W. Reinhardt: completed his thesis while a winter T.O. in Ottawa. He was granted his Ph.D. from Queen's in May, and joined the Western Shield section.

L.P. Tremblay: attended the meetings of l'Association Canadienne Francaise pour l'Avancement des Sciences and gave a talk on Roches Cataclastiques de la Region de Beaverlodge, Sask. In November he went to Edmonton for the Ph.D. orals of Roy Watanabe, whose dissertation dealt with the cataclastic rocks of northeastern Alberta.

G.M. Wright: attended a three-day field trip in the Sudbury area in May, and the combined C.I.M.M. (Western)-G.A.C. meetings in Winnipeg in October. He also attended a two-day course in Ottawa on the principles and applications of computers.

Membership on Committees

J.A. Donaldson - Secretary, Logan Club

J.C. McGlynn - Member, G.S.C. Committee on Absolute Age Member, American Committee on Stratigraphic Nomenclature

Member, G.S.C. Committee on Stratigraphic Nomenclature

L.P. Tremblay - Member, Staff Relations Committee, Professional Institute of the Public Service

EASTERN SHIELD SECTION

S. Duffell

Officers of the Eastern Shield section engaged in field, office, and laboratory investigations pertaining to the geology of that part of the Canadian Precambrian Shield lying east of the Manitoba-Ontario boundary and including Baffin Island. Field research and investigation were carried out on 11 projects, which varied from detailed investigation of pertinent and complicated geological problems to large scale air-supported reconnaissance surveys of previously unknown terrain. Personnel of the section submitted 1 memoir and 1 bulletin for publication by the Survey and 5 papers for publication in outside journals. Short reports on the results of field operations will be found in the "Report of Activities, May to October, 1965", G.S.C. Paper 66-1. Many of these short reports took the place of preliminary publications of previous years and this change is reflected in the reduced number of manuscripts submitted during the year.

Field investigations included reconnaissance in Western Ontario, Newfoundland, Labrador, and Southwestern Baffin Island;

detailed investigations of the Grenville front in the Panache Lake area of Ontario; the aeromagnetic anomaly indicated by recent magnetic maps of the Moose River area 42 I; structural studies in the Hastings Basin near Coe Hill, Ontario, as well as a continuation of the study of the Morin Anorthosite in Quebec.

In Ottawa, laboratory investigations of the average chemical composition of large cratonic areas of the shield were continued as well as investigations into the composition of specific volcanic piles. Much use was made of the chemical analytical facilities of the survey in providing data on regional and local geological problems. Similarly the isotopic age-dating laboratories supplied many dates, which were helpful in providing data on regional problems.

Activities

W.R.A. Baragar: submitted a paper for publication in the Canadian Journal of Earth Sciences on the 'Geochemistry of the Yellowknife Volcanic Rocks' and with A.M. Goodwin and J.G. Souther co-authored a paper for publication in the annual number of the Northern Miner on the association of Mineral Deposits and Volcanic Rocks. He gave a paper on the Yellowknife Volcanic Belt before the Upper Mantle Workshop held in Ottawa in September. In August 22-28 he attended the Oregon Lunar Geological Field Conference.

In the field he investigated the stratigraphy of the volcanic pile near Noranda and made a detailed cross-section of the volcanic rocks.

R.G. Blackadar: was the officer responsible for Operation Amadjuak, a helicopter and light plane supported reconnaissance survey of Baffin Island south of latitude 66°N. He was assisted in the pre-field planning and organization as well as field investigation by F.C. Taylor; P.H. Smith and R.N. McNeely, two graduate students acted as assistants. W. Blake Jr. of the Pleistocene section was attached to the party to study the surficial deposits.

The survey indicates that Precambrian granitic gneisses predominate, but that sufficient metasediments are recognizable to suggest that much of the gneissic complex is of sedimentary origin. The Palaeozoic cover south and west of Lake Amadjuak was more accurately delineated and numerous fossil collections were made from these rocks. Despite numerous rusty gossans in the Precambrian gneisses no mineral occurrence of economic interest were noted.

In March G.S.C. Paper 64-42 'Geological Reconnaissance of Baffin Island' was published.

In December Dr. Blackadar was transferred to the Manuscripts and Cartography section of the Survey.

D.M. Carmichael: a graduate student at the University of California, Berkley, commenced a thesis study in the Hastings area to establish the nature of the stratigraphic sequence, metamorphism, and deformation of the Hastings Synclinorium.

S. Duffell: in addition to duties as Head of section, critically read 1 memoir, 1 bulletin, and 4 papers for publication in outside journals as well as numerous progress reports submitted for internal use and all section reports on field work for 66-1. With R.A. Roach he submitted for publication as a Survey Bulletin a manuscript on the Hypersthene Granulites of the Mount Wright Area, Quebec-Newfoundland and with G.M. Wright wrote an article on the work of the Survey in the Northern Canadian Shield since 1952, which was published in the annual number of the Northern Miner.

In March he attended the C.I.M.M. convention in Toronto and took the opportunity to consult with officers of the Ontario Department of Mines and Baffinland Iron Mines.

In May he attended a field trip on Sudbury geology, which was conducted by officers of the Sudbury office of the Ontario Department of Mines.

In July, for inspection purposes, he visited the Moose River project, which was the investigation of a large magnetic anomaly delineated in the aeromagnetic maps of the area. Also he visited M.J. Frarey in the Panache Lake area and in August visited the operations of Quebec Cartier Mining Company at Port Cartier, Gagnon, Mount Reed and Mount Wright. These visits proved to be most beneficial from the point of view of consultation with the officers in the field and liaison with geologists in industry.

In December he was appointed Acting Chief of Division for an indeterminate period while Dr. R.J.W. Douglas is preparing the manuscript for the 5th edition of Geology and Economic Minerals of Canada.

R.F. Emslie: continued his field and laboratory studies of the structure, petrology, and tectonic significance of anorthositic intrusions of the Eastern Canadian Shield. During the field season he completed his study of the Morin Anorthosite in Quebec. In September he received leave of absence from the Survey to lecture at Queen's University for the academic year during the absence of H.R. Wynne-Edwards.

His paper "The Michikamau Anorthositic Intrusion Labrador" was published in Vol. 2, No. 4 of the Canadian Journal of Earth Sciences.

W.F. Fahrig: continued field, office and laboratory investigations on the age, petrology, and tectonic importance of Diabase Dyke Swarms in the Canadian Shield. With K. Eade and J. Maxwell he continued study of the variations in the chemical composition of large cratonic segments of the Shield in New Quebec. With A. Larochelle and E. Gaucher he published a paper in Vol. 2, No. 4 of Canadian Journal of Earth Sciences on Palaeomagnetism of Diabase Dykes of the Canadian Shield. He acted as Chairman of the Precambrian section of the Upper Mantle Workshop in February 1965, is a member of the Age Determination and Palaeomagnetic committees of the Survey, and in November was appointed a member of the American Committee on Stratigraphic Nomenclature.

M.J. Frarey: continued his study of the stratigraphy and structure of the Huronian rocks and the nature and significance of the Grenville front in the Panache Lake area on Lake Huron. Associated with him in this work was Dr. R.T. Cannon, an N.R.C. Post Doctorate Fellow from McGill University. Dr. Cannon's special studies were concerned with the analyses of structures and rock fabrics along the Grenville front, particularly in the vicinity of Killarney.

Dr. Frarey attended the N.S.F. field trip on Lake Superior geology from June 15-30, which was held under the auspices of Michigan Technological University and which included visits to all the major mining districts surrounding Lake Superior.

A.M. Goodwin: joined the section in July, coming to the Survey from the Ontario Department of Mines. He has had many years of experience in the Canadian Shield with particular interest in volcanic rocks of the Superior Province and their contained mineral deposits. In August and September he made a short preliminary reconnaissance of the Timmins-Kirkland Lake belt prior to commencing a full scale study next year. He lectured to the Dawson Club of McGill University on Archaean Volcanism and presented a paper at the G.S.A. in Kansas City on Archaean Volcanism Patterns and Problems and acted as chairman of the "Symposium on Strata Bound Sulphides" at the C.I.M.M. meeting in Toronto in March.

His publications during the year, all on work done while with the Ontario Department of Mines were as follows:

1. Geology of Heenan, Marion and Genoa Townships, O.D.M. Geol. Rept. No. 38.

2. Volcanism and Gold Deposition in the Birch-Uche Lakes Area, Trans. C.I.M.M., vol. 68, pp. 94-104.

3. Mineralized Volcanic Complexes in the Porcupine-Kirkland Lake-Noranda Region, Canada; Econ. Geol., vol. 60, No. 5.

4. Preliminary Report Volcanism and Mineralization in the Lake of the Woods-Manitou Lake-Wabigoon Region of Northwestern Ontario; O.D.M. P.R. 1965-2.

G.D. Jackson: with J.A. Donaldson submitted a manuscript on the "Archaean Clastic Sedimentary Rocks of the North Spirit Lake Area, N.W. Ontario" to the Canadian Journal of Earth Sciences. Publication is expected soon.

In the field he carried out a study of the geology in the vicinity of the Baffinland Iron Mines for publication on a scale of 1 inch to 1 mile. Work was completed in N.T.S. blocks 37 G/5 and 37 G/6. Results of work are outlined in Paper 66-1.

R. Skinner: during the field season of 1965 completed investigations in the Sioux Lookout area of N.W. Ontario, making particular use of recently published aeromagnetic maps of the area. He also investigated the bedrock geology of the Moose River area (42 I) in order to determine the cause of the strong northeasterly trending magnetic anomaly delineated on recently published aeromagnetic maps of the region.

In the office he continued preparation of a memoir on the Tetagouche Lake, Bathurst and Nepisquit Falls map-areas of New Brunswick.

I.M. Stevenson: submitted for publication a memoir and final map on Operation Leaf River, the field work for which was completed in 1963.

He commenced reconnaissance geological investigation of a relatively unknown area of Labrador, Newfoundland N.T.S. blocks 23 A and 13 C, D, E and F, covering most of blocks 13 E and F in the season of 1965. In September he accepted an invitation to attend the official plant opening of the Maritime Cement Company at Brookfield, Nova Scotia on September 29. The economic potential of the limestone deposits in the Brookfield area was recognized by Stevenson during the course of field work in the Truro map-area in 1950, and subsequently reported in Memoir 297.

F.C. Taylor: was assigned to Operation Amadjuak for approximately six months of the year, during which time he conducted pre-field planning and preparations, study of maps and air photos and logistics organization. He submitted final maps of previous work in the Wholdia and Nonacho map-areas of the Northwest Territories, which are to be subsequently included in an 8-mile publication. With E. Schiller he published a paper in Vol. 50, No. 9 September 1965 issue of the American Mineralogist on "Spessartite-Quartz Rocks from Nova Scotia". He is a member of the Equipment Committee.

Personnel Notes

S. Duffell: Attended the C.I.M.M. Convention in Toronto in March.

R.F. Emslie: is on leave of absence from the Survey from September to May to act as a substitute professor at Queen's for H.R. Wynne-Edwards.

W.R.A. Baragar: attended the Oregon Lunar Geological Field Conference in August.

I.M. Stevenson: attended the official opening of the Maritime Cement Company at Brookfield, Nova Scotia in September.

G.D. Jackson: attended the C.I.M.M. Convention in Toronto in March.

M.J. Frarey: participated in the N.S.F. field trip on Lake Superior geology in June.

A.M. Goodwin: attended the G.S.A. convention at Kansas City in November and C.I.M.M. Convention in March at own expense.

R.G. Blackadar: transferred to Manuscripts and Cartography section in December.

Membership on Committees

F.C. Taylor	- Branch Equipment Committee
R.G. Blackadar	- President, Arctic Circle Club
W.F. Fahrig	- Age Determination Committee of G.S.C. Palaeomagnetic Committee - American Committee on Stratigraphic Nomenclature as of November, 1965
W.R.A. Baragar	- Executive Committee, Ottawa Branch, C.I.M.M. - Executive Committee, Geologist Group, Professional Institute
M.J. Frarey	- Advisory Committee, Department of Geology, University of Western Ontario
R.F. Emslie	- Stable Isotope Committee of G.S.C.
S. Duffell	- Executive Committee, Ottawa Branch C.I.M.M. until April, 1965
A.M. Goodwin	- Vice President and Chairman, Program and Publications Committee, Geological Association of Canada 1965-66. - Member National Advisory Council on Research in the Geological Sciences until July.

APPALACHIAN SECTION

W.H. Poole

The Appalachian Section undertakes geological studies and mapping of all geological materials within the folded and unfolded rocks of the Appalachian system in Canada, that is, in southern Quebec, New Brunswick, Prince Edward Island, Nova Scotia and Newfoundland (Island). The objectives of this research are the description, interpretation, and synthesis of the stratigraphy and sedimentology, structure, igneous and metamorphic petrology, tectonic history, and metallogeny of the region, and to relate all rocks and deposits of economic minerals to one another in space, time, and evolution.

In the Eastern Townships of Quebec and western and southern New Brunswick, short examinations were made of the lower Palaeozoic rocks and their complex stratigraphic and structural relationships; and samples of old granites in Eastern Townships and southern New Brunswick were collected for possible isotopic age determinations. In northern Nova Scotia, detailed studies of lower Palaeozoic strata were continued in Cobequid Mountains and completed in Antigonish Highlands. In Newfoundland, a structural study of Bay d'Espoir strata was completed. Investigation of the Ordovician and Silurian rocks of the Red Indian Lake and Burgeo areas, which contain the rich Buchans base metal mine, was begun. And study of the Great Northern Peninsula was started with the lower Palaeozoic strata and ultramafic rocks of the Hare Bay region. These latter two projects will complete 4-mile studies of all but a small area of Newfoundland on the Avalon Peninsula. Summary accounts of the investigations are carried in Geological Survey Paper 66-1.

Throughout the year, geologists of the section were consulted by earth scientists in government, universities, and mineral exploration companies and by students.

During 1965, geologists of the section published 8 short accounts and one edited symposium in Geological Survey papers and 2 papers in outside journals. Submitted for publication by the Geological Survey were 2 maps.

Activities

F.D. Anderson: completed a detailed structural study of the Ordovician slate and phyllite succession in southern Newfoundland. Superimposed structures and the thermal history associated with granitic intrusions were integrated with tectonic evolution of the area (mainly 1 M/13). With W.H. Poole, he examined the stratigraphy of

Woodstock area and adjacent Maine. With D.K. Norris he published a short account on deformation of strain-slip cleavage by bedding slippage in Paper 65-2. He submitted for publication a final map of Big Bald Mountain map-area (21 O/1), central New Brunswick, and with H. Williams a final map of Gander Lake (West Half) map-area (2 D W 1/2), central Newfoundland. He continued preparation of a memoir on the geology of Belleoram map-area (1 M), southern Newfoundland. He provided advice on the geology of mineral claims and of possible sources of rip-rap in southern Newfoundland.

D.G. Benson: completed investigations in the Merigomish area (11 E/9) as part of a continuing program of stratigraphic and structural study of the pre-Carboniferous rocks and granites in the Antigonish Highland, northern Nova Scotia. In a test of the value of SCUBA diving to stratigraphic studies, he examined sea bottom outcrops and collected Palaeozoic fossils of the offshore extension of Silurian Arisaig Group, aided by G. Bartlett of Bedford Institute of Oceanography. He began preparation of a preliminary map of Merigomish and Malignant Cove (11E/16) map-areas and of a memoir on the four contigous map-areas: Lochaber (11 E/8), Merigomish, Malignant Cove, and Cape George (11 F/13).

J.W. Gillis: began investigations in the Great Northern Peninsula (parts of 12 I, P; and of 2 L, M) Newfoundland for publication at a scale of one inch to four miles. The past season's work was concentrated on the allochthone of lower Palaeozoic strata and ultramafic suite in the Hare Bay area, and the nearby autochthonous lower Palaeozoic shelf-type carbonates, quartzites, and shales. As an aid to this work, he examined type sections of the Cow Head Group and Table Head Formation on the west coast of the Newfoundland accompanied by Professors H.B. Whittington and C.H. Kindle and by Dr. R.B. Neuman of U.S. Geological Survey. He is continuing preparation of a memoir on Port aux Basques area (11 O), southwest Newfoundland.

D.G. Kelley: continued investigation of the pre-Carboniferous strata and granitic rocks in the Cobequid Mountains, northern Nova Scotia. Particular attention was given to structures and to Silurian and Devonian strata, which include Devonian strata lying above the Lower Devonian Knoydart Formation. He spent a week in Cape Breton Island arranging for a Geological Association of Canada field trip in 1966, and participating in a tour of Mariner Mines property with four exploration geologists and the Nova Scotia Deputy Minister of Mines. He spent several days in the Cobequids and Joggins areas with M.J. Copeland on Silurian and Carboniferous stratigraphy.

He was consulted during the year by geologists engaged in or planning exploration in Nova Scotia. He critically examined a map proposed for publication by an outside agency. He commenced preparation of a summary of the Carboniferous in the Canadian Appalachians for the Fifth Edition of Geology and Economic Minerals of

Canada (R.J.W. Douglas, editor). He served as a member of a Branch Committee on Central Technical Files; as a Director of the Professional Institute, vice-chairman of a standing committee and member of another; and as chairman of a committee of Geological Association of Canada organizing field trips for 1966 meeting in Halifax. In December he published with W.O. Mackasey, G.S.C. Paper 64-34 "Basal Mississippian Volcanic Rocks in Cape Breton Island, Nova Scotia".

E.R.W. Neale: completed in August a two-year assignment as Commonwealth Geological Liaison Officer in London, England. Before returning to Ottawa, he made brief visits to the base metal deposit at Tynagh, Ireland, to the Cornish tin mines, to the Dalradian strata in northern Ireland, and to the Carboniferous strata in Scotland. His final report on the Bethoulat Lake area, Mistassini Territory, Quebec, was published by the Quebec Department of Natural Resources. He edited a symposium on guides to mineral exploration which was republished in the paper series of the Geological Survey. While in England he served as a member of the Royal Society's subcommittee on volcanism and of the Geological Society of London's steering committee for the volcanic studies group.

W.H. Poole: served as Acting Head of the section. He examined the lower Palaeozoic stratigraphy, structure, and tectonic relations in Eastern Townships and western and southern New Brunswick. He carried out a sampling program aimed at obtaining Rb-Sr isotopic age determinations of several granite bodies believed to have been emplaced early in the evolution of these regions. In October, he examined the geology of Woodstock area and adjacent Maine with F.D. Anderson. He prepared a bibliography of research projects carried out by the Survey from 1955 to the present (458 entries) for Atlantic Provinces Economic Council (APEC). He published a paper in Maritime sediments on activities of the section. He organized, contributed to, and chaired a 2-day workshop in Ottawa on the geology and geophysics of the Canadian Appalachian region. In September, he was a reporter for part of the 6-day International Upper Mantle meeting, and was selected as the editor of over forty papers to comprise the Symposium on Continental Margins and Island Arcs to be published by the Survey. He served as a member of a Departmental Committee on Recent Crustal Movements and Seismic Regionalization, and as a member of a sub-committee on structural geology of the National Advisory Committee on Research in Geological Sciences. He critically examined a memoir and a paper for publication by the Survey, and examined one paper and one map intended for publication by outside agencies. He is preparing a contribution on the stratigraphy and tectonics of the pre-Carboniferous rocks of the mainland part of the Canadian Appalachian region for the current revision of Economic Geology No. 1 - Geological and Economic Minerals of Canada - R.J.W. Douglas, editor.

H. Williams: began investigations of the Ordovician and Silurian strata in Red Indian Lake (East Half) map-area (12 A E 1/2) and Burgeo

(East Half) map-area (11 P), the last areas to be examined in central Newfoundland for publication scale of one inch to four miles. He briefly examined the geology of several areas in Newfoundland: Notre Dame Bay area with W.S. McKerrow and R.B. Neuman, White Bay area with W.R. Church, Fortune Bay area with F.D. Anderson, and Avalon Peninsula. During August, he accompanied Professors Marshall Kay and J.F. Dewey on an examination of the geology of Ireland to determine its similarities with Newfoundland. In two days of October, he briefly examined the geology of southern New Brunswick under the guidance of R.R. Potter of New Brunswick Mines Branch. With F.D. Anderson, he submitted for publication a final map of Gander Lake (West Half) map-area (2 D W 1/2), central Newfoundland. He continued preparation of a memoir on the geology of Botwood map-area (2 E), and began preparation of a contribution on the stratigraphy and tectonics of the pre-Carboniferous rocks of Newfoundland (Island) to the current revision of Economic Geology No. 1 - Geological and Economic Minerals of Canada - R.J.W. Douglas, editor.

Personnel Notes

W.H. Poole: continued as Acting Head of the Appalachian Section. He attended the Canadian Institute of Mining and Metallurgy meeting in Toronto and the New England Intercollegiate Geological Conference in southern Maine.

F.D. Anderson: attended the New England Intercollegiate Geological Conference in southern Maine.

D.G. Benson: attended the New England Intercollegiate Geological Geological Conference in southern Maine. He presented a talk to the New Glasgow Rotary Club on the historical geology of Pictou County.

J.W. Gillis: transferred to the Halifax office at the Bedford Institute of Oceanography during the spring of the year, where he joined D.G. Benson.

D.G. Kelley: attended the Nova Scotia Mining Society meeting at Ingonish, Nova Scotia.

E.R.W. Neale: returned to Ottawa in September having completed a two-year posting as Commonwealth Geological Liaison Officer in London, England. He returned to Ottawa via the Pacific, and en route, he visited the Geological Survey of India, the Geological Survey of Japan, and the Hawaiian Volcanological Observatory.

H. Williams: attended the Canadian Institute of Mining and Metallurgy meeting in Toronto and the New England Intercollegiate Geological Conference in southern Maine. He contributed a summary of the tectonics of Newfoundland to the Upper Mantle Workshop, Appalachian Session, in Ottawa.

Membership on Committees

W.H. Poole:
- Member, Departmental Committee on Recent Crustal Movements and Seismic Regionalization
- Member, Subcommittee on Structural Geology, National Advisory Committee on Research in Geological Sciences

J.W. Gillis
- Member, Founding Committee, A Northeastern Section, Geological Society of America
- Chairman, Appalachian Discussion Group, winter session 1964-65

D.G. Kelley
- Member, Branch Committee on Central Technical Files
- Chairman, Committee organizing field trips, Geological Association of Canada, Halifax 1966.
- Director, Professional Institute of Public Service of Canada
- Vice-chairman, Classification and Salaries Committee, Professional Institute
- Member, Legislation and By-Laws Committee, Professional Institute.

FUELS AND STRATIGRAPHY DIVISION

J.F. Caley, Chief

INTRODUCTION

The Division is concerned primarily with the geological investigation of the unmetamorphosed, stratified, and largely marine fossiliferous rocks - the Phanerozoic rocks - in which the oil, natural gas, and coal are most generally found.

The principal work of the Division, therefore, is to determine the succession, lithology, structure, age and correlation of

the sedimentary bedrock formations in Canada; to chart and otherwise illustrate the surface and subsurface distribution of these rocks in space and time; to carry on research in structural geology, stratigraphy, palaeontology, and to study the petrologic and organic constitution of coal seams.

To discharge its functions the Division has an interlocking scientific staff consisting of stratigraphers, structural geologists, palaeontologists, petrologists, sedimentologists, and subsurface geologists, and is subdivided into the following 5 sections, each with its own sphere of responsibility.

Petroleum Geology Section: - D.K. Norris, Head

The section is responsible for investigation of the stratigraphy, sedimentology, and structure of the relatively unaltered rocks, which may be source rocks or serve as reservoirs, for natural hydrocarbons and coal; for the delineation of areas of possible economic importance; and for basic research into the origin, migrations, and accumulation of fossil fuels.

Palaeontology Section: - D.J. McLaren, Head

The function of this section is to define and recognize in layered rocks the biochronological units of the geological time scale, and to furnish regional and intercontinental correlations; to conduct research into the taxonomy, morphology, evolution, ecology, and distribution in space and time of fossil plants and animals; to catalogue and curate the National Collections of invertebrate and plant fossils; and to advise Branch geologists on the application of palaeontology to the solution of geological problems.

Arctic Islands Section: - R. Thorsteinsson, Head

Responsible for the stratigraphic and structural investigations of the sedimentary rocks in the Canadian Arctic Archipelago; to interpret the results of this work for the purpose of delineating areas of possible economic potential for oil and gas; and to conduct basic research into the origin of sedimentary rocks and the mechanics of their deformation, to furnish data on the processes of migration and accumulation of natural hydrocarbons. The work is essentially similar to that of the Petroleum Geology Section, but the section faces special logistical problems peculiar to this region of Canada.

Western Plains Oil and Gas Office, Calgary: - *R.T.D. Wickenden, Head

This office is responsible for regional subsurface studies in the western provinces, the Northwest Territories, and Arctic Archipelago, as an aid to exploration for oil and gas; and for research in sedimentology, sedimentary petrology, and micropalaeontology to provide data for solution of problems of the migration and accumulation of natural hydrocarbons. In addition this office stores, maintains, preserves, and makes available for examination by Branch and Industry geologists, the cores and samples resulting from drilling on lands administered by other federal government departments; maintains stocks of Survey reports and maps for distribution by sale as a service to industry; and furnishes geological information and advice to other government agencies, such as Department of Northern Affairs and National Resources, the Indian Affairs Branch, Department of Citizenship and Immigration, and the National Energy Board.

Coal Research Section: - P.A. Hacquebard, Head

The responsibilities of this unit are to study the physical properties of Canadian coals by use of quantitative petrographic analyses in order to provide data on (a) technological behaviour of coal (b) correlation of coal seams, and (c) compositional and textural characteristics of coal seams on a regional and chronological basis; to undertake palynological studies to provide a better understanding of Carboniferous and Permian stratigraphy by (a) establishment of vertical distribution of spores through detailed investigation of type sections, (b) providing field geologists with palynological age determinations, and (c) taxonomic studies of new spore types; to carry out fundamental palyno-petrolographic studies on origin of various coal constituents, on palaeocology of ancient peat bogs, on metamorphism of coal and organic constituents, on effect of geologic setting on nature of coal; to evaluate the geology and mining possibilities of Canadian coals, using petrography and palynology combined with other stratigraphic methods in the study of coals and contiguous rocks; and to provide training, research facilities, and study projects for foreign geology graduates in cooperation with United Nations and N.R.C. fellowship arrangements.

GENERAL

The Division maintains at Ottawa a permanent repository and examination facilities for rock cuttings and cores from all wells drilled for oil and gas in Ontario. During the year 39,085 samples, representing 222 wells in Ontario were received, and prepared for microscopic

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*SEE under PERSONNEL

examination. This material was made available to visiting geologists for study and representatives of the following companies availed themselves of this service: Consumers Gas Company, Imperial Oil Enterprises Limited, Socony Mobil Oil of Canada, Limited, Pan American Petroleum Corporation, British American Oil Company, Sun Oil Company, British Petroleums, Nith River Petroleums Limited, Robertson and Associates, Consolidated Mining and Smelting Company, Shell Canada Limited.

Samples from wells drilled in the western provinces, and samples and cores from wells drilled in Northwest Territories, Yukon Territory, and Arctic Islands are made available for study at the Western Plains Oil and Gas Office in Calgary. (See report of Western Plains Office).

Acknowledgment is made to the following persons and organizations through whose cooperation information and/or drilling samples and cores were received: W.D. Brittain, Director, Drilling and Production, Ontario Department of Energy Resources and Management, for samples of wells drilled in Ontario; Mr. W.A. Roliff, Imperial Oil Enterprises, for cores of wells drilled on Anticosti Island, Quebec; Oil and Gas Conservation Board, Alberta for electric logs and samples of wells drilled in Alberta; Department of Mines and Petroleum Resources, Victoria for samples of wells drilled in British Columbia; Nova Scotia Department of Mines for making available drilling information; Department of Mines, Agriculture and Resources for drilling information in Newfoundland; Mines Branch, Department of Lands and Mines, Fredericton for drilling samples in New Brunswick; Petroleum and Natural Gas Branch, Department of Natural Resources, Regina for well samples, and to officers of many oil companies for much useful information and discussion relative to exploration for oil and gas in many parts of Canada.

PERSONNEL

The total continuing staff of the Division at time of writing is shown below:

Location	Scientists	Technicians	Clerks & Typists
OTTAWA	26	10	3
CALGARY	21	3	5

Mrs. P.J. Hakan, stenographer and Mrs. M.E. Neilson, typist at the Calgary Office resigned and were replaced by Mrs. M.L. Hellard and Mrs. M.A. Seburn respectively. Mr. R.B. Miller, Assistant Technician at the same office resigned. Mr. A.L. Bowering joined the staff as an Assistant Technician. Drs. W.S. Mackenzie and

R.W. Macqueen joined the Petroleum Geology Section and Dr. W.W. Nassichuk became a member of the Arctic Islands Section; all are based at Calgary. Dr. N.C. Ollerenshaw and Mr. B.A. Latour of the Petroleum Geology Section, were transferred to Calgary. Dr. R.T.D. Wickenden relinquished his duties as Officer in Charge of the Calgary Office in order to devote full time to micropalaentological work, and Mr. B.A. Latour assumed the duties of "office manager". In this connection also, and as an interim measure, Drs. Belyea, Stott, and Aitken assumed the responsibility of scientific leadership at the Calgary Office. Mr. R.L. Cox continued post-graduate study in palynology at Stanford University. Mr. R.L. Herr, Scientific Officer, Petroleum Geology Section, resigned in August to take a teaching position.

MEMBERSHIP ON COMMITTEES

Caley, J.F.
- Associate Editor, Eastern Canada, A.A.P.G. 1961-1966
- Representative for Eastern Canada, Basement Rocks Project, A.A.P.G., 1960-1966.
- Member, Committee for Publication, A.A.P.G.
- Member, Committee on Committees, G.S.A. 1965-1966.
- Member, Permanent Council, World Petroleum Congresses, 1959-1967.

Frebold, H.
- Representative for Canada, Sous-Commission du Jurassique Commission de Stratigraphic. Union Internationale des Sciences Geologiques.

PRINCIPAL RESEARCH SCIENTIST

Dr. H. Frebold

Dr. Frebold continued his research on the Jurassic System in Canada in the field and office. In the field, special attention was given to the Triassic-Jurassic boundary. In the office, study of the large collections of Jurassic fossils made by Dr. H.W. Tipper, in the Taseko Lakes area of British Columbia, was continued and a manuscript on the Hettangian Ammonoids of this area was prepared for publication as a G.S.C. bulletin. During a 3 week stay at Stanford University the described faunas were compared with Hettangian faunas collected in Nevada by Professor S.W. Muller.

Research on fossil collections made by the British Columbia Department of Mines and Petroleum Resources was continued, and results of this work will be published as a G.S.C. bulletin. In addition 3 reports were prepared on fossil collections from British Columbia and Yukon.

Dr. Frebold represented Canada on the Jurassic Committee of the International Geological Union.

REPORTS ON SECTIONS AND LABORATORIES

PETROLEUM GEOLOGY SECTION

D.K. Norris

The Petroleum Geology Section is responsible for the systematic investigation of formations that may contain oil, gas, coal, or saline substances, in both undisturbed and orogenically deformed, sedimentary sequences, for the delineation of areas of possible economic potential for these substances, and for basic research into the mechanics of deformation of layered media, the kinematics and dynamics of structural types in layered, sedimentary rocks, and the origin, migration, and accumulation of fossil fuels. Maps, suitably illustrated reports, and compilations portraying the areal distribution, geologic structure, and physical history of these formations, are prepared for general use. Progress and final reports on the mechanics of formation of structural types have been published by the Geological Survey as well as by professional, non-governmental organizations. Samples for all wells in eastern Canada and for selected wells elsewhere are made available for study by interested persons that they may extend basic data on the stratigraphy and structure of areas where active search for fossil fuels is continuing.

Eight staff members undertook field investigations in Canada's sedimentary basins during 1965. A preliminary account of their findings is published in Paper 66-1 of the Geological Survey. A summary account of their research activities follows:

Activities

R.L. Herr: prior to his resignation continued his study of Upper Cretaceous rocks in the subsurface of the southern Alberta Foothills. He submitted for publication by the Geological Survey a paper titled "Upper Cretaceous Alberta Group in the Waterton Gas Field".

R.D. Howie: continued examination of wells drilled in the Atlantic Provinces, assisted oil company geologists interested in the area, and prepared a detailed geological log of Langley Frozen Food Plant Montague No. 3 well. In addition to the preparation of the annual A.A.P.G. report on developments in the oil and gas exploration of eastern Canada for 1965, he continued the preparation of maps and sections for the fifth edition of the Geology and Economic Minerals of Canada, and completed the final revision (with L.M. Cumming) of the Basement Rocks project of the A.A.P.G. Mr. Howie is continuing his study of the structure and stratigraphy of the Stone Creek oil and gas field, New Brunswick, is preparing an index of wells drilled for oil, gas, and water in Quebec, and is making a detailed log of the Kelly's Cross No. 1 diamond drill-hole, Prince Edward Island.

Mr. Howie, in joint authorship with J.E.S. Milne, published "Oil and Gas Developments in Eastern Canada in 1964" in Bull. Amer. Assoc. Petrol. Geol., vol. 49, no. 6, pp. 841-853, 1965. He has submitted for publication by the Geological Survey "Index of Wells Drilled for Oil, Gas and Water in the Atlantic Provinces for which samples are on file in Ottawa".

E.J.W. Irish: continued his study of the stratigraphy and structure of the Belly River, Bearpaw, Edmonton, and higher formations of the Alberta Plains. Detailed petrographic studies of rock samples from these formations are continuing.

During the year Memoir 334 titled "Geology of the Rocky Mountain Foothills, Alberta", was published. Dr. Irish submitted for publication by the Geological Survey a manuscript titled "Structure of the Foothills and Eastern Mountain Ranges, Alberta and British Columbia between Latitudes 53°15' and 57°20' North", and prepared the map compilation, geological notes and selected references for the Guidebook of the Cypress Hills Plateau published by the Alberta Society of Petroleum Geologists, September, 1965.

B.A. Liberty: spent two weeks in the field with Dr. T.E. Bolton on detailed studies of the Silurian stratigraphy of the Niagara escarpment from Niagara Falls to Manitoulin Island, and spent one week with Dr. G. Marshall Kay of Columbia University, examining and tracing Ordovician rock units from New York State into Ontario. He continued studies of Middle Ordovician stratigraphy in the Peterborough-Kingston area, of Middle Ordovician bryozoa, of trace elements in Ordovician rocks of Ontario, and of post-Precambrian outliers in the Canadian Shield. Dr. Liberty continued the preparation of a memoir on the Palaeozoic Geology of Manitoulin Island, and was extensively consulted on the geology of the Ottawa Valley for construction and engineering projects. He answered enquiries relating to the industrial minerals and petroleum possibilities of Ontario.

Dr. Liberty published two papers, titled respectively "Middle Ordovician Stratigraphy of Central Ontario" and Upper

Ordovician Stratigraphy of the Toronto Area" in the Michigan Basin Geological Society Guidebook for 1965.

B. MacLean: continued the cataloguing and classification of reports received under the Canada Oil and Gas Regulations, prepared for publication maps showing the oil and gas fields and related data for the Prairie Provinces and British Columbia, assisted in the compilation of geological data on northern Canada for the revision of the geological map of Canada, prepared monthly summaries of oil and gas activities in Western Canada and continued the preparation of isopachous and facies maps for southern Yukon and Northwest Territories.

Revised editions of Map 1039A - "Oil and Gas Fields and related data, Alberta and northeastern British Columbia", and Map 1044A - "Oil and Gas Fields and related data, Saskatchewan and western Manitoba" were submitted by Mr. MacLean and published by the Geological Survey.

D.K. Norris: continued structure fabric studies in coal mines of the Canadian Cordillera with a view to analyzing the kinematics and dynamics of deformation of the layered Kootenay Formation and the mechanics of transport of thrust plates. He continued detailed studies of the lithostratigraphy of the non-marine Jurassic and Lower Cretaceous rocks of the southeastern Cordillera of Canada, and with Dr. W. Fritz extended correlations of the early Middle Cambrian Formations from southern Alberta and British Columbia to northern Montana. Eight manuscripts arising from research investigations within the section were critically read, and administrative duties were carried out.

During the year Dr. Norris published "Stratigraphy of the Rocky Mountain Group in the Southeastern Cordillera of Canada"; Geol. Surv. Can., Bull. 125; "Structural Analysis of Three Extension Faults in Number 4 Mine, Canmore, Alberta", Geol. Surv. Can., Paper 65-16; in joint authorship with R.D. Stevens and R.K. Wanless "K-Ar Age of Igneous Pebbles in the McDougall-Segur Conglomerate, Southeastern Canadian Cordillera", Geol. Surv. Can., Paper 65-26, and with F.D. Anderson "Deformation of Strain Slip Cleavage by Bedding Slippage in Bay d'Espoir Group, Newfoundland", Geol. Surv. Can., Paper 65-2. With W.H. Fritz, he submitted for publication in Geol. Surv. Can., Paper 66-1, a paper titled "Lower Middle Cambrian Correlations in the East-Central Cordillera". Dr. Norris also submitted for publication in an outside journal a paper titled "Structural Analysis of the Queensway Fold, Ottawa, Canada".

N.C. Ollerenshaw: continued studies of the structure and stratigraphy of the southern foothills of Alberta. A preliminary map with notes is in preparation for the Limestone Mountain area. A geological investigation of the Marble Mountain and Fallentimber West areas was initiated

and completed in the 1965 field season. Preparatory photogeologic work was initiated on the Lake Minnewanka East area, and he provided preliminary geological data for the Department of National Defence.

Dr. Ollerenshaw submitted for publication by the Geological Survey a preliminary geological map "Burnt Timber Creek" with marginal notes.

R.A. Price: commenced work on Operation Bow-Athabasca, a reconnaissance investigation of the regional geology of part of the Rocky Mountains in Alberta and British Columbia, in collaboration with Dr. J.D. Aitken, and with Dr. E.W. Mountjoy of McGill University. A preliminary photogeologic interpretation of most of the area was prepared prior to the field season; approximately one-half of the field work was completed in 1965. The preparation of geological maps and other illustrations presenting the results of this investigation was initiated. Dr. Price critically read eight Geological Survey manuscripts.

A paper titled "The Tectonic Significance of Mesoscopic Subfabrics in the Southern Rocky Mountains of Alberta and British Columbia" was presented to the Royal Society of Canada and submitted for publication by the Society.

B.V. Sanford: continued studies of the Palaeozoic rocks of southwestern Ontario, with emphasis on the remapping of the Devonian System and its lithofacies in the subsurface.

Two of Mr. Sanford's papers were published by the Geological Survey in 1965, the one titled "Salina Salt Beds" (G.S.C. Paper 65-9) and the other "Oil and Gas Fields, Southwestern Ontario" (G.S.C. Map 6-1965). He submitted "The Silurian Oil and Gas Fields of Southwestern Ontario" for publication in the Paper Series of the Geological Survey.

G.C. Taylor: completed the field phase of Operation Liard. Compilation of a preliminary map of the total area has been completed, and a preliminary report is being prepared. He supervised a Ph.D. thesis project by R.T. Bell on the Proterozoic rocks of the area.

Well Sample Preparation Laboratory (W.U. ter Haar Romeny in charge): During the 12-month period December 1, 1964 to December 1, 1965, output of processed samples totalled 218,228, of which 175,838 were from Western Canada and 40,764 from Ontario, Quebec, and New Brunswick. In addition, approximately 94 samples were reprocessed and 1,626 samples were reserved and stored. The average monthly output was approximately 18,200 samples.

The Core Centre on Laperriere Street, Ottawa, was reorganized in 1965 and considerable time was spent in the development

of diamond drill core slicing procedures and techniques, and the setting up of a work shop and viewing facilities. Throughout the year examination facilities of the laboratory were made use of by a large number of industry geologists, especially those concerned with wells in Eastern Canada. The following table shows samples received and processed, as well as other related statistical information.

Personnel Notes

E.J.W. Irish: attended the Fifteenth Annual Field Conference of the Alberta Society of Petroleum Geologists in the Cypress Hills Plateau, Alberta and Saskatchewan.

B.A. Liberty: lectured at Carleton University, to the Weston Club, and to the Kiwanis Club on the geology of the Ottawa Lowlands and environs. He was co-leader with Dr. N. Gadd on a lecture and field trip given the Brookfield High School Science Club, and was co-leader on the field conference in central Ontario of the Michigan Basin Geological Society.

D.K. Norris: spoke on the structural analysis of small scale features in coal mines to the Montreal Geological Discussion Group, and on the XXII International Geological Congress to the Logan Club and the Geological Wives Association.

N.C. Ollerenshaw: was one of the judges for the Geological Survey's Annual Field Photography competition.

R.A. Price: attended the annual meeting of the Royal Society of Canada, where he spoke on his investigations of tectonic fabrics in the Eastern Cordillera. He also delivered two lectures at Princeton University on these investigations.

B.V. Sanford: attended the annual meeting of the Ontario Petroleum Institute and participated in the field trip to study Devonian rocks in New York State and Ontario.

W.U. ter Haar Romeny: visited the Alberta Conservation Board and the Saskatchewan Department of Mineral Resources to study well-and-core sample preparation and storage procedures.

Province or District		RECEIVED			PROCESSED			REPROCESSED			RESERVED	
	Core footage	Samples	Wells	Core footage	Samples	Wells	Core footage	Samples	Wells	Core footage	Sam-ples	Well
Alberta	UNDED	90.627	565	0	175.038	1101	0	0	0	0	0	0
N.W.T.		0	0	0	0	0	0	0	0	0	0	0
Yukon T.		0	0	0	0	0	0	0	0	0	0	0
Ontario		39.085	222	1535	39.085	223	0	94	I	1535	434	1
Quebec		1.192	2	0	1.192	2	0	0	0		II92	2
New Brunswick		487	1	0	487	1	0	0	0	0	0	0
Totals	0	131.391	790	1535	218.322	1330	0	94	1	1535'	1626	3
Western	0	90.627	565	0	175.838	1101	0	0	0	0	0	0
Eastern	0	40.764	225	1535	42.484	229	0	94	1	1535	1626	3

Operating days	246	Man Days	1187
Overtime	29		29
Training, leave, other work, etc.	309		309
Production days W.S.P.			871
Production days C.S.P.			36
Development and Production days			81

Membership on Committees

R.D. Howie: - Chairman, Appalachian Discussion Group, 1965-66.

E.J.W. Irish:
- Chairman, Calgary Branch, Professional Institute of the Public Service.
- Technical Chairman, Fifteenth Annual Field Conference, Alberta Society of Petroleum Geologists.

B.A. Liberty:
- Chairman, Ottawa Geoscience Discussion Group, 1965-66.
- Chairman, Vocational Guidance Committee, Kiwanis Club of Carlingwood.

D.K. Norris:
- Member, Departmental Seismic Regionalization Committee.
- Member, Departmental Satellite Information Committee.
- Member, Geological Survey Exhibits Committee.
- Scientific liaison between the Geological Survey and the National Film Board.

R.A. Price:
- Member, Geological Survey Library Committee.
- Member, Geological Survey Central Technical Files Committee.

B.V. Sanford:
- Chairman, Committee on Statistics of Exploratory Drilling, American Association of Petroleum Geologists.
- Member, Ontario Computer Project Committee.
- Member, Ontario Stratigraphic Committee.

PALAEONTOLOGY SECTION

D.J. McLaren

A total of 124 reports were prepared by members of the Section on 1,628 lots of fossils. These lots were submitted by the following:

GSC Field Officers	1,498
Other Government Departments	21
Industry	58
Universities	48
Miscellaneous	3

In addition, 8 reports on 73 lots were prepared for GSC officers by outside experts at our request.

Loans totalling 800 lots other than types were made to 28 individuals and institutions in Canada and elsewhere; a total of 126 lots of fossils and 133 plaster replicas were sent as gifts or in exchange to 10 individuals or institutions throughout the world.

In Canada and five other countries there are 39 experts on particular groups of fossils, or students working under supervision of such experts, engaged in studies of GSC material that result in reports to field officers and/or publications on Canadian fossils. All material identified, types, and figured specimens are returned and deposited with the Geological Survey. During the year, in addition to 8 reports to field officers, such studies have resulted in 4 manuscripts for publication by the Survey, and 6 papers published elsewhere.

Forty-two geologists from universities, oil companies, and abroad have visited the Section in order to examine collections or consult with members of the Section.

The Section continued its responsibility, in collaboration with the U.S. Geological Survey, to review translations of the Russian Paleontologicheskiy Zhurnal for the American Geological Institute, for publication in International Geology Review. Several members of the Section are readers for the Paleontological Society.

During the year two additional papers in the "Illustrations of Canadian Fossils" Series were published, bringing the total now published to 8. Members of the Section published 1 Memoir, 5 Bulletins, 4 Papers and 6 abstracts with the Survey; and, in addition, 7 contributions in outside journals, and 1 abstract.

Type Collection

T.E. Bolton continued as curator of the Type Collection.

A total of 1,431 types described in both Survey and outside publications were added to the Type Collection of the Survey in 1965. Publications in which these types were reported are as follows:

GSC Bull.	103	Cretaceous pelecypods, British Columbia	119 types
	120	Cretaceous ammonites, Canadian Arctic	5
	121	Pleistocene fauna	22
	123	Triassic ammonites	57
	127	Ordovician ostracods, Northern Ontario	302
Paper	64-55	Mesozoic Flora, Canadian Arctic	343
	65-5	Cretaceous Flora, Western Canada	120
			968

Types in Outside Publications:

Boucot, A.J. et al. (Calif. Inst. Tech.), J. Pal., 39:3	5
Carlisle, D. and Susuki, F. (Univ. Calif.), Can. J. Earth Sci., 2:5	29
Cobban, W.A. (USGS) and Jeletzky, J.A. (GSC), J. Pal. 39:5	2
McGregor, D.C. (GSC), Bull. Can. Petrol. Geol., 13:3	51
McLaren, D.J. (GSC), Bull. Can. Petrol. Geol., 13:3	21
Nassichuk, W.W. and Furnish, W.M. (Univ. Iowa), J. Pal. 39:4	4
Parsley, R.L. and Caster, K.E. (Univ. Cincinnati), Bull. Am. Pal., 49:221	9
Whittington, H.B. (Harvard Univ.), Bull. Mus. Comp. Zool. Harvard, 132:4	342
	463

Ten loans of 49 type specimens have been made to outside specialists at their request.

Activities

E.W. Bamber: wrote 13 reports on 540 lots of Carboniferous and Permian fossils collected by GSC field officers and others; did two months of field work with Operation Liard in northeastern British Columbia and southeastern Yukon; acted as outside reader for the Journal of Palaeontology; attended the 1965 Geological Society of America meetings; and assembled information and photographs for a contribution on Carboniferous and Permian palaeontology in "Geology and Economic Minerals of Canada".

W.A. Bell: (retired) wrote 19 reports on 109 lots of plant megafossils and completed one manuscript entitled "Illustrations of Canadian Fossils: Carboniferous Megaplants of Eastern Canada" for publication by the Geological Survey. He was author of GSC Paper 65-5 published during the year.

T.E. Bolton: reported on 36 lots of Silurian fossils from Northern Ontario and Arctic Canada. With Miss J.A. Legault, he continued an investigation of trilobites collected from the Ordovician and Silurian rocks of Anticosti Island, Quebec. Description of an Upper Silurian bryozoan faunule from Arctic Islands was completed and submitted for outside publication. Biostratigraphic studies of Ordovician and Silurian rocks of Southwestern Ontario, in cooperation with B.A. Liberty, were undertaken during the field season. A paper illustrating Silurian Fossils of Ontario was completed. He attended the October CIM-GAC meetings at Winnipeg. He continued as Chairman of the GSC Committee on Stratigraphic Nomenclature. Ten manuscripts were reviewed as chairman of the Publications Committee and Assistant Editor to the Geological Association of Canada. Two manuscripts were critically read for the Paleontology Society and two evaluated for the American Geological Institute.

T.P. Chamney: wrote 5 reports on 96 lots of Mesozoic and Palaeozoic microfossil samples for GSC field officers. He contributed several verbal reports to industry as a result of numerous visits throughout the year to the Calgary laboratory. In a two week visit by an industrial worker more than 1,000 microfossil lots were reviewed and compared with the Alaskan zonation. This has brought our gross Mesozoic microfossil zonation to near completion for the Canadian Arctic Coastal Plains and Mackenzie River Delta area. Field sampling on the northern mainland east of the Mackenzie Delta will complete the regional Mesozoic control. This latter project for 1966 will be conducted in cooperation with a National Museum field party in the same area. Field and laboratory research was undertaken on the uppermost Cretaceous and Paleocene beds of the Cypress Hills Plateau. Results included geological road logs, field lectures, and a geological map (co-authored) of the area for the Alberta Society of Petroleum Geologists' field conference at Medicine Hat. He was general chairman of this conference. A display of Geological Survey maps, publications, rocks and minerals was prepared, displayed and supervised at the annual exhibition of the Calgary Rock and Lapidary Society. Liaison with the Research Council and University of Alberta continued with the presentation of a lecture and laboratory demonstration in the spring in which a Mesozoic Micropalaeontological Zonation of the Arctic Coastal Plains was presented.

M.J. Copeland: wrote 7 fossil reports on 65 lots of Palaeozoic microfossils for field officers, industry, and other organizations. He spent part of a field season collecting Silurian and Devonian microfossils in Nova Scotia, New Brunswick, and Gaspé, Quebec. He published Geological Survey Bulletin 127 on Ordovician Ostracoda from Lake Timiskaming, Ontario. He continued his studies of Ordovician-Silurian-Devonian Ostracods of Eastern and Arctic Canada and Eurypterida from

various localities. He visited Washington in October to examine type specimens at the United States National Museum and confer with palaeontologists of the United States Geological Survey.

L. M. Cumming: attended structural geology and palaeoecology seminars at McGill University, annual meetings and field trips of the G.S.A. in Missouri, and the meetings of the International Upper Mantle Symposium in Ottawa. A talk concerning the XXII I.G.C. was presented to the Logan Club. A paper on Regional Geology of western Newfoundland was presented at the G.S.A. meetings. Four talks were given to Service Clubs, topics were: Geology as a Career; Newfoundland, Persia and India. A GSC paper "Geology of Passamaquoddy Bay Region" was completed. A GSC Bulletin on Gaspé Sandstone Faunas, jointly with A.J. Boucot and H. Jaeger, was completed. A C.I.M.M. Abstract "Possible Basement Graben beneath Miramichi Bay, New Brunswick" was written jointly with R.D. Howie. He assisted in checking final manuscript of A.A.P.G. Basement Rock Map and contributed to Ord.-Sil. palaeontology manuscript for E.G.-1. He prepared 6 fossil reports on 13 lots of fossils. A report on the meetings of the International Palaeontological Union in New Delhi appeared as part of Newsletter No. 5 of the Canadian Palaeontological Association.

W.H. Fritz: wrote 13 reports on 97 lots of Cambrian fossils. Eight weeks of field work were accomplished in the eastern Cordillera and collections made from 300 fossil localities. One additional week was devoted to a project of examing Lower and early Middle Cambrian strata in the southern Rocky Mountains of Canada and in adjacent Montana. Fossil collections made during this project were studied and the results incorporated in a short paper co-authored with D.K. Norris. Several days were spent at the U.S. National Museum making a final appraisal of trilobite types relevant to a manuscript on the Lower and Middle Cambrian trilobites of Nevada. Three North American critics have completed the reading of this manuscript, and it will soon be offered for publication to "Paleontology" in London. Arrangements for the duplication of a Cambrian synonymy file of 20,000 entries and a bibliography file of 1,000 entries has been completed through the generosity of the U.S. Geological Survey. These duplicate files are now being kept current in Ottawa and are available to Canadian scientists. Two papers on Cambrian trilobites were critically read and one was edited.

J.A. Jeletzky: wrote 12 fossil reports on 224 lots from the Cretaceous and late Upper Jurassic rocks of Western and Arctic Canada. In September he spent five days at the Survey's Calgary Office and at the Calgary headquarters of various oil companies for consultation and liaison. In this connection he attended meetings and excursions of the 15th Annual Field Meeting of ASPG at Medicine Hat and acted as one of its excursion speakers. In November he acted as one of the panel speakers of Biostratigraphy Seminar at Queen's University, Kingston,

and gave a lecture on "Palaeontology, the Basis of Practical Geochronology of Phanerozoic Rocks". In the office he began and completed a bulletin (in co-authorship with H. W. Tipper): "Upper Jurassic and Cretaceous rocks of Taseko Lake Map-area and their bearing on the geological history of southwestern British Columbia", and a short GSC paper: "Taxonomy and Phylogeny of Fossil Coleoidea (= Dibranchiata)". He started the pre-editing of the posthumous Cretaceous manuscript of F. H. McLearn, continued to work on the manuscript and illustrations of the Coleoidea volume of the Treatise on Invertebrate Palaeontology, served as a critical reader of two Survey and one outside Cretaceous manuscripts, and continued to check Russian translations of short summaries, titles, and authors' names to be included in final reports of the Survey. He continued to serve as a member of the Stratigraphic Committee of U. S. National Research Council.

D. C. McGregor: continued laboratory study of the Lower Devonian plant microfossils of eastern Gaspé Peninsula, Quebec. In November he presented a paper entitled "Devonian spore succession in Eastern Gaspé, Canada" at the Geological Society of America convention in Kansas City. In May he attended the founding meeting of the Canadian Botanical Association, and was elected Secretary-Treasurer of the proposed Palaeobotanical Section. He continued compilation of a reference collection of slides and photographs of spores and pollen of pre-Quarternary age, and effected exchanges of material with palynologists in various parts of the world. He wrote 14 fossil reports on 64 lots of fossils from Palaeozoic, Mesozoic, and Tertiary rocks of eastern, western, and Arctic Canada. In the laboratory he prepared 126 samples for microfossil analysis, ranging in age from Silurian to Tertiary, prepared 418 slides and made 850 photomicrographs of plant microfossils. He was critical reader for one GSC manuscript and one manuscript for the Palaeontological Society. He reviewed and wrote abstracts for three papers translated from Russian by the American Geological Institute, and wrote criticisms of seven other AGI translations. He submitted a review to the Journal of Palaeontology for publication, was author of one GSC paper published during the year, and was co-author of another paper published in an outside journal. He agreed to act as leader for a field excursion for the International Symposium on the Devonian System to be held by the Alberta Society of Petroleum Geologists in 1967. He is a contributing member of the International Committee on Microflora of the Palaeozoic.

D. J. McLaren: was responsible for the administration of the Palaeontology Section, and for the necessary correspondence and administrative procedures involved in the study of Survey collections by workers elsewhere. He wrote 9 reports on 218 lots of fossils from Western and Arctic Canada. He continued his researches into Lower and Middle Devonian coral faunas and rhynchonelloid brachiopods. He

contributed a description and discussion of Arctic Famennian faunas in a joint paper with J.W. Kerr and D.C. McGregor, published in the Bull. Can. Petrol. Geol.; his contribution on Palaeozoic rhynchonelloids for the Brachiopod Volume of the Treatise on Invertebrate Paleontology was published. He continued as Co-chairman, with H.R. Belyea, of the Planning Committee of the International Symposium on the Devonian System, Calgary, 1967, for the Alberta Society of Petroleum Geologists, and visited Calgary 3 times for planning meetings. He was joint leader of a field trip in the Alberta Rocky Mountains for the purpose of planning Symposium field trips. He continued as a member of the Committee on the Silurian-Devonian Boundary of the International Commission on Stratigraphy. He attended 2 field trips in Western New York and Southwestern Ontario in connection with boundary problems in the Devonian. He acted as a reader for the Paleontological Society, the American Geological Institute, and as a critical reader of GSC manuscripts. He attended seminars in biostratigraphy at McGill and Queen's Universities and led a discussion on the Stratigraphic Code at the latter.

B.S. Norford: wrote 8 reports on 68 lots of fossils from Ordovician and Silurian rocks of Western Canada. Field and laboratory studies continued on Ordovician and Silurian biostratigraphy of British Columbia, Alberta, and the District of Mackenzie. Field work included four weeks with Dr. R.J. Ross, Jr., of the United States Geological Survey, during which the sequence of the southern Rocky Mountains was compared lithologically and faunally with similar sequences in Nevada, Utah, and Idaho. A paper on an occurrence of Middle Cambrian trilobites in the District of Mackenzie was submitted for publication as part of a bulletin. In association with T.E. Bolton, M.J. Copeland, L.M. Cumming, and G.W. Sinclair, a contribution on Ordovician and Silurian palaeontology was completed for inclusion in Geology and Economic Minerals of Canada. A manuscript on Ordovician and Silurian stratigraphy of the southern Rocky Mountains was submitted as a bulletin. This last study was presented to the Logan Club and a condensed version was given to the Geological Society of America at its annual meeting. A week was spent in Washington, discussing lower Middle Ordovician brachiopods with Dr. G.A. Cooper of the Smithsonian Institution. He attended day seminars in palaeoecology and biostratigraphy at McGill and Queen's Universities, and the annual meetings of the Paleontological and Geological Society of America in Kansas City. He edited a manuscript for publication as a bulletin by the Survey, another was critically read for the Survey, and a third for an outside journal. He acted as Secretary for the Logan Club in the session 1964-1965.

A.W. Norris: completed field work on the Devonian formations outcropping in the Lake Manitoba-Lake Winnipegosis area. He acted as a leader on a field trip sponsored by the Saskatchewan Geological Society to examine some of the outcrops of the Ordovician,

Silurian, and Devonian in Manitoba. One week was spent in Calgary examining Devonian drill core and consulting with Helen R. Belyea. Four days were spent on a field trip to examine outcrops of the Onondaga and Schoharie Formations and equivalent beds in northern New York State and Southwestern Ontario. He visited Calgary to attend a meeting called by H.G. Bassett to prepare for the International Symposium on the Devonian System to be held in Calgary in September, 1967. While in Calgary he also examined drill core and consulted with Helen R. Belyea and J.E. Tassonyi on current Devonian projects. He identified 240 lots of Devonian fossils from Western and Arctic Canada.

G.W. Sinclair: prepared 4 reports on 82 lots of Ordovician fossils from Central and Arctic Canada. He continued detailed studies of Ordovician faunas, mainly from areas peripheral to the Canadian Shield. Field studies were made of exposures in the Ottawa and Bonnechere Valleys, in Lakes Timiskaming and Nipissing, and along the St. Lawrence River. A summary of the faunal studies of the Cat Head Formation of Lake Winnipeg, now almost completed, was prepared for the CIMM meeting in Winnipeg. A memorial notice of Dr. Alice E. Wilson was published in the Proceedings of the Geological Association Canada. GSC Paper 65-34 and a part of Bulletin 134 were published.

E.T. Tozer: prepared 12 reports on Triassic fossils submitted for age determination by officers of the Geological Survey and the British Columbia Department of Mines. Six weeks were spent in the field, studying Triassic formations in Toad River, Tuchodi Lakes, Halfway River, and Pine Pass areas, northeastern British Columbia. In this work Tozer was joined by N.J. Silberling of the U.S. Geological Survey, who also visited the Geological Survey for a week in November. The result of this visit, together with results deriving from joint field conferences in 1964 and 1965, and a visit by Tozer to the U.S. Geological Survey office at Menlo Park, California, in 1964, will be a new Time-Stratigraphic classification for the Triassic period. In the early part of the year, the first draft of the chapter on the Arctic Islands for "Geology and Economic Minerals of Canada", to be published in 1967, was prepared, with R. Thorsteinsson of the Arctic Islands section. In the latter part of the year, Tozer was appointed to assist in the compilation of the 1:10,000,000 Geological Map of the Arctic to be published by the Commission of the Geological Map of the World. He published one Bulletin and two Papers with the GSC, and two papers in outside journals.

T.T. Uyeno: wrote 3 fossil reports on 18 lots from Ordovician rocks of Western Canada. A study of the conodont biostratigraphy of the Devonian Waterways and Beaverhill Lake Formations was continued. A manuscript on the Ordovician Hull conodonts has been critically read by outside specialists, and revised. He spent three weeks in the United States, visiting various conodont experts, namely those at the

Universities of Iowa, Missouri, and Texas, and the Research Centre, Pan American Petroleum Corporation in Tulsa, Oklahoma. Extensive type conodont collections stored at these institutions were also examined. Comparative materials were obtained, which facilitate proper identification of Canadian fossils. While in Taxas, various Waterways conodont problems were discussed with one of the foremost German Devonian conodont specialists, Dr. Willi Ziegler.

Palaeontology Preparation Laboratory

Technical Curator: B.J. Botte (in charge)

Preparators: J.J. Callahan (Chief), J.E.A. Matte (Micropalaeontology), D.C. Jarvis, G.P. Moore

Calgary Preparator: D.L. Herron

Clerk: S. Carbone

Labourers: A.J. Claude, G. Prudhomme

In order to conserve all available storage space, plans were submitted and carried out to rearrange some 775 metal storage cabinets, containing general palaeontology study collections.

Under supervision, and with the help of four labourers, approximately a thousand square feet of floor space was reclaimed, without storage loss, by moving the cabinets so as to reduce the corridor width from approximately 6 feet to 3 feet. Extra storage space was achieved by bolting new half size metal cabinets on top of the existing full size cabinets. This allowed approximately 50 per cent more storage space on the same floor area. Approximately 500 trays of palaeontology study specimens were transferred from main storage collections in B-60, ~~601 Booth Street~~, to the storage depot on Laperriere Street in order to allow adequate storage facilities for the current collections.

In the micropalaeontological laboratory 329 samples were washed or disintegrated by mechanical or chemical means and picked for microfossils. A total of 800 feet of drill core from Anticosti Island was examined for fossil content.

In the micropalaeontological laboratory in Calgary, 1,644 samples of predominantly Cretaceous material were received. A total of 2,244 samples were disintegrated and 949 were picked, mainly on contract. The preparator assisted in the field in measuring and collecting from Cretaceous sections on Operation Liard.

Services performed in the general laboratory are outlined below:

	Peels	Polished Specimens	Thin Sections	Saw Cuts	Plaster Casts & Jackets	Rubber Molds & Casts	Prep. by Mech. Methods
Bamber, E.W.			772	1206	327	275	
Bell, W.A.	12				25	25	11
Bolton, T.E.			335	211			
Copeland, M.J.			5	5			
Cumming, L.M.			1	1			
Frebold, H.W.					11	6	3
Fritz, W.H.					40	40	150
Jeletzky, J.A.					431	207	
Liberty, B.A.		2	2	2			
Macqueen, R.W.		648		648			
McLaren, D.J.	287	30	468	806			17
Norford, B.S.			48	68			
Sinclair, G.W.					56	1	
Steele, M.			3	3			
Tozer, E.T.					112	55	
Totals	299	680	1634	2950	1002	609	181

Boxes received during 1965 field season 421
Fossil localities catalogued (Invert.) 5358
Fossil localities catalogued (Plants) 237
Parcels shipped 99

ARCTIC ISLANDS SECTION

R. Thorsteinsson

Activities

Members of the Arctic Islands Section were engaged in mapping and stratigraphic studies on two field parties.

The projects were:

(1) Operation Grant Land, which carried out the first of a two-year field program designed to study the stratigraphy, metamorphic and structural geology of parts of northern Ellesmere Island. Staff members of the project were R.L. Christie, and H.P. Trettin.

(2) Stratigraphic and structural studies of Cornwallis Island and adjacent smaller islands. Members of this project included R. Thorsteinsson and J.W. Kerr.

R.L. Christie: worked principally on the planning and execution of Operation Grand Land, a two-year, air-supported project based in 1965 at Alert, northern Ellesmere Island. In the field, Christie studied Lower Palaeozoic, Permo-Carboniferous, and Tertiary sections, and examined proposed sites for a triangulation net between Northwest Greenland and Ellesmere Island. Additional duties included service on the Geological Survey Equipment Committee and chairmanship of the Departmental Field Equipment Committee. The writing of a chapter of a memoir on the Bennett map-area (British Columbia) moved this project slightly closer to completion.

J.W. Kerr: collaborated with R. Thorsteinsson in geological studies on Cornwallis Island. Kerr is nearing completion of his part of a final report with R. Thorsteinsson and E.T. Tozer on the geology of Ellesmere and Axel Heiberg Islands. He is also engaged in preparing a final report with P.G. Temple on the geology of Bathurst Island. He is author or co-author of the following publications: (1) Kerr, J.W., and Christie, R.L., Tectonic history of the Boothia Uplift and Cornwallis fold belt Arctic Canada: Bull. Amer. Assoc. Petrol. Geol., July 1965, pp. 905-926, (2) Kerr, J.W., McGregor, D.C., and McLaren, D.J. An unconformity between Middle and Upper Devonian rocks of Bathurst Island, with comments on Upper Devonian faunas and microfloras of the Parry Islands; Bull. Can. Petrol. Geol., September 1965, pp. 409-431. He has also prepared a paper entitled, Cornwallis Group, a revised Early and Middle Ordovician unit of the Queen Elizabeth Islands, Arctic Canada: Bull. Can. Petrol. Geol. (in press, December 1965).

W.W. Nassichuk: received his doctorate in June from the University of Iowa. A partial requirement of his degree was a study of Early Pennsylvanian ammonoid faunas from Ellesmere Island, which will be submitted to the Survey for publication as a bulletin. He was a joint author, with W.M. Furnish, of a paper entitled "Christioceras, a new Pennsylvanian ammonoid from the Canadian Arctic"; Jour. Paleontology, vol. 39, No. 4, July 1965. After receiving his degree Nassichuk remained at the University of Iowa for six months where he was engaged in research on late Palaeozoic ammonoids and prepared several papers. Relative to his Arctic Pennsylvanian studies he visited typical reference sections in Oklahoma and prepared a paper jointly with H.L. Strimple "Correlation notes on the Upper Wapanucka Limestone of Southeastern Oklahoma"; Oklahoma Geol. Notes, vol. 25, No. 11, November 1965. He has ready to submit for publication a paper entitled "A morphologic character new to Ammonoids demonstrated by a new Pennsylvanian Taxon from the Canadian Arctic". Also in the final stages of preparation are two additional papers dealing with: (A) late Palaeozoic biostratigraphy of the southern Sverdrup Basin, (B) Lower Permian ammonoids from the northern Yukon Territory and British Columbia. Nassichuk joined the western office of the Survey in December.

R. Thorsteinsson: together with J.W. Kerr, completed the first of a two-year project designed to study in detail the stratigraphy and structural geology of the Cornwallis Island area. An interim report and geologic map of this project has been submitted for publication. Thorsteinsson has also completed a report on Palaeozoic rocks of the Arctic Archipelago for the fifth edition Geology and Economic Minerals of Canada, Series No. 1. He is presently engaged in preparing a final report and map of reconnaissance studies carried out in Axel Heiberg and Ellesmere Islands in 1956, 1957, 1961, 1962 and 1963.

H.P. Trettin: as a member of Operation Grant Land, he studied the stratigraphy and structure of Precambrian to Carboniferous rocks on the north coast of Ellesmere Island. After the end of the Arctic field season, he carried out additional stratigraphic and structural studies in the Marble Range of British Columbia. He attended the annual meeting of the S.E.P.M. at New Orleans, where he presented a paper on the Silurian and Devonian arenites of the Franklinian eugeosyncline. He submitted a final report on the geology and bituminous deposits of the Lower Triassic, Bjorne Formation of northwestern Melville Island. Together with R.G. Blackadar, he completed for publication eight geological maps of northwestern Baffin Island. He is the author of the following two publications: (1) Geol. Surv. Can., Paper 64-47; (2) "Middle Ordovician to Middle Silurian Carbonate cycle, Brodeur Peninsula, northwestern Baffin Island"; Bull. Can. Petrol. Geol., vol. 13, pp. 155-180. During the year he served as a member of the Research Committee of the Alberta Society of Petroleum Geologists.

COAL RESEARCH SECTION

P.A. Hacquebard

Introduction

The Section is mainly responsible for microscopic investigations of Canadian coals and associated clastic sediments in the fields of coal petrology and Carboniferous palynology. The petrological studies are carried out to obtain information valuable for coal geology, coal mining and coal utilization purposes (particularly as applied to research on coking coals). The palynological investigations are concerned with the stratigraphy of the coalfields and regions with Carboniferous (and Permian) rocks. In specific instances, the Section also carries out the logging and locating of bore-holes drilled for coal and makes underground geological surveys with the purpose of advising on mining possibilities and evaluating mining reserves. Fundamental research studies on the origin of the various coal constituents and their control by geological conditions are also undertaken.

Palaeocological and Environmental Studies of Coal

For these investigations, in which petrological, palynological, and sedimentological studies are coordinated for the various Canadian coal basins the following progress has been made.

P.A. Hacquebard has prepared microscopic coal logs of two complete column samples of the Wellington seam of the Nanaimo coalfield in British Columbia.

From the Minto coalfield in New Brunswick he has examined six column samples of the Minto Main seam. From the data obtained with the 1964 drilling campaign in this field, sponsored by the Dominion Coal Board, coal isopach, environmental and lithofacies maps have been constructed. Spore studies on the various petrographic intervals into which the seam has been divided have been started by M.S. Barss.

For the petrographic study of the subbituminous coals of the Edmonton Formation of Alberta, T.F. Birmingham prepared 430 polished sections of seven column samples taken at Sheerness, Three Hills, Trochu, Forestburg, Alix (2), and Edmonton. The microscopic examination of these columns has commenced and will continue in 1966. The preparation of these samples by the same person who carries out the microscopic analysis retards progress considerably. As was mentioned in last year's report, the section is handicapped because it has no full-time technician to do this work; part-time summer employees have relieved this situation to some extent.

Coal Mine Geology

P.A. Hacquebard and J.R. Donaldson carried out an underground geological survey of the Syndicate mine in the Springhill coalfield, Nova Scotia. This work was undertaken by request of the Nova Scotia Department of Mines in view of our previous detailed studies of this field. The survey has resulted in the compilation of a contour plan of the No. 3 seam in the Syndicate mine, at a scale of 1 inch equals 100 feet with contour intervals of 10 feet. This plan shows the position and displacements of several high angle normal faults and their projection into the virgin coal area. The geological information has been given to the mine management and has much contributed to the continued exploitation of the 8 foot-thick seam of this mine. At the time the survey was made it was thought that on account of the faulting the mine probably would be abandoned. Approximately 120 men are employed at the Syndicate mine.

Studies on Coal Metamorphism

These studies are concerned with rank variations of coals that are a reflection of the local and regional metamorphism of the area

in which they occur. The rank variations are determined on the vitrinite component by means of detailed reflectance measurements on polished specimens. For this work a Leitz ortholux microscope equipped with a search unit and photometer is used. The instrument is extremely sensitive to outside interference (particularly to fluctuations in humidity and electrical power) and requires constant calibration. Some time was spent to iron out irregularities in order to make the results reproducible, and the assistance given by Mr. F.W. Jones as regards tht electrical equipment has been very helpful. For this project J.R. Donaldson has prepared 95 polished specimens of samples collected in Nova Scotia and New Brunswick in 1964. He has made first reflectance readings on 45 of these specimens, which will be followed by second readings after regrinding and repolishing.

C.C.F.R. Exchange Program of Coals for Comparative Petrographic Analyses

For this project, initiated by the Commonwealth Committee on Fuel Research, T.F. Birmingham examined and repolished (with new techniques) grain mounts of low rank coals from Alberta, Australia, and India. The rank variation involved in the current exchange program ranges from soft brown coal to subbituminous "B" coal. In all, 15 grain mounts have been examined under reflected light for both maceral and microlithotype contents. Two reports on this study have been submitted to the coordinator of this program in Australia.

Research on Coking Coals

Petrographic investigations on the carbonization characteristics of coals from the Crowsnest area of British Columbia were carried out by A.R. Cameron and S.K. Babu, the latter an N.R.C. postdoctural fellow from Saugor University in India.

Three samples of the No. 10 (Balmer) seam were examined microscopically. One of these samples, a 55 foot column, collected in the Balmer mine, was divided into twenty-two intervals on the basis of a detailed megascopic description. A total of 66 grain mounts were prepared from these intervals and reflectance values and maceral and microlithotype contents determined.

In addition a second sample of this seam collected in a strip mine and representing 41 feet of coal, was studied in one foot intervals and data recorded for reflectance and maceral content. A total of 123 grain mounts were prepared and examined for this sample.

In an attempt to further establish the lateral petrographic variation, a third series of samples, collected in 1965 from a freshly exposed face in the Balmer mine, was examined in the previously established petrographic intervals. Three grain mounts were prepared from each interval, giving a total of 51, of which the maceral composition and reflectance measurements have been completed.

The petrographic intervals of the two samples from the Balmer mine were combined into larger units. Of each unit, two samples, one representing whole coal and the other hand-picked vitrain, were submitted to the Fuels Division of the Mines Branch for proximate analysis, swelling and fluidity data. Thirty-six samples were thus analysed to establish the differences in physico-chemical properties between the vitrain and whole coal of this seam, and to compare these results with those obtained from the petrographic examination.

Only microlithotype data remain to be determined on the strip mine sample and on some of the intervals of the 1965 Balmer mine sample. When this has been done the material on the Balmer seam will be put in order for publication.

Carboniferous Palynology

During 1965, M.S. Barss compiled 7 reports on 38 samples submitted for age determinations by G.S.C. field geologists, and geologists from universities and institutions. For the spore studies he made 90 macerations, prepared 300 slides, 200 single mounts, and took 400 photomicrographs. The reports mentioned, with reference to region, number of samples, geologists concerned, and age determined, are as follows:

1. Nova Scotia, 10 samples, D.G. Kelley of G.S.C.
   Age: Pennsylvanian - Permian.

2. Quebec (Gaspé), 1 sample, D.G. Kelley of G.S.C.
   Age: Mississippian.

3. Newfoundland, 4 samples, D. Baird of University of Ottawa.
   Age: Mississippian.

4. Newfoundland, 5 samples, J. Utting of Memorial University.
   Age: Mississippian - Pennsylvanian.

5. Nova Scotia, 16 samples, D. Benson of G.S.C.
   Age: Pennsylvanian.

6. New Brunswick, 1 sample, F. Anderson of G.S.C.
   Age: Devonian.

7. Nova Scotia, 1 sub-marine sample, D. J. Stanley of Dalhousie University.
   Age: Pennsylvanian.

8. Yukon, 6 samples from Tatonduk River section for a joint G. S. C. paper with E. W. Bamber.
   Age: Permian.

Apart from the spore reports listed above, M. S. Barss has continued with the long ranging project of studying the spore ranges in the various type sections of the Carboniferous in the Maritimes and some in Northern and Western Canada; 52 of the 90 macerations mentioned were devoted to this project.

For a spore contribution to the G. S. C. series on "Illustrations of Canadian fossils", M. S. Barss has prepared 22 plates with 450 photos of characteristic miospores of the various Carboniferous formations in Canada. An additional 12 plates are required to complete this project.

For the International Committee on the Microflora of the Palaeozoic (I. C. M. P.) a range chart of Mississippian spores in Canada has been prepared and submitted to the secretary.

Field Activities

In February, 1965, P. A. Hacquebard and J. R. Donaldson spent one week at the Syndicate mine of the Springhill coalfield, Nova Scotia, to carry out an underground geological survey.

In June, 1965, A. R. Cameron, P. A. Hacquebard, and S. K. Babu spent one month in British Columbia to collect column samples from the following coalfields: Princeton, Tulameen, Merritt, Telkwa, Nanaimo, and Comox. A total of 12 columns were taken. Also visited was the Michel area, where additional channel samples were collected for the coke research program.

In September, 1965, P. A. Hacquebard visited the Syndicate mine at Springhill, Nova Scotia, and collected 6 column samples from the Main seam in the Minto coalfield, New Brunswick during a one week stay.

Laboratory Visits and Attendance at Meetings

1. P. A. Hacquebard attended the Fifth Annual Meeting of the Canadian Advisory Committee on Coal Research held in Toronto on April 1, 1965.

2. From May 4-19, 1965, A.R. Cameron visited the following six Coal Petrology Laboratories in the United States to familiarize himself with new developments in technique and new equipment in use:

1) Illinois Geological Survey at Urbana, Illinois.
2) Youngstown Sheet and Tube Company at Youngstown, Ohio.
3) Bituminous Coal Research Inc. at Monroeville, Pennsylvania.
4) United States Steel Corporation at Monroeville, Pennsylvania.
5) Pennsylvania State University at University Park, Pennsylvania.
6) Bethlehem Steel Company at Bethlehem, Pennsylvania.

3. A.R. Cameron attended the Informal Meeting of American Coal Petrographers, held in Monroeville at B.C.R. on May 13, 1965.

4. P.A. Hacquebard was present at the Founding Meeting of the Palaeobotanical Section of the Canadian Botanical Association, which took place at Carleton University, Ottawa, on May 27, 1965.

5. P.A. Hacquebard attended the Annual Meeting of the Royal Society of Canada, held at the University of British Columbia in Vancouver, from June 7-9, 1965.

6. P.A. Hacquebard attended the 78th Annual Meeting of the G.S.A. held in Kansas City, Missouri, from November 4-6, 1965.

Other Activities

From February 23-26, 1965, P.A. Hacquebard gave a short course in Coal Petrology and Carboniferous Palynology at the Geology Department of Dalhousie University. The course consisted of three lectures and two afternoon practical sessions.

A.R. Cameron cooperated with S.K. Babu in the preparation of two short papers published in Current Science (India) and dealing with some petrological aspects of Indian coals.

T.F. Birmingham reorganized the coal science library of the Section and prepared an index file of all available reprints and publications.

As Chairman of the Logan Club, P.A. Hacquebard spent time organizing the 1965-66 program of lectures by G.S.C. and outside geologists.

Membership on Committees

P.A. Hacquebard
- Member, Nomenclature Subcommittee, International Committee on Coal Petrology.
- Member, International Committee on the Microflora of the Palaeozoic.
- Chairman, Nominating Committee of Division on Coal Geology of G.S.A.
- Member, Executive Council of G.S.A. Coal Geology Division.
- Member, Canadian Advisory Committee on Coal Research.
- Chairman (1965-66) Logan Club.

A.R. Cameron
- Member, Canadian Advisory Committee on Coal Research.
- Member of Geologists Group on Advisory Council of Professional Institute.

M.S. Barss
- Member, International Committee on the Microflora of the Palaeozoic.

Outside Talks

On February 26, 1965, P.A. Hacquebard gave a public lecture at Dalhousie University, which was entitled: "Environments of Coal Deposition in the Sydney and Pictou Coalfields of Nova Scotia".

Publications and Reports

Babu, S.K., and Cameron, A.R.

1965a: Theoretical considerations on the value of coal petrography in coke studies of Chirmiri coal (M.P.), India. - Curr. Sci. 34, No. 6, pp. 172-174.

1965b: Reflectance study of some of the Indian coals - Curr. Sci. 34, No. 14, pp. 425-426.

Birmingham, T.F.

1965: Microscopic examination of some Australian low rank coals - Internal Rpt. for C.C.F.R. program on exchange of coals for petrographic analyses, 7 pp.

Cameron, A.R.

1965: Report on visit to Coal Petrography Laboratories in the United States - Internal Rpt., 30 pp.

Hacquebard, P.A., Cameron, A.R., and Donaldson, J.R.
1965: A depositional study of the Harbour Seam, Sydney Coalfield, Nova Scotia - Geol. Surv. Can., Paper 65-15, 31 p.

Hacquebard, P.A., and Donaldson, J.R.
1965: Preliminary report on structure and mining possibilities of the Syndicate mine at Springhill, N.S. - Internal Rpt. 4 p. with contour plan of No. 3 seam at scale of 1 inch equals 100 feet.

WESTERN PLAINS OFFICE, CALGARY

B.A. Latour, Office Manager

The staff of the Western Plains Office underwent considerable change and increase. There were three resignations, five transfers from Ottawa, and seven new members added. Details are as follows: resignations - Mrs. P.J. Hokan, R.B. Miller, and Mrs. M.E. Neilson; transfers - O.L. Hughes, B.A. Latour, P. Meyboom, and N.C. Ollerenshaw; new members - A.L. Bowering, L.D. Delorme, Mrs. M.L. Hellard, R.W. Klassen, R.W. Macqueen, N.W. Rutter, Mrs. M.A. Seburn, and Miss P.L. Walters. The total staff numbers thirty-six and there is one vacant position.

The geological staff includes 21 from the Fuels and Stratigraphy Division and five from the Economic Geology Division. These are accorded support by 10 staff members including clerical staff, technicians, and draftsmen.

Registered visitors to the office numbered 2,988. Some 1,530 examined well samples and logs, 1,145 purchased publications, and 311 consulted with staff members concerning various geological problems. Publication sales involving 9,521 items amounted to $5,126.05.

Drilling samples were received as follows: Manitoba, 4,146; Saskatchewan, 53,173; Alberta, 91,597; British Columbia, 54,836; and Northwest Territories, 10,800. The total number of samples is 214,562, which is considerably less than the previous year's figure of 337,192. This difference does not indicate a reduction in drilling activity, but rather is a reflection of a new policy of sample distribution effected by the Alberta Oil and Gas Conservation Board early in 1965. Whereas the Board had been sending the confidential samples to this office as soon as they were processed, under the new

policy this confidential material is not supplied to us until the confidential period has elapsed, usually about one year after the Board receives them. Thus, the confidential samples from early 1965 and later will not start arriving at this office until early 1966, and this accounts for the apparent decline in samples received during 1965.

Core received from the Northwest Territories amounted to 453 boxes.

The office received 6,452 electric and other mechanical logs. Here again the reduction from last year is for the same reason as outlined for the drilling samples.

The growth rate of the library has increased sharply through acquisitions of back numbers as well as current material. The library is past the stage where it can be maintained as part time work by untrained persons, and the need for a qualified librarian is vital.

The McConnell Club, whose founding was reported last year, has continued to hold meetings during the year and has well met the purpose for which it was founded.

Construction of the new building to house the Calgary Office started in mid-November and is now well under way.

Mesozoic Stratigraphy Unit: D.F. Stott, Leader

Members of the Mesozoic Stratigraphy Unit were engaged mainly in stratigraphic studies of Cretaceous rocks in Saskatchewan, Alberta, and northeastern British Columbia. These investigations are primarily directed to the gathering of basic data from subsurface and outcrop, leading to the determination of facies variations, correlation of strata, and potentialities as source and reservoirs of coal, oil, and gas.

A current project involving the Dunvegan Formation in Alberta will illustrate the usefulness of computerized data in stratigraphic studies. Another project is obtaining valuable sedimentological information, stratigraphic details, and palaeontological collections from the sinking of shafts of potash mines in Saskatchewan. During the 1965 field season, a large scale regional stratigraphic study of Cretaceous rocks was completed in northeastern British Columbia, southeastern Yukon, and the southern District of Mackenzie.

Although a few stratigraphic studies of Mesozoic rocks are being carried on outside this unit, research into several Mesozoic

problems of major economic significance cannot be properly continued or undertaken by the small staff presently available.

C.F. Burk, Jr. continued studies of the subsurface Upper Cretaceous Dunvegan Formation in west-central Alberta and adjacent British Columbia. He increased his well control to more than 700 wells, and established correlation within a network of electric log cross-sections as a prerequisite for the preparation of isopach and other maps. Some results of this study were presented in Geol. Surv. Can., Paper 65-2. Considerable time was devoted by Burk to the study of computer techniques for processing the considerable volume of numerical data that he has collected. After he consulted I.B.M. representatives and considered the preliminary recommendations of the Ad Hoc Committee on Storage and Retrieval of Geological Data in Canada, Burk designed formats for three cards and commenced the transfer of data to this form. His objective is to develop standard computer programs for the preparation of isopach and structure maps and analysis of these by trend surface techniques.

L.L. Price continued supervision of a joint project with the Saskatchewan Department of Mineral Resources for collecting data, fossil and rock specimens from four large diameter shafts in process of sinking for potash at Esterhazy, Allen, and Lanigan. Information from detailed geological observations and photographs are being included in a joint report with the Saskatchewan department. An interim joint report, based on the Cutorm (No. 2) shaft at Esterhazy, is being prepared. Price also examined core from several pilot holes in order to make recommendations for studies of future shafts. In addition, he is studying cores taken in the "White Specks" zone of the Pasquia Hills. His resulting report will incorporate data from previous studies of outcrop and exposures in potash shafts, and will also contain the results of systematic assays for oil content of the shales. Price is also preparing a report on the correlation of the Swan River Formation in its type outcrop area with Lower Cretaceous rocks in the subsurface of eastern Saskatchewan.

D.F. Stott was assigned the duties of unit leader in August. He completed, in conjunction with Operation Liard, stratigraphic studies of Jurassic and Cretaceous rocks in outcrop between Peace River and latitude 60 degrees in northeastern British Columbia. A brief summary is contained in Geol. Surv. Can., Paper 66-1. The distribution of those rocks was compiled from air photographs and ground observations for Fort Nelson (94J), Tuchodi Lakes (94K), Toad River (94N), Maxhamish Lake (94O), and for a revision of Trutch (94G). In addition, several critical localities were examined north of latitude 60 degrees, resulting in revision of the stratigraphy and distribution of Cretaceous rocks in Fort Liard (95B) and La Biche (95C). Stott submitted a preliminary report on "Jurassic and Cretaceous Stratigraphy between Peace and

Tetsa Rivers, northeastern British Columbia" and is preparing the last preliminary paper and final reports on the Bullhead and Fort St. John Groups. He continued to prepare material for the revision of "Geology and Economic Minerals of Canada", submitting a text on the "Mesozoic and Tertiary Stratigraphy of the Interior Plains and eastern Cordillera". He examined well records and submitted data pertaining to Cretaceous rocks for the Schedule of Wells, Northwest Territories. He critically read two manuscripts submitted for Survey publication. He devoted considerable time to the development of adequate library facilities in the Calgary office.

Outside Publications

C.F. Burk, Jr. published, with G.D. Williams, "Upper Cretaceous" in Geological History of Western Canada, Alta. Soc. Petrol. Geol., Chapt. 12, pp. 169-189. He also published "Silurian stratigraphy of Gaspé Peninsula, Quebec"; A Reply (to discussion by A.J. Boucot and W.B.N. Berry); Bull. Amer. Assoc. Petrol. Geol., vol. 49, No. 12.

Attendance at Conferences, Meetings, and Field Trips

C.F. Burk, Jr. consulted with Dr. C.G. Winder and Mr. R. Brigham, London, Ontario, April 19-20, concerning the "Ontario Computer Project" supported by the University of Western Ontario and the Ontario Department of Energy and Resources Management.

He also consulted, in Ottawa, April 21-28, with Drs. S.C. Robinson, K.R. Dawson, and F.P. Agterberg on data processing, and sat in on some of the meetings of the National Advisory Committee on Research in the Geological Sciences concerned with data processing.

He attended a meeting in Ottawa, July 9, of the Ad Hoc Committee on Storage and Retrieval of Geological Data in Canada, and another meeting in Winnipeg, December 16, of the subcommittee on Fossil Fuels and Related Economic Sedimentary Deposits.

He took, from September to December, an extension course on computer programming for scientific applications, given by the University of Alberta, Calgary.

He attended the symposium on "Marine Shallow-Water Sedimentation", Banff, Alberta, May 10-14 (National Earth Sciences conference).

He also attended the Field Conference, Alberta Society of Petroleum Geologists, Cypress Hills, September 9-11.

L. L. Price attended the Field Conference, Alberta Society of Petroleum Geologists, Cypress Hills, September 9-11.

He also attended the Potash Show, promoted by the Saskatchewan Department of Industry and Commerce, Saskatoon, October 25-26.

D. F. Stott attended the combined meetings of the American Association of Petroleum Geologists and Society of Economic Palaeontologists and Mineralogists in New Orleans, April 26-29, and took the field trip down the Mississippi delta.

He attended the Heavy Oil Seminar, held in conjunction with the meetings of the Canadian Institute of Mining and Metallurgy, Calgary, May 4.

He attended the Field Conference, Alberta Society of Petroleum Geologists, Cypress Hills, September 9-11.

He substituted for Dr. R. J. W. Douglas at the annual meeting of the Geology Advisory Committee, Research Council of Alberta, Edmonton, October 14.

Membership on Committees

C. F. Burk, Jr: Member, Ad Hoc Committee on Storage and Retrieval Geological Data in Canada, established by National Advisory Committee on Research in the Geological Sciences in Canada; Chairman, of its subcommittee on Mnemonic Coding of Geological Names and Terms; pro tem chairman, of its subcommittee on Fossil Fuels and related Economic Sedimentary Deposits.

Member, Advisory Committee, National Conference on Earth Sciences, Banff, May 10-14; Symposium on "Marine Shallow-Water Sedimentation" sponsored by University of Alberta and Alberta Society of Petroleum Geologists.

Business Manager, Alberta Society of Petroleum Geologists.

D. F. Stott: Member, Canadian National Committee, Seventh World Petroleum Congress, Mexico City, 1967.

Chairman, Calgary Library Committee and Liaison Officer between Calgary and Ottawa libraries and library committees.

Lower and Upper Palaeozoic Stratigraphy Unit: J.D. Aitken, Leader

J.D. Aitken continued his field studies of the Pre-Devonian of the southern Rockies, while attached to Operation Bow-Athabasca. He devoted a large proportion of his office time to the study of lower Palaeozoic carbonate rocks. A manuscript, "Representative Cambrian sections in the easternmost southern Rocky Mountains, Alberta and adjacent subsurface", was submitted for publication as a GSC paper.

He served as guide and speaker at the Edmonton Geological Society's annual field trip, August 28, and attended, at his own expense, the Joint Meetings of the Geological Association of Canada, and the Canadian Institute of Mining and Metallurgy, at Winnipeg, October 18-20, where he presented a paper, "Upper Cambrian Formations, Southern Rocky Mountains of Alberta", jointly authored by R.G. Greggs and himself. He attended, at Survey expense, the annual meeting of the Geological Society of America at Kansas City, November 2-7, participating in field trips to Pennsylvanian carbonate bank and megacyclotherm localities.

R.W. Macqueen extended observations on Mississippian stratigraphy and sedimentology from the Bow River area to the North Saskatchewan River areas in association with Operation Bow-Athabasca. Critical stratigraphic sections were also examined in the Bow Valley, Mount Head, and Crowsnest Pass areas.

A Ph.D. thesis, "Stratigraphy and Sedimentology of the Mount Head Formation, Alberta, Canada", was submitted to Princeton University.

Manuscripts in preparation include, an outside paper and GSC Bulletin on the Mount Head Formation, and (with E.W. Bamber as co-author) a short outside paper on Banff-Rundle problems.

H.L. Martin submitted two manuscripts for publication as GSC papers as follows: "Mississippian Subsurface Geology in the Rocky Mountain House Area, Alberta" (Paper 65-27); "Mississippian Subsurface Geology in the Pembina Area, Alberta".

He also prepared a map, stratigraphic cross-section, and short note on Mississippian oil and gas accumulations in relation to structure and stratigraphy in western-central Alberta, for inclusion in the new edition of Economic Geology, Series 1.

A new project, the study of the productive subsurface Mississippian Turner Valley Formation in the Edson area of Alberta has been commenced. He attended the Schlumberger of Canada Logging Conference in Calgary, April 19-23 and the Rocky Mountain Section American Association of Petroleum Geologists annual meeting in Billings, Montana, September 26-29.

H. L. Martin and R. M. Procter jointly prepared a confidential report entitled "Lithology and Stratigraphy of western Kyanite, Morley No. 1, Stoney Indian Reserve, Alberta", for the Indian Affairs Branch of the Department of Citizenship and Immigration.

R. M. Procter completed a regional study of Triassic stratigraphy in northeastern British Columbia; two GSC manuscripts are in an advance state of preparation. He also picked formation tops for the Mississippian in wells in the Northwest Territories for publication in the Schedule of Wells, Northwest Territories and Yukon, published by the Department of Northern Affairs and National Resources.

He continued his study of later Palaeozoic subsurface stratigraphy in northeastern British Columbia. Primary results of the study were included in, "Geological History of Western Canada" (Alberta Society of Petroleum Geologists), published in January, 1965. He spent two summer months examining upper Palaeozoic sections in the mountains west of Fort Nelson and examing cores at Charley Lake, British Columbia. He attended the American Association of Petroleum Geologists Rocky Mountain Section Conference at Billings, Montana, and the western Inter-University Geological Conference at Edmonton, Alberta.

Personnel Notes

R. W. Macqueen completed his Ph. D. degree at Princeton University in May, spent the summer in the field, and arrived at his permanent post at the Calgary office in September.

Membership on Committees and in Societies

J. D. Aitken was chairman of the MacConnell Club, 1965-66. He is a member of the American Association of Petroleum Geologists, Alberta Society of Petroleum Geologists, and Geological Society of America, and a Fellow of Geological Association of Canada.

R. W. Macqueen acted as secretary *pro tem* for the third meeting of the *ad hoc* Committee on Storage and Retrieval of Geological Data in Canada, chaired by Dr. S. C. Robinson, held in Calgary, October 27-28. He is a member of Alberta Society of Petroleum Geologists, American Association for the Advancement of Science, Geological Society of America, Society of Economic Palaeontologists and Mineralogists, and Fellow of Geological Association of Canada, and junior member of American Association of Petroleum Geologists.

H. L. Martin is a member of the Alberta Society of Petroleum Geologists.

R.M. Procter served on the Calgary Library Committee of Geological Society of Canada and the Medal of Merit Committee of the Alberta Society of Petroleum Geologists. He is secretary-treasurer of the Calgary Branch, Professional Institute. He is a member of American Association of Petroleum Geologists, Society of Economic Palaeontologists and Mineralogists, and Alberta Society of Petroleum Geologists.

Devonian Stratigraphy Unit: Helen R. Belyea, Leader

Helen R. Belyea completed cross-sections and manuscript on the subsurface Palaeozoic rocks of District of Mackenzie, northeastern British Columbia and western Interior Plains. This required summarization of published and unpublished information on rock units of Cambrian, Ordovician, Silurian, Upper Devonian, and Mississippian ages and revision of Middle Devonian correlations. From the facies variations, the palaeogeography and tectonic controls on sedimentation have been established and will be presented in detail in a separate paper. She commenced the subsurface part of a joint project with A.W. Norris on correlation of late Middle and early Upper Devonian formations from District of Mackenzie to Manitoba. She also supervised preparation of the list of formation tops and wrote an abstract on Palaeozoic geology of District of Mackenzie for the 1966 edition of the Department of Northern Affairs and National Reources, Schedule of Wells. Dr. Belyea attended the annual meeting of the American Association of Petroleum Geologists at New Orleans, April 26-29; took a field excursion to Yucatan to study Tertiary reef and associated carbonates and, while en route to New Orleans visited the United States Geological Survey offices at Denver and examined the Permian "reef complex" and off-reef deposits of Guadaloupe Mountains, New Mexico.

W.S. MacKenzie studied Devonian outcrop sections along and near the Alaska Highway between 58°30' and 60°00' north latitude, the results of which will be published in 1966, in a joint paper with G.C. Taylor. He described measured sections and prepared thin sections of Devonian strata in the vicinity of the "Ancient Wall" northwest of Jasper, Alberta, in preparation of a joint paper with E.W. Mountjoy. In addition he picked information tops for wells drilled in the Northwest Territories and Yukon Territory, for publication in the Schedule of Wells. A manuscript "The Geology of the Southesk Cairn Carbonate Complex" was submitted for publication as a G.S.C. Bulletin, and a paper entitled "Upper Devonian Carbonates of the Southesk Cairn Complex and Associated Strata" was submitted for publication in the December issue of the Canadian Bulletin of Petroleum Geology.

E.J. Tassonyi revised a manuscript entitled "Subsurface Geology, Lower Mackenzie River Area, District of Mackenzie". He has under preparation a paper "Recent Exploratory Well Data, Yukon Territory,

District of Mackenzie and Arctic Islands, North of Latitude 63°00'", and a joint paper with A.W. Norris "Windy Point Reef, Great Slave Lake". He continued to determine formation tops and stratigraphy from mechanical logs and well samples for inclusion in the Schedule of Wells, published by Department of Northern Affairs and National Resources.

D.C. Pugh began revision of Map 51-1959 to incorporate information from recent drilling. He also did mechanical log correlations of late Middle - early Upper Devonian rock units of Alberta to assist Dr. Belyea in establishing regional correlations.

ECONOMIC GEOLOGY DIVISION

S.C. Robinson, Chief

INTRODUCTION

FUNCTIONS

During the year functions of the Branch and of each section were intensively reviewed. Resulting statements of functions were promulgated in draft form in September and those of sections comprising the Economic Geology Division are reproduced below:

Engineering and Groundwater Geology Section -

1. To study the hydrogeology of Canada by conducting field and office research into the occurrence, source, movement, quantity and quality of groundwater in relation to its geological framework.

2. To develop methods, techniques, and instruments required for hydrogeological studies.

3. To gather statistical data for local and regional investigations of changes in the physical and chemical character of groundwater.

4. To cooperate with and assist other government agencies regarding groundwater investigations.

5. To conduct fundamental investigations on a regional or local scale of all aspects of geology that may have an effect on civil engineering projects.

6. To conduct geological investigations of specific engineering sites or problems in response to requests from other government agencies.

Geochemistry Section -

1. To investigate in the field and in the laboratory chemical (inorganic, organic and biochemical) processes in geology and their role in distribution and concentration of elements, minerals, and isotopes in rocks, rock derivatives, and in natural fluids.

2. To develop and test geochemical and biogeochemical methods and instruments to aid in efficient exploration for mineral resources.

Geology of Mineral Deposits Section -

1. To conduct field and office research relating to the origin of mineral deposits.

2. To study the regional and local geological setting of mineral deposits in order to develop geological criteria for the finding of mineral deposits.

3. To devise and evaluate methods and instruments applicable to the search for mineral deposits.

Pleistocene Section -

1. To study all aspects of the geology of Quaternary deposits, including their history and enclosed organic remains.

2. To study geomorphology and attendant geological processes, both past and present.

3. To provide comprehensive data applicable to engineering, urban development etc; to those concerned with archaeology, plant and animal distribution, and recent trends in climate and uplift.

4. To develop and evaluate methods of mineral exploration through an understanding of the Quaternary materials.

In order to carry out these functions it is an advantage to select primary objectives and an organization to implement them that may be attained within a few years. As an example the Geology of Mineral Deposits Section was chosen and the following three-fold division of its objectives and corresponding organization has been proposed. Research will be concentrated a on general geological concepts concerning mineral deposits; b on the geology of specific commodities; and c on the economic geology of the various geologically-defined regions of Canada that lie outside the jurisdiction of the provinces.

a General concepts linking the relations of mineral deposits in Canada to other geological phenomena provide the basis for selecting regions in which to concentrate the search for new mining camps, and for selecting formations and structures most favourable to location of additional deposits in known mining camps. Examples of current projects in this field are the study of the development of mineral deposits during evolution of a geosyncline, the relation of various ores to rocks and orogenies of different ages, and the detailed studies of deposits as they are mined out. Results of this research are published in bulletins and professional journals.

b Studies of geological occurrence and research into the genesis of deposits of specific metals and minerals provide essential criteria for finding and evaluating potential deposits and are an important basis for assessing the mineral potential of various regions of Canada. If the principal economic metals and minerals are grouped by similarity of geological occurrence and research on each such group becomes the responsibility of one geologist, a total of about twelve major 'portfolios' would result. The geological occurrence, classification, genesis and other significant geological criteria for each commodity will be studied, and the results will be released in comprehensive publications of the Geological Survey Economic Geology Series, which would be updated periodically by supplements in the 'Paper Series'. This program will provide a corps of senior geologists, each of whom will be a national authority on the geology of a group of commodities.

c In those territories of Canada outside provincial jurisdiction, a group of geologists will provide a comprehensive account of the mineral potential of the different geological regions. These studies will result in delineation of metallogenic provinces and will indicate areas most favourable to the occurrence of concentrations of various metals and minerals. Such studies are being undertaken in various parts of the Yukon and Northwest Territories.

Similar organization by objective is being developed in the other sections.

STAFF

1. At the end of 1965, staff of Economic Geology included 37 geologists, 3 senior scientific officers, 10 scientific officers, 1 technical officer, 8 technicians and 3 clerks. Of these, 4 were stationed in Calgary, 3 were on educational leave, 2 were in Yellowknife, 1 in Vancouver, 1 in Bedford, and the remainder in Ottawa.

With the exception of Mr. E.B. Owen and Dr. J.S. Scott, staff of the Groundwater Section are to join the new Water Research Branch on April 1st, 1966. In June 1965, staff of the resident geologist

at Yellowknife were transferred to this Division. The Economic Geology Division has been asked to organize geological research in the Great Lakes on behalf of the Water Research Branch and staff positions for this purpose have been seconded to the Division until such time as the new Branch has facilities to take over the programme.

Changes in staff are listed in the reports of Sections.

2. Collaboration of officers of Canadian mining companies, universities, and provincial and other government agencies is so essential to the Division's programme that it is difficult to express adequately our deep appreciation to those concerned. The association of Post-Doctoral Fellows and others from abroad is not as well known, but is also an important source of new ideas to the Division. The following non-Canadians were involved in field or laboratory projects of the Division in 1965:

Mr. M. Carter, Geological Survey of British Guiana.
Mr. K.R. Everett, United States Army Laboratory, Natick, New Jersey.
Professor Gunther Friedrich, University of Aachen.
Mr. B. Fouroughi, Geological Survey of Iran.
Dr. J. Ineson, Water Resources Board, Great Britain.
Dr. K. Kanehira, Chiba University, Japan (P.D. Fellow).
Dr. G.P.D. Laberge, Wisconsin State University (P.D. Fellow).
Captain J. LeMenestrel, French Army, Scientific and Technical Unit.
Professor Anders Rapp, University of Uppsala.
Dr. A.T. Rozkowski, Geological Institute of Silesia (P.D. Fellow).
Mr. M. Shafiqullah, Pakistan.
Mr. Francis Synge, University of Leicester.
Mr. P. Umar, Geological Survey of Pakistan.
Mr. M. Ziauddin, Geological Survey of India.

SUMMARY OF ACTIVITIES

During the year, staff of the Division submitted manuscripts for publication in the following categories: 5 G.S.C. bulletin, 1 Economic Geology Series Report, 12 G.S.C. Paper Series Reports, 17 maps and 36 papers in outside journals. Bibliographic data on publications are included in the annual index to publications of the Geological Survey. In addition 10 Topical Reports and 16 Internal Reports were written.

As described in reports of sections, staff of the Division presented 24 talks to various organizations during the year, mainly at meetings and field trips. Of particular interest are the following:

1. R.W. Boyle visited the Maritime universities under auspices of the C.I.M. Distinguished Lecture Series.

2. Peter Meyboom lectured on groundwater to the major universities in Ontario under auspices of the Lecture Tour Programme of the National Advisory Committee on Research in the Geological Sciences.

3. H.A. Lee was on leave of absence during the academic year as a lecturer at the University of New Brunswick.

There were a large number of meetings and field trips attended by members of the staff, particularly those concerned with Quaternary geology. Total for the year was 45 man-meetings as listed in the reports of Sections. Of particular note in this connection are:

1. Award of the Leonard Medal to Dr. G.A. Gross by the Engineering Institute of Canada.

2. Representation of Canada by I.C. Brown at hydrogeological meetings in Hannover, Budapest, and Dubrovnik.

3. Leadership of the Canadian Delegation to the INQUA Congress at Boulder, Colorado by J.G. Fyles.

Field and laboratory activities of the Division are summarized in reports of the sections and in more detail are reported in Papers 66-1 and 65-2. Some highlights are:

1. The interest aroused among mining companies and prospectors by H.A. Lee's paper (65-14) on "Investigation of Eskers for Mineral Exploration".

2. The scope of research on iron deposits of Canada by G.A. Gross and his co-workers.

3. The convincing demonstration of the effectiveness of geochemical surveys of waters and stream sediments as a prospecting tool in the Bathurst, New Brunswick area by a large party under direction of R.W. Boyle.

4. The successful field tests of J.S. Scott's method for measuring groundwater pressures by means of transducers in a sealed system.

5. The important advances in statistical evaluation of the various contributing factors to geochemical anomalies achieved by R.H.C. Holman, E.M. Cameron and J.A.C. Fortescue in collaboration with the Departmental Data Centre.

6. Peter Meyboom's recognition of the importance of the role played by phreatophytes in locally depressing the groundwater table on the Prairies.

7. Initiation of a plot system for biogeochemical studies as a control measure by J.A.C. Fortescue.

8. Use of water-soluble dyes by J.E. Charron to determine direction and speed of groundwater flow.

Officers of the Division are taking leading roles in the attempts to systematize the recording, storage, and retrieval of geological data in Canada, currently being organized by a Committee set up by the National Advisory Committee. Availability of such data from all sources will greatly facilitate research in Economic Geology.

ACKNOWLEDGMENTS

Mention has been made earlier of the importance to our work of the collaboration of other scientists in mining companies, universities and provincial and other agencies of government. Many of these collaborators are mentioned in reports of Sections and as co-authors of papers.

Much of the work of the Division is dependent in part upon laboratories in other organizations. It is a pleasure to have this opportunity of expressing our gratitude for analyses done by the Mines Branch, in particular, the Analytical Chemistry subdivision of the Mineral Sciences and the Industrial Waters Laboratory. The Departmental Data Centre despite its limited staff has greatly facilitated our use of data processing procedures.

Within the Geological Survey the analytical chemistry, isotope, mineral separation, radiocarbon, and X-ray laboratories of the Petrological Sciences Division have all made major contributions to work of this Division. Assistance and advice from Geophysics, particularly in the seismic and aeromagnetic fields, has been of particular assistance to the Pleistocene and Groundwater Sections. Relationship of the economic aspects of geology to the geological framework of Canada as a whole has been achieved through time devoted to our problems by officers of Regional Geology and of Fuels and Stratigraphy. Our products in written or spoken form owe much to the interest and assistance of the manuscripts unit, and to the cartography and library staff.

Finally it is a pleasure to acknowledge assistance, guidance and services throughout the year of the Branch administration at all levels.

MEMBERSHIP ON COMMITTEES

S. C. Robinson
- Honourable Secretary, Royal Society of Canada to June, 1965.
- Chairman, National Research Council Associate Committee on Meteorites.
- Chairman, Ad Hoc Committee on Storage and Retrieval of Geological Data in Canada.
- Chairman, Branch Appraisal Committee for Technicians.
- Member, Nominating Committee, Mineralogical Society of America.
- Member, Departmental Training Committee.

REPORTS ON SECTIONS AND LABORATORIES

GEOLOGY OF MINERAL DEPOSITS SECTION

R. Mulligan

Officers within the section are concerned with the relationship of mineralization to the whole geological environment, with the object of providing information necessary to the effective search for ore deposits.

The studies and resulting reports fall mainly into one of two classes: those dealing with the geological factors responsible for the concentration of particular metals and other mineral commodities, and those dealing with the geological environment and development of certain mineralized belts or metallogenic provinces. In the first class, field work was done on occurrences of beryllium, coppper, iron, lithium, manganese, nickel, tin, uranium, and vanadium. In the second class, the relationship of mineralization of all kinds to the geological development of type areas was the subject of field studies in the Precambrian Shield, the Appalachian region, the northwest Cordillera, and Vancouver Island. A third class, the comprehensive study of massive sulphide bodies, involved field work on deposits of this type in Newfoundland. G.S.C. Paper 66-1 gives the scope and detailed interim accounts of all these field projects, with particular emphasis on results of possible economic interest.

In the laboratory, detailed investigation of sulphides and other ores were carried out. The study of ores in the Survey is concentrated mainly in the metallogeny laboratory, which is under the direction of officers in the section. The production of polished sections

reached a high stage of efficiency, and the reference collection of polished ore specimens is gradually being augmented. Studies of lead isotope ratios and trace element content of minerals were carried out with the object of establishing more meaningful classification of ore minerals. G.S.C. Paper 65-2 summarized these activities and deals more fully with several of particular current interest.

Much of the work involved in the study of mineral deposits is done in other laboratories of the Survey, notably the spectrochemical laboratories. The lack of adequate facilities and personnel to carry out required analyses and other determinations is a constant source of delay and hindrance to the work of the section.

In the office, mineral occurrence locations and data were compiled for use in metallogenic maps and studies. Many office projects require advanced laboratory investigation and techniques. Modern data-processing techniques are being adapted to the resolution of problems arising from field and laboratory investigations.

Services in cooperation with other agencies and research institutions, such as the North American Committee for a world metallogenic map, and External Aid office programs for Africa, form an important part of the work of several members of the section. Other duties include consultation with, and preparation of itineraries for visitors, and replies to enquiries regarding mineral commodities and economic geology.

Activities

J.A. Chamberlain

As part of his study of the geology of Canadian nickel deposits, Dr. Chamberlain completed a detailed investigation of sulphides in the Muskox intrusion and a preliminary study of nickel distribution in serpentinites of the Eastern Township, Quebec (see "outside papers submitted"). A study of nickel distribution in serpentinites of the Puddy Lake area, Northwestern Ontario, was initiated in collaboration with P.R. Simpson. Dr. Chamberlain continued to supervise a thesis project by Mr. Simpson on sulphide-oxide relations in the St. Stephen gabbroic intrusion, New Brunswick.

C.F. Gleeson

Was transferred at the beginning of the year to the Geochemical Section, Economic Geology Division. His report on heavy mineral studies in the Klondike area, Yukon, is in the editorial stage.

G.A. Gross

Continued studies of iron formations and iron deposits in Quebec, Labrador, Central Canada, and Baffin Island during the field season. The geological setting and origin of high-grade iron deposits in the Mary River area of Baffin Island were studied in detail by a three-man party in cooperation with Dr. G.D. Jackson, who was engaged in regional studies.

Further work on iron-formations in Central Canada carried out by H.P. Wilton included stratigraphic studies and systematic sampling of various facies of Algoma-type iron-formation associated with volcanic rocks.

Field supervision of work by I.S. Zajac in the Knob Lake area, Quebec and Labrador, supervision of research by Dr. Gene L. Laberge and further examination of iron deposits near Schefferville and Labrador City were completed in the field program. A study of the stratigraphy and sedimentary facies in the Sokoman iron-formation in the Knob Lake area, Quebec and Labrador-Newfoundland, started by I.S. Zajac will provide new detailed information on the depositional environment and origin of Superior-type iron-formation, and will be the basis of a Ph.D. dissertation at University of Michigan, Ann Arbor, Michigan.

Gene L. LaBerge

A Post-Doctorate Fellow, carried out research on microfossils in iron-formation and chart rocks from Australia, South Africa, and selected areas in Canada.

A.G. Johnston

Completed a metallogenic map to accompany an Economic Geology report on silver by Dr. R.W. Boyle. He also prepared a map locating mineral deposits in northern British Columbia and the Yukon for Dr. H.S. Bostock and assisted Dr. D.R.E. Whitmore to prepare a short report summarizing exploration activity in the Yukon during 1965. As well as summarizing developments in mineral exploration for his monthly newsletter, he assisted in compilation of material for the proposed revision of Economic Geology Series No. 1 "Geology and Economic Minerals of Canada - 5th Edition".

E.D. Kindle

Continued his field and office studies of copper deposits in the Cordilleran Region of Canada. Data on over 1,000 copper occurrences are being assembled and classified for publication as an Economic Geology Series Report.

W.D. McCartney

Dr. McCartney completed metallogenic field studies in the Canadian Appalachians with studies of selected Newfoundland mineral deposits. He supervised the field and preliminary laboratory studies of P. Ghosh Dastidar leading to a Ph.D thesis on trace-element distribution in sulphides in selected mineral deposits of the Canadian Appalachians, and supervised a study of the metallogeny of Vancouver Island by D.J.T. Carson, which is a Ph.D. thesis project. He also conducted a directed reading course and delivered one lecture on metallogeny at the request of Carleton University, and contributed to the text and Mineral Deposit Map for the revised Economic Geology Series 1.

C.R. McLeod

Mr. McLeod supervised the metallogenic laboratories, with most of his efforts directed to the production of polished sections. About 775 high-quality machine polished and 260 hand polished sections were produced with part-time assistance. He collaborated with Dr. W.D. McCartney in investigating heavy mineral studies as an aid in prospecting and in defining metallogenic provinces. Two weeks field investigation was carried out in selected areas of carboniferous rocks in Nova Scotia.

R. Mulligan

Dr. Mulligan continued field and office work on the geology of tin and beryllium deposits, investigating known and prospective occurrences in southern British Columbia and beryllliferous pegmatites in northern Saskatchewan. A metallogenic study of the beryllium-molybdenum-tin-tungsten and lead-zinc-silver province of the northern Cassiar Batholith, Yukon and British Columbia, was started in conjunction with mapping of the Jennings River area by the Regional Geology Division. In addition he examined lithium-bearing pegmatites in the belt extending from the Superior into the Churchill structural province of northern Manitoba and collected samples for age determination.

A study of tin-bearing garnet and pyroxene from the Cassiar district, involving complex electron-probe, mineral separation and spectrochemical methods was reclassified as an office project, involving the collaboration of J.L. Jambor. Samples were prepared and submitted for analysis in connection with another office project dealing with the relative distribution of lithium in granitic rocks of the Cordillera, Shield, and Appalachian regions. Map 1207A, Metallogenic Map "Lithium in Canada" was prepared and published, to supplement Economic Geology Report 21 "Geology of Canadian Lithium Deposits" published during 1965. A paper "Geology of Canadian Tin Occurrences" and accompanying metallogenic map was in the editorial stage.

At the end of the year Dr. Mulligan assumed temporary duties as acting head of the Mineral Deposits Section.

S.M. Roscoe

Activities included preparation of a paper on "Atomic Energy Developments and Future Uranium requirements as Envisaged at the Third International United Nations Conference on the Peaceful uses of Atomic Energy, Geneva, September 1964". This was issued in December 1965 as Paper 65-33.

Preparation of a paper on "Geochemical and Isotopic Studies, Noranda and Mattagami areas"; this was presented orally as a contribution to a symposium on strata-bound sulphides at the annual general meeting of the C.I.M.M., Toronto, March 1965, and published in the C.I.M.M. Bulletin (Sept. '65).

Field work in the Elliot Lake, Sudbury, Sault Ste. Marie, Michipicoten, Ville-Marie Belleterre, Timmins, Noranda, Jontel, and Mattagami areas in connection with project "Metallogenic studies, Lake Superior-Chibougamau".

Preparation of samples for elemental and lead-isotope analyses. Compilation and study of results of lead isotope analytical program involved about 100 lead isotope analyses and is now nearing completion.

Preparation of a report on 'Future Canadian uranium supplies' to be presented at a February 1 meeting in Toronto.

E.R. Rose

Dr. Rose carried out field work on the geology of vanadium deposits in Western Canada. Traces and strong traces of vanadium were detected in many new localities and in various sedimentary and other rocks and specific minerals. A number of gabbroic rocks with associated anorthositic phases and disseminations of titaniferous magnetite in the Coast Ranges and Islands, were found to be vanadiferous. Samples from deposits of bituminous sandstone near Fort McMurray, Alberta were also found to be faintly vanadiferous.

In connection with field work, several main centres of vanadium production in the western United States were visited. The characteristics and geological framework of these have been outlined in a "Report on Vanadium Producing Areas in the United States". Copies have been filed with the Division and Chief Geologist, and it will be placed on open file for those who may be interest.

D.R.E. Whitmore

In addition to his routine duties as head of the Mineral Deposits Section, and work arising out of his field projects, was active in many committees (see committees).

He continued consultation with the External Aid Office and Mineral Resources Division on aid projects in Africa, and work on Economic Geology Report No. 1, Geology Economic Minerals of Canada and the Mineral Deposit Map of Canada, on display at Kansas City.

Attendance at Meetings

G.A. Gross attended the C.I.M.M. General Meeting in Toronto, where he presented a paper "Principal Types of Iron Formation and Derived Ores", part of a Symposium Geology and Development of Iron Deposits in Eastern Canada.

W.D. McCartney attended the C.I.M.M. Annual General Meeting in Toronto, and the Society of Economic Geologists, Kansas City, November 1965, where he presented a paper "Metallogeny and Geochronology; Canadian Appalachians". He also served as a panellist on "Mineral Renaissance of Eastern Canada", Annual meeting, American Association for the Advancement of Science, Montreal, December 29, 1964.

S.M. Roscoe presented a paper orally at the C.I.M.M. in Toronto, 1965.

J.A. Chamberlain "Sulphides in the Muskox Intrusion" to Geochemical Discussion Group, Carleton University, November 15th.

Membership on Committees

G.A. Gross - Assisted the Geology Committee of the C.I.M.M. in the organization of a Symposium on the Geology and Development of Iron Deposits in Eastern Canada.

W.D. McCartney - Served as the Canadian representative on the Subcommission of the Metallogenic Map of the World and its North American Committee.
- Chairman of the Canadian Metallogenic Map Committee, and Member of the Branch Palaeomagnetic Committee.

D.R.E. Whitmore - Chairman of Symposium on Renaissance of Mineral Exploration in Eastern Canada for Montreal Meeting AAAS.
- Committee work of the Ad Hoc Committee for the Storage and Retrieval of Geological Data in Canada and the following subcommittees:
- No. 2 Digitizing Geological Data Meetings in Ottawa and Calgary.
- No. 4 National Index Meetings in Montreal and Toronto.
- No. 5 Mineral Deposits - Chairman, Meeting in Winnipeg.
- Chairman of the Branch Stable Isotope Committee.

Outside Papers Submitted

J.A. Chamberlain: "Sulphides in the Muskox Intrusion" to Canadian Journal of Earth Sciences.

"Heazlewoodite and Awarvite in Serpentinites of the Eastern Townships, Quebec", to The Canadian Mineralogist.

E.R. Rose: "The copper-nickel deposits of Timagami Island (Ont.)"; Econ. Geol. (in press)..

Awards

G.A. Gross was the recipient of the Leonard Medal from the Engineering Institute of Canada for the best paper published by the Canadian Institute of Mining and Metallurgy or the Engineering Institute of Canada on a mining subject during 1964.

Publications

Gross, G.A.
1965: "General geology and evaluation of iron deposits"; Geol. Surv. Can., Econ. Geol. Report 22, vol. 1.

Discussion - Origin of Precambrian Iron Formations; Econ. Geol., vol. 60, No. 5, pp. 1063-1064.

Johnston, A.G., and McCartney, W.D.
1965: "Manganese occurrences in Canada"; Geol. Surv. Can., Paper 64-37.

McCartney, W.D., and McLeod, C.R.
1965: "Preliminary application of heavy mineral analyses to metallogeny of carboniferous areas, Nova Scotia and New Brunswick"; Geol. Surv. Can., Paper 64-29.

Rose, E.R.
1965: "Pyritic nodules of the Timagami copper-nickel deposits"; Canadian Mineralogist, vol. 8, pt. 3, pp. 317-324.

GEOCHEMICAL SECTION

R.W. Boyle

During 1965, research in geochemistry and geochemical prospecting was carried out in a number of field areas. These included a large geochemical survey in the Bathurst-Jacquet River area of New Brunswick (Operation Bathurst); an investigation of Mississippi Valley type lead-zinc deposits in various parts of Canada; biogeochemical field work in Ontario, Manitoba, and British Columbia; preliminary field work on the application of geochemical prospecting in the Cobalt area, Ontario; field work on circular structures in Quebec; sample collection and field work on a quartz monzonite body in southeastern Ontario; and collection of samples for analysis from cores of the Upper Devonian Swan Hills Member in the Swan Hills and Virginia Hills oilfields of Alberta.

Laboratory research in the chemistry of ore genesis, isotope geochemistry, radiochemistry, analytical chemistry, geochemical prospecting, statistical geochemistry, and sedimentary geochemistry was continued.

Summary of Field Work

D.F. Sangster began a study of trace elements in galena and sphalerite from lead-zinc deposits of the "Mississippi Valley type" in Canada. During the 1965 field season, fifteen such deposits were mapped or examined and samples collected for analysis.

J.A.C. Fortescue and E.H. Hornbrook continued the development of field and laboratory methods for the analysis of biological materials for use in biogeochemical research. J. Fortescue took the biogeochemical sample preparation trailer to Fraserdale, Ontario, in order to carry out a biogeochemical project as a part of a combined geological geophysical and geochemical project under the direction of Dr. D.T. Anderson. During this project some 2,000 samples of soils and vegetation were taken from twelve plots, seven of which were

located in the vicinity of aeromagnetic anomalies. During a trip to Manitoba and British Columbia later in the summer, several drilled, but undisturbed, mineral deposits were inspected where field investigations may be carried out during 1966. During both the field projects the services of a botanist Miss L. Usik were included and the foundations laid for a herbarium collection of plants for use in biogeochemical research.

E.H. Hornbrook supervised a drilling programme carried out to obtain samples of overburden material in the down-ice direction from the Texas Gulf Sulphur orebody near Timmins during February, March, and April. During July, Mr. Hornbrook spent two weeks in the Moose River area, Ontario, observing and participating in the sample collection programme while J. Fortescue was absent in Ottawa.

Operation Bathurst was conducted in the Bathurst-Jacquet River area of New Brunswick and covered some 1,200 square miles. W.M. Tupper of Carleton University was in charge of the field work, J.J. Lynch organized and supervised the analytical chemical laboratory and mobile spectrographic laboratory in the field, and R.W. Boyle supervised the operation as a whole. C.C. Durham was in charge of the mobile spectrographic laboratory, which carried out 25,634 determinations (Table 2, Appendix). Fourteen elements were determined in 3,508 samples of stream sediments, and total heavy metals were determined in the same number of water samples. The elements determined in the field analytical laboratory included Zn, Cu, Pb, As, Sb, Mo, and W; those determined by the spectrograph included Mn, Ba, Cr, Ni, Co, Sn, and Ag. All results were plotted in the field to facilitate early publication of the data.

J.J. Lynch accompanied C.F. Gleeson in a short field trip to the Cobalt area to collect samples of rocks, stream sediments, soils, and waters. Arrangements were also made for the establishment of mobile chemical and spectrographic laboratories in the area for the 1966 field season.

R.W. Boyle visited some old gold deposits in Eastern Ontario (Cordova mine and Deloro area) in September to collect material for a publication on the geochemistry of gold.

K.L. Currie continued the study of the Manicouagan circular structure, concentrating on the stratigraphy and petrography of the volcanic sequence, and the contacts between the lavas and the Precambrian rocks.

K.L. Currie concluded a study of the Crow Lake quartz monzonite, southeastern Ontario. The mass was shown to be sill like in gross structure, with very intricate small scale structure. In the Perth Road syenite, I.F. Ermanovics, under the direction of K.L. Currie, measured the lineation and concluded that the syenite occupies a steeply plunging anticlinal nose.

K. L. Currie made a brief study of seven 'cryptovolcanic' structures in the central United States. Despite many petrographic similarities, the structure of these occurrences differs markedly from that of Canadian craters.

C. F. Gleeson collected samples of water, soil, rock, and stream sediments from the Cobalt area, Ontario for geochemical analyses. The data obtained from these samples will provide a guide for future geochemical work in the area.

A study of the limestones and dolomites of the Slave Point Formation begun in 1963 by E. M. Cameron has revealed interesting patterns of regional chemical variation. The composition of such carbonate rocks is determined by processes that occur both during and after sedimentation. The effects of diagenesis are often difficult to distinguish from those taking place during deposition, but their understanding is of economic significance since the accumulation of both petroleum and metallic minerals in carbonates is likely to be dependent on the same diagenetic processes that affect the host rock.

One approach that may help to distinguish the effects of different processes is to study carbonate units that have a somewhat dissimilar history. During the summer of 1965 more than a thousand samples were collected from cores of the Upper Devonian Swan Hills Member in the Swan Hills and Virginia Hills oilfields of Alberta. The reef deposits that comprise this member are in many respects similar to those of the Slave Point Formation. However, the former have not been dolomitized as has the Slave Point reefs.

Office and Laboratory Work

W. Dyck, who joined the section in May, continued the work started by R. A. Washington on the co-precipitation and adsorption of cobalt on ferric hydroxide using radioactive tracer techniques.

He carried out radiometric analyses on 100 samples of ash from birch trees growing in pots salted with Co^{60}. This work was done to assist J. Fortescue in his biogeochemical research on the uptake of metals by trees.

He began experiments on the diffusion of silver in aqueous solutions using a radioactive silver tracer. This work is continuing.

Equipment for measuring very low natural radioactivities in meteorites was assembled and tested by W. Dyck.

In all of the above work on radio tracers W. Dyck was assisted by J. C. Pelchat, who joined the geochemistry section in June.

J. J. Lynch carried out research on methods of analyses employing preconcentration techniques to determine traces (parts per billion) of various metals in water.

J. Fortescue and O. L. Hughes of the Pleistocene Geology section devised a plan for a drilling programme, which was carried out in record time by Mr. Hornbrook. During the spring a computor programme was devised by J. Fortescue for printing out the results from the spectrographic laboratory. As a result of this, all the results obtained in the spectrographic laboratory during the summer months were plotted during three weeks in October. During the last quarter of the year work was begun on a progress report, which will be a description of all research carried out in biogeochemistry at the Survey during the past three years.

E. H. Hornbrook completed development work on a semi-quantitative spectrochemical method for the determination of Zn, Mn, Cu, Mo, Ba, Sr, Ti, Pb, Ni, Co, Cr, Ag in the ash of organic material during January and a part of April. During the latter part of May and June Mr. Hornbrook trained two student assistants to run the spectrograph in the biogeochemical trailer. By the end of the summer 1,185 samples (involving 15,405 single element determinations) had been analysed by this team of three men.

This analytical programme completed analysis on all samples of organic material accumulated prior to 1965 as well as the analysis of composite samples of material collected from the plots in the Moose River area, Ontario. For the remainder of the year Mr. Hornbrook was engaged in detailed checking of the results obtained in the spectrographic laboratory during the summer months. This involved repeat analysis on 191 samples analyzed during the summer. The activities of the mobile biogeochemical spectrographic laboratory are summarized in Table 5 of the Appendix.

D. F. Sangster completed petrographic and mineralographic studies pertaining to a detailed geological and geophysical study of magnetite iron-formation carried out in collaboration with Drs. G. A. Gross and P. J. Hood. Final geological and geophysical results are being prepared jointly by Gross, Hood, and Sangster for Survey publication.

In collaboration with P. J. Hood of the Geophysics Division as senior author, a paper describing the calibration and operation of an in situ susceptibility meter was submitted for Survey publication.

A final manuscript was prepared and submitted by D.F. Sangster for a GSC Bulletin on magnetite deposits of British Columbia, based on research for a Ph. D. thesis.

A geochemical investigation of magnetite was initiated by D.F. Sangster to study the trace element content in magnetites from a variety of deposits.

R.W. Boyle completed a manuscript for a Survey Bulletin on the geochemistry of silver.

M. Tauchid completed his research on the geochemistry of molybdenum in the Bathurst-Newcastle area of New Brunswick.

R. Martin completed analytical work and geological correlations on the geochemistry of the granitic rocks of New Brunswick.

K.L. Currie completed the study of the solubility of albite in supercritical water between 400 and 625°C. A publication is in preparation. Study of the solubility of microcline under the same conditions was commenced. Study of reaction of water with Belleoram granite was continued, under both non-equilibrium and quasi-equilibrium conditions.

He completed the construction of a new continuous flow apparatus for use up to 10 kilobars and 1000°C, and began the construction of a very high pressure apparatus for pressures up to 50 kilobars.

Dr. Currie completed a study of the occurrence of hafnium and zirconium in the Crow Lake granite, and a publication is in press. It was concluded that Hf and Zr show differential mobility during metamorphism.

He also continued experiments on features associated with craters. Sand box studies are in progress to elucidate the formation and shape of various types of craters. Experiments involving rapid heating of rocks to 1000°C were continued. A number of glassy phases, and unusual melting phenomena have been observed.

C.F. Gleeson completed a set of fourteen preliminary geochemical maps of the Keno Hill area, Yukon Territory. These have now been published.

He continued work on the preparation of a series of maps showing the distribution of Cu, Pb, Zn, As, Sb, W, Mn, Ni, Co, Ag and B in 6,000 stream sediment samples collected from the Keno Hill area, Yukon.

Dr. Gleeson in conjunction with R. Bolton studied methods of mechanically plotting geochemical data on maps. A program using an X-Y plotter was developed. In addition, statistical studies using computer analyses are continuing on the field and laboratory data obtained during Operation Keno. Analytical work is also continuing on heavy mineral samples from the Keno Hill area, Yukon.

E.M. Cameron researched and completed a paper on sampling errors in chemical studies of sedimentary rocks, and the desired relation between sampling and analytical precision. It was found that errors due to sampling vary greatly for different elements in the same rock. Thus if geochemical variation is to be used on a geological indicator or tool those elements subject to the least sampling error should be used.

The sample preparation laboratory under the supervision of P.J. Lavergne operated to capacity during the year. Mr. Lavergne also spent a month in Bathurst, New Brunswick organizing a field preparation laboratory and training personnel in sample preparation for Operation Bathurst. Mr. Lavergne's report on the operation of the preparation laboratory in Ottawa is given in Table 3 of the Appendix.

The trace element laboratory and field spectrographic laboratory (C. Durham in charge), both supervised by J.J. Lynch, operated at capacity during the year. The reports for both these laboratories covering operations in Ottawa and in the field are given in Tables 1 and 2. During the absence of Mr. Lynch in the field, the trace element laboratory in Ottawa was supervised by G. Mihailov.

The reports covering the operations of the moveable biogeochemical laboratory and direct reading spectrographic laboratory are given in Tables 5 and 6 respectively.

Attendance at Conventions

J.J. Lynch attended the Ottawa Symposium on Applied Spectroscopy.

C.C. Durham attended the Ottawa Symposium on Applied Spectroscopy and presented a paper entitled "A mobile spectrographic laboratory".

W. Dyck attended the 6th International C^{14} and H^3 dating conference in Pullman, Washington, June 7-11, and presented a paper entitled "Secular variations in the C^{14} concentration of Douglas Fir tree rings".

D.F. Sangster gave a talk to the Appalachian Discussion Group on the host rock geology of two lead-zinc deposits in Palaeozoic carbonate rocks (Pine Point and Western Newfoundland).

R.W. Boyle gave a series of lectures on thermodynamics in December at the University of New Brunswick, Mount Allison University, St. Francis Xavier University, Dalhousie University, Nova Scotia Technical College, Acadia University, and Memorial University under the auspices of the Canadian Institute of Mining and Metallurgy distinguished lecture series.

C. F. Gleeson attended the Society of Economic Geologists convention in Kansas City in November.

R. Horton attended the 1965 Ottawa symposium on Applied Spectroscopy.

E. M. Cameron presented a paper entitled "Geochemistry of Slave Point Formation, Western Canada", at the Geological Society of America meeting in November in Kansas City, Missouri.

Membership on Committees

J. J. Lynch served on a Mines Branch Technician Appraisal Board in March.

R. Horton was a member of the organizing committee of the 1965 Ottawa Symposium on Applied Spectroscopy and a member of the Exhibits Committee for the 1967 International Symposium on Spectroscopy.

E. M. Cameron was chairman of the Ottawa Branch of the Canadian Association for Applied Spectroscopy and is acting as the Convenor for the Geochemical Sessions of the 23rd Colloquium Spectroscopicium Internationale.

Personnel Notes

R. H. C. Holman resigned from the section in August to take up employment in geochemical exploration with a private company.

R. A. Washington resigned from the section in May to take up employment with Atomic Energy of Canada Limited, Ottawa.

D. F. Sangster joined the section in March.

J. C. Pelchat joined the section in June as a technician in the radioactive tracer laboratory.

During the year the section was pleased to assist in the training of a number of geologists and geochemists on the Colombo and other training plans. These included M. Ziauddin, Geological Survey of India at Hyderabad; P. Umar, Geological Survey of Pakistan; M. Carter, Geological Survey of British Guiana; M. Shafiqullah, Pakistan; and B. Fouroughi, Geological Survey of Iran.

Professor Gunther Friedrich, University of Aachen, Germany spent the summer with the section and took part in Operation Bathurst.

Trace Element Laboratory Report

J.J. Lynch

Table I. Summary of Analyses Completed in Trace Element Laboratory in 1965 (J.J. Lynch in charge).

Field Geologist	Type of Samples	Metals Analyzed	No. of Samples	No. of Analyses
		A) Field		
W. Tupper	Stream Sediments	Zn, Cu, Pb, As, Sb, Mo, W	3,508	25,524
		Totals	3,508	25,524
		B) Ottawa		
R.W. Boyle	Minerals	Zn, Cu, Pb, As, Sb, Ni, Co, Mo, W	90	545
C.F. Gleeson	Stream Sediments	Zn, Cu, Pb, As, Sb, Mo, W	427	3,088
J. Fortescue	Soils	Zn, Cu	2	8
J. Fortescue	Soils	Zn, Cu, Pb, Ni	358	1,474
C.F. Gleeson	Stream Sediments	Mo	4,637	4,831
C.F. Gleeson	Stream Sediments	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	41	370
C.F. Gleeson	Minerals	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	315	2,321
K.L. Currie	Waters	Na, K, Al, SiO_2, pH	9	45
C.F. Gleeson	Waters	Zn, Cu, Pb, Ni, Co, As, Sb	9	150
R.W. Boyle	Stream Sediments	Zn, Cu, Pb, Ni, Co, As, Sb	3	26
R.W. Boyle	Soils	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	21	315
H.A. Lee	Soils	Zn, Cu, Pb, Ni, Co.	81	405
D.C. Findlay	Rocks	Zn, Cu, Pb, Ni, Co	90	462
G.A. Gross	Rocks	Cu, As	4	10
S.M. Roscoe	Minerals	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	207	2,114
E.B. Owen	Sediment	Zn, Cu, Pb, Ni	1	8
S.M. Roscoe	Minerals	Pb	35	39
B. Liberty	Minerals	Pb	4	4
		Totals	6,334	16,215
		Grand Totals	9,842	41,739

Table II. Summary of Analyses Completed in Mobile Spectrographic Laboratory in 1965.

(C. Durham in charge)

A) Field

Field Geologist	Type of Sample	Metals Analyzed	No. of Samples	No. of Determ.
W. Tupper	Stream Sediment	Mn, Ba, Cr, Ni, Co, Sn, Ag	3508	25,634
		Total	3508	25,634
		B) Ottawa		
C.F. Gleeson	Stream Sediment	B, Mn, Mo, Sn, Cu, Ag, Ni, Co, Bi, Au	2718	27,180
		Total	2718	27,180
		Grand Total	6226	52,814

Table III. Summary of Samples prepared in Geochemistry Preparation Lab. in 1965.

(P.J. Lavergne in charge)

A) Field

Field Geologist	Sizing	Ball Mill (Paint Shaker)
W. Tupper	3508	3508
Total	3508	3508

Table III (cont'd.) B) Ottawa

Field Geologist	Grinding	Crushing	Sizing	Superpanner	Frantz	Ball Mill (Paint Shaker)	Heavy Liquid
E.M. Cameron	1000	1000				1000	
C.F. Gleeson	450	450	100			556	25
J.J. Lynch	5	5	5			15	
W. Tupper	75	75				75	
J.A. Chamberlain	15	15	15				
S.M. Roscoe	40	40	40			24	
R. Mulligan	13	13	13				10
W.D. McCartney							8
R.W. Boyle	155	155	155	80	25	50	
H.A. Lee	10	10				10	
R. Martin	140	140				140	
J. Fortescue						7	
Total	1903	1904	328	80	25	1877	43
Grand Total	1903	1903	3836	80	25	5385	43

Table IV. Seasonal Personnel employed by Trace Element Laboratory, Mobile Spectrographic Laboratory and Sample Preparation Laboratory.

Laboratory	Seasonal Personnel	
Trace Element (Ottawa)	Barbara Mathie	
Trace Element (Ottawa)	Donna McEachern	
Trace Element (Ottawa)	Judith Robinson	
Trace Element (Field)	Sandra Blundon	
Trace Element (Field)	Dianne Church	
Trace Element (Field)	Joyce Huculak	
Trace Element (Field)	Gerard MacGillivray	
Trace Element (Field)	Ida Smith	
Trace Element (Field)	Arlene Thompson	
Mobile Spectrographic	William Blann	(1)
Mobile Spectrographic	Georges Godin	(2)
Mobile Spectrographic	Malcolm Throp	
Sample Preparation (Ottawa)	F. Dagenais	(1)
Sample Preparation (Ottawa)	Robert Grey	(2)
Sample Preparation (Field)	Bernard Durepos	

(1) Resigned early in summer

(2) Replaced resigned personnel

Table V. Summary of Analyses Completed during the summer of 1965 Moveable Biogeochemical Spectrographic Laboratory.

Dr. J.A.C. Fortescue, Mr. E.H. Hornbrook (in charge) assisted by K. Aspila and D. Forman.

Project	Material	No. of Samples Analyzed	No. of Determ.	Elements
Mer Bleue[3]	Organic soil	156	2028	(13[1], see below)
Iroquois Falls	"	75	975	"
Silvermine Cape Breton I.	Plants Humus	301	3913	"
Biogeochemical Greenhouse	Plants	105	1365	"
Texas Gulf Sulphur, Timmins	Plants Humus	426	5538	"
Moose River	Plants and Humus	122	1586	"
		Total 1185	15,405	

Notes: 1) Thirteen elements were determined in each sample (Zn, Mn, Cu, Mo, Ba, Sr, Ti, Pb, Ni, Co, Cr, and Ag). A small amount of indium was added to each sample during preparation and this element was determined in each sample as a reference standard.

2) This number includes some 7 per cent of standards and check samples.

3) The Mer Bleue samples were collected during 1963.
Silvermine samples were collected during 1963.
Greenhouse samples were collected during 1963 and 1964.
Texas Gulf Sulphur samples were collected during 1964.
Iroquois Falls samples were collected during 1964.
Moose River samples were collected during 1965.

Direct Reading Spectrochemistry Laboratory

E. M. Cameron and R. E. Horton

Most of the production work in the laboratory is carried out during the summer when seasonal staff are available. During the summer of 1965 Mr. Horton and three assistants carried out the following analysis.

Table VI. Summary of Analyses during 1965 by Direct Reading Spectrochemistry Laboratory.

Donor	No. of Samples	No. of Determinations	Time spent (days)
K. L. Currie	111	777	19
J. A. Fortescue	129	903	20
R. Martin	124	868	23
T. Pierce	68	204	13
J. K. Norris	81	81	9
J. S. Scott	107	107	7
B. R. Pelletier	20	20	2
E. M. Cameron	1694	15,204	46
Total	2334	18,164	139

During the year development work was carried out on two fronts. An ultra-rapid, but precise analytical method, was devised for Cameron's carbonate samples, which are of very uniform matrix. Both major and trace elements can be determined on a single sample pellet. Also a new method was devised for analysis of sodium. The other development was to convert the Quantograph to digital output. The electrometer output voltages are now being converted in per cent concentration by directly feeding the data to the Department's computer. This, in part, accounts for the high output per man day achieved during the summer. Much of the credit for this successful conversion and also the excellent service record of all instrumentation must be given to Mr. F. W. Jones.

Outside Publications

Boyle, R.W.

1965: The geochemistry of silver in the Keno Hill-Galena area, Yukon; Vernadsky Memorial Volume, Akad Sci. U.S.S.R. Moscow.

1965: The geochemistry of arsenic, Keno Hill area, Yukon, Canada; Geol. Metall. Inst. India. Volume in honour of Dr. D.N. Wadia.

1965: The geochemistry of cadmium in the lead-zinc-silver deposits of the Keno Hill area, Yukon, Canada: Akad. Sci. U.S.S.R. Volume in honour of Academician, A.P. Vinogradov.

1965: Moorhouseite and aplowite, new cobalt minerals from Walton, Nova Scotia - J.L. Jambor and R.W. Boyle. Can. Mineralogist, vol. 8, pat. 2, pp. 166-171.

Cameron, E.M.

1965: The application of geochemistry to stratigraphic problems in Lower Cretaceous of Western Canada; Bull. Amer. Assoc. Petr. Geol., vol. 49, pp. 62-80.

1965: Geochemistry of Slave Point Formation, Western Canada; (Abstract) Geol. Soc. America, Program 1965 Annual Meeting.

Currie, K.L.

1965: Analogues of lunar craters on the Canadian Shield; N.Y. Acad. Science Annals, vol. 123, art. 2, pp. 915-940.

1965: The geology of the New Quebec Crater; Can. J. Earth Sciences, vol. 2, pp. 141-160.

Dyck, W., Fyles, J.G., and Blake, W., Jr.

1965: Geological Survey of Canada Radiocarbon Dates IV; Radiocarbon, vol. 7, pp. 24-26.

Sangster, D.V.

1965: Colloform magnetite in a contact metasomatic iron deposit; Econ. Geol., vol. 60, pp. 824-826.

PLEISTOCENE GEOLOGY SECTION

J.G. Fyles

This section is engaged in geological investigation of the latest or Quaternary Period and deals with surficial, unconsolidated deposits mantling the bedrock, organic remains associated with them, constructional and erosional landforms making up the landscapes, and geological processes and changes active on the surface of the earth both today and in the past. The Pleistocene Section endeavours to contribute to general knowledge within this field and to carry activities throughout Canada in so far as staff permits.

Most projects undertaken during the year deal with deposits, geomorphology, and Quaternary history of areas, and provide data applicable in a number of other fields. Other projects have narrower objectives, such as development of mineral exploration techniques, solution of chronological problems, documentation of recent climate change, determination of rates of uplift, etc. On several field projects, data were collected relative to present geological processes, such as deltaic sedimentation in a lake, mass movements in mountainous terrain, soil development and movement under permafrost conditions, and marginal fluctuation of glaciers. Moreover, a number of projects were undertaken to meet requests for information in various fields including forestry, agricultural soils, land inventory (ARDA), and engineering. Projects in the Columbia and Peace River valleys are scheduled in advance of completion of hydroelectric reservoirs. Field projects were carried out by fifteen officers of the section, one professor, and one Ph.D. candidate in eight provinces, Yukon, and Northwest Territories. In addition a second Ph.D. project was carried as a sub-party and three professors were engaged in the field for short periods as consultants. Accounts of the objectives and results of the field projects are given in Geological Survey of Canada Paper 66-1.

Investigations supporting the field activities were carried out by the Sedimentology Laboratory, the Quaternary Palynology Laboratory, and by a number of laboratories operated by other units of the Geological Survey. The dating program of the Radiocarbon Laboratory (Petrological Sciences Division) is largely organized by the Pleistocene Section and directed towards the research of the section. During the year a cool storage room and a freezer chest were obtained to aid in storage and preservation of sediment cores and organic samples.

The Pleistocene Section was indeed fortunate in being granted positions for three new geologists in addition to the replacement for Dr. Mirynech, who had resigned during 1964. Three officers of the section were assigned to the Calgary office during the year.

Field and Office Activities

W. Blake, Jr. took part in 'Operation Amadjuak' in southern Baffin Island, concentrating on glacial deposits and landforms, raised marine features, late Quaternary chronology. Information was also collected on current variation in the position of glacier margins. Blake was assisted by F.M. Synge of the University of Leicester, who has carried out extensive Pleistocene studies in Ireland. Blake is preparing a preliminary account of these investigations and a final report on his earlier studies in the Bathurst Inlet area. He has shared in preparation of 'Geological Survey of Canada Radiocarbon Dates V'.

In conjunction with W. Blake, Jr., K.R. Everett of the U.S. Army Natick Laboratory initiated studies of soil development and movement on southern Baffin Island. He also carried out similar studies on Ellef Ringnes, Prince Patrick, and Victoria Islands with support from the Polar Continental Shelf Project.

B.G. Craig made a brief, preliminary reconnaissance of the Cree Lake and associated moraines in northern Saskatchewan and, in conjunction with R.W. Klassen studied The Pas Moraine in Manitoba. He spent a week with Dr. E.A. Christiansen of the Saskatchewan Research Council in the Battleford area, Saskatchewan, and is preparing a joint publication with Christiansen regarding the surficial geology of part of this area. Craig also took part in the Alaska field conference of INQUA and spent two days in the Dawson area, Yukon, with O.L. Hughes. He prepared a short report on moraines in northwestern Baffin Island and northeastern Keewatin, published as Geological Survey Paper 65-20, and organized a display for the INQUA Congress. Bulletin 122 on Glacial Lake McConnell was published by the Geological Survey at the end of the year.

R.J. Fulton continued Quaternary geology investigations in the southern interior of British Columbia, completing his study of the Vernon map-area and commencing a study of the parts of the Columbia River valley to be flooded by the Columbia River Development Project. The latter involved general investigations at the Duncan Lake dam and in the Revelstoke-Arrow Lakes area as well as a bottom sediment sampling program at the head of Upper Arrow Lake. He also set up and led part of the INQUA Pacific Northwest Field Conference passing through his Nicola map-area and the adjoining country to the west. A memoir on the surficial geology of the Nicola and Vernon area is in preparation.

J.G. Fyles spent one month in the Mackenzie delta and Arctic Coast region (N.W.T. and Yukon) on a preliminary survey of Quaternary stratigraphy. He also made brief visits to the southern interior of British Columbia and the Iosegun area of Alberta in connection with the field projects of R.J. Fulton and D. St. Onge, and briefly examined surficial deposits in the Peace River damsite and reservoir area to aid in planning a field program to start next year. At the close of the field season he conferred with officers of the Alberta Research Council and the Alberta Department of Lands and Forests in Edmonton regarding Pleistocene section projects in Alberta, and with O.L. Hughes and

N. Rutter in Calgary. Fyles also carried section administrative duties, organized the radiocarbon dating program (see below), took part in preparation of Geological Survey of Canada Radiocarbon Dates V, and served as chairman of the Canadian Delegation to the INQUA Congress.

N.R. Gadd completed areal investigation of the surficial geology of the Chaudiere River valley region, Quebec, with particular reference to glaciation, and studied the occurrence of placer gold and of asbestos-bearing boulders in the same region. Gadd also acted as field supervisor for B.C. McDonald in the Richmond-Sherbrooke area, Quebec. He is preparing a final report on his surficial geology studies in the Ottawa area.

E.P. Henderson commenced systematic areal investigation of surficial geology in the Gananoque-Brockville area, Ontario, as an extension of his earlier work in the adjoining area to the west. He also began a regional study directed towards outstanding problems of glaciation, Champlain Sea, and subsequent changes in the eastern lowland of Ontario between the Ottawa and St. Lawrence River. His map of the surficial geology of the Kingston-Gananoque area has been submitted for publication.

O.L. Hughes completed investigation of Quaternary and late Tertiary deposits and geomorphology in the Klondike placer area, Yukon, and commenced a study of the sequence of glaciations and other aspects of Quaternary geology in the southwest Yukon. Under Hughes direction V. Rampton began a Ph.D. thesis project in the Snag area as part of the southwest Yukon program. For a two week period, Professor Anders Rapp, University of Uppsala, accompanied Hughes on an examination of mass wasting features in central and southern Yukon. Following the field season, Hughes transferred to the Calgary Office of the Geological Survey and heads the small group of Pleistocene geologists at Calgary. Earlier in the year, he directed the program of the Sedimentology Laboratory in Ottawa. Hughes collaborated with J.A.C. Fortescue in continuation of a study of a geochemical anomaly in till related to an orebody (Geological Survey Paper 65-2, pp. 23-27) by planning the drilling grid and logging Shelby-tube samples.

P.F. Karrow of the Department of Earth Sciences, University of Waterloo, commenced study and mapping of the surficial geology of the Stratford and Conestago map-area, southern Ontario, to provide background data for detailed soils mapping of Waterloo county. It is an extension of Karrow's investigations for the Ontario Department of Mines and was taken up by the Geological Survey, at the request of the Canada Department of Agriculture, after the Ontario Department of Mines discontinued its Pleistocene program.

R. W. Klassen joined the staff of the Geological Survey during the spring, after spending the winter as a "seasonal" assistant, and transferred to the Calgary office of the Geological Survey in October. During the field season he carried out reconnaissance study and mapping of the surficial geology of the Interlake area, Manitoba. This project was undertaken at the request of A. R. D. A. to provide background information for land-inventory programs. As an outgrowth of the Interlake project, Klassen made a brief investigation of the Pas Moraine in conjunction with B. G. Craig. He also made selected observations along the Assiniboine Valley and its tributaries. (Manitoba and Saskatchewan) in preparation for a study of the history of the valley system. He is preparing a preliminary map of the Interlake area and is modifying his doctoral dissertation on the Riding Mountain map-area, Manitoba, for publication as a memoir of the Geological Survey.

H. A. Lee returned to the Geological Survey in May following an 8-month period as visiting lecturer at the University of New Brunswick. During the field season he made observations at a number of places in New Brunswick to round out his Quaternary investigations in that region and conducted brief investigations in northern Ontario in connection with his program in the Kirkland Lake area on the use of glacial geology in mineral exploration. He prepared a report on investigation of eskers for mineral exploration, published as Geological Survey Paper 65-14, has drawn up plans for a further stage of development of mineral exploration techniques, and is designing a display illustrating these techniques for an exhibit at the Mining and Metallurgy show in Toronto, May 1966. Lee is also preparing an account of the Quaternary history of Hudson Bay for inclusion in the Hudson Bay Centennial Volume. On behalf of the section, he has undertaken appraisal and interpretation of the experimental infra-red imagery prepared for the Geological Survey.

Captain Le Menestrel of the Scientific and Technical Unit of the French Military Service commenced a 6-month association with the Geological Survey and is preparing a geomorphological map of part of the Ottawa area under the guidance of N. R. Gadd and D. St. Onge. Le Menestrel is in Canada for one year to gain experience in topographic surveying and in geomorphology.

C. F. M. Lewis joined the Geological Survey in August and has begun a project aimed at geological appraisal of changes of lake level and tilt in the Lake Huron basin during the last few thousand years.

B. C. McDonald, a seasonal employee, completed investigation and mapping of surficial deposits and glacial geomorphology in the Richmond-Sherbrooke area, Quebec, under the direction of N. R. Gadd. He has prepared and submitted surficial geology maps of the area for publication by the Geological Survey and is compiling a report on the project as his Ph. D. dissertation at Yale University.

R. J. Mott commenced a palynological program in Saskatchewan designed to provide information in late-glacial and post-glacial vegetational and climatic changes and geochronology, including changes in forest-grassland relations. He also continued his varied duties in the palynology laboratory and in support of programs of J. Terasmae.

V. K. Prest continued preparation of the new Pleistocene Map of Canada and of the Pleistocene geology chapter of the forthcoming centenary edition of Geology and Economic Minerals of Canada. In connection with these projects, he made specific field observations in western Quebec and Ontario, visited various areas and individuals in Western Canada, and took part in two INQUA field conferences.

N. Rutter joined the Geological Survey at Calgary in November. He is preparing a report and map illustrating surficial geology and erodability of slopes in part of the Bow River Valley, Alberta, and is preparing for a surficial geology survey of the Peace River dam and reservoir area in advance of flooding.

D. St. Onge joined the staff of the Geological Survey in April. During the field season he studied and mapped the surficial deposits and geomorphology of the Iosegun area, Alberta. This project was undertaken at the request of the Alberta Department of Lands and Forests; air photographs and field office facilities were supplied by that Department. The map and report on the area are being designed to meet the needs of forestry. In answer to a request from the Canada, Department of Forestry, St. Onge has prepared a detailed map and short report on a small section of the Iosequn area. While in the field he exchanged visits with M. Roed, who is engaged in similar studies in the adjoining Edson area on behalf of the Alberta Research Council. During the year St. Onge's geomorphological map of Lancer, Saskatchewan was published by the Geographical Branch.

A. M. Stalker continued investigation and mapping of surficial geology in the Kananaskis area, Alberta (east of the Continental Divide), concentrating this year on the northeastern part of the area. Detailed maps were prepared of the Kananaskis' experimental station of the Canada Department of Forestry and of the Marmot Creek basin (a watershed research basin nearby). He also made further progress in tracing the Foothills Erratico Train and in stratigraphic study of Quaternary exposures along various rivers in southern Alberta. His map of the surficial geology of the Bassano area, Alberta, was published by the Geological Survey as Map 5-1965. C. S. Churcher of the Department of Zoology, University of Toronto was attached to Stalker's party for approximately one month as a professional consultant and collected vertebrate fossils from various Quaternary deposits in southern Alberta and Saskatchewan. Seventeen potential sites were visited of which 11 were fossiliferous and 2 were of archeological interest.

J. Terasmae (activities listed under Quaternary Palynology Laboratory).

Quaternary Palynology Laboratory

J. Terasmae

Laboratory and field investigations were carried out during the year by J. Terasmae and R.J. Mott, assisted by T.W. Anderson (winter seasonal) and summer assistants. Reports were prepared on materials submitted for analysis and identification by officers of the Geological Survey, by other governmental agencies, and by several scientists at universities. The laboratory has provided technical assistance and introductory training in palynological and limnological methods for several geology and botany students from Canadian universities.

Research Activities

Terasmae and Mott collected samples for palynological studies and radiocarbon dating in connection with various programs of the Geological Survey. In particular samples were collected in Nova Scotia in Cape Breton Island and the adjoining Port Hood Island, and in Quebec at Mount St. Hilaire, in the Sherbrooke area, and in the Chaudière Valley.

Investigation of modern airborne pollen distribution was continued during the year and included a cooperative program with the Plant Research Institute, Canada Department of Agriculture. A study of modern pollen desposition in bogs of the Nichicun Lake area, northern Quebec, was completed by Terasmae and Mott and results reported in an outside publication.

Work continued on a joint program with the Forest Research Branch, Canada Department of Forestry at Iroquois Falls, Ontario to investigate the growth of black spruce on muskeg and the development of forest sites in post-glacial time. Several sediment cores from lakes and bogs in the test area were collected for palynological study and radiocarbon dating.

Terasmae continued investigating recent climate trends in the Great Lakes region by means of ecological-sedimentological-palynological study of bog, pond, and lake deposits. Work was also continued on limnological investigations designed to provide modern control date for the above program.

R.J. Mott commenced a palynological program in Saskatchewan (reported separately above).

Stratigraphic drilling of the deposits occupying the buried St. David's Gorge at Niagara Falls, Ontario was undertaken at the end of the year, as well as drilling to supplement data on the Port Talbot interstadial beds and associated stratigraphic units.

Sedimentology Laboratory

Five hundred and seventy five analyses and preparations of 7 different types were completed during the year by the laboratory staff consisting of D.E. Field (in charge) and R.G. Kelly. Mr. G.S. Campbell served as summer assistant. A break-down of analyses and preparations into categories, with comparative figures for 1964, is given below.

	1964	1965
Complete sieve and pipette analyses	137	182
Sieve analyses	65	97
Heavy mineral separations	46	52
Slide Preparation	80	10
Ca/Mg ratios, chittick apparatus	87	113
Micro-fossil preparations	108	82
Atterberg limits	20	39
Natural water determinations	47	-

In addition to the systematic work of the laboratory staff, the laboratory facilities were used for a variety of separations and tests by a number of officers of the Geological Survey, by a few scientists from other branches of the government, and by a few visitors from the local universities. Mr. Kelly spent three weeks working with O.L. Hughes in the engineering geology laboratory, opening core samples.

Radiocarbon Dating Program

As in former years, samples for age determination in the Radiocarbon Dating Laboratory were selected by an informal committee of the Pleistocene Section. Currently the committee includes W. Blake Jr., J.G. Fyles (Chairman), and J.A. Lowden, together with other members of the staff as appropriate to the samples under consideration. During the year approximately 200 age determinations were made on about 175 samples applying to a wide range of Quaternary chronological problems (in addition to geochemical determinations originating within the laboratory). This total includes about 20 archaeological dates for the National Museum of Canada.

Attendance at Meetings

W. Blake, Jr., B.G. Craig, H.A. Lee, D. St. Onge and J. Terasmae attended the Symposium on Glacier Mapping in Ottawa during September. J. Terasmae led a field trip in the Ottawa-Cornwall area associated with this conference.

J.G. Fyles and B.G. Craig presented the subject of recent uplift at the Upper Mantle workshop in Ottawa early in the year. Fyles also talked to the Logan Club and to the Pleistocene Discussion Group at the Lamont Geological Observatory, Palisades, New York.

N.R. Gadd attended the 57th annual meeting of the New England Intercollegiate Geological Conference and took part in field trips in the Kennebec River valley and wind-eroded areas in Maine. He presented a talk on deglaciation of southern Quebec to the Miller Geology Club, Queen's University in March, and assisted B.A. Liberty in leading a field trip on the geology of the Ottawa area for the Geography Club, Brookfield High School, Ottawa, in November.

E.P. Henderson, R.W. Klassen, and A.M. Stalker took part in the eastern Pleistocene "Friends" Conference on Long Island, New York, and J. Terasmae and R.J. Mott attended the mid-western conference in Iowa.

H.A. Lee attended the annual meeting of the Geological Society of America at Kansas City. While visiting lecturer at the University of New Brunswick during the early part of the year, he gave public lectures on mineral exploration using glacial geology both at the University of New Brunswick and at the University of Maine.

D. St. Onge took part in the Alberta Society of Petroleum Geologists field conference in the Cypress Hills in September, acted as bus guide for part of the trip, and presented a talk on the part of the area covered by his investigations during 1964. He also attended the annual meeting of A.C.F.A.S. in Montreal, where he read a paper on the geomorphological map of Lancer, Saskatchewan.

J. Terasmae and R.J. Mott attended the meeting of the Canadian Botanical Association at Carleton University and Terasmae lead a field excursion in the Ottawa area associated with this conference. In April, Terasmae visited the Geochronology Laboratory and Laboratory of Tree Ring Research at the University of Arizona.

The INQUA CONGRESS in Boulder, Colorado, was attended by R.J. Fulton, J.G. Fyles, V.K. Prest, N. Rutter, A.M. Stalker and J. Terasmae. Fyles acted as chairman of the Canadian delegation.

Seven of the INQUA Field Conferences were attended by officers of the Geological Survey. N.R. Gadd took part in the New York-New England trip. J. Terasmae attended the Great Lakes trip and presented a talk at the Symposium associated with the Upper Mississippi Valley Field Conference. V.K. Prest attended the Great Plains Conference and A.M. Stalker attended the Rocky Mountain Conference. R.J. Fulton, J.G. Fyles, and V.K. Prest took part in the Pacific Northwest trip; Fulton acted as guide for part of this conference and

Fyles presented a paper at the symposium associated with it. O.L. Hughes and B.C. Craig attended the Alaska Field Conference.

Outside Publications

Blake, W., Jr., Olsson, I.V., and Srodon, Andrzej.
1965: A radiocarbon dated peat deposit near Hornsund, Vastspitsbergen, and its bearing on the problem of land uplift; Norsk Polar-institutt Arb. 1963, pp. 173-180.

1965: The Late Pleistocene chronology of Nordaustlondet, Spitsbergen; in Vortrage des Fridtjof-Nansen-Gedachnis-Symposions über Spitsbergen, Ergebisse der Staufferland-Expedition 1959/60: Franz Steiner Verlag, Wiesbaden, Heft 3, p. 29 (abstract).

Clayton, L., Laird, W.M., Klassen, R.W., and Kupach, W.O.
1965: Intersecting minor lineations on Lake Agassiz Plain; J. Geol., vol. 73, pp. 652-656.

Craig, B.C., and Fyles, J.G.
1965: Quaternary of Arctic Canada; in Markov, G.F. et al., eds., Antropagen period in the Arctic and Subarctic; U.S.S.R. Research Inst. of the geology of the Arctic, Trans., vol. 143, pp. 5-33 (in Russian).

Dreimanis, A., Terasmae, J., and McKenzie, G.D.
1965: The Port Talbot Interstadial of the Wisconsin glaciation; VII Internat. Congress INQUA, Boulder, Colorado, pp. 108-109.(abstract).

Dyck, W., Fyles, J.G., and Blake, W. Jr.
1965: Geological Survey of Canada radiocarbon dates IV; Radiocarbon, vol. 7, pp. 24-46.

Fulton, R.J.
1965: Silt deposition in late-glacial lakes of southern British Columbia; Am. J. Sci., vol. 263, pp. 553-570.

Fyles, J.G., and Blake, W., Jr.
1965: Glaciation of the northwestern Canadian Arctic Islands; VII Internat. Congress INQUA, Boulder, Colorado, p. 156 (abstract).

Harrison, W., Malloy, R.J., Rusnak, G.A., and Terasmae, J.
1965: Possible late Pleistocene uplift, Chesapeake Bay entrance; J. Geol., vol. 73, pp. 201-229.

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

Rutter, N.W.
1965: A late Pleistocene ? glacial advance, Bow River Valley, Canadian Rocky Mountains, Alberta, Canada; VII Internat. Congress INQUA, Boulder, Colorado, p. 405 (abstract).

1965: Foliation pattern of Gulkana Glacier, Alaska Range, Alaska; J. Glaciology, vol. 5, No. 41, pp. 711-718.

St. Onge, D.
1965: Notes on the geomorphological maps of Ellef Ringnes Island, N.W.T.; Instituto Panamericano de Geografia e Historia, Reunion des Cartas Especiales, Ottawa, Ontario, pp. 97-112.

Stalker, A.M.
1965: Pleistocene ice surface, Cypress Hills area; Alberta Soc. Pet. Geol., 15th Ann. Field Conf. Guidebook, Part 1, pp. 116-130.

Terasmae, J.
1965: A review of palynological studies in eastern Maritime Canada; Maritime Sediments, vol. 1, No. 2, pp. 19-21.

1965: Postglacial chronology and forest history in the northern Lake Huron and Superior region; VII Internat. Congress INQUA, p. 463 (abstract).

1965: Problems of Quaternary Palynology in the Canadian Arctic; VII Internat. Congress INQUA, pp. 464-465 (abstract).

Terasmae, J., Mott, R.J.
1965: Modern pollen deposition in the Nichicun Lake area, Quebec; Can. J. Bot., vol. 43, pp. 393-404.

Webber, P.J., Terasmae, J., and Andrews, J.T.
1965: A study of late-Quaternary plant bearing beds in north-central Baffin Island, Canada; VII Internat. Congress INQUA, pp. 496-497 (abstract).

Membership on Committees

W. Blake, Jr. - Geological Survey Radiocarbon Dating Committee.

B.G. Craig - Canadian Air Photo Interpretation Committee.
- Subcommittee for Pleistocene Shorelines for the Americas, International Shoreline Commission, INQUA.

J.G. Fyles	- Subcommittee on Permafrost, Associate Committee on Soil and Snow Mechanics, N.R.C. - Geological Survey Radiocarbon Dating Committee. - Advisory Committee for Symposium on Till, Extension Department, University of Alberta.
N.R. Gadd	- Geological Survey Equipment Committee.
V.K. Prest	- Royal Society of Canada, Geology Membership Committee.
D. St. Onge	- Corresponding member, Commission on Periglacial Studies, I.G.U. - Corresponding member, Subcommission on Geomorphological Mapping, I.G.U. - Co-opt councillor, Canadian Association of Geographers.
A.M. Stalker	- Subcommittee on Pleistocene Geology, National Advisory Committee on Research in the Geological Sciences.
J. Terasmae	- Advisory Committee on Geology, Toronto Rapid Transit Subway Extension. - Subcommittee on Muskeg, Associate Committee on Soil and Snow Mechanics, N.R.C.

ENGINEERING AND GROUNDWATER GEOLOGY SECTION

I.C. Brown

The section's responsibilities remain the same as described in previous annual reports and consist briefly of research in the fields of hydrogeology and engineering geology and assistance and advice in both fields to other government agencies on request.

The groundwater part of this section will be leaving the Geological Survey to join the new Water Research Branch announced in September. However, its functions during the entire calendar year were conducted as a unit of the Geological Survey of Canada.

Studies of groundwater flow systems within type drainage basins continue to be the main focus of research and one new basin study was started in an area of high relief southeast of Kelowna, British Columbia.

Cooperation and exchange of information with provincial groundwater agencies continue to increase. A cooperative representative basin study was arranged with the province of New Brunswick and will be carried on with the cooperation of their newly appointed groundwater man, Mr. L.V. Brandon.

Considerable time and effort were put into coordination of International Hydrologic Decade projects following the approval by the government of the I.H.D. program. I.C. Brown participated in meetings with all the provincial committees to coordinate planning of instrumentation for representative and experimental basin studies.

A new method of measuring water pressures in piezometers by the use of pressure transducers in a sealed system was developed and worked successfully on the slope stability study program and on the south Saskatchewan Reservoir project.

H.G. Acres and Company continued development of the groundwater model prototype, but because of difficulties in the design of pressure sensing elements this was not delivered during the year.

Due to rewriting of the ARDA agreements with the provinces no coordinating meeting was held on groundwater research in the Prairie Provinces, but it was agreed that these meetings are useful and they will be started again under the Chairmanship of I.C. Brown.

Summary of Field and Office Activities

The observation well program changed emphasis under the guidance of M.L. Parsons and J.A. Gilliland. This change in emphasis involved installation of experimental observation wells at Iroquois Falls, Ontario, Carberry, Manitoba, Cypress Hills and Moose Mountain areas, Saskatchewan. These consist of a central observation well and satellite piezometers designed to give information on how far the results from an observation well can be reliably extrapolated.

Numerous requests for groundwater and engineering geology information continued to be received from individuals, industries, drilling companies, consultants, and other government departments. These were answered in detail where we had specialized knowledge of the problem or were referred to the increasingly active provincial government agencies where they had more recent or accurate knowledge.

I.C. Brown attended international meetings and visited groundwater and hydrology labs in England and Holland.

P.A. Carr conducted initial studies of relationship of fresh groundwater to salt groundwater in coastal-areas. First of a series of piezometers were installed for the purpose of studying groundwater flow systems in a coastal area near Charlottetown, Prince Edward Island.

J.E. Charron completed studies of groundwater in the Red River Valley in Manitoba. Conducted studies of small flow systems using dyes as tracers.

L.D. Delorme assisted P. Carr in studies in Prince Edward Island and started planning a program of palaeohydrogeological studies in the prairie region.

R.A. Freeze completed studies of the application of computer methods to analysis of groundwater flow systems under prairie conditions at Berkeley. Spent a short field season checking instrumentation in Good Spirit Lake Basins.

J.A. Gilliland assisted M.L. Parsons in installing experimental observation wells. Following field season looked into application of electronic data storage and processing for observation well network use. Also investigating types of recording instruments best suited to use with electronic handling of data.

E.C. Halstead completed surficial mapping of southern Vancouver Island and installed instruments on two small basins for future water balance studies. Also visited the site of the Queen Elizabeth Observatory, Mount Kobau, to advise on possible sources of water supply.

D.W. Lawson started hydrogeological study of Trapping Creek Basin, British Columbia. This consisted of mapping surficial deposits and installation of piezometers and stream gauges required for determination of underflow at outlet of basin.

A. Lissey continued studies of Oak River Basin, Manitoba. This seasons work involved further instrumentation to determine regional flow systems and pump tests to provide quantitative data on the materials in the basin so that an electrical analog model could be constructed for future studies.

P. Meyboom continued the third phase of his major study of groundwater replenishment under prairie conditions. This study is taking place within the Assiniboine River basin. This part of the study was specifically of groundwater flow systems in a till plain of Moose Mountain area, Saskatchewan.

E.B. Owen at request of NANR visited five potential dam sites in the Yukon drainage area and mapped three of these. Also spent considerable time providing engineering consultation on Welland Canal Twinning Project to Seaway Authority.

M.L. Parsons installed experimental observation wells at Iroquois Falls, Ontario; Carberry, Manitoba; Cypress Hills and Moose Mountain, Saskatchewan. He also installed observation wells and piezometers in the Wilson Creek Experimental Watershed to assist the study of water balance and erosion control by the provincial agencies.

R.G. Pearce visited and maintained observation wells in Western Canada.

J.S. Scott installed pressure transducers on sealed piezometers installed in Bearpaw shales near the South Saskatchewan River south of Lucky Lake. This was for the purpose of developing a method of obtaining instantaneous response to changes in groundwater pressure in a slide area. He also spent some time near Vernon, British Columbia advising on control of a flowing artesian test hole. Dr. Scott continued providing advise and assistance on the groundwater aspects of the Winnipeg Floodway. As Chairman of the Till Characterization Subcommittee, Scott is preparing the second draft of the Till Manual to incorporate comments received on the previous draft.

R.O. van Everdingen continued studies of groundwater flow near and under the South Saskatchewan Reservoir as flooding process. Pressure transducers were installed on a number of piezometers. These will make it possible to study pressure changes beneath the reservoir even though the instruments are submerged.

Personnel Notes

L.D. Delorme joined our staff of hydrogeologists from the University of Saskatchewan.

The following three men returned to university to continue their graduate studies: D.W. Lawson, to University of Guelph, A. Lissey, to University of Saskatchewan, M.L. Parsons, to the University of Michigan.

R.A. Freeze returned from his graduate studies at Berkeley.

P. Meyboom and L.D. Delorme moved to the Calgary offices of the Geological Survey. Dr. P. Meyboom delivered lectures on groundwater at the major Ontario universities under the auspices of the National Advisory Committee on Research in the Geological Sciences, Lecture Tour program.

P.A. Carr moved to Dartmouth to work from the B.I.O. laboratories.

Membership on Committees

I.C. Brown - Subcommittee on Pleistocene Geology, National Advisory Committee on Research in the Geological Sciences.

- Chairman, ARDA Committee for Coordination of Groundwater Research Programs in the Prairie Provinces.
- Groundwater Advisory Committee, Research Council of Alberta.

P. Meyboom
- Subcommittee on Hydrology, N.R.C. Associate Committee on Geodesy and Geophysics.
- Associate Editor, Hydrology, Canadian Journal of Earth Sciences.
- Member, Editorial Board, Journal of Hydrology.

J.S. Scott
- Member, N.R.C. Associate Committee on Soil and Snow Mechanics.
- Chairman, Till Characterization Committee of the Subcommittee on Pleistocene Geology, National Committee on Research in the Geological Sciences.
- Chairman, Ottawa Geotechnical Group.
- Associate Editor, Canadian Geotechnical Journal.

Attendance at Meetings

I.C. Brown
- W.M.O. - I.A.S.H. Symposium on Design of Hydrometeorological Networks, Quebec.
- I.A.H. Congress, Hannover, Germany.
- U.N.E.S.C.O. - I.A.S.H. Symposium on Representative and Experimental Basins, Budapest, Hungary.
- I.A.S.H. Symposium of Hydrology of Fractured Rocks, Dubrovnik, Yugoslavia.
- Visits to British and Dutch Groundwater Agencies.

P.A. Carr
- I.A.H. Congress, Hannover, Germany.

R.O. van Everdingen - I.A.H. Congress, Hannover, Germany.

J.S. Scott,
E.B. Owen
- Sixth International Conference on Soil Mechanics and Foundation Engineering, Montreal.

E.B. Owen
- International Association for Quaternary Research, Field Trip, Alaska.

Outside Papers Submitted

P. Meyboom
- "Unsteady groundwater flow in Hummocky Moraines"; J. Hydrology.

R.O. van Everdingen - "Use of pressure transducers in piezometers in bedrock"; J. Hydrology.

Internal Reports

E.B. Owen
- Geological sections and descriptive notes on Welland Canal Twinning Project (two reports).
- Report on hydroelectric power resources of Porcupine, Peel, and Rat River region, Yukon and N.W.T. (for NANR).

E.C. Halstead
- Two internal reports on water supply for Queen Elizabeth Observatory.

I.C. Brown
- Report on International Symposium on Network Design, Quebec.
- Report (to come) on IAH Congress, Hannover; Representative and Experimental Basin Symposium, Budapest; Karst Hydrology, Dubrovnik.

Topical Reports

P.A. Carr
- 106 Geological and Hydrogeological Reconnaissance of Wilson Creek Basin, Manitoba.
- 107 Brief Appraisal of Hydrogeology near Carberry, Manitoba.

J.E. Charron
- 111 Measuring and Tracing Groundwater Movement with dye tracers in Red River Valley, Manitoba.

E.C. Halstead
- 101 Water Supply of Queen Elizabeth Observatory, Mount Kobau, British Columbia.

E.B. Owen
- 99 Porcupine Dam Site, Stewart River, Yukon.
- 100 Independence Dam Site, Stewart River, Yukon.
- 102 Five Mile Rapids Dam Site, Stewart River, Yukon.
- 103 Upper Canyon Site, Francis River, Yukon.
- 105 Hool Canyon Dam Site, Pelly River, Yukon.
- 110 Geological Conditions on Welland Canal Twinning Project.

GEOPHYSICS DIVISION

L.W. Morley, Chief

INTRODUCTION

During 1965 the Geophysics Division was reorganized into seven sections. The purpose of this was to spread authority and responsibility amongst the senior specialists of the division, rather than continue as previously with much of the authority and responsibility centred in the office of the Division Chief. More easily identified boundaries between the functions of the sections now exist. At the time of the reorganization there was considerable discussion as to whether the sections should be organized by discipline or by geographic and geological responsibility. The former method was selected both because of the small size of the division and the feeling that unless the disciplines were strong, they would not be properly equipped to serve the Geological Survey. The importance of providing assistance and advice in inter-disciplinary studies of specific areas was not overlooked and in future expansion of these aspects should receive high priority.

HIGHLIGHTS

An historic assault on the study of Hudson Bay, by Marine Sciences, the G.S.C., and the Dominion Observatory, in which the Geophysics Division played a key role was successfully carried out in August and September. Scientists in the C.G.S. "Hudson" and a charter vessel obtained valuable data on both crustal and shallow seismology, gravity, magnetism, water temperatures, and salinity, currents, and bottom sediments. Five universities provided seismic shore parties for the crustal seismic investigations. The Geophysics Division provided a survey planning, instrument technicians, and digital compilation staff for a high sensitivity rubidium vapour aero-magnetic survey of a portion of the Bay by the National Aeronautical Establishment. This survey was sparked by interest arising from previous surveys by the Geophysics Division in which the existence of a sizeable sedimentary basin in the Bay was indicated.

A successful 'Upper Mantle Workshop' was organized by the Department in which the Geophysics Division played a key role.

The E.M. and Resistivity Section "chalked up a first" by conducting an experimental airborne e.m. survey using the Barringer INPUT system for measuring the near-surface resistivity of surficial deposits. The Winkler aquifer was one test site selected and it was shown that this was easily detected from the air. The possibility of applying this technique on a world-wide basis is considered to be a real contribution to the International Hydrological Decade.

A regional study of the aeromagnetic data in a large area surrounding the Nelson River Gravity High is leading to new concepts in the tectonics of this region.

The second set of 3-year aeromagnetic contracts in the 9-year Federal-Provincial Aeromagnetic Scheme was let.

Maps from the 1964 aeromagnetic survey in the vicinity southwest of James Bay were released in April. These maps revealed a hitherto unknown magnetic feature running southwest from Moosonee along the Moose River. A staking and concession "spree" resulted on the theory that it was caused by an ultramafic intrusion with which base metals might be associated. Regional Geology organized the 4-mile mapping of a critical part of the area and the Geophysics Division conducted a magnetic rock sampling survey and gravity profiling survey over critical areas. Economic Geology conducted biogeochemical investigations over magnetic anomaly sources, which were indicated by hammer seismic to be within "range" of the method. Cursory results indicate the major sources of the anomaly is not an ultramafic intrusion but is a granulite rock similar in nature to exposures along the Churchill boundary.

An aeromagnetic map published in June 1965 (31 L/13) resulted in the discovery of a sizeable magnetite iron ore prospect in the Grenville province 35 miles northeast of North Bay. Discovery quoted in Northern Miner, December 30th.

The development of the continuously-recording Overhauser magnetometer continued. It has now reached the stage where it has been satisfactorily bench-tested. It should provide for 1/10 gamma sensitivity.

Test surveys with the high-sensitivity, rubidium-vapour magnetometer indicate that it will be of value in sedimentary areas by detecting shallow-anomaly sources caused by faults and folds within the sedimentary rocks themselves. Over igneous and metamorphic terrains, in the gradiometer configuration, it should be useful in mapping the less magnetic formations and in providing increased resolution over the single element detector.

A test survey in the Vaudreuil area, Quebec, and along the north shore of Lake Ontario with an Infrared Scanning device showed great promise for hydrogeologic purposes in detecting groundwater seepage from the land to the water.

FOREIGN AID

There were a number of requests from the United Nations for assistance from government geophysicists, most of which could not be fulfilled because of domestic work. L. W. Morley at the request of

the Economic Commission for Africa was sent by the Department to serve on a three-man mission to inspect proposed sites for regional training centres in photogrammetry and aerogeophysics. Six countries that offered facilities were visited between September 5th and October 4th and a report was submitted to the Economic Commission for Africa.

CHANGES IN PERSONNEL

Dr. E.J. Schwarz - a palaeomagnetician joined the Rock Magnetism Section in September.

Dr. A. Becker - became a member of the E.M. and Resistivity Section in October and is doing magnetotelluric studies.

Mr. A. Overton - seismologist - has been with the Seismic Section since August 1st. He was previously with the Polar Continental Shelf Seismology Group.

Dr. P.S. Naidu - Postdoctorate Fellow, came to the Theoretical Geophysics Section in August to work under Dr. B.K. Bhattacharyya, for a one-year term.

Mr. H. Gross - joined the Rock Magnetism Section on a temporary basis and is working on susceptibility anisotropy.

B. Charbonneau, L.J. Kornik, J. Clarke, and S.C. Weeks are the division's winter seasonals. Charbonneau and Kornik with the Federal-Provincial Aeromagnetic Survey Section, Clarke with the Magnetic Methods Section, and Weeks with the Rock Magnetism Section.

Dr. D.T. Anderson resigned in September to become a staff member at the University of Manitoba, Geology Department.

Mr. R.F. Black left the division in April to take up employment with the Civil Service Commission.

Mr. A.L. Zebarth of the Theoretical Geophysics Section resigned in August to work with an air survey company in the U.S.A.

ATTENDANCE AT CONVENTIONS

Canadian Institute of Mining and Metallurgy

L.W. Morley and B.K. Bhattacharyya presented a joint paper: "Quantitative Treatment of Aeromagnetic Data".

P. J. Hood presented a paper: "Relationships between Geology and Geophysical Parameters of a Magnetite Iron-Formation"; joint paper with D. Sangster and G. Gross.

E. H. Gaucher presented a paper: "Quantitative Interpretation of a few Aeromagnetic Anomalies in the Grenville".

Geological Society of America

A. S. MacLaren

Royal Society of Canada

L. W. Morley received into membership.

Society of Exploration Geophysicists

B. K. Bhattacharyya presented a paper: "A Method for Computing the Total Magnetization Vector and the Dimensions of a Rectangular Block-Shaped Body from Magnetic Anomalies".

L. S. Collett presented a paper: "The Measurements of the Resistivity of Surficial Deposits by Airborne Pulsed Electromagnetic Equipment".

L. W. Morley presented a paper entitled: "Can the Study of Magnetic Rock Properties Aid Interpretation of Magnetic Curves?".

A. F. Gregory.

G. D. Hobson.

Association Canadienne Francaise pur l'Avancement des Sciences

E. H. Gaucher presented a paper: "Anomalies Magnetiques et Gravimetriques du N. E. de l'Ontario".

American Geophysical Union

P. J. Hood presented a paper: "Aeromagnetic Reconnaissance of the Labrador Sea".

IBM Symposium on Computers in Geophysical Data Analysis

P.J. Hood

B.K. Bhattacharyya presented a paper: "Geophysical Anomaly Interpretation using Two-Dimensional Harmonic Analysis".

International Symposium on Remote Sensing

L.W. Morley

Upper Mantle Symposium

P.J. Hood presented a paper: "Magnetic Surveys of the Continental Shelves of Eastern Canada".

G.D. Hobson gave a paper on "Geophysical Logs".

A. Larochelle attended as a reporter.

A.S. MacLaren on Organizing Committee.

L.S. Collett.

SPECIAL TALKS

L.S. Collett -

Canadian Exploration Geophysical Society (KEGS) in Toronto, December 14, 1965: "The Measurement of the Resistivity of Surficial Deposits by Airborne Pulsed Electromagnetic Equipment".

A.F. Gregory -

Canadian Association for Applied Spectroscopy; Ottawa Section, February 9, 1965; "Geophysical Exploration with the Gamma-Ray Spectrometer".

G.D. Hobson -

Ottawa Soil Mechanics Group; "Engineering Geophysics".

Appalachian Discussion Group; "Seismics in the Gulf of St. Lawrence".

On board the CSS "Hudson"; "Use of Geophysics in Marine Studies".

P.J. Hood (Coordinator):
G.D. Hobson
A.F. Gregory
L.S. Collett

Gave their regular series of lectures at Carleton University on Exploration Geophysics.

A.S. MacLaren: Ottawa Secondary Schools Geography and History Teachers: "Geology as it affects the teaching of Geography".

Weston Club, GSC; "The adaptation of Laboratory Assistants and Draftsman's work to GSC Exhibits".

L.W. Morley: Upper Mantle Workshop, Ottawa, February 1965; "Aeromagnetic Atlas of Canada".

MEMBERSHIP ON COMMITTEES

B.K. Bhattacharyya: Member, Ad Hoc Committee on Storage and Retrieval of Geological Data in Canada
Member, Subcommittee No. 1 Reference Numbering and Geographic Location.
Member, Departmental Electronic Data Processing Committee.

L.S. Collett: Secretary, Subcommittee on Exploration Geophysics.

A.F. Gregory: Member, Subcommittee on Technical Requirements of the Interdepartmental Committee on Aerial Surveying.
G.S.C. Library Committee.
Member, Subcommittee on Geology and Hydrology, Air Photo Interpretation Committee, Canadian Institute of Surveying.

G.D. Hobson: Member, Subcommittee on Seismology of NRC Associate Committee on Geodesy and Geophysics.
Liaison Officer, NRC Industrial Research Assistance Program.

P.J. Hood: Member, Subcommittee on Geomagnetism, Associate Committee on Geodesy and Geophysics.
Member, DMTS Satellite Committee.
Member, Advisory Council, Professional Institute.
Liaison Officer, NRC Industrial Research Assistance Program.

A. Larochelle: Member, Subcommittee on Geomagnetism of the Associate Committee on Geodesy and Geophysics.

	Member, Palaeomagnetism Committee, G.S.C. Member, Subcommittee on Isotope Studies and Geochronology of the Associate Committee on Geodesy and Geophysics of the NRC.
A.S. MacLaren	Member, Exhibits Committee, G.S.C. Member, Central Technical File Committee.
L.W. Morley	Associate Committee on Geodesy and Geophysics. Chairman, Subcommittee on Exploration Geophysics. Member, Working Group on Geomagnetic Anomalies International Association of Geomagnetism and Aeronomy. Defence Research Board - MAD Committee. Departmental Committee on Crustal Seismology. Chairman, Palaeomagnetism Committee, G.S.C.

REPORTS OF SECTIONS

ELECTROMAGNETIC AND RESISTIVITY SECTION

L.S. Collett

1. Function of the Section - The function of the section is to carry out electromagnetic, resistivity, and magnetotelluric surveys to aid in the scientific understanding of the surficial and bedrock formations in Canada, and to conduct research into new methods and instruments. The section advises other divisions of the G.S.C., N.R.C., United Nations, and private companies in matters relating to electrical methods.

2. Introduction to the Year's Work - The work of the section during 1965 has been focused mainly on geophysical problems pertaining to groundwater and surficial deposit mapping. An important highlight of the year was an experimental survey to test the application of the airborne INPUT (Induced Pulse Transient) electromagnetic system to the resistivity mapping of surficial deposits. DC ground resistivity survey and drilling was done in the Frobisher, Saskatchewan area. The instrumentation group produced a portable magnetic susceptibility meter that was field-tested this summer, continued work on the design of variable frequency resistivity equipment, and on induced and galvanic pulse equipment. With Dr. A. Becker joining the staff, the section has entered the field of telluric and magnetotelluric studies to investigate the use of natural fields for surficial and ore environment mapping.

Report by projects

OP 97: Portable magnetic susceptibility meter - T.R. Flint, Dr. E. Gaucher.

The construction of a battery-operated portable susceptibility instrument was completed in May to measure the magnetic susceptibility of rock outcrops. The design was simplified from that of previous portable units in that, instead of using a bridge to balance out the in-phase and quadrature voltages, only the magnitude of the deviation of the output signal from the null condition is measured. The total weight of the instrument is approximately 10 lb. Calibration was done using known mixtures of magnetite mixed with sand. Dr. Gaucher tested the instrument in the field this summer. There is still a problem of temperature stability of the coils.

OP 255: (1) Low frequency resistivity equipment - R. Ahrens, C. Gauvreau and L.S. Collett

Design and construction is continuing with an extended frequency range from 1 to 1,000 cycles per second. Increased stability and frequency sweeping technique has been added to measure the amplitude and phase of the received signals from the ground. The measurements using this equipment will give fundamental knowledge of the electrical parameters of soils and rocks.

(2) Galvanic pulse resistivity equipment - R.A. Ahrens, C. Gauvreau, L.S. Collett

Some local field testing of equipment that is capable of generating a square wave of current into the ground through current electrodes was done this summer. A receiving device was designed to faithfully reproduce the pulse seen at the potential electrodes. This equipment is being used to study the charging effects of an impressed step function of current on soils and rocks.

(3) Magnetic pulse dipole EM system - I.B. Faulks, T.R. Flint and L.S. Collett

This project has been initiated for two reasons:

(a) to design an EM system that can be operated from a continuously moving vehicle; and (b) to study the frequency components in phase and amplitude in the received transient.

Mr. Faulks has designed a multi-harmonic lock-in receiver apparatus that can detect a repetitive transient signal buried in noise. A big disadvantage of this particular receiver is that it can only be used at a fixed fundamental frequency of 500 cycles per second.

Mr. Flint has designed the transmitter generator, which is capable of producing a ramp function of current with base width of one millisecond and a variable time-off period from 1 to 10 milliseconds. Work is continuing.

Field Project 61-25: DC resistivity method for locating aquifers

- J.E. Wyder

Surface resistivity measurements using the Schlumberger, Wenner, and 3-electrode configurations were completed in the Frobisher area, Saskatchewan, during the 1965 field season. The gravel deposit discovered last year (G.S.C. Paper 65-1, p. 92) has been extended to a point 3 miles east of the discovery location (SW1-14-5-4W2). In cooperation with Dr. K.B.S. Burke, University of Saskatchewan, a horizontal-gradient gravity survey was conducted over this gravel deposit. Initial interpretation of the results is inconclusive. A flux-gate magnetometer ground survey was also completed over the gravel deposit. Due to the amount of magnetic noise at the time of the survey, the results of the survey have been inconclusive.

A prediction, based on the resistivity results, as to the location of the buried Missouri River channel has been made at location NE 23-3-4W2.

Approximately 7,000 feet of drilling (16 holes) and 5,800 feet of E-logging has been completed in 1965.

Field Project (special): Experimental airborne resistivity survey using the INPUT electromagnetic pulse system

- L.S. Collett

A contract was let with Barringer Research Limited, Rexdale, Ontario, to fly 1,200 line-miles in Manitoba and Saskatchewan. The purpose of the survey was to test the INPUT (Induced Pulse Transient) electromagnetic system to see if the technique could be used for reconnaissance mapping of the surficial deposits. The areas flown were Winkler and Oak River Basin in Manitoba and Steelman-Frobisher and Nokomis areas in Saskatchewan. The flying height was 500 feet, with the exception of 380 feet in the Steelman-Frobisher area, and flight spacing of one mile.

Excellent correlation was obtained over the Winkler aquifer and was confirmed by the DC ground resistivity (Wyder, M.Sc. Thesis, University of Saskatchewan, 1964). Good correlation was

obtained in the Nokomis area. The results of the other two areas have not been assessed yet.

Conclusions are that the INPUT system can map changes in resistivity between clay, till, sand, and gravel in the top 100 feet of surficial deposits in the Prairies. By studying the transient pulse at times later than 650 microseconds, resistivity contrasts below 100 feet should be detectable. The rapidity with which a survey can be done is an important factor; for instance, the ground DC resistivity survey at Winkler, Manitoba, took several weeks to complete while the airborne survey took 3 hours operating from the Winnipeg airport. The airborne survey can be done at any time of the year even when it is impossible to get into the area on the ground. The groundwater hydrologist and Pleistocene geologist will be aided in their mapping programs in the same manner as airborne magnetic maps are now used by the geologist, with the use of this new tool; it should be able to pinpoint in a direct way where to concentrate future drilling programs for exploring for local, municipal, and farm water supplies.

FEDERAL-PROVINCIAL AEROMAGNETIC SURVEYS SECTION

A. S. MacLaren

The duties of this section may be summarized as follows:

(1) To plan contract aeromagnetic surveys in cooperation with other divisions of the Geological Survey.

(2) To confer with Provincial authorities and the Department of Northern Affairs and National Resources on the selection of areas to be covered by aeromagnetic surveys.

(3) To prepare contracts for Federal-Provincial aeromagnetic surveys.

(4) To check survey standards of field and office procedures of all contracts.

(5) To check all aeromagnetic maps prior to delivery, accept delivery, and certify invoicing of completed maps.

(6) To organize and qualitatively interpret any aeromagnetic data published in Canada, and arrange publication of these maps on various scales.

(7) To advise and assist geologists in the interpretation of aeromagnetic data.

Aeromagnetic Surveys

During the year the following work was carried out:

A. Federal-Provincial Aeromagnetic Surveys.

1. Sheets Checked and Published - 1965.

New Brunswick	12 sheets,	scale = 1: 63,360
Quebec	108 sheets,	scale = 1: 63,360
Manitoba	80 sheets,	scale = 1: 63,360
Saskatchewan	64 sheets,	scale = 1: 63,360
British Columbia	8 sheets,	scale = 1: 25,000
N.W.T.	155 sheets,	scale = 1: 63,360
Polar Continental Shelf	49 sheets,	scale = 1:126,720
Total	476 sheets	

B. Aeromagnetic Surveys by the Geological Survey

1. Sheets Compiled, Checked and Published

Great Bank of Newfoundland (Seamagnetometer)	4 sheets,	scale = 1:126,720
Quebec (by G.S.C.)	9 sheets,	scale = 1: 63,360
Quebec (compilation contract)	18 sheets,	scale = 1: 63,360
Ontario (compilation contract)	59 sheets,	scale = 1: 63,360
Ontario (private data purchased)	21 sheets,	scale = 1: 63,360
Manitoba (by G.S.C.)	32 sheets,	scale = 1: 63,360
Polar Continental Shelf	9 sheets,	scale = 1:126,720
Total	152 sheets	

C. Composite Maps Edited and Published - scale 1:253,440

Maritime Provinces	11 sheets
Quebec	3 sheets
Ontario	19 sheets
Manitoba	12 sheets
Alberta	2 sheets
N.W.T.	6 sheets
Total	53 sheets

Data for approximately 681 map sheets at various scales, were checked, processed, and edited during 1965.

Aeromagnetic contracts were completed for certain areas in New Brunswick, Manitoba, Saskatchewan, British Columbia, Northwest Territories, and Polar Continental Shelf.

Three-year aeromagnetic contracts were let for areas in Newfoundland, Ontario, Manitoba, Saskatchewan, Northwest Territories, Yukon Territory, and Baffin Island.

Field inspection of aeromagnetic contracts were made in Manitoba, British Columbia, and the Yukon Territory during the latter part of June and early July. An average of two compilation laboratory inspections per month were made of three local survey companies carrying out Federal-Provincial aeromagnetic surveys.

Aeromagnetic Interpretation

An aeromagnetic-geologic study of the Churchill-Superior boundary was carried out. This study suggests a relocation of the boundary to an eastward trend north of 56°N latitude.

In a multi-discipline field project on the Moose River magnetic anomaly, gravity, magnetic susceptibility, and remanent magnetic measurements were made. The principal rock types in this anomalous magnetic belt were granulites of high specific gravity and with strong magnetic properties. Small strongly ferromagnetic gabbro and ultramafic bodies also occur in this zone. It is considered that a major zone of dislocation occurs along the Moose River magnetic anomaly.

This section was responsible for the coordination and design of two exhibits. The first, for the G.S.A. annual meeting, illustrated work of the Geological Survey in Economic Geology and Tectonics of the Canadian Shield. A second exhibit for the Mining and Metallurgical Conference in Toronto illustrated the correlation between geology and geophysics in the Sudbury area.

This section also supplied aeromagnetic data for the interpretation of tectonic linears and diabase dykes.

MAGNETIC METHODS SECTION

P.J. Hood

Functions

(1) To conduct and interpret special aeromagnetic surveys over land and sea. The latter includes deep ocean studies and areas where a substantial thickness of oil-bearing sediments may exist.

(2) To develop new magnetic instrumentation, survey techniques, and methods of compilation and interpretation.

(3) To study magnetic rock properties in cooperation with the Rock Magnetism Section with particular reference to the interpretation of magnetic surveys.

Projects

Cooperative aeromagnetic project with the National Aeronautical Establishment.

Instrumentation

P. Sawatzky, A. Dicaire, and H.W.C. Knapp

The above personnel have been working closely with their counterparts at NAE, and have been mostly engaged in the development of the digital recording system for the high sensitivity magnetometer installed in NAE's North Star aircraft. Much effort was expended in the digitization of the Decca navigation system, which was successfully used for the Hudson Bay aeromagnetic survey during the 1965 field season. This system enabled readings from two rubidium-vapour magnetometers, the red and green Decca coordinates, WWV time from a digital clock, and the rubidium crystal frequency to be recorded sequentially in condensed binary format on the same digital magnetic tape. Current efforts include the design and construction of a digital recording system for Loran navigation data, a readout system for use on survey flights so that data recorded on the magnetic tape may be inspected in analog form on a suitable chart recorder. Howard Knapp has been involved in modifications to the base station rubidium-vapour magnetometer to make it a more versatile diurnal recording instrument. The magnetic readings are now recorded digitally on punched paper tape and by using WWV time may be synchronized exactly with those recorded in the survey aircraft.

Data Compilation

Miss M.E. Bower

During the past year several new techniques have been employed in the recording and compilation of aeromagnetic survey data. The Hudson Bay project was the first one on which all essential information was recorded in digital form on a single incremental magnetic tape.

Computer programs to process the data are being prepared by Mr. H.N.C. Lyster of National Aeronautical Establishment.

At present the P.B. 250 computer is being used to decode the magnetic tapes, separate magnetometer and Decca readings, and output them in a form which can be used by the Bendix G15 computer. Programs previously written for the Bendix are being used to convert Decca readings to latitude-longitude coordinates, establish magnetic control, correct for diurnal drift, and to calculate and plot intercept levels. The major problem so far has been with the Decca system. Weak signal strength in the survey area caused a variable lag in the decometer readings, and it has been necessary to compensate for this by applying a smoothing factor. This greatly reduces the accuracy of the survey and will cause errors in magnetic control. Another problem is one which is inherent in any system using electronic computers. Any error or variation in the format of the data, however small, can bring the whole computing process to an abrupt halt.

Some work has been done on a program to calculate vertical magnetic gradient from the bird and inboard magnetometers. To obtain true vertical gradient both the aircraft's ground speed and the length of the tow cable must be taken into account. This had not been done on previous trails. A Calcomp plotter with 29" chart width is now in use with the P.B. 250 computer. A program now being written for this system will adjust magnetometer readings for aircraft ground speed, and plot profiles at any desired map scale.

Field Work

P.J. Hood, P. Sawatzky, M.E. Bower,

A. Dicaire, and H.W.C. Knapp

Experimental flights were made in February, 1965 over several producing oilfields in Western Canada in an attempt to ascertain whether reef structures could be delineated by the gradiometer method. A more detailed aeromagnetic survey of an area in central Hudson Bay was carried out during July and August 1965. The area is bounded by the following coordinates 58°20'N, 89°W; 58°47'N, 89°W; 58°58'N, 86°W; and 59°45'N, 86°W. The primary navigational aid used was the 6F Lambda Decca chain on loan from the Polar Continental Shelf Project which was installed in the southwest part of the bay for the Hudson Bay Oceanographic Project. The survey lines flown were integral red Decca lines, whose distance apart varied from about 2,400 feet in the southwest to 3,800 feet in the northeast end of the survey area. The flight elevation was closely maintained at 500 feet above sea level. A rubidium-vapour magnetometer system modified by the National Aeronautical Establishment was used to digitally record on magnetic tape the total intensity of the earth's magnetic field at two heights. This was accomplished using a tail "stinger" installation together with a "bird", which was towed below the aircraft and thus was an attempt to measure the first vertical

derivative of the earth's magnetic field directly. Approximately 7,000 line miles of aeromagnetic data with values every half second (approximately 150 feet) were obtained in the survey area and the Decca coordinates were also recorded at 10 second intervals (3,000 feet) on the same magnetic tape. In addition as much survey information as possible was obtained on the ferry trips between the survey area and Fort Churchill where the North Star Aircraft was based. A rubidium-vapour magnetometer was set up at Fort Churchill to record the diurnal variation of the earth's magnetic field during the flights. As both the navigational and aeromagnetic data has been digitally recorded it is hoped to automate the compilation of the total intensity maps as much as possible.

The opportunity was also taken of augmenting the aeromagnetic survey results obtained during an R.C.A.F. Argus sortie over the Flemish Cap in January 1963.

Ten east-west lines spaced about 10 miles apart and about 70 miles long were obtained on two sorties carried out from the US base at Argentia, Newfoundland on November 13 and 14, 1965. The area is bounded approximately by the coordinates 47°50'N, 45°30'W, 47°50'N, 43°40'W, 46°10'N, 43°40'W, 46°10'N, 45°30'W. The Survey altitude was 300 feet and navigation was by Loran A.

The expected sharp short-wave length anomalies were recorded on all lines except the most northerly, and are presumably due to basic igneous intrusions whose tops are buried at no great distance below the ocean bottom. More detailed interpretation must await the compilation of the resultant aeromagnetic profiles.

Overhauser Magnetometer

S. Washkurak

Development work is continuing on the Overhauser spin-precession magnetometer, and some little effort has gone into the establishment of a liquid proton sample for use in the coil system, which has more permanent atomic properties. The exact position of the electron resonance line has been found for the stable free radical in the earth's field. Apparatus to properly degas the sample is being constructed. To eliminate the Q-multiplier previously used, a set of orthogonal coils has been built to provide feedback only at the precession frequency.

Sea Magnetometer Map Compilation; Grand Banks of Newfoundland

D. Reveler and P.J. Hood

Four sea magnetometer maps (4543G, 4544G, 4545G, and 4546G) resulting from the 1963 CSS Baffin survey of the Great Bank of Newfoundland were published during 1965. The total-intensity magnetic coverage extends over the area 44°9' to 45°N, 50°46' to 52°35'W. A new format has been used for these maps. The 50-gamma contours are printed in red, and the ship's track and the bathymetry contours at 25-foot intervals are printed in a subdued grey.

Scotian Shelf Project

An area bounded on the south by 42°N, on the east by 60°W, on the north by the south shore of Nova Scotia, on the west by 64°30'W, and comprised of Decca-controlled data recorded by sea-magnetometers and airborne magnetometer flights at 200 feet above sea-level is now ready for final drafting and publication. The above area totals approximately 83 one-mile sheets, of which 41 sheets make up the airborne survey, and covers the following four-mile map-areas: 10K, 10L, 10M, 10N, 11C, 11D, 11F. The published maps will show the magnetic contours overprinted in red on a grey background, which will include the bathymetric contours at intervals of 25 feet, the Decca Lattice from Nova Scotia Chain 7, the ship's track or the track of the aircraft. The tender for the drafting of these maps is now being written up and it is expected the work will be delivered by May 31, 1966.

In the area covered by sea-magnetometer surveys east of 60°W (13 two-mile sheets, see aeromagnetic index sheet 1) the magnetic data have been compiled and contoured leaving only the bathymetric and Decca Lattice information to be added to the manuscripts. Mr. Dwight Reveler is responsible for completing the sea-magnetometer compilation.

Vertical Magnetic Gradient Studies

P.J. Hood and K.H. Owens

Two papers on this topic were published in the Journal "Geophysics" during 1965, which mostly concerned theoretical studies. There has been a favourable reaction to the use of gradient measurements in exploration and at least one Canadian instrument manufacturer is contemplating building an aeromagnetic gradiometer at the present time.

Theoretical studies of the first vertical derivative over various geometrical models is continuing, and a paper on interpreting the gradiometer profiles over the dipping dyke will be submitted to an outside publication during 1966.

REMOTE SENSING SECTION

A. F. Gregory

Function

This section is concerned with the development and use of various sensing devices, which measure electromagnetic radiations ranging in frequency from microwaves through the visible spectrum to gamma rays. Research is directed toward:

(1) the remote measurement of various physical properties of rocks and minerals; and,

(2) the geological interpretation of these geophysical data.

General

This section was established in mid-1965. Field work included a radioisotope survey of selected rock outcrops in the vicinity of Elliott Lake, Ontario, and confidential experiments on the geophysical potential of military airborne infrared scanners. During the month of November, Dr. Gregory visited selected laboratories concerned with remote sensing in the United States. The purpose of the trip was to review the problems of organizing a remote sensing effort with emphasis on the capabilities and the utilization of remote sensors to obtain data of geological value in Canada. Both Dr. Gregory and Mr. Washkurak continued work on projects that had been their responsibility before establishment of the remote sensing section. Because of the resignation of Dr. D. T. Anderson, research in photogeology has ceased temporarily.

Project Reports

Radioisotope Survey - P.G. Killeen (graduate student) and A. F. Gregory.

The G.S.C. gamma-ray spectrometer was used to survey for U, Th, and K in exposed rocks near Elliott Lake. M.Sc. thesis project undertaken by P.G. Killeen. Preliminary report in G.S.C. Paper 66-1.

Airborne Infrared Scanning Experiments - A. F. Gregory.

Under contract to the G.S.C., H.R.B.-Singer Incorporated completed airborne infrared scanning experiments in the vicinity of

Vaudreuil, P.Q., Carleton Place, Ontario, and along the Lake Ontario shoreline from Port Hope to Niagara River.

The detector and imagery are at present subject to military security regulations. A confidential, preliminary report was submitted recommending certain instrument refinements for future airborne infrared surveys. Such surveys have a high potential for hydrologic research, especially for the location of pollution effluents, currents, thermal wastes, and underwater obstructions in surface waters. There is considerable evidence that groundwater outflow into surface waters can also be recognized; however, field checking remains to be done. Further experiments with more refined detectors are recommended to define the geological potential of airborne infrared surveys in Canada. A more detailed study of the observations is in progress.

Infrared Scanner Development - S. Washkurak

During the summer a laboratory evaluation was made on a U.S. Army surplus infrared scanner (type AAS-6) with respect to its application to airborne infrared surveys. It was concluded that considerable modification and expense would be entailed in adopting this scanner for infrared mapping.

Grenville Project - A.F. Gregory

The results of this rapid reconnaissance mapping project were described in G.S.C. Paper 65-1 (pages 119, 121). However, considerable effort was expended during the year in compiling the final geological maps. A lesser effort was directed to the preparation of final reports on the operation of the project and on related studies in rock magnetism. The manuscripts remain to be completed.

Spectra of Gamma Radiation from Rocks - A.F. Gregory and J.L. Horwood (Mines Branch)

After several lengthy delays, the report on this research with a gamma-ray spectrometer was completed and published as Mines Branch Research Report R 110.

Visits

A.F. Gregory to remote sensing laboratories at:

U.S. Geological Survey, Washington, D.C.
U.S. Army Waterways Experiment Station, Vicksburg, Mississippi.
Marshall Space Flight Centre, Huntsville, Alabama.
Department of Geology, Rice University, Houston, Texas.
Texas Instruments, Dallas, Texas.

Space-General Corporation, El Monte, California.
Edgerton, Germeshausen and Grier, Incorporated, Santa Barbara, California.
Lawrence Radiation Laboratory)
Department of Forestry) University of California, Berkeley, California.
Department of Mineral Technology)
Itek Corporation, Vedya Division, Palo Alto, California.
Department of Geophysics, Stanford University, Palo Alto, California.
U.S.G.S., Denver, Colorado.
H.R.B.-Singer Incorporated, State College, Pennsylvania.

Courses

A.F. Gregory - French Language Training Course, 1965-66.

ROCK MAGNETISM SECTION

A. Larochelle

Function of Section

To study the magnetic properties of rocks and minerals and to make use of results obtained in such studies in the solution of certain geological and geophysical problems.

Introduction to year's work and report by projects.

Improving laboratory facilities was the most time consuming activity of the section during the past year, although time was also spent in field work and magnetization measurements.

For palaeomagnetic research the sensitivity and stability of the astatic magnetometer had to be increased, computer programs had to be adapted to the new computer recently acquired by the Department, and additional programs were written to automate further the operation and the statistical tests.

For research in rock magnetism a susceptibility anisotropy meter was built and the construction of a ballistic magnetometer and Curie balance was initiated.

Over 300 oriented samples were collected in the field from diabase dykes, mostly in the region of Sudbury, Ontario, and Noranda, Quebec. A number of samples were also brought in for preliminary testing, in order to investigate the possibility of initiating new field projects. The International Nickel Company with whom we are working on a joint project has submitted samples collected from the Sudbury irruptive.

Magnetization measurements were done on 75 samples from a belt of ultrabasic rocks in Newfoundland and on 50 oriented samples from Baffinland. Samples of diabase dykes for which magnetization data were published last year were reprocessed, resulting in a considerable improvement in the clustering of the magnetization directions after alternating field cleaning.

Preliminary measurements on diabase dyke samples collected this year with the recently adopted portable drill prove encouraging.

SEISMIC SECTION

G.D. Hobson

The activities of this section are largely reported in G.S.C. Paper 65-1. These consisted of seismic projects undertaken in Hudson Bay, Gulf of St. Lawrence, Suffield, Alberta, and Moose River, Ontario.

Other smaller projects were undertaken at Green Creek in Ottawa for N.R.C., and at the Canadian Centre for the Performing Arts in Ottawa for D.P.W. An experimental marine seismic survey was also conducted in a few lakes in the interior of British Columbia.

THEORETICAL GEOPHYSICS

B.K. Bhattacharyya
(written by L.W. Morley)

1. Function of the Section

The function of this section is to devise new computer-oriented methods of interpreting geophysical data and to carry out interpretations using existing methods. It is also to do research on and to establish a system for the storage and retrieval of geophysical data compatible with the electronically-stored geological data.

2. Aeromagnetic Map of Canada

This project has been proceeding for about one year. The first step is to digitize all available aeromagnetic data in Canada on a two-mile grid. This has now been done for about half the available areas. Complications arise from the fact that some of the data are taken at 500 feet and some at 1,000 feet, furthermore they were taken during different secular variation epochs. These corrections must all be made before the final Map of Canada is assembled. Data from private companies in the Great Plains area must also be obtained for this study.

3. Regional Studies of Yukon and New Brunswick Data.

The primary purpose of these projects was to determine the polarization direction of the major anomalies in order to test the theory developed for the Northern Ontario data that these directions are in some way related to the palaeomagnetic directions. All of the digitizing and most of the analysis have been completed. Final interpretation is now being completed.

Analysis of Moose River Anomaly

This is the major project of the section involving three map compilers and computers on a full-time basis. The project has been active for about one year. It involved digitizing, with the help of the ECARS digitizer about 104 one-mile aeromagnetic sheets on a 1/4 mile grid, fitting a double harmonic function to the data and carrying out 2nd-derivative determinations and conversion-to-the-pole. This phase of the work has been completed and the men are now working on determining the polarization vectors of most of the major anomalies in the area. Unlike the reconnaissance data, the near-surface components are not being filtered out, since it is a more detailed analysis designed to interpret the nearer-surface rather than the deep crustal effects. There are two main objects of the project. The first is to calculate polarization direction of anomalies with the hope that it may be possible to determine whether the major source of this enormous regional anomaly is composed of intrusive material or whether it represents old crustal formations, which were twisted into their present position by tectonic forces. The second purpose is to derive 2nd-derivative maps for detailed interpretation and correlation with surface geological mapping.

Summer Projects

Mr. Allan Spector and Dr. Bhattacharyya evolved a method of determining the depth of an anomaly source by the use of 2-dimensional harmonic analysis.

Mr. Dean Clay and Dr. Bhattacharyya devised a method of converting from a geographical square grid projection to a standard polyconic projection. This will be useful for mapping geophysical data that has been treated in the square grid form into the standard N.T.S. planimetric maps.

OUTSIDE PUBLICATIONS

Bhattacharyya, B.K.
1965: Two-dimensional harmonic analysis as a tool for magnetic interpretation; 2nd special issue of "Geophysics" on magnetic methods, vol. XXX, No. 5, pp. 829-857.

Collett, L.S.
1965: Airborne resistivity; Northern Miner Annual Review, November 25, p. 68.

Fahrig, W.F., Gaucher, E.H., and Larochelle, A.
1965: Palaeomagnetism of diabase dykes of the Canadian Shield; Can. J. Earth Sciences, vol. 2, pp. 278-298.

Gaucher, E.H.
1965: Quantitative interpretation of the Montagne du Sorcier magnetic anomaly; Geophysics, vol. XXX, No. 5, pp. 762-782.

Gregory, A.F.
1965: Geophysical sensing devices; Northern Miner Annual Review, November 25, p. 67.

Gregory, A.F., and Horwood, J.L.
1965: Spectrometric study of the attenuations in air of gamma rays from mineral sources; Mines Branch Research Rept. R110.

Hood, Peter.
1965: Mineral exploration: trends and developments in 1964; Can. Mining Journal, vol. 86, No. 2, pp. 140-150.

1965: Gradient measurements in aeromagnetic surveying; Geophysics, vol. XXX, No. 5, pp. 891-902.

Hood, P.J., and Godby, E.A.
1965: Magnetic profile across the Grand Banks and Flemish Cap off Newfoundland; Can. J. Earth Sciences, vol. 2, No. 2, pp. 85-92.

Hood, Peter, and McClure, D.J.
1965: Gradient measurements in ground magnetic prospecting; Geophysics, vol. XXX, No. 2, pp. 403-410.

Larochelle, A., and Black, R.F.
1965: The design and testing of an alternating field magnetic demagnetizing apparatus; Can. J. Earth Sciences, vol. 2, December 2, 1965.

Larochelle, A., Black, R.F., and Wanless, R.K.
1965: Palaeomagnetism of the Isachsen diabasic rocks; Nature, No. 5006, October 9.

Lyster, H.N.C., and Bower, M.E.
1965: Semi-automatic reduction of data from an experimental airborne magnetometer system; DME/NAE, Quarterly Bull., No. 1965(2), pp. 39-45.

Sander, G.W., and Overton, A.
1965: Deep seismic refraction investigation in the Canadian Archipelago; Geophysics, vol. XXX, No. 1, pp. 87-96.

PETROLOGICAL SCIENCES DIVISION

C.H. Smith, Chief

INTRODUCTION

The Petrological Sciences Division is responsible for studying the materials of Geology - rocks and minerals - and for interpreting the results of these studies in terms of geological association and processes leading to their formation. To carry out these objectives, measurements, summaries and interpretations must be made in a group of allied disciplines as exemplified by the units of the Division.

The Division is composed of four sections, namely the Isotope Geology, Analytical Chemistry, Mineralogy and Petrology Sections. Each is responsible for analytical services and basic research in a specific area of geology. During 1965 a Data Processing Unit was established to apply the new methods of data handling to the output of the Division and eventually to enlarge its operations to handle data for the Geological Survey as a whole and ultimately to operate on a national basis. The functions of these units, in relation to the objectives

of the Geological Survey, were redefined during the year and are stated in the introduction to each sectional report.

The Division is to some extent the "Cinderella" division of the Survey and turns out a great deal of basic data for the use of geologists in the other divisions. During the past year, requests from other divisions have been out of balance with the facilities available. For instance, requests for mineral identification by X-ray methods are below the capacity of our facilities and one wonders why this routine service is not used to a greater extent by the field geologists. On the other hand, requests for isotopic age determinations continue to exceed the annual output by a ratio of 2:1 and the Age Committee continues to render a valuable service in setting priorities on the requests received. The situation concerning requests for chemical data is now most critical. Here, the samples on hand during the past year have exceeded the capacity by at least 3 to 1. 'Turn around' time for chemical requests is now 6-9 months. Requests for additional staff to work on the backlog have been turned down. Mr. Lachance has been seconded from the Mineralogy Section to assist with the XRF development. In the meantime, field geologists will have to exercise patience and greater restraint in launching new projects which depend heavily on chemical services.

PERSONNEL

A. Trainees

Mr. Solomon A. Armaquaye, a Colombo Plan trainee from Ghana, has worked in the Division since August. He was assigned to the Mineral Separation laboratory, and has now moved to the X-ray laboratory. His period of study is proposed to extend to 1967.

Mr. Eliseo Ubeda, a United Nations Fellow from Nicaragua, spent the summer studying analytical methods in the Spectrographic Laboratories.

B. Professional staff

Dr. Fabrizio Aumento joined the Mineralogy Section in September, filling the vacancy caused by Dr. Pouliot. Dr. Aumento is a recent graduate of Dalhousie University and is starting a mineralogical study of serpentine.

Dr. J.A.V. Douglas joined the staff of the Geological Survey in April and took over the responsibilities of the Petrology Laboratory, rock, thin section, and meteorite collections.

Mr. Cletus J. Peters, chemist in charge of the trace lead laboratory since May, 1963, resigned in September to return to university.

Dr. Gaston Pouliot resigned in September to accept a teaching appointment at Ecole Polytechnique. Dr. Pouliot carried out research on feldspars as part of the Upper Mantle program.

Dr. C.H. Smith was presented with the "Distinguished Lecture Award for Eminence in Research" by the Society of Economic Geologists in Kansas City.

C. Technical staff

Mr. L.H. Boutet joined the Data Processing Unit as an engineering clerk in July, filling a new position.

Mr. G. Cimermanis left the Mineral Separation Unit to return to school. His position was filled by P. Gauthier.

Mr. Albert Lacroix retired in May after 36 years service with the Department. Mr. Lacroix was engaged in the preparation of mineral sets for the public. His position has been filled by Mr. M. Larose.

Miss P. LaRiviere joined the Isotopic Geology Section as an Assistant Technician 1 in April.

Mr. W.A. Smith resigned from the Isotopic Geology Section to enter the Departmental administrative trainee program in September.

K.J. Tanino transferred from the Spectrographic Laboratory to the National Gallery. His position has been filled by K.A. Church, on transfer from the Department of National Defence.

POST-DOCTORAL FELLOWS

During the past year four NRC post-doctoral fellows have carried out studies in the Division. Their work, interests and presence are a vital part of the research program.

Dr. Akari Sasaki, from the Geological Survey of Japan, completed a sulphur isotope study of the Muskox Intrusion in March. Dr. Sasaki's study provided data suggesting a wall-rock origin for part of the sulphur in the Intrusion. His manuscript is being edited for publication.

Dr. Victor Koeppel, from Switzerland, continued an isotopic study of the uranium-lead minerals at Goldfields, Saskatchewan, supported by the Eldorado Mining and Refining Company (see report of the Isotope Geology Section).

Dr. Peter Blattner, from Switzerland, continued studies of the petrochemistry of the veined, augen granodiorite gneiss in the core zone of the Thor-Odin gneiss dome, British Columbia, in association with Dr. J.E. Reesor. He studied classical, X-ray and spectrographic methods of analysis and spent a short period in the field collecting further material for study.

Dr. Aniruddha De, from Calcutta University, arrived in October to start a study of the "white rocks" occurring in the ultrabasic rocks at Thetford Mines and Asbestos, Quebec. Drill cores have been provided by the Johns Manville Company and Asbestos Corporation for the study.

MEMBERSHIP ON COMMITTEES

S. Abbey
- Member, Staff Relations Committee, Professional Institute.
- Member, Reserve Panel of Appeals Representatives, Professional Institute.
- Member, Editorial Board, Chemistry in Canada.
- Member of Executive, Analytical Chemistry Division, Chemical Institute of Canada.

W.H. Champ
- Member, Non-metallic Standards Committee, Canadian Association for Applied Spectroscopy.

K.R. Dawson
- Member, Departmental Data Processing Committee.

J.A.V. Douglas
- Member, Associate Committee on Meteorites, National Research Council.

D.C. Findlay
- Secretary, Deep Drilling Subcommittee of Canadian Scientific Committee for the Upper Mantle Project.

T.N. Irvine
- Member, G.S.C. Library Committee.
- Member, G.S.C. Stable Isotope Committee.
- Member, Subcommittee on Volcanology of the Associate Committee on Geodesy and Geophysics (NRC).

J.A. Maxwell
- Member, Standards Committee of the Geochemical Society.

J.E. Reesor
- Chairman, G.S.C. Age Determination Committee.
- Member, Subcommittee on Cordilleran Cross-Section of the Committee on Structural Geology of NACRGS.
- Member, Subcommittee on Mineralogy, Petrology and Geochemistry, of NACRGS.

- Member, Subcommittee No. 2 of the Ad Hoc Committee on Storage and Retrieval of Geological Data in Canada.
- Member, University Recruiting Team for Physical Sciences.

J.G. Sen Gupta
- Member, Advisory Council of Professional Institute.
- Member, Aims and Activities Committee, Professional Institute.

C.H. Smith
- Chairman, Committee on Upper Mantle Project, International Union of Geological Sciences.
- Deputy Secretary General, International Upper Mantle Project.
- Secretary, Canadian Upper Mantle Project.
- Member, Committee on Research, Society of Economic Geologists.
- Member, Advisory Committee on Science and Medicine, Expo '67.
- Member, Departmental Crustal Seismic Studies Advisory Committee.
- Member, Advisory Board, Mineralium Depositor.
- Chairman, Deep Drilling Subcommittee of SCUM.

H.R. Steacy
- Treasurer, Mineralogical Association of Canada.
- Member, G.S.C. Exhibits Committee.

R.J. Traill
- Member for Canada, Commission on New Minerals and Mineral names of the International Mineralogical Association.
- Member, G.S.C. Committee on Central Technical Files.
- Chairman, Nominating Committee, Mineralogical Association of Canada.

R.K. Wanless
- Member, G.S.C. Age Determination Committee.
- Member, G.S.C. Stable Isotope Committee.
- Secretary, Subcommittee on Isotopic Studies and Geochronology, NRC Committee on Geodesy and Geophysics.

ATTENDANCE AT MEETINGS

Mineralogical Association of Canada, Annual Meeting (Toronto, March 8-10): J.L. Jambor
H.R. Steacy

Chemical Institute of Canada, Annual Meeting, (Montreal, May 30-June 2): S. Abbey

Canadian Association of Physicists, (Vancouver, June):
W.D. Loveridge

International Upper Mantle Symposia, (Ottawa, September):
T.N. Irvine
C.H. Smith
D.C. Findlay
F.P. Agterberg

Canadian Association for Applied Spectroscopy (Ottawa, September):
S. Abbey
J.P. Malone
S. Courville
R.J. Traill
G.R. Lachance
W.H. Champ
W.F. White

Subcommittee on Digit Geological Observations (Calgary, October):
K.R. Dawson
J.E. Reesor

5th International Symposium on the Application of Computers in the Mineral Industry, (Tuscon, Arizona, March 15-19):
F.P. Agterberg

American Geophysical Union (Washington, D.C., April 19-22):
R.K. Wanless
T.N. Irvine

Mineralogical Society of America, (Gatlinburg, Tennessee, June 22-July 2): G. Pouliot

U.S.G.S. Bureau of Geochemical Census Operation (Denver, Colorado, July): K.R. Dawson

Geological Society of America, 1965 Annual Meeting (Kansas City, November 4-6): R.K. Wanless

Mineralogical Society of America, 1965 Annual Meeting (Kansas City, November 4-6): J.L. Jambor

Society of Economic Geologists, 1965 Annual Meeting, (Kansas City, November 4-6): C.H. Smith

8th Commonwealth Mining and Metallurgical Congress (Australia and New Zealand, February 27-March 10):
H.R. Steacy
F.P. Agterberg

UNESCO - IUGS Colloquium on Granites in West Africa (West Africa, March): J.E. Reesor

Pan American Institute of Geography and History (Guatemala City, Guatemala, June 25-July 4): C.H. Smith

Upper Mantle Committee, Working Group on Petrology and Volcanism (Copenhagen, September 13, 14): T.N. Irvine

Field Trip to Metamorphic Terrains in Southern Idaho and Northern Nevada (September 3-10): J.E. Reesor

OUTSIDE LECTURES

(Speaker indicated by *)

R.K. Wanless*, J.E. Reesor, W.D. Loveridge and G. Mursky - "Rb/Sr whole rock and mineral ages of the White Creek batholith and associated Precambrian country rocks of the Kootenay District of British Columbia", A.G.U., Washington, D.C.

G. Pouliot - "Use and applications of X-ray diffraction of the Geological Survey of Canada", Symposium on "Some Applications of X-ray and Neutron Diffraction", McMaster University, Hamilton.

G.R. Lachance* and R.J. Traill, - "A practical solution to the Matrix Problem in X-ray analysis", Part 1 "Method", 12th Ottawa Symposium on Applied Spectroscopy.

R.J. Traill* and G.R. Lachance, - Part 11 "Application to a multi-component alloy system"; 12th Ottawa Symposium on Applied Spectroscopy.

C.H. Smith - "The Muskox Project from Birth to Adolescence" Society of Economic Geologists, Kansas City.

T.N. Irvine* and C.H. Smith - "Cyclic units in the Muskox Intrusion, N.W.T.", A.G.U. Annual Meeting, Washington, D.C.

T.N. Irvine - "Crystallization history of the Muskox Intrusion", McGill University, University of Minnesota.

T.N. Irvine - "Chromian spinel as a petrogenetic indicator", Meeting of the I.U.M.C. Working Group 7 on Volcanology and Petrology, Copenhagen.

T.N. Irvine - "Graphical projections for examining the Crystallization and Geochemistry of Basaltic Magmas", Ottawa Geochemical Discussion Group.

D.C. Findlay and C.H. Smith* - "Drilling for scientific purposes in Canada", IUMC Symposium on Deep Drilling, Ottawa, September.

OUTSIDE PUBLICATIONS

Abbey, S.
1965: Determination of potassium, sodium and calcium in feldspars; Can. Mineralogist, vol. 8, No. 3, pp. 347-353.

Agterberg, F.P.
1965: The technique of serial correlation applied to continuous series of element concentration values in homogeneous rocks; J. Geol. , vol. 73, pp. 142-154.

(in press) Computer oriented analysis of mineral deposits; Eighth Commonwealth Min. and Met. Congress, preprint 2, pp. 23-28.

1965: Frequency distribution of trace elements in the Muskox Layered Intrusion; Proc. Fifth Symposium on Computers in the Mineral Industry, University of Arizona, vol. 1, pp. G1-33.

(in press) Polynomial trend surfaces; chapter for "Mine Sampling and Evolution", edited by R.F. Hewlett.

(in press) The use of multivariate Markov Schemes in petrology; J. Geol., special issue on multivariate analysis.

(in press) Techniques for ore valuation; Proc. South African Symposium on ore valuation by computer to be held in Johannesburg, March, 1966.

Chamberlain, J.A., and Delabio, R.N.
1965: Mackinawite and valleriite in the Muskox Intrusion; American Mineralogist 50, pp. 682-695.

Chamberlain, J.A., McLeod, C.R., Traill, R.J., and Lachance, G.R.
1965: Native metals in the Muskox Intrusion; Can. J. Earth Sciences, vol. 2, pp. 188-215.

Dyck, W. Lowdon, J.A., Fyles, J.G., and Blake, Jr., W.
(in press) Geological Survey of Canada, Radiocarbon Dates V; Radiocarbon, vol. 8.

Findlay, D.C., and Smith, C.H.
(in press) Drilling for scientific purposes in Canada; Tectonophysics.

Irvine, T.N.
1965: Sedimentary structures in igneous intrusions with particular reference to the Duke Island ultramafic complex; Soc. Econ. Palaeontologists and Mineralogists, Spec. Publ. No. 12, pp. 220-232.

1965: Chromian spinel as a petrogenetic indicator: Part 1 Theory; Can. J. Earth Sciences, vol. 2, No. 6.

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1965: Moorhouseite and aplowite, new cobalt minerals from Walton, Nova Scotia; Can. Mineralogist, vol. 8, part 2, pp. 166-171.

Jambor, J.L., and Pouliot, G.
1965: X-ray crystallography of aurichalcite and hydrozincite; Can. Mineralogist, vol. 8, part 3, pp. 385-389.

Lachance, G.R., and Traill, R.J.
(in press) A practical solution to the matrix problem in X-ray analysis, Part 1. Method; Canadian Spectroscopy.

Rimsaite, J., and Lachance, G.R.
(in press) Illustrations of heterogeneity in phlogopite, feldspar, euxenite and associated minerals; Indian Mineralogist.

Smith, C.H.
(in press) Chromium; Encyclopaedia of Earth Sciences, Reinhald Publications.

Traill, R.J., and Lachance, G.R.
(in press) Part 11. Application to a multicomponent alloy system; Canadian Spectroscopy.

ISOTOPE GEOLOGY SECTION

R.K. Wanless

The functions of the Isotope Geology Section are: (1) To determine the age of rocks, minerals, and carbonaceous materials using methods based on the radioactive decay of naturally occurring nuclides. (2) To investigate stable isotopic variations in nature and interpret the fundamental physical and chemical phenomena responsible for the observed trends. (3) To conduct fundamental research projects

using enriched stable and radioactive isotopes in laboratory and field studies, designed to yield information regarding the magnitude of isotopic fractionation to be expected in biogeochemical and geological environments. (4) To develop instrumental, chemical, and physical techniques in isotopic geology.

During the current year, the major laboratory effort has been devoted to age determinations based on isotopic measurement of the K-Ar, Rb-Sr, and U-Th-Pb systems, while investigations based on the distribution of the stable isotopes of S and Pb have assumed a minor role.

AGE DETERMINATION PROGRAM

K^{40}-Ar^{40} AGE MEASUREMENTS (O.P. 28)

The laboratory facilities were again taxed to the limit in processing 209 samples for K-Ar age determination. In an attempt to reduce the time and staff requirements, several modifications are currently being incorporated into the laboratory procedures. These include a new argon-38 spike preparation apparatus designed to permit the filling of 185 spike tubes at one time, all at precisely the same pressure. This manifold will replace an antiquated system on which only 20 tubes could be handled at one time. With the new arrangement only one set of calibration analyses will be required to establish the gas pressure in all the tubes, whereas with the current system calibration analyses are necessary for each set of 20 spikes. In addition, a new low cost mass spectrometer (Associated Electrical Industries, M.S. 10) has been purchased and some components have now been received. The unit will be incorporated into the argon extraction apparatus to permit the analysis of purified argon immediately after extraction from the mineral or rock. The new instrument will remove the analytical load from the existing 6 inch radius gas source mass spectrometer thereby allowing its modification to a solid source instrument and its application to related age determination problems. An additional advantage of the M.S. 10 arises from the fact that the volume of the analyser is small and the instrument may be operated in the static mode, thereby increasing the sensitivity appreciably. This feature may be applied to advantage when determining the age of samples containing minimal quantities of radiogenic argon as a consequence of young age, low potassium content, and/or small sample size.

The geographical distribution of age measurements carried out during the year was as follows: Shield areas - 47%; Cordilleran regions 31%; Appalachian provinces 17.5% and

miscellaneous sources 4.5% (including samples submitted by the Fuels and Stratigraphy Division and the Pleistocene Section). The experimental details of the individual measurements and their geological significance are being prepared for publication in the annual G.S.C. Isotopic Age Determination Report.

On occasion, the results obtained for a particular sample indicate an anomalous isotopic parent-daughter association in the mineral requiring further laboratory investigation. Several determinations have consequently been carried out to expand the age determination coverage of a particular region, or formation, and/or to establish the various factors responsible for anomalous argon retention or loss in the mineral system. As an example of the former, K/Ar age measurements carried out on material from the Shaler Group and the overlying Natkusiak Formation of basic flows on Victoria Island, District of Franklin, have indicated that at least portions of the Shaler Group may not be as old as previously postulated (i.e. Precambrian). Glauconite collected from the Wynniatt Formation of the Shaler Group has now been dated at 450-460 m.y. by both the K/Ar and Rb/Sr techniques, and a preliminary K/Ar determination for a whole rock sample of the overlying Natkusiak Formation has indicated a mid-Ordovician age at most. Additional determinations are to be carried out on samples from dykes intruding the Natkusiak Formation and from sills in the Wynniatt Formation in an attempt to resolve the age relationships of the region. The investigation of the problem of anomalous argon retention or loss has, to date, received very little attention but plans are being made to study this problem in more detail (O.P. 466). One biotite sample that has yielded an anomalously high K/Ar 'age' in excess of 3,500 m.y. has been subjected to various experimental grinding and heating procedures, in order to determine if part of the radiogenic argon is more loosely held within the mineral and might therefore have been incorporated at the time of, or subsequent to, the crystallization of the biotite. This investigation was hampered through lack of sufficient sample material, due to the inaccessibility of the region, but new field collections have been made and preliminary experiments are underway. At this point it may be stated that the 'excess radiogenic argon is not readily expelled from the crystal lattice by severe grinding or heating. The associated problem of radiogenic argon loss is being approached from the point of view of variations in 'age' observed between primary potassium-bearing minerals and associated alteration products. K/Ar measurements have been carried out on suites of minerals from two localities and results indicate rather large variations in the K^{40}/Ar^{40} ratio between the minerals of a suite. Studies are to continue in order to determine the relationship of the lower 'ages' to possible geological events, which occurred subsequent to the period of primary mineral formation.

In view of the increased interest in K/Ar determinations on whole rock samples, measurements have been carried out on young

basalts in order to establish our lower practical dating limit. We have found that whole rock basalt samples as young as 10 m.y. may be reliably dated. Younger samples have not been available to us, with the exception of one group of basalts for which a zero age was obtained.

Measurable quantities of argon have also been recovered from igneous whole rock samples and this technique has been applied to the determination of the K^{40}/Ar^{40} ratio in a series of igneous pebbles from the McDougall-Segur conglomerate, of the Lower Cretaceous Blairmore Group, southeastern Canadian Cordillera (O.P. 399). The ratios indicate ages for the pebbles that are compatible with the stratigraphic position of the conglomerate and are suggestive of a source area for the pebbles to the west of their present location. Details of this investigation have been published in G.S.C. Paper 65-26 (with D.K. Norris).

The large error limits assigned to early whole-rock age measurements were primarily attributable to uncertainties in the determination of the low potassium content. The preliminary calibration of the X-ray fluorescence apparatus, used to determine the K content of all age samples, had been based on a comparison with chemically analyzed micaceous samples containing from 4-9% potassium. In order to extend the calibration of the X-ray equipment to the lower potassium range (less than 1% K) a series of comparisons were made with potassium determinations carried out using mass spectrometric isotope dilution techniques. The comparison group included standard samples (G-1 and W-1), whole rock gabbros, and micas, spanning the range from 0.2 to 9% K. Using the new calibration in the low concentration range, error estimates were revised downward with a consequent improvement in the quoted error limits to be applied to whole-rock age determinations. The results of this comparison and the revised table of error limits are published in the introduction to the annual Isotope Age Determination Report G.S.C. Paper 65-17.

Rb^{87}-Sr^{87} AGE DETERMINATIONS (O.P. 28)

The facilities required for Rb-Sr age measurement were brought into full operation during the year with the final calibration of the new 6 inch radius mass spectrometer, M.S. No. 4. The installation of the new polyvinylchloride fume hood, reported in the last annual report, has been found to be most satisfactory and extraction procedures have received only minor modification throughout the year. A double strontium spike solution containing Sr^{84} and Sr^{86} has been prepared and is routinely used to provide a correction for mass spectrometer discrimination in analyses of spiked strontium samples. A series of analyses has been carried out on the M.I.T. standard $SrCO_3$ solution using both solid source mass spectrometers thereby providing a comparison with those carried out in other laboratories.

The status of the Rb/Sr isochron studies undertaken is as follows:

Project	Status
White Creek Batholith, B.C.	Completed
Preissac Lacorne Batholith, Quebec	Mineral samples from pegmatite to be analyzed.
Holyrood Granite, Newfoundland	Completed (manuscript in preparation)
Deloro Stock, Ontario	Completed
Fluorite Granites, Manitoba	Completed
Pre-Acadian Granites, New Brunswick	In progress
Quetico Belt, Ontario	Completed
Basler Lake, N.W.T.	Completed
Timiskaming Rocks, Ontario	In progress
Pre-Timiskaming Rocks, Ontario	In progress
Brisbane Lake, Stock, N.W.T.	In progress
Muskox Intrusion, N.W.T.	In progress

In most instances, as the studies proceed, it has become apparent that additional whole rock or mineral samples are required in order to precisely define the isochron or isochrons. As a consequence of this it is often necessary to await specific mineral separations before the work can be completed, hence the rather high proportion of projects designated as 'in progress'.

In addition to analyses carried out for the isochron projects a few determinations have been made on biotite samples containing excessive radiogenic argon contents and on glauconite from the Wynniatt Formation of the Shaler Group, Victoria Island, District of Franklin (see discussion of K-Ar age determinations).

A total of 331 separate mass spectrometric analyses were carried out to sustain the isochron program and 39 analyses of standards and rubidium and strontium spike solutions were required for calibration purposes. Of the 331 analyses only seven were lost due to filament failure or other malfunction of the equipment. This points up a very marked improvement in the chemical processing of samples (particularly the extraction of strontium) over the previous year.

U-Th-Pb AGE DETERMINATIONS (O.P. 463)

Dr. V. Koeppel (NRC Post-doctorate Fellow) has undertaken an investigation of the age of the pitchblende deposits of the Goldfields, Saskatchewan region. Attempts have been made to select and remove pitchblende representative of a single generation and to carry out U, Th, and Pb concentration determinations, and Pb isotopic measurements. The electron microprobe has been used to help locate suitable areas of the polished section for isotopic study. While this

work has been hampered somewhat as a consequence of loss of personnel in the lead preparation laboratory, nevertheless a total of 27 pitchblende samples from hydrothermal vein deposits have been processed and analyzed. In addition, 18 galena and clausthalite samples, and lead from a basic dyke, have been analyzed isotopically.

In a few instances concordant 1,800 m.y. ages have been determined but the majority are discordant. The latter may be explained by assuming one period of uranium mineralization at 1,780-1,800 m.y., followed by the lead loss at 1,100-1,150 m.y., at approximately 250 m.y. and finally at 60 m.y. Continuous Pb loss by diffusion alone does not appear to account for the observed distribution of the ages.

Of the 18 galena and clausthalite samples analyzed, 15 contain radiogenic lead. When these are displayed on a Pb^{207}/Pb^{204} vs Pb^{206}/Pb^{204} plot, 10 samples define a line indicating loss of lead from the 1,800 m.y. old pitchblende at approximately 1,100 m.y., agreeing well with the pattern of apparent pitchblende ages. Some samples contain a lower radiogenic Pb^{207}/Pb^{206} ratio indicating a more recent lead loss, but the times indicated are not in agreement with those deduced from the pitchblende data. This is probably due to the fact that this lead was derived from pitchblende that had already suffered loss of lead subsequent to the 1,100 m.y. event.

The study is continuing and plans are being made to compare the U-Th-Pb ages with Rb/Sr whole rock and K/Ar mineral ages for the area.

RADIOCARBON DATING LABORATORY (O.P. 457)

The two sample counters (2 litre and 5 litre volumes) were operated continually for the complete year, and consequently the laboratory output increased to a new high of 216 determinations. The 2 litre counter was operated routinely at 2 atmospheres pressure whereas sample measurements in the 5 litre counter were carried out at 1 atmosphere and 4 atmospheres pressure. The higher pressure was employed when an extension of the age limit was desired. Several interlaboratory comparisons were carried out during the year which served to confirm the calibration of the laboratory. A total of 102 determinations have been submitted for publication in Radiocarbon, Volume 8.

The low background counting levels noted in the report for 1964 were maintained for both counters, although some seasonal variation was observed for both units. The background was found to be generally higher during the winter months, perhaps due to the increased precipitation and the retention of artificially produced activity at ground level for long periods of time.

The C-14 concentrations in leaves from Champlain Lookout were again monitored (O.P. 338) and surprisingly, it was discovered that the C-14 activity had decreased from the 1964 level. In 1963 the level was 21 per cent above the pre-bomb plateau, in 1964 this had increased to 86 per cent, and the 1965 level was expected to advance beyond this figure. However, leaves collected in May indicated a 3 per cent decrease from the 1964 figure, and those collected in June, August and September were found to be 6 per cent lower on the average. This reduction may be attributable to the lower precipitation levels noted throughout the area during the 1965 season.

Research has continued into the validity of C-14 determinations of bones. It has been shown that the collagen fraction yields a reliable date whereas the carbonate fraction is grossly in error. In future only the collagen fraction will be processed.

In December fabrication of a new 1 litre proportioned counter was completed and testing undertaken. Unfortunately, the background counting rate has been found to be very high and the assembly therefore useless. The source of the activity has been traced to the copper tubing used for the outer shell. The counter incorporated some novel design features with respect to the quartz insulators and unfortunately evaluation of these will have to await fabrication of another tube from uncontaminated material.

In May Mr. J.A. Lowdon took over the operation of the Radiocarbon Laboratory from Mr. W. Dyck who was transferred to the Economic Geology Division. It is a tribute to both men that the transfer was realized with minimum disruption of the laboratory operation. The present success of the operation may be attributed to the painstaking preliminary work of Mr. Dyck.

STABLE ISOTOPE STUDIES

ISO-BIO-GEO-CHEMICAL INVESTIGATION (O.P. 401)

A pilot project was initiated (with Dr. J. Fortescue) to test the feasibility of tracing the movement of enriched stable isotopes from the soil to the stems and leaves of plants. Willow cuttings were chosen for the initial study and since enriched strontium and lead tracers were available these elements were selected for investigation.

Six willow cuttings were grown in the G.S.C. greenhouse for a summer and during that time were given known quantities of strontium and lead containing normal and enriched isotopic abundances. At the end of the growth period the stems and leaves were harvested

and ashed. Samples of soil were also ashed. Lead and strontium were extracted from all components and analyzed isotopically. In addition, isotope dilution techniques were used to establish the concentration levels of the two elements in soil and plant components.

The experiments have provided precise information regarding the concentration of Pb and Sr in soil and plant material, the rate and extent of assimilation by the plants, and the movement of original and introduced material from stems to leaves. Attempts have been made to arrive at a material balance in each experiment.

The preliminary study has highlighted the precautions and refinements necessary in future studies of this type if one is to obtain the maximum information from each experiment. The results of the investigation are now being prepared for publication.

SULPHUR ISOTOPE DETERMINATIONS (O.P. 62)

The number of sulphur isotope analyses carried out during 1965 has dropped considerably due to reduction in laboratory technical assistance. A total of 170 samples, mainly from the Keno Hill project were completed (O.P. 144). No new projects were undertaken.

LEAD ISOTOPE INVESTIGATIONS (O.P. 98)

Trace quantities of lead have been successfully extracted from seven samples of the Aldridge quartzites, granites, and diorites of the Kootenay District of British Columbia. (Dr. G.B. Leech). Isotopic ratios have been determined and are to be compared with ratios obtained for ore leads of the area. The project is continuing.

STATISTICS

MASS SPECTROMETRIC ANALYSES

A) SAMPLES IN GASEOUS FORM

Extracted argon samples	224
Argon-38 calibrations	42
Linde atmospheric argon standard	11
Zurich argon-38	12
Sulphur dioxide (simultaneous collection)	170
Total	459

B) SAMPLES IN SOLID FORM

Rubidium	125
Strontium	268
Potassium	94
Lead	166
Uranium	44
Total	697
Total analyses	1,156

Radiocarbon age determinations 216

ANALYTICAL CHEMISTRY SECTION

J.A. Maxwell

INTRODUCTION

The functions of the Analytical Chemistry Section are:

(1) To provide chemical and instrumental analyses of rocks, minerals and related terrestrial and extraterrestrial materials for the solution of geological problems.

(2) To adapt, develop and publish methods and techniques for analyses of geological materials.

(3) To advise Branch geologists on the use of chemical theory, analytical techniques, and data for the solution of geological problems.

(4) To compile and publish chemical data on geological materials.

(5) To train scientists and technicians from Canada and abroad in methods of analysis of geological materials.

The total number of samples submitted increased (to just under 5,000) over that submitted in 1964 and, in spite of a determined effort to eliminate it and in part due to instrumental breakdown and staff illness, a backlog of about 1,500 samples must be carried over to 1966. The volume of work received and completed, in terms of classical and rapid chemical analyses and spectrographic analyses, is summarized in the section on "Statistics" at the end of this report.

CHEMICAL LABORATORIES

1. The production of analyses for use in Geological Survey research products, which constitutes a major part of the work of the section, is summarized under "Statistics" at the end of this report. Specific activities of note include:

(a) In the X-ray fluorescence spectroscopy part of our Rapid Method Analysis a change to a flux in which cerium replaced lanthanum a heavy absorber brought about improved results, but led to difficulties in the fusion process. An increased ratio of sample to flux also improved results, but the extent of the expected increase in matrix effect has not yet been established. A possible "whole rock" method, in which the fusion step is eliminated, is under investigation.

(b) Apart from analyses of the more common rock types, special analyses included work on meteorites, a zinc spinel, yukonite, chromites, and the determination of fluorine, sulphur, thorium, uranium, and the rare alkalis.

(c) The combustion train for total carbon determination was reactivated and a number of samples analyzed. Apparatus was also assembled for the determination of carbon dioxide by measurement of volume of gas evolved. The method has been applied satisfactorily to limestones, but also appears promising for use with silicate rocks.

(d) Because the existing "low temperature" combustion method gave incomplete recovery of sulphur on some samples, the method was changed to a high temperature combustion, where all sulphur trioxide is decomposed to the dioxide. A new method for fluorine is being examined, with a view to possible elimination of the time-consuming distillation step.

(e) The study of the determination of the platinum metals in meteorites continued, when permitted by pressure of other work. The perchloric acid decomposition and ion exchange separations have been applied to the determination of osmium, ruthenium, palladium, and thorium in five stony and three iron meteorites. Work is continuing on further separations and on the determination of platinum, rhodium, and iridium.

(f) The Isotopic Chemistry laboratory set up a solvent extraction method for lead and an ion exchange method for uranium, for use in preparing samples for isotopic analysis. Leaching of rocks, and other methods of isolating lead were also studied. Samples processed included pitchblende, plant ash, soil, and a wide variety of rocks.

(g) Automated analysis systems are being explored as a means of increasing the output of the chemical determinations required to supplement X-ray fluorescence analysis. The purchase of an atomic absorption spectrophotometer was recommended, for use in determining low concentrations of magnesium, where X-ray results are less reliable, and for the determination of traces of zinc, lithium, and a number of other elements.

(h) Considerable data on the proposed new U.S. Geological Survey standard rock samples has been accumulated, using a variety of analytical methods.

(i) A study of the operation of our chemical laboratories was undertaken by the Methods and Procedures Group. Although implementation of their recommendations for a complete sample control and record system awaits their final report, some changes have already been made. The sample control centre has been removed from the balance room and new data recording forms have been introduced. In a related but independent step, the laboratory supply room was moved to the Supply Section.

SPECTROGRAPHIC LABORATORIES

The number of samples received for spectrographic analysis in 1965 was almost twice the number received in 1964. Although the output of samples completed increased by about 25 per cent over the output for 1964 (to almost 2,600 samples), in spite of the prolonged absence due to illness of one senior staff member and the loss of another through resignation, there remains a formidable backlog of samples to be carried into 1966.

It was expected that our development programs, particularly for the new direct-reading spectrometer, would be much further advanced than is the case. The illness and resignation mentioned above necessitated a temporary reshuffling of staff to cope with the demand for analytical service and it was necessary to curtail drastically our development work during the first six months.

Photographic Methods Development: Working curves were revised and extended for the determination of Zn (10-1,000 ppm) and Ag (.05-10 ppm) by our fractional distillation procedure for volatile elements in aluminosilicates.

Twenty-six working curves were established for our revised air-jet controlled DC arc method for trace elements in rocks,

covering Ag, B, Ba, Be, Bi, Ca, Co, Cr, Cu, Ge, Mg, Mn, Mo, Nb, Ni, Sn, Sr, Ti, V, and Zr. The establishment of additional curves is in progress but all other photographic methods development has been deferred.

Direct-Reading Analysis Development: Physical installation of the new Jarrell-Ash "Atom counter" (direct-reading photoelectric spectrometer) was completed in January. The preliminary alignment of the exit slits for the 10 analytical channels was done. It was then necessary to shut the instrument down until June because of the pressure of other analytical commitments.

Problems with air conditioning of the laboratory, plus unexpected mechanical and electronic problems (resulting in part from the enforced shut-down) delayed serious work on the optical part of the instrument until September. A complete realignment, involving changes in the position of some exit slits, has been completed and the instrument is now functioning well. Analytical programming and establishment of working curves are now in progress and will continue until early 1966.

ACTIVE OFFICE PROJECTS

The following official projects are underway in the section:

O.P. 77: Chemical and instrumental analyses of rocks and minerals. 4,937 samples were submitted by Survey officers for analysis and 4,749 were completed. Further details are listed in the section on statistics. We have reached the point where the demand on these facilities exceeds the possible output and greater consideration must be given by other Divisions to tailoring the requests to the existing facilities.

O.P. 119: Study of meteorites. Chemical analyses were made on four Canadian meteorites (Belly River, Dresden, Holman Island, and Benton) as part of a detailed description of these specimens from the Survey Collection.

O.P. 121: Compilation of Canadian rock and mineral analyses. This is a continuing project. Analyses for the period 1846-1955 were published in Bulletin 115, which was issued this year. The use of data processing methods for future publications is being investigated.

O.P. 201: Preparation of abstracts for Mineralogical Abstracts. A continuing project of J.A. Maxwell, which involved the preparation of abstracts from the Geological Reports of the Ontario Department of Mines.

O.P. 280: Preparation of an ultrabasic rock sample for analytical reference use. A large quantity of picrite has been prepared for use as an internal reference sample and replicate determinations are being made of its major, minor, and trace constituents.

O.P. 288: Composition of the Canadian Shield. The chemical and instrumental determination of the major and minor constituent of individual cratonic segments of the Shield is being carried out for comparison and for relating element abundance to lithology. Chemical work on this project was completed during the year and final interpretation is being undertaken by Drs. Fahrig and Eade.

O.P. 397: Platinum metals in Meteorites. The separation and determination by chemical procedures, of the abundance of the platinum metals (Pt, Pd, Ir, Rh, Os and Ru) in stony-iron and iron meteorites. This project is nearing completion.

O.P. 411: Analysis of proposed reference rock powders prepared by U.S. Geological Survey. The data being obtained on six samples of granite, andesite, peridotite, dunite, basalt, and granodiorite are part of an international inter-laboratory program to assign reliable major, minor, and trace-element compositions to these proposed reference samples. Major and minor element analyses have been made by X-ray fluorescence and rapid chemical methods and by "classical" chemical methods, and emission spectrographic analyses are being completed.

O.P. 474: Study of field sampling errors. The magnitude of possible errors in the field sampling of a rock mass is being investigated by replicate sampling and analysis. This project is being started, using samples of syenite collected from a small pluton near the village of Westport, Ontario.

STATISTICS

A. Samples Received and Completed

	Chemical & XRF	Spectrographic
Carried from 1964	967	543
Received, 1965	1,863	3,074
	2,830	3,617

Completed, 1965	2,185	2,564
	645	1,053
Withdrawals, etc.	96	47
Carried to 1966	549	1,006

B. Summary and Comparison with Preceding Year

	1964	1965
Samples received	3,775	4,937
Samples completed		
Chemical and XRF	2,990	2,185
Spectrographic	2,028	2,564
Backlog at year end		
Chemical and XRF	967	549
Spectrographic	543	1,006
Analyses and Preparations Made		
Chemical and XRF	2,990	2,185
Spectrographic		
Qualitative	59	425
Semi-quantitative	750	253
Quantitative	1,308	2,256
Determinations Made		
Chemical	10,868	7,176
X-Ray Fluorescence*	43,990	34,342
Spectrographic		
Total	24,106	33,474
Qualitative	885	6,375
Semi-quantitative	12,385	3,092
Quantitative	10,836	24,007
Spectrographic Exposures		
Analytical	2,467	3,663
Development	2,196	1,123
Direct Reader Development	.....	121

*Includes calibrations, rechecks, etc.

MINERALOGY SECTION

R.J. Traill

INTRODUCTION

The functions of the Mineralogy Section are:

(1) To study the physical and chemical properties of minerals using field, determinative and experimental methods so as to elucidate problems concerning their identification, classification, occurrence, associations, origin, and history.

(2) To develop X-ray electron beam and other techniques for use in producing analytical results of geological significance.

(3) To provide mineralogical data to staff geologists for use in solving geologic problems.

(4) To compile and publish data on Canadian mineral localities.

(5) To catalogue the National Mineral Collection and to develop, extend, and study the Systematic Reference Series of that collection.

(6) To mechanically concentrate geological materials for use in analytical laboratories of the Geological Survey.

(7) To collect bulk mineral and rock samples in order to assemble and sell collections to the Canadian public.

(8) To identify mineral and rock samples as a public service and deal with public queries in this regard.

FIELD ACTIVITIES

During the period July 7-August 19, Miss A.P. Sabina carried out a study of mineral and rock collecting localities in New Brunswick, Gaspé, and in the Eastern Townships of Quebec (G.S. 64-48). Descriptions of these localities will be published as a guide book for mineral collectors.

C.H.R. Gauthier visited about 60 localities in Manitoba, Ontario, and Quebec and collected bulk supplies of minerals and rocks for the preparation of collections for sale to the Canadian public (O.P. 6). The total distance travelled by truck exceeded 16,000 miles and approximately 22 tons of raw materials were collected.

S.F. Leaming visited mineral localities in southern British Columbia to collect material for the mineral sets and National Collection (see details in report of British Columbia Office).

LABORATORY ACTIVITIES

Office Projects

Distribution of collections of Canadian rocks, minerals, ores and fuels (O.P. 6)

The Mineral Sets Unit prepared a number of special collections including: 600 sets in cooperation with the National Film Board to accompany educational film strips; one 45-specimen collection for shipment to Brazil; two collections consisting of 120 specimens each for Canadian universities; a group of 305 specimens from the Muskox intrusion; and 93 large specimens in connection with Expo 67. The following amounts of rocks have been supplied in the form of chips for use in the preparation of a mosaic map of Canada for display at Expo 67: 500 lb. greenstone, 505 lb. limestone, 410 lb. dolomite, 310 lb. greywacke, and 305 lb. rose granite.

Good progress was made on the preparation of special editions of the 120 specimen set representing Canada's mineral industry for display at Canadian embassies throughout the world. Over 5,000 specimens have been specially prepared and a shipment of 70 wooden cabinets to house the collections has been received.

Detailed description sheets were prepared to accompany the rock and mineral sets prepared for sale to the public. Six thousand one hundred and thirty sets were distributed at a price of $2.00 each. This was considerably less than the previous years sales (10,007). The distribution of sales was as follows:

Location	No. shipped, 1964	No. shipped, 1965
Ontario	2,708	2,239
British Columbia	1,713	942
Alberta	1,269	452
Saskatchewan	334	447
Quebec	855	384
Yukon	137	200
Nova Scotia	356	166
Manitoba	316	127
New Brunswick	51	42
Northwest Territories	74	17
Labrador		3
Newfoundland	114	1
Prince Edward Island	6	0
Ottawa Office	2,074	1,107
Total	10,007	6,130

Sales of the 120 specimen collection representing Canada's mineral industry amounted to 98 collections.

The work of the mineral and rock collection preparation unit is supervised by C.H.R. Gauthier. On May 27, 1965, Mr. Albert Lacroix retired after 36 years service with the Department, most of it devoted to work on the mineral and rock collections. Mr. Gauthier was assisted by J. Turpin and H. Houle and four student assistants for the summer, Gaston Dallaire, Michael Doyle, Al Porter, and Wayne Walton.

Examination of mineral and rock samples (O.P. 7)

R.N. Delabio, J.L. Jambor and Miss A. Sabina provided mineralogical assistance to officers of the Geological Survey through the preparation of 1269 X-ray powder diffraction patterns for the identification of minerals; 89 measurements of X-ray patterns and calculation of unit cell constants; 192 determinations of chemical composition from X-ray diffraction measurements; and 156 identifications and measurements of relative abundances of clay minerals in clays and shales. As a free service to the public, C.H.R. Gauthier and R.N. Delabio examined 1,517 specimens of minerals and rocks. The results of these examinations were communicated to the submitters of the samples in 292 letters and by oral communication.

Reference collection of X-ray powder photographs of minerals (O.P. 15)

Ninety-three new standard patterns were added to the reference collection mainly due to extension of the Systematic Reference Series of the National Mineral Collection. A seasonal employee, R. Trischuk contributed largely to this work. Revision of our catalogue of patterns, Paper 60-4, is desirable and a start was made on this work by J.L. Jambor and H.R. Steacy.

Age determination of rocks and minerals (O.P. 28)

Examination of mineral concentrates and rocks submitted for K-Ar dating was continued by Miss C. Hunt under the direction of J. Rimsaite. This work involved 187 X-ray diffraction analyses, 130 optical studies of mineral concentrates, and optical examination of 59 thin sections of rocks. Sixty photomicrographs were taken to record features of scientific interest.

G.S.C. mineral and ore collections (O.P. 101)

The Systematic Reference Series is the research portion of the National Mineral Collection and is the responsibility of the Geological Survey of Canada. The Series is maintained as an active working collection that is available to qualified scientists in all fields of research. Officers of the Geological Survey are free to consult the

Series at any time and upon application to the Curator, Mr. H.R. Steacy, may use the material it contains for research projects.

In 1965, 211 specimens or groups of similar specimens were acquired by exchange (69), purchase (84), donation (53), and collection (5). These additions included 53 minerals previously unrepresented in the Series and improved the quality of many that were inadequately represented. The number of recognized species and varieties currently on file now totals 1,387, which is almost double the representation that existed in the Survey's classified collection prior to its evolution in 1961 to the Reference Series of the National Collection.

The Series is indebted to the following persons for gifts of specimens: Dr. George Baker (Australia); Dr. George Chao; Mr. John Lamb; Mr. R. Lee; Mr. S. Lochnan; Mr. C.S. Longley; Mr. Gordon Marconi; Dr. G. Pouliot; Dr. E.A. Schiller; Mr. Rodger Smith; Mr. D. Whillan, and within the Geological Survey, to Dr. R.W. Boyle, (consistently one of our main benefactors); Dr. J.A. Chamberlain; Mr. C.H.R. Gauthier; Mr. J. Jambor, Dr. C.F. Gleeson, Dr. O.L. Hughes; Dr. V. Koeppel; Mr. S. Leaming, Dr. H. Little, Dr. C.S. Lord, Dr. A.S. MacLaren; Dr. S.C. Robinson; Dr. E.R. Rose; Miss A.P. Sabina, Dr. D.F. Sangster; and Mr. J. Wyder. Exhanges were made during the year with sources in Australia, Brazil, Canada, France, and the United States.

There were 24 individual requests for specimen material. These requests ranged from the simple loan or gift of specimens to the preparation of 16 mineral samples consisting of visually pure fragments hand-picked from crushed specimens under the binocular microscope. In all, 74 samples of varying nature and labour were provided for research studies at universities and government agencies.

Significant progress was made on the conversion of the Series to Dana's new system. Most pre-silicate groups, embracing specimens of more than 800 minerals and occupying 18 full size cabinets, were regrouped and reindexed during the summer with the assistance of a student assistant. Upon completion of this project in 1966 the formal numbering and cataloguing of specimens in the collection will be undertaken.

The economic collection was enlarged by the addition of eleven suites of specimens, namely: seven suites from iron properties in British Columbia, donated by Dr. D.F. Sangster; one suite each from the Broulan Reef and Porcupine Paymaster Mines, donated by Mr. C.S. Longley; one suite of iron ores from the U.S.S.R., donated by Mr. C.S. Longley; one suite of iron ores from the U.S.S.R., donated by Mr. T.H. Janes; and one suite from Broken Hill, Australia, obtained by exchange.

In the spring of 1965 Mr. Steacy attended the Eighth Commonwealth Mining and Metallurgical Congress in Australia and New Zealand. In the interests of the collection he visited major government and university collections in Melbourne, Canberra, Sydney, Brisbane and Kalgoorlie, and on his return journey paid a brief visit to the headquarters and museum of the Geological Survey of India in Calcutta. During the year he also attended two executive meetings of the Mineralogical Association of Canada in Toronto; assembled the two mineral displays on exhibit in the Geological Survey building; conducted, with Dr. D.K. Norris, a study on the feasibility of constructing a large geological map of Canada using natural rocks; assisted with local arrangements for the International Upper Mantle Symposia Meeting; and handled certain matters pertaining to the Display Series at the National Museum of Canada until the appointment, on September 15th, of its Curator, Mr. L. Moyd.

A catalogue of Canadian mineral occurrences (O.P. 160)

Work continued on this project which has as its immediate objective the publication of a reasonably up-to-date catalogue of Canadian minerals. With the assistance of a summer student, Brian Graham, good progress was made on preparation of the final manuscript. It is anticipated that the manuscript will be submitted for editing in 1966.

Mineralogy of new and rare minerals (O.P. 306)

A major study of the mineralogy of sulphosalts from Madoc, Ontario, by J.L. Jambor neared completion. This study involves descriptive mineralogy, crystallography, chemical and para-genetic relationships of a suite of lead - antimony - arsenic - sulphur minerals containing about nine previously unidentified minerals. Several comparative synthetic compounds have been prepared. An ore microscopy study supported by electron probe microanalyses has been completed.

The laboratory aspects of a study of the mineralogy of the barite - sulphide deposit at Walton, Nova Scotia has been completed, A paper describing the geochemistry, mineralogy, and origin of this deposit has been prepared by R.W. Boyle and J.L. Jambor.

Some work was also done on (a) a new hydrous magnesium-iron oxide mineral from the Muskox Intrusion; (b) rubidian micas from the Gods Lake area, Manitoba; (c) a complex chloro-sulphate mineral; (d) re-examination of type specimens of yukonite; and (e) a tin-rich andradite garnet.

Results of three studies were published in outside journals in 1965. They were:

"Moorehouseite and Aplowite, New Cobalt Minerals from Walton, Nova Scotia" by J.L. Jambor and R.W. Boyle; "X-ray Crystallography of Aurichalcite and Hydrozincite" by J.L. Jambor and G. Pouliot; and "Mackinawite and Valleriite in the Muskox Intrusion" by J.A. Chamberlain and R.N. Delabio.

Applications of X-ray spectrography (O.P. 307)

Research was carried out on the basic problem of converting measured X-ray intensities into mass concentrations.

One paper (G.S.C. Paper 64-17), based on work completed in 1964 appeared in print early in 1965 and two outside papers were published. Synthetic samples have been prepared and analyzed to determine empirical coefficients for the correction of interelement effects in rock analysis. Computer programs have been developed to facilitate computation of coefficients and conversion of measured intensities into mass concentrations.

A total of 3,217 quantitative analyses, 148 complete qualitative and 613 partial qualitative analyses, were made on 1,195 samples, which included; 688 rocks; 379 micas; 66 minerals; and 62 miscellaneous samples.

Electron probe microanalyses (O.P. 308)

The electron probe was in operation for 140 days and about 100 days of the operating time were devoted to the analyses of samples submitted by various G.S.C. officers. Generally, the work involved semi-quantitative analyses for the identification of inclusions or other small grains and measurement of variations in concentrations of one or more elements between mineral grains or across zoned minerals. Analyses were performed on a variety of specimens including meteorites, native metals, sulphides, sulphosalts, olivines, chromites, micas, euxenite, pyrochlore, pitchblende, uraninite, and zircon.

Development work continued on the application of non-dispersive analysis to electron probe work, and on the establishment of a comprehensive set of reference standards.

Studies of rock-forming micas (O.P. 309)

Research for much of the past year has been focused on the relationship between the chemical composition of mica and that of associated minerals and the host rock. This aspect of the research has involved preparation of 50 special mineral concentrates, microscopic examination of about 200 mineral separation fractions, 126 X-ray diffraction analyses, and the taking of about 300 photomicrographs.

Several concentrates of altered and unaltered portions of the same mica have been prepared to study variations in properties and chemical composition as the result of alteration. A paper was submitted to the Indian Mineralogist for publication.

Feldspar mineralogy (O.P. 311)

This project terminated in September with the departure of Dr. G. Pouliot, who resigned his position with the G.S.C., to accept a teaching post at Ecole Polytechnique. Dr. Pouliot spent most of the year completing his investigation and is preparing a comprehensive report on his work.

Investigation of the relative argon retentivity in suites of primary potassium-bearing minerals and associated alteration products (O.P. 422).

The effect of alkali metasomatism on K-Ar and Rb-Sr ages is being studied on samples collected in the areas of Blue Mountain, Ontario, and Val d'Or, Quebec. Preliminary results indicate hydrothermal activity of Palaeozoic age in the Blue Mountain area. Several mineral concentrates have been prepared for dating to verify the preliminary observations.

Study of serpentines

Dr. F. Aumento joined our staff in September and has undertaken a review of the literature and preliminary X-ray investigation of the serpentine group of minerals. Previous studies of the serpentines present conflicting evidence and ambiguous results. This appears to be due in part to the difficulty of preparing reliable X-ray powder diffraction patterns. This problem is under investigation.

Sample preparation and mineral separation (J.C. Paris)

At the year's end the permanent staff of the laboratory consisted of J.C. Paris, B. Machin, J. Valenzuela, and P. Gauthier. One position was temporarily vacant. Equipment additions include a Carpco Electrostatic Separator and demagnetizer. These have been put to good use for sulphide separations. The laboratories have been reorganized with regard to disposition of equipment so that magnetic and heavy liquid separations are now made in room 852 and wet separations have been brought together in 855. The Wilfley table has been modified to occupy less space and provide improved separations.

A summary of activities follows:

Samples on hand, Dec. 1, 1964	1,204
Samples received to Dec. 1, 1965	4,405
	5,609

Samples processed to Dec. 1, 1965	4,762
Samples on hand, Dec. 1, 1965	847

Samples crushed and ground and forwarded to:

Rock analysis laboratory	1,080
X-ray laboratory	380
Spectrographic laboratory	601
Fuels and Stratigraphy Division	761
Retained for separations	1,935
Total	4,757

Mineral separation operations:

Carpco Separator	1,020
Frantz Separator	4,056
Heavy Liquids	4,190
Superpanner	1,665

Mineral concentrates prepared:

Magnetite	1,244
Pyrite	821
Heavy minerals	427
Chalcopyrite	355
Pyrrhotite	297
Sphalerite	160
Micas	141
Galena	100
Feldspars	79
Pyroxenes	53
Olivine	23
Hornblende	22
Arsenopyrite	18
Zircon	15
Gold	15
Ilmenite	14
Other minerals	55
Total	3,839

PETROLOGY SECTION

The functions of the Petrology Section are:

(1) To conduct field and laboratory (determinative and experimental) research into the theories and problems of petrology and to carry out systematic studies of specific rock types.

(2) To provide from the above and related studies, a means of elucidating petrologic problems of economic or regional significance encountered by other units of the Branch.

(3) To conduct studies on extraterrestrial materials such as meteorites and to maintain the National Meteorite Collection.

(4) To consult with government agencies and the public concerning petrographic problems.

(5) To advise Branch geologists on matters concerning rock identification, description and classification, forms of mineral identification; to maintain facilities for independent petrographic study by Branch geologists; to maintain the Geological Survey rock and thin section collections; to deal with public queries on rock and petrographic problems.

(G.S. 57-27) STUDY OF GRANITES IN CANADA

J.E. Reesor

The granite study continues to be aimed toward obtaining an understanding of plutonism and metamorphism during a single orogenic cycle. In a metamorphic complex in the core of a mountain range, how early in the history of the deposition-cycle does metamorphism and associated deformation begin? Where clear evidence of superposition of structural and metamorphic events is obtained, how long is the total cycle of plutonism, and how long are individual episodes within the cycle? If plutonism begins early in the deposition-cycle of a geosyncline, what are the exact relationships between metamorphism and granite emplacement on the one hand, and sedimentation and volcanism on the other. To answer these and other questions relating to plutonism in a mountain belt this study continues to be directed toward detailed mapping, geochronology, and chemical petrological studies in a well-defined, well exposed mountain belt in southern British Columbia.

In the field, studies were continued on the Thor-Odin gneiss dome. Dr. P. Blattner, an N.R.C. post-doctoral fellow, made a detailed study of the veined, augen granodiorite gneiss of the core zone (GS 57-27-7). An examination of other parts of the eastern crystalline belt of the Cordillera was made, including 10 days with Dr. H. Gabrielse in northern British Columbia. D.B. Craig re-examined part of the area southwest of Revelstoke (G.S. 57-27-3).

Professor G. Mursky continued office studies on the synthesis of geochemical and petrographic data from the White Creek batholith during the summer. Much of the synthesis was dependent on complex computer correlation calculation which could not be completed

by the computer services during the period he was on staff. Dr. E. Froese joined the staff in October and is starting a study of the chemical petrology of the Thor-Odin complex.

(G.S. 57-28) STUDY OF ULTRABASIC ROCKS IN CANADA

The progress of this study was retarded by the appointment of the originator, C.H. Smith, to Chief of the Division.

D.C. Findlay, assisted by R.G.H. Allen, graduate student at the University of Minnesota began a regional study of ultramafic and mafic intrusions of the Abitibi-Porcupine district, northern Ontario. This igneous belt is important by virtue of its location within a major mineral producing area (Au, Cu, Ni and Zn) and it is of special petrologic interest since it contains many ultramafic intrusions ranging from those composed of peridotite alone, to differentiated sill-like bodies composed of peridotite (or dunite), pyroxenites, gabbro, and various transitional rock types. During the 1965 field season, intrusions in the part of the belt lying between Reeves Twp. (about 40 miles west of Timmins) and Munro and McCool Twps. (60 miles east of Timmins) were examined and sampled. A few were mapped in detail, but in most cases existing Ontario Department of Mines or Mining Company geological maps were used as a basis for sampling. Laboratory studies on this project will commence in 1966.

Dr. Findlay also continued laboratory studies on material collected last year from the Bay of Islands Igneous Complex, Newfoundland. Preliminary thin section studies on sample sections through the North Arm and Table Mountain plutons have been made. Rock analyses of 90 samples are completed and chemical variations through the plutons have been plotted on stratigraphic sections. Compositions of olivine and cell edge values of chrome spinels have been determined throughout the sections.

T.N. Irvine began a study of two ultramafic-gabbroic intrusions in the Aiken Lake and McConnel Creek areas of British Columbia. The Aiken Lake intrusion is important as a well exposed representative of an apparently fairly distinctive type of ultramafic body occurring at several places in northern British Columbia. The McConnel Creek body has a well layered gabbroic part and may provide information on the relation of gabbroic and alpine-type ultramafic rocks. Laboratory studies of the material collected will commence in 1966.

Dr. Irvine also continued to study the petrology of the Muskox intrusion. Part of the work has involved processing and compilation of the large quantity of chemical data now available on the intrusion with the purpose of outlining the chemical evolution of

Muskox magma during its solidification. On the basis of this work, a scheme has been developed whereby the order of mineral crystallization from basaltic magmas may be related to their chemical composition, and the composition and crystallization of the Muskox magma has been compared with those of basaltic liquids in several major volcanic provinces and in other layered intrusions. The study has also concentrated on the crystallization of the oxide minerals chromite, magnetite, and ilmenite and their compositional relation to the magma and to coexisting minerals. It appears possible to use these minerals to define variations in the temperature and partial oxygen pressure of the magma. T.N. Irvine and C.H. Smith prepared a short paper on the Muskox intrusion for inclusion in a book on ultramafic rocks to be edited by P.J. Wyllie of the University of Chicago and published by the Wiley Book Company. Manuscripts on the Duke Island ultramafic complex and the use of chromian spinels as a petrogenetic were also completed.

The status of thesis studies started under this project is as follows:

R.G.H. Allen - Bird River sill - Ph.D. thesis, University of Minnesota. Field work complete. Thesis and report incomplete.

R.F.J. Scoates - Gordon Lake, Ontario - Ph.D. thesis, University of Manitoba. Field and lab work complete. Thesis and report incomplete.

W.J. Wolfe - Blue River intrusion, British Columbia - Ph.D. thesis, Yale University. Thesis complete. Will be submitted shortly for publication by G.S.C.

DRILLING FOR SCIENTIFIC PURPOSES

A.E. Beck, University of Western Ontario, visited the Muskox Intrusion in July, 1965 and made temperature measurements in the south drill-hole for heat flow studies. Some preliminary results from this and previous heat flow work will be published early in 1966 in the report of the International Upper Mantle Symposium on Drilling for Scientific Purposes. (See International Upper Mantle Symposia).

In June 1965, the Geological Survey was asked to provide technical assistance to a deep drilling project to be carried out by the Department of National Defence near Flin Flon, Manitoba. D.C. Findlay and C.H. Smith were assigned as Survey representatives and Findlay spent much of the 1965 field season working on the project in

connection with site selection studies and the preparation of drilling specifications. The Flin Flon project will involve drilling one 10,000 foot bore-hole and 16 shallow (approximately 200 feet) holes. A program of scientific studies is being planned for the deep hole and this work will be coordinated by the Geological Survey. Drilling of the deep hole commenced in November, 1965 and by December 31 a depth of 3,150 feet was reached. It is expected that Dr. Findlay will continue to make periodic visits to the site throughout the winter for the purpose of logging cuttings and cores and providing other geological services as required.

A paper entitled "Drilling for Scientific Purposes in Canada" was completed by D.C. Findlay and C.H. Smith for publication in Tectonophysics. A similar paper was presented (by C.H. Smith) at the Upper Mantle Symposium on Deep Drilling and will be published in the report on this Symposium. A second paper, by D.C. Findlay, G. Hobson, and A.E. Beck on results of the Muskox geophysical bore-hole logs and temperature measurements was prepared for publications in the Symposium Volume. Editorial work on the Drilling Symposium report involved considerable time since September, 1965.

C.H. Smith attended a meeting of an "ad hoc" group at the National Academy of Sciences, Washington, D.C., to assist in the preparation of a program of continental scientific drilling in the U.S.A.

(GS 62-11) INTERNATIONAL UPPER MANTLE PROJECT

The International Upper Mantle Project was originally planned for the years 1962-64, but due to the slow start of many countries it has developed that the period 1962-64 was the "organizing stage". The period 1964-67 is the actual working period of the project, and 1967-70 will be the reporting period.

The Canadian Scientific Committee for the Project was reorganized in 1965 and its membership is as follows:

Chairman: R.J. Uffen
Secretary: C.H. Smith

Members at large: G. Garland, T. Harwood, J.T. Wilson

1. Seismology: J. Hodgson, J.E. Blanchard
2. Physics and Chemistry of the Upper Mantle: A.E. Beck
3. Gravity, Geodesy, Tides and Recent Movements: M.J. Innes
4. Magnetism: L.W. Morley, P. Serson
5. Theory and Computers: J. Jacobs

6. Deep Drilling: C.H. Smith

7. Petrology and Volcanism: H.D.B. Wilson, C.H. Smith

8. Tectonics: J.O. Wheeler, H.D.B. Wilson

9. Submarine Geology: J.E. Blanchard, F. Roots, W. Mathews

10. Isotope Geochemistry and Chemical Composition of the Upper Mantle: R.E. Folinsbee, D. Shaw

(Reporters are underlined)

Apart from the scientific work on ultrabasic rocks carried out in this Division as a contribution to the Upper Mantle Project, members were deeply involved in the organization of the International Upper Mantle Symposia and Bureau meetings held in Camsell Hall from September 2-11. These meetings were attended by 180 delegates from Australia, Canada, Czechoslovakia, France, Germany, Great Britain, Ireland, Israel, Japan, Mexico, Holland, New Zealand, South Africa, Switzerland, U.S.A., U.S.S.R. The meetings were a great success.

Three technical symposia were organized, namely - (i) Drilling for Scientific Purposes - C.H. Smith, program organizer (ii) The World Rift System - B. Heezen, program organizer (iii) Continental Margins and Island Arcs - B. Heezen, program organizer. The 75 papers, and the discussions and resolutions arising from the Symposia, are being edited and prepared for publication in three separate G.S.C. Papers by F. Aitkens, D.C. Findlay, T.N. Irvine, W.H. Poole, and C.H. Smith.

The local arrangements committee for the meetings consisted of C.H. Smith (Chairman), A.S. MacLaren (Exhibits, etc.), A. Hamilton (Tours), Mrs. B. Thomas (Secretariat office), H. Steacy (Treasurer), Miss F. Aitkens and Miss L. Styler (Hotels). Reporters included D.C. Findlay, T.N. Irvine, E.R. Niblett, W.H. Poole, A. Larochelle, F. Roots. Numerous other staff members contributed to meeting the delegates, providing transportation and advice at the meetings and receptions, printing and distributing abstracts, papers, name tags, and the many jobs, which are so important at the moment and control the success of a meeting. It is not practical to name them all, but merely to say that the cooperation given by our staff has been remarked upon by many delegates in correspondence following the meeting and made a remarkable impression.

Apart from the G.S.C. Papers in preparation on the Symposia, reports have been submitted to the International Union of

Geological Sciences for publication. J.M. Harrison, as well as other members of the Upper Mantle Bureau, were presented with International Cooperation Year medals at a special dinner in the House of Commons. C.H. Smith was appointed Deputy Secretary-General of the International Committee, which involves acting in the absence of the Secretary-General, Professor L. Knopoff, who leaves his post at UCLA for a sabbatical period next year. C.H. Smith was also appointed chairman of the Upper Mantle committee of the International Union of Geological Sciences.

(O.P. 455) PETROLOGY LABORATORY

J.A.V. Douglas

The Petrology Section maintains a petrographic laboratory, provides special services, and is responsible for the various rock, thin section, and meteorite collections of the Branch. Equipment is provided for petrographic investigations and certain custom mineral separations. Petrographic services, carried out on request, include specific gravity of rock specimens, feldspar determination by fusion, staining of feldspar and carbonates in thin section and rock slices, special petrographic studies, modal analyses, and certain optical properties of minerals.

Collections:

The Representative Rock Collection is designed to bring together 80-100 specimens for each half of a 4-mile map area. Thin sections cut from these specimens are stored in the same tray and an index map and IBM card catalogue are kept on file. Requests to use the collection have been few. The following suites were submitted during the year:

23, 24, 25, 34, 35	Leaf River Operation*	I.M. Stevenson
210	Tobique, N.B.*	F.D. Anderson
31J, O	Kempt Lake, Mont Laurier	H.R. Wynne-Edwards
105N, O	Mayo and McQuester*	H.H. Bostock

(*Thin sections accompany a selection of samples)

The National Meteorite Collection received by purchase representative specimens of two new Canadian meteorites. Three exchanges were made.

Revelstoke, B.C.	carbonaceous chondrite	0.6 gm	Mr. E.R. Daniels
Mayerthorpe, Alta.	octahedrite	3.7 Kgs	U. of Alberta, Edmonton
Sikhote-Alin	octahedrite	10 gm	Dr. Wasson
Norton County	achondrite	33 gm	Dr. LaPaz
Johnstown	achondrite	49 gm	Dr. Mason

Laboratory Services:
(Work performed on request and by others using the facilities)

	1964	1965
Specific gravity determinations (rock chips)	667	1,000
Staining - feldspar:		
thin sections	347	300
rock slabs		10
- carbonates:		
thin sections	42	30
rock slabs		24
Mineral identification		
- refractive index	909	95
- plagioclase fusions	246	116
- 2v (U-stage)	20	5
- Others		20
Petrographic-descriptions thin sections		300
special studies	8	6
Modes -thin sections	24	67
Sample preparation - hand picking		80
heavy liquids		
Collections catalogued (suites) - rocks	12	5
thin sections	8	2
Pseudometeorites Identified	635	236

An electrically heated low temperature stage adapted to a petrographic microscope has been installed and calibrated in the laboratory. By replacing the clumsy pre-existing water heated stage this equipment has proven more facile and less time consuming in the accurate determination of refractive indices of mineral grains.

Study of Meteorites (O.P. 119)

J.A.V. Douglas assumed responsibility for this study from K.R. Dawson in April. Descriptions on the petrology and chemistry of 4 Canadian meteorites are being prepared for publication. Attempts are being made to expand the program of meteorite research with particular emphasis on the Canadian falls. One new fall, the Revelstoke, was recovered this year and a preliminary report prepared on it. It is proposed to prepare a final manuscript in association with Prof. R.E. Folinsbee of the University of Alberta.

DATA PROCESSING UNIT

K.R. Dawson and F.P. Agterberg

The functions of the Geological Survey Data Processing Unit are:

(i) to develop and apply electronic data processing (EDP) methods to the handling of geologic data;
(ii) to apply mathematical techniques to the quantitative definition and interpretation of geologic problems;
(iii) to maintain liaison with Departmental EDP units on matters concerning programming and uses of the Departmental computing facilities for geological purposes;
(iv) to advise Survey officers and others on the applications of EDP and mathematical techniques to their studies.

This is a new unit, established in 1965, and staffed by Dr. K.R. Dawson, Dr. F.P. Agterberg, and Mr. L.H. Boutet.

K.R. Dawson has supervised the development of the G.S.C. Data File. The immediate objectives have been (1) the editing and punching of all new requisitions and laboratory reports; (2) the development of a computer oriented tape file; (3) the incorporation of all chemical analyses reported since 1955 into the data file; and (4) aid to geologists in designing forms, punching cards, and liaison with the Departmental Scientific Computer Division.

Dr. Dawson visited the Bureau of Geochemical Census operated by the United States Geological Survey in Denver, Colorado. The U.S.G.S. card oriented system has been in operation for 3 years and contains more than 100,000 chemical and optical spectrograph analyses. The system resembles the G.S.C. data file in several respects and the exchange of ideas was most helpful. Since April 1st the G.S.C. data file has grown to a total of 10,000 optical spectrograph and chemical analyses reported as elements or oxides, plus all K/Ar and C_{14} age determinations. There are also small modal analysis and mineralogical files. The Data File now exceeds one hundred thousand

cards, fifty thousand of which were punched since the end of September. Service to Survey geologists has included advice on the design of report forms and card formats, supervision of unit record treatment of card decks, provision of data from the file, and the punching and verification of small card decks for G.S.C. officers.

F.P. Agterberg has done work on the development of mathematical techniques for the quantitative definition and interpretation of geological problems. The main subjects of investigation were:

(1) Frequency distributions and information theory
(2) Trend surface analysis
(3) Multivariate analysis.

Frequency distributions: Trace element determinations from the rock units of the Muskox Intrusion satisfy the three-parameter Lognormal model. The frequency distributions are truncated at their low value end. Theoretical maximum entropy solutions for the frequency distribution, which were developed in information theory, provide the best fit to the observed frequencies.

Trend surface analysis: A start was made with a project of computer-based analysis of mineral deposits. Sets of assay values from the Coronation and Whalesback Projects are used for this purpose. Methods were developed to compute correlograms, power spectra, and variance-volume curves for series of assay data. Theoretical curves appear to fit the observations reasonably well. It shows that autocorrelation effects are highly significant for series of drill-hole assays, and existing methods of trend surface analysis should be revised to account for these effects.

A computer program has been prepared for surface fitting with autocorrelated residuals. In this method, it is assumed that the residuals from the surface satisfy a moving average scheme.

Multivariate analysis: A few relevant factors may explain the individual correlations between a large number of variables. In cooperation with the Departmental Data Processing Unit, existing computer programs for factor analysis were adapted for use on the CDC 3100. A new program was prepared to compute the transition matrix for multiple series of element concentration data. From this matrix, a trend factor can be extracted, which denotes the linear combination of the variables that shows most trend. Thus, results of factor analysis are amplified, as the spatial position of the original specimen is considered as a variable in the new method.

BRITISH COLUMBIA OFFICE REPORT

J.E. Armstrong

GENERAL

The British Columbia office at Vancouver is under the supervision of J.E. Armstrong; S.F. Leaming and a clerical staff of three complete personnel. One stenographer was absent on account of illness for more than three months in 1965, and temporary help was employed part of this time. Nine other geologists, eight in Regional Geology (one transferred to Ottawa in October) and one in Economic Geology are attached to this office. Also one student assistant spent the summer in the office, a second from September to December inclusive, and a T.O. from September to December.

A complete stock of Geological Survey publications relating to Western Canada is maintained for sale. Also kept for sale are stocks of Mines Branch and Mineral Resources Division publications and of National topographic maps. The office also stocks and sells the publications of the B.C. Department of Mines and Petroleum Resources. A Library and reading room are maintained for the use of the public and staff. About 12,000 books and periodicals are in the library; this includes all the publications of the Geological Survey and the B.C. Department of Mines and Petroleum Resources.

1965 was the busiest year ever recorded in the British Columbia office. 10,210 visitors registered and 27,863 publications of various kinds were sold. 915 collections of rocks and minerals were sold. The total sales amounted to $17,306.95. This does not include money collected for the B.C. Department of Mines and Petroleum Resources, and turned over to them directly, amounting to about $1200.00 in 1965. Approximately 5000 letters and requests by telephone were answered by the staff. In addition several thousand other phone calls were received and made. About 1000 pages of geological manuscript were typed.

The B.C. office provides space, phone service, and secretarial services for the Federal Explosives Inspector for Western Canada. The Office also provides storage for three surveyors with Legal Surveys of the Department.

MONTHLY REPORT

	Visitors	Publications Distributed	B.C. Dept. of Mines	Rocks	Minerals	$25.00 Sets	SALES
Dec. 1964	600	1304	70	33	31		888.15
Jan. 1965	750	1773	111	8	16	2	1024.00
Feb.	750	1046	186	17	15		957.60
Mar.	960	2364	183	39	52	1	1503.85
Apr.	900	2500	77	58	63		1576.05
May	850	3301	104	23	25	1	1900.90
June	1000	3442	91	16	20	3	2020.85
July	850	2698	70	15	16		1263.30
Aug.	880	2636	102	20	13	1	1449.55
Sept.	840	3018	87	17	23	1	1413.75
Oct.	820	2233	129	46	51		1507.30
Nov.*	1010	1548	179	85	104		1801.65
	10210	27,863	1389	377	429	9	$17,306.95

*Estimated

ACTIVITIES

J.E. Armstrong:

Armstrong did 60 days field work during 1965. The time was spent as follows: (1) 24 days in the Kitimat-Terrace area making a study of the surficial geology; (2) 14 days in the Fraser Lowland in order to gain additional information for the final manuscript and map for Field Project 54-10; (3) 6 days in cooperation with the B.C. Provincial Soils Survey in the Okanagan and Fraser Lowland; (4) 6 days in the Quesnel-Prince George area in cooperation with the ARDA soils studies; (5) 5 days in southwestern B.C. preparing for INQUA field trip J; (6) 3 days on Vancouver Island in cooperation with the Forest Soils Committee (Federal and Provincial); and (7) 2 days with C.E. Borden, archeologist, examining surficial geology in the Yale area.

Armstrong conducted the following field trips during the year:

(1) He took approximately 35 fellows of the Royal Society on a one-day field trip of the Howe Sound area.
(2) He took approximately 50 members of the Canadian Soils Society on a one-day field trip of the Fraser Lowland.

(3) He, in conjunction with W.R. Danner, took 80 members of the Vancouver Natural History Society on a weekend trip to the San Juan Islands.
(4) He acted as guide for 2 1/2 days on INQUA field trip J. Approximately 30 people attended.
(5) He took 30 members of the Kelowna Natural History Society on a Sunday field trip in the Kelowna area.
(6) He took 75 members of the B.C. Nature Council on a Sunday field trip to Caufield.
(7) He took 40 students of Vancouver City College on a Saturday field trip in the Fraser Lowland.
(8) He took about 40 members of the Vancouver Natural History Society on a Saturday field trip to Abbotsford.

Armstrong attended the following meetings during the year:

(1) The Royal Society of Canada meeting in Vancouver during June.
(2) The Section III Council Meeting of the Royal Society of Canada in Ottawa in November.
(3) The Agricultural Institute (Canadian Soils Society) in June.
(4) Canadian Institute of Mining and Metallurgy, B.C. Section meeting in Merritt in October.
(5) B.C. Nature Council meeting in Kelowna in May (on a weekend).
(6) B.C. Nature Council meeting in Vancouver (on a weekend).
(7) Participated in INQUA field trip J in September.

Armstrong gave the following public talks during the year:

(1) A geologist looks at B.C. and the Yukon. Presented at B.C. Chamber of Mines Lectures series in February, - 700 present.
(2) Same talk as (1) to Burnaby Rockhounds in April, - 100 present.
(3) Same talk as (1) to the North Shore Lapidary Club in March, - 30 present.
(4) Same talk as (1) to Kelowna Natural History Society in May, - 100 present.
(5) The pre-History of the Chilliwack area, presented to the Chilliwack Historical Society in March, - 75 present.
(6) The Geological Background of Soils in the Fraser Lowland, presented to the Canadian Soils Society in June, - 200 present.
(7) The Pleistocene Geology of the Fraser Lowland, 2 talks presented to the Geomorphology class at U.B.C. - 40 present.
(8) Same talk as (7) to the Agricultural Engineers at U.B.C. - 10 present.
(9) Geology of the Pacific Northwest, A talk in the Distinguished Lecture Series, at Western Washington College, Bellingham, in April, - 100 present.

(10) The Landforms and Geology of B.C. and the Yukon, presented to the Vancouver Natural History Society in November, - 300 present.
(11) Geology of Great Britain, presented to Melrose Masonic Lodge in May, - 75 present.

During the year, Armstrong had 4 papers accepted for outside publication:

(1) Late Pleistocene Stratigraphy and Chronology in southwestern British Columbia and northwestern Washington; Armstrong, et al. Bull. of Geol. Soc. Am., V.76, March 1965.
(2) Pages 80-87 and 103-108 of Inqua Field Conference Guidebook J; Pacific Northwest, pub. Aug. 1965 by Inqua.
(3) Tectonics and Mercury Deposits in British Columbia, to be published in C.I.M. special vol. 8, in press.
(4) J.G. Souther and J.E. Armstrong, Tectonic Framework of North Central British Columbia, to be published in C.I.M. special vol. 8, in press.

During the year Armstrong interviewed about 725 people, the average interview lasting about 20 minutes, the total time involved equalled at least 35 working days. In addition he answered several hundred letters and more than 1500 phone calls seeking information.

Armstrong acted as a judge at the B.C. Science Fair, along with 4 professors. This took all day on Good Friday. The winner went on to win the Canadian title.

Armstrong critically reviewed S.F. Leaming's revised paper on the Geology of Gravel Deposits in the Strait of Georgia Area. This was about 10 days work.

Armstrong took part in the following societies:

(1) He was Treasurer for the B.C. Section of the C.I.M. He was a member and later Chairman of a special committee set up to prepare for publication special volume No. 8 of the C.I.M., the subject to be Tectonics and Mineral Deposits of the Western Cordillera. This has involved critical reading and editing 4 papers, about 150 manuscript pages. He has also helped H.C. Gunning with proof-reading of other papers.
(2) He was an Associate Editor for the Geological Society of America and was responsible for reading critically or finding critical readers for papers on the Geology of the Pacific Northwest. He processed nine papers in 1965.
(3) He was Vice-Convenor and Program Chairman of the Geology Subject Division of the Royal Society of Canada from January to June; he was Convenor from June to December. He arranged the geological program at the 1965 meeting and was appointed co-editor along with H.C. Gunning to process the papers for a geology volume.

(4) He was Past-President of the Vancouver Natural History Society from January to April and a Director from May to December.
(5) He was a Director of the B.C. Nature Council.
(6) He was a Director of the B.C. and Yukon Chamber of Mines.
(7) He was Chairman of the Vancouver Geological Discussion Club.
(8) He was a Director of the proposed B.C. Federation of Outdoor Clubs.

During the year Armstrong arranged book and map displays at 3 meetings. He also spent 2 days along with Campbell and Hutchison interviewing students with regards to summer employment.

S.F. Leaming

S.F. Leaming spent 107 days in the field visiting occurrences of lapidary minerals in British Columbia, and at the same time he collected about 7,000 lbs. of various rocks and minerals for mineral and rock sets as well as a smaller quantity of special minerals for the National Collection and trading purposes.

He identified about 500 rocks and minerals for the general public and was consulted by about 1600 people in connection with geology, minerals, and related subjects. This involved a total of about 80 working days.

Leaming continued the class in Geology for Rockhounds begun in 1964. One lecture was given to the Richmond Rock Club.

He had a short article on Gemstones and Lapidary Materials in Western Canada published in the Lapidary Journal, April 1965.

WHITEHORSE OFFICE REPORT

L.H. Green

The function of the Whitehorse Office of the Geological Survey is to assist mining exploration in the Yukon and the part of the District of Mackenzie more readily accessible from points in the Yukon. The staff consists of a Resident Geologist, and a Clerk.

The office has a reasonably well stocked library containing many of the out-of-print publications on the Yukon, northern British Columbia, and the District of Mackenzie. A large stock of current geological and topographical publications is maintained for sale, and the office statistics for the year up to 30 November 1965 are:

Visitors	Publications Distributed* Topographical	Geological
1,826	4,801	2,094

*(includes 1,060 Topographical and 346 Geological Publications distributed free of charge to GSC parties or other government departments).

Other office services include supplying geological information and advice to prospectors, exploration geologists, other government departments, and the general public. The most common technical requests are for information on old showings and the regional geology of mineralized areas. A technical file containing information on various properties is gradually being built up and should prove increasingly useful. The file includes reports submitted as representation work and private reports supplied by both companies and individuals. During the summer months, the clerk handles a very large number of requests for topographical information from tourists and weekend prospectors. During the year large numbers of mineral and rock specimens were identified; in some cases these were forwarded to Ottawa for X-ray or spectrographic work. An annual prospectors course is given in the early spring in conjunction with the Yukon Chamber of Mines.

The Resident Geologist keeps in touch with mining and exploration developments within the Yukon and headquarters are kept informed through a monthly letter to the Chief Geologist. An annual report on the Mining Industry of the Yukon and Southwestern District of Mackenzie is prepared for publication in the G.S.C. Paper Series. During the field season, all of the operating lode mines and most of the more important lode prospects and placer operations were visited. Other field work during the 1965 field season included about 3 weeks required for the completion of Operation Ogilvie and the supervision of a thesis project by D. Tempelman-Kluit in a portion of the Ogilvie area. Technical meetings attended during the year included the Eighth Commonwealth Mining Congress in Australia in March and April, the Alaskan Science Conference in September, and the Geological Society of America in November.

The Resident Geologist cooperates with and supplies technical information to the Department of Northern Affairs and National Resources and the Yukon Territorial Government on a number of matters. He is a member of both the Screening Board and the Review Board as set up under the Prospectors Assistance

Program of the former department. He is a member of the Tote Trail Committee, which advises the Commissioner of the Yukon on tote trail assistance. He cooperates with the Resident Mining Inspector in reviewing and recommending to the Commissioner the value of geological, geophysical, and geochemical work submitted as representation work on mining claims.

YELLOWKNIFE OFFICE REPORT

R.I. Thorpe

The Yellowknife office of the Geological Survey of Canada provides a range of services to representatives of the mineral industry in the Northwest Territories. The office is informed in all aspects of mining and exploration in Mackenzie District, and to a lesser extent in Keewatin District. The office is staffed by a Resident Geologist and a secretary. During 1965 the position of Resident Geologist was vacant, following the departure of Dr. E.A. Schiller, from April 15th to June 17th, during which period the secretary, Mrs. Norma L. Pearson, was placed in charge. A change in secretaries was accomplished in July.

The office is the only source of geological information in the Northwest Territories. A library is maintained and contains all Survey publications, pertinent Mines Branch publications, a good selection of geology, mining and general science textbooks, and a number of geology and mining periodicals. Geological maps, aeromagnetic maps, papers and memoirs, published by the Geological Survey and pertaining to the Territories are stocked and are available for purchase. Special reports, rock and mineral kits, and the "Raw Materials of the Canadian Mineral Industry" collections are available for purchase. From January 1, 1965 to December 31, 1965, 367 aeromagnetic maps, 1323 other geological publications and 47 rock and mineral kits and 3 sets of "Raw Materials of the Canadian Mineral Industry" were sold. A small number of publications are distributed free to Government personnel and to prospectors subsidized under the Prospectors Assistance Program of the Department of Northern Affairs and National Resources. A supply of vertical aerial photographs covering the general area from Yellowknife to the Beaulieu River and also the East Arm area of Great Slave Lake is maintained and these are available for loan to prospectors and geologists.

The Resident Geologist reports on mineral exploration and mining activities throughout the year on a monthly or bi-monthly basis.

This year the Resident Geologist visited most of the areas in Mackenzie and Keewatin Districts where major exploration work was being conducted. Visits were made to four producing mines and one developing mine in Mackenzie District. Interim accounts of these visits have been given in monthly reports.

The Resident Geologist co-operated with the Department of Northern Affairs and National Resources by reviewing and approving, as to technical content, all geological, geophysical and geochemical reports submitted as assessment work on mining claims. Copies of the reports concerned are filed in the Yellowknife office where, following a confidential period of 3 years, they will be available for use by the general public. Providing prospectors and geologists access to these reports and to logs of diamond drill core is an increasingly important service. The Resident Geologist also assisted in the administration of the Prospectors Assistance Program of the Department of Northern Affairs and National Resources. He served on the screening and reviewing boards which, respectively, selected the prospectors best qualified for assistance and assessed the data they submitted at the end of the season. During the summer most of the prospectors aided by the program were visited in the field.

SPECIAL PROJECTS

REPORT ON ACTIVITIES

C.H. Stockwell

TECTONIC MAP OF CANADA (O.P. 154)

The purpose is to prepare a Tectonic Map of Canada for publication by the Geological Survey of Canada on the scale of 1:5,000,000. The map 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. That part of the map covering the Canadian Shield, the Arctic Islands, and the Appalachian Region was completed in 1964 and a preliminary Tectonic Map of the Canadian Shield was published in 1965 (G.S.C. Map 4-1965). The manuscript map for the whole of Canada will be completed by May 1966.

A punch card file of isotopic age determinations in Canada was kept up to date.

The Tectonic Map of Canada will also serve as Canada's contribution toward the preparation of a World Tectonic Map to be compiled and published by the International Geological Congress. Our contribution will be submitted to the Congress through the Vice-President of the North American Subcommission for the Tectonic Map of the World, a position held by Dr. George V. Cohee (assisted by Philip B. King) of the United States Geological Survey.

MEMBERSHIP ON COMMITTEES

Canadian representative on the International Geological Congress, Subcommission on the Tectonic Map of the World.

Member, Editorial Committee, Tectonic Map of the World.

Chairman, Committee on the Tectonic Map of Canada.

REPORT ON ACTIVITIES

A.H. Lang

Most of the year was devoted to compilation of a new Geological Map of Canada on the scale of 1 to 5,000,000 (publication scale). The work for about half the country was completed and considerable work for other parts was partly finished, but the project was delayed by an illness and by lack of assistance. At the end of November the project was transferred to Dr. R.J.W. Douglas because he had staff that could be assigned to finish it. I then resumed compilation of geological maps on the scale of 1 to 1,000,000.

MEMBERSHIP ON COMMITTEES

1. Geological Map of the World, International Geological Congress.

2. Rapporteur, Geological Sciences Division, and Councillor, Science Section, Royal Society of Canada.

3. Mineral Deposits Subcommittee, National Advisory Committee on Research in Geological Sciences.

4. Working Group on Geological and Petrographical Symbols, International Organization for Standardization.

GEOLOGY AND ECONOMIC MINERALS OF CANADA

R.J.W. Douglas

During the year considerable progress was made in the preparation of the text and accompanying charts and maps. Most chapters have been brought to the draft manuscript stage and two have reached a final stage. Arrangements were made for translation from the manuscript under the guidance of Dr. L.P. Tremblay so that early publication of an edition in French is anticipated.

REPORT ON ACTIVITIES

H.S. Bostock

NOTES ON GLACIATION IN CENTRAL YUKON TERRITORY (O.P. 324)

This paper and map give the first picture of multiple glaciation in the central Yukon. The map traces the extent of four glacial advances. The earliest advance antidates the concentration of the gold of some placer creeks. The limits of both of the earlier two are only known in a few places while those of the later two can in part be traced by means of airphotographs. The paper is now in the hands of the Manuscript and Cartography Section in preparation for publication as Paper 65-36.

PHYSIOGRAPHY CHAPTER AND MAP OF CANADA FOR ECONOMIC GEOLOGY SERIES NO. 1, FIFTH EDITION

In this new edition the physiography of the whole of Canada is to be described in one chapter, which will be accompanied by a physiographic map of Canada. The first draft of the text and map have been completed.

A CATALOGUE OF SELECTED AIRPHOTOGRAPHS OF CANADA (O.P. 275)

This catalogue will include descriptions of about 400 airphotographs, a geomorphological classification of them and a map enabling the reader to choose airphotographs of particular major geomorphological features or of particular parts of Canada such as southern Saskatchewan. The typing of the first draft of the manuscript is now under way.

MANUSCRIPTS AND CARTOGRAPHY SECTION

Peter Harker

All manuscripts submitted for publication by the Geological Survey are processed through the office of the Chief Scientific Editor who is also responsible for the overall organization of the Manuscripts and Cartography Section. The basic responsibilities of this section are to ensure the continuing high standard of GSC publications, to assist authors in producing accurate and unambiguous maps and reports, and to coordinate all stages in the publication of text and preparation of illustrative material.

As a temporary expedient, to clear some of the backlog of manuscripts awaiting processing in the Section, some scientific editing has been passed to the divisional level. Through the good co-operation of all concerned this operation has served its prime purpose; it may also have served to emphasize, at the working scientist level, that more care in initial preparation and writing leads to more expeditious processing.

Continuing efforts have been made to make effective use of commercial drafting facilities; this has proved satisfactory for some classes of work but for some jobs the involvement of planning staff scarcely justifies the saving in actual drafting time.

The residual backlog of reports awaiting processing outside the Branch, at M&TS Editorial and Information Division remains serious, although one new editor has been assigned for GSC work. The prospect of another editor remains, but no appointment has yet been made.

In addition to processing manuscripts, the staff of the section have prepared a new edition of the Guide for Preparation of Geological Maps and Reports, a new Manual of Geological Cartography, the two Reports of Activities, and the Index of Geological Survey Publications.

H.M.A. Rice retired in September and P. Harker was appointed Chief Scientific Editor. R.G. Blackadar has been assigned to the Section as a scientific editor. Mrs. M.A. Yeager has joined the section to perform secretarial duties.

Membership on Committees

G.S. Daughtry
- Member, M.&T.S. Advisory Board on Draftsman and Compilers.
- Chairman, G.S.C. Advisory Committee on Draftsman and Compilers.

P. Harker
- Vice-Chairman and Secretary American Commission on Stratigraphic Nomenclature.
- Exhibits Committee.
- GSC Advisory Committee on Draftsmen and Compilers.

C.E. McNeil
- Member of G.S.C. Exhibits Committee.

E.P. Nunn
- Member, M.&T.S. Suggestion Awards Committee.
- Chairman, Cartography Suggestion Awards Subcommittee.

J.B.F. Williams
- Secretary, Cartography Suggestion Awards Subcommittee.

R.C. Romhild
- Chairman, Weston Club.

Attendance at Conventions, etc.

G.S. Daughtry - American Congress on Surveying and Mapping, Washington, April 1965.
- Visit to United States Geological Survey, Washington.

P. Harker - American Commission on Stratigraphic Nomenclature and GSA, Kansas City, November 1965.
- American Association of Petroleum Geologists, Toronto, April 1965.

L.W. Babcock and N.E. Buck - Canadian Graphic Arts Exhibition, Toronto, October 1965.

STATUS OF GEOLOGICAL MANUSCRIPTS ON DEC. 31, 1965 WITH COMPARABLE FIGURES FOR 1963 AND 1964

Type of Report	In process: Scientific Editing			In process: Cartography and M&TS Ed. Div.			Published during year			Total Active during year		
	1965	1964	1963	1965	1964	1963	1965	1964	1963	1965	1964	1963
Memoirs	6	15	19	23	19	14	3	6	10	32	40	43
Bulletins	20	39	24	37	38	38	12	14	15	69	91	77
Ec. Geol. Repts.	0	3	5	5	3	1	2	0	1	7	6	7
Misc. Repts. etc.	2	1	2	0	6	5	2	1	3	4	8	10
Multicolour maps[1]	7	4	3	38	39	39	7	11	8	52	54	50
P.S. Papers	14	16	13	31	32	19	45	44	50	90	92	82
P.S. Maps[1]	5	5	3	6	3	11	5	20	34	11	28	48
Topical Repts.				1			15	17	15	16		

[1]Does not include multicolour maps to illustrate Memoirs, Bulletins, and Papers.

This table does not include completed reports awaiting critical reading and approval at the divisional level; these are as follows: - Memoirs 4, Bulletins 13, Misc. Reports 1, Multicolour maps 6, P.S. Papers 9, P.S. maps 1.

GEOLOGICAL CARTOGRAPHY UNIT

G.S. Daughtry

During 1965 the reorganization of the Cartography Unit into compilation and drafting groups was extended by the reclassification of five employees into the compiler series. It appears that this change will result in a smoother flow of work through the Unit. Production of maps in the Preliminary Series was lower than in recent years, but an increase was recorded in all other categories. This increase is reflected in the fact that at the end of the year 159 completed illustrations comprising 19 reports were being held in the Unit until required for publication. Base-maps were prepared for the 1:5,000,000 series of maps scheduled for publication in 1967.

Twenty individual contracts were entered into with private drafting firms. These include 3 maps and 72 figures for G.S.C. publications, 25 illustrations for outside publications, and 13 lantern slides.

The Cartography Unit was involved in the preparation of the following displays:

1. INQUA display for Boulder, Colorado.

2. "New map" display for Logan Hall.

3. Mineral specimen cabinet, Logan Hall.

4. "Echoes of the Past" display, Logan Hall.

5. Sixth Annual Field Photograph Salon, Logan Hall.

6. Exhibition Commission's petroleum display for universities.

Personnel

One draftsman, R.M. Gagne was recruited under the International Hydrological Decade program. Other new staff members are J.A.R. Sauvageau, N. Grenier, and B.G. Hill. J.L. Guibord resigned to accept a position in Montreal and A.L. Stachiw to attend university.

At the end of the year the strength of the Unit was sixty-four, including one vacant position.

Production Data

Maps and figure illustrations prepared by the Cartography Unit and printed during 1965 comprised the following:

Multicoloured geological maps	27
Preliminary geological maps	32
Preliminary geological maps reprinted (lithographed)	3
Preliminary geological maps reprinted (blue-line)	21
Aeromagnetic maps	104
Aeromagnetic maps reprinted (lithographed)	8
Aeromagnetic maps reprinted (blue-line)	100
Figure illustrations (lithographed)	79
Figure illustrations (zinc cut)	204
Water Supply Paper maps reprinted (blue-line)	62
Miscellaneous (index maps, etc.)	27

Miscellaneous drafting consisted of 122 items comprising 551 pieces, including drafting illustrations for scientific papers, colouring lantern slides, map mounting, preparing displays, and other general drafting services.

Maps, etc. at Surveys and Mapping Branch for printing at December 31, 1965

Multicoloured geological maps	4
Preliminary geological maps	2
Figure illustrations	1

Figure illustrations completed and held in unit totalled 159.

Maps and Illustrations in progress at December 31, 1965

Multicoloured geological maps	43
Preliminary geological maps	23
Aeromagnetic maps	17
Figure illustrations	183

Work completed in photo-mechanical section

Mapping camera

Film negatives and positives	5,245

Contact processes

Film negative and positives	6,179
Blue-lines	912
Peelcoats	63
Vandyke prints	8,873
Colour proofs	82
Blue-line map prints	15,850
Copyflex prints	2,712
Photostat prints	1,773
Mimeograph impressions	12,401
Xerox prints	92,240

Typesetting

Map names, titles, etc. were set up and printed for all maps and illustrations being drafted. Covers, etc. printed totalled 734 impressions of 67 items. Typesetting for the Mineral Resources Division involved 63 hours' work.

Manuscripts received

Multicoloured geological maps	25
Preliminary geological maps	46
Aeromagnetic maps	63
Figure illustrations	537
Miscellaneous	27

Back-log of maps and illustrations in Cartography Unit

	Dec. 31, 1965	Dec. 31, 1964
Multicoloured geological maps	19	30
Preliminary geological maps	13	1
Aeromagnetic maps	4	0
Figure illustrations	387	244

STUDENT PROGRAM - 1965

Edward Hall

Graduate Assistants

The establishment of Graduate Assistants (Technical Officers 1 to 3 in previous years) was 125. As shown in tables 1 and 3 there was a sharp decrease in Canadian applicants and eight G.A.'s

refused after acceptance compared to three last year. Fortunately there was an increase in the number of non-Canadian applicants and in addition it was possible to obtain the services of ten graduates who were not listed in the Civil Service competition.

Technical Officers 11

This year eleven of our twelve T.O. 11 positions were filled by university professors at various levels below T.O. 11.

Student Assistants

The S.A. establishment was 184. This year 27 undergraduates resigned after accepting offers compared to 14 last year indicating numerous other employment opportunities for students. There is still a serious shortage of experienced third year students - of 31 employed at this level almost one quarter had no previous relevent experience. Three S.A. positions were used to employ technical school students for electrical and machine shop positions.

Table 1

Recruiting of Geology Students

		1965		1964		1963		1962	1961	1960	1959
		Can.	non-Can.	Can.	non-Can.	Can.	non-Can.				
Graduate Assistants	Applications	128	42								
	Offered	117	37								
	Accepted	67	18								
	% "	57%	48%								
T.O. 3	Applications			67	11	60	7	72	66	50	
	Offered			63	9	58	4	71	64	50	
	Accepted			46	3	44	2	54	39	33	
	% "			73%	33%	76%	50%	76%	61%	66%	
T.O. 2	Applications			48	16	64	12	68	67	82	
	Offered			47	7	63	8	58	63	64	
	Accepted			29	4	38	1	33	42	36	
	% "			62%	57%	60%	12%	57%	67%	56%	
T.O. 1	Applications			48	3	21	3	17	44	34	
	Offered			26	0	19	2	3	10	5	
	Accepted			11	0	8	0	2	7	4	
	% "			42%	0	42%	0	66%	70%	73%	
TOTAL	Applications	128	42	163	30	145	22	157	177	166	172
	Offered	117	37	136	16	140	14	132	137	119	155
	Accepted	67	18	86	7	90	3	89	88	73	80
	% "	57%	48%	63%	44%	64%	21%	67%	64%	61%	52%

Table 1A

Recruiting of Geology Students

		1965		1964		1963		1962	1961	1960	1959
		Can.	non-Can.	Can.	non-Can.	Can.	non-Can.				
S.A. 3rd year	Applications	104	5	98	11	110	7	96	128	144	171
	Offered	81	0	83	0	104	0	94	123	135	133
	Accepted	31	0	52	0	56	0	49	75	75	89
	% "	38%		63%		54%		53%	61%	58%	67%
S.A. 2nd year	Applications	128	12	213	14	247	16	213	139	170	210
	Offered	122	1	128	1	154	0	192	132	120	67
	Accepted	73	1	66	1	78	0	77	84	67	28
	% "	59.8%		51%		50%		40%	64%	56%	44%
S.A. 1st year	Applications	246	13	269	19	279	16	230	144		
	Offered	120	0	79	0	88	0	40	13		
	Accepted	60	0	38	0	35	0	24	4		
	% "	50%		48%		40%		58%	31%		
TOTAL S.A.	Applications	478	30	579	44	647	40	558	411	314	381
	Offered	323	1	290	1	356	0	357	268	255	200
	Accepted	163	1	156	1	175	0	165	163	142	117
	% "	50%		54%		49%		47%	61%	56%	59%

Table 2

Actual Employment 1965

	G.A.		S.A.	
	Field	Office	Field	Office
RG	36	7	58	0
EG	26	7	44	14
PS	3	12	4	14
G	6	6	8	3
FS	10	7	18	8
A	0	1	0	6
MG	6	1	6	3
Total	87	41	138	48

Note: This table includes the following personnel not included in Tables 1 or 3

11	T.O.'s	professors
10	G.A.'s	special cases
12	T.O.'s	extended from last year
5	G.A.'s	chemistry
7	G.A.'s	geophysics and electrical engineering
1	G.A.	botany
10	S.A.'s	chemistry
5	S.A.'s	geophysics and electrical engineering
1	S.A.	botany
3	A.T.'s	Technical school students occupying S.A. positions

Table 3

Distribution of Geology Students 1965

University	G.A. Total Offers	G.A. Refused After Accept.	G.A. Final Accept.	S.A. Total Offers.	S.A. Refused After Accept.	S.A. Final Accept.
MEMORIAL	5		2	9	1	7
ACADIA	1			1		
DALHOUSIE	3	1	1	6	1	2
ST. FRANCIS X.				5	1	2
MT. ALLISON				2		
ST. THOMAS				1		1
U. NEW BRUNSWICK	5	1	3	13		7
LAVAL	1			18		14
LOYOLA	1					
McGILL	9		6	11	1	4
MONTREAL U.	2			15	1	8
(E.P.)	1			5	1	
(Chicoutimi)				1	1	
BROCK				1		
CARLETON U.	17	1	11	30	3	1
GUELPH				1		22
McMASTER	5		3	19	4	1
OTTAWA U.			2	16	3	8
QUEEN'S	9		8	34	1	7
TORONTO	8	2	3	18		15
WESTERN	10		6	13	1	11
WINDSOR				1		4
WATERLOO				3		1
MANITOBA	10	1	4	19		9
BRANDON	2		1	2		
UNITED COLLEGE				1		1
SASKATCHEWAN				28	4	10
ALBERTA	7	1	2	14	2	9
U. BRITISH COLUMBIA	17		11	37	2	18
U.S.	33	1	21			
OTHER	2		1			

NATIONAL ADVISORY COMMITTEE ON RESEARCH IN THE GEOLOGICAL SCIENCES

J.F. Henderson

The Geological Survey on behalf of the National Advisory Committee on Research in the Geological Sciences publishes the annual report of this Committee. The report for 1963-64 was published in February, 1965. Seven hundred copies were printed and all were distributed within 2 months of its publication.

The annual report of the Committee for 1964-65 will be published early in 1966 in two parts. Part I includes discussions of the Geological Survey grants to universities for geological research; of two comprehensive, cooperative studies of Canada sulphide deposits, which are sponsored by the Committee and coordinated by the Geological Survey; the storage and retrieval of geological data; the International Upper Mantle Project; and other matters. It includes also the reports of the seven subcommittees that cover the different fields of the geological sciences with summaries of discussions that followed their presentation at the annual meeting.

Part II of the annual report, which will be published as a separate volume, is a survey of current research in the geological sciences in Canada in 1964-65. This compilation of research projects is useful in indicating lines of geological research receiving the greatest attention, and by inference those being neglected, and in enabling research workers to see who are working in similar fields and on similar problems.

The Geological Survey is involved in several projects of the National Advisory Committee. Summary accounts of some of these follow:

Research Grants to Universities

Grants by the Geological Survey of Canada were initiated in 1951 at the instigation of the National Advisory Committee on Research in the Geological Sciences to stimulate and support geological research in Canadian universities. Applications from members of university staffs are submitted to the Director, Geological Survey of Canada. They are reviewed by the Projects Subcommittee of the National Advisory Committee and the grants are awarded by the Survey on the basis of the Committee's recommendations.

For 1965-66, 92 applications were received (compared with 74 in 1964-65) and the total grants applied for was $264,263 (compared with $206,263 in 1964-65). Seventy-four grants totalling $150,000 were

awarded to 19 universities. Of the 74 grants 30, totalling $61,840 were for support of projects that had been supported previously and the remainder, totalling $88,160, were for support of new projects. The names of the recipients, the titles of their research projects and the amounts awarded are listed in an Appendix to Part I of the Fifteenth Annual Report of the National Advisory Committee for 1964-65.

Comprehensive Studies of Canadian Sulphide Deposits

The cooperative, comprehensive study or series of studies, of the Coronation cupriferous, pyrite orebody southeast of Flin Flon, Manitoba, which was initiated at the instigation of this Committee in 1960, is now nearing completion. No work was carried out at the property during the year, but some work continued on material collected previously.

J.R. Smith, Saskatchewan Research Council, is analyzing by X-ray fluorescence the metallic trace elements in all specimens collected around the Coronation mine during the geological mapping of the area. This is an extension into the mine area of a geochemical study by the Saskatchewan Research Council of the region west and southwest of Flin Flon[1]. Another study, not forming a part of the Coronation Project, but which has an important bearing on it, has been undertaken by D. Gendzwill, Saskatchewan Research Council, who is investigating the rock density and gravity patterns of the area. Dr. K. Kanehira, Chiba University, Japan, has completed an exhaustive study of the mineralogy of the Coronation ores as a N.R.C. Post-doctorate Fellow with the Geological Survey.

Dr. F.P. Agterberg, Geological Survey, is making statistical studies of the distribution of copper and zinc through the Coronation orebodies using assay records. In addition to the obvious application of improved sampling and analytical techniques to ore evaluation and grade control in mining, distribution characteristics found in the orebodies of one type may prove to be similar to one another, and different from other types.

Another cooperative, comprehensive project involving studies of the Whalesback Pond copper ore deposit near Springdale, Newfoundland was initiated in 1964[2].

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[1]Distribution of Nickel, Copper and Zinc in the bedrock of the East Amisk area, Saskatchewan; Saskatchewan Research Council, Report No. 6.

[2]National Advisory Committee on Research in the Geological Sciences, Fourteenth Annual Report, 1963-64, pp. 4-5.

Geological mapping of the volcanic pile in which the Whalesback orebody lies is being carried out by D. Bachinski, for the Geological Survey of Canada. In an effort to unravel the stratigraphy on an objective basis, field observations on traverse lines were standardized and entered on cards to be manipulated by computer; the attempt does not appear to have been successful. Dr. V.S. Papezik, Memorial University, continued detailed petrographic studies in the immediate mine area with particular emphasis on the significance of spilites in the volcanic sequence. Dr. E.R. Deutsch, also of Memorial University, investigated the possibility of using palaeomagnetism as a tool to unravel the volcanic sequence. Dr. K. Kanehira has completed an exhaustive study of the mineralogy of the orebody and Dr. D.J. McDougall, Loyola College, is studying the thermoluminescence of the ore and wall rocks in a number of sections across the orebody.

Data Compilation and Processing

In April, 1964 the National Advisory Committee asked the Geological Survey, which was well advanced in the planning of an electronic analytical file for its own use, to assess the possibility of formulating a system for storage and retrieval of geological data, which might come into general use in Canada. Dr. Y.O. Fortier, Director of the Geological Survey, appointed Dr. S.C. Robinson to carry out this assessment and his report was completed early in 1965. Following discussion of Dr. Robinson's report, the National Advisory Committee endorsed in principle the conclusions in the report regarding the development of a national system and recommended that an ad hoc committee be appointed to take the necessary steps in cooperation with interested Canadian organizations to develop such a national system. The National Advisory Committee further recommended that Dr. Robinson be appointed Chairman of the ad hoc committee with power to appoint members of his own choosing.

These recommendations have been implemented and the ad hoc committee under the chairmanship of Dr. Robinson has been established and is functioning. The report of the ad hoc committee will be ready for presentation to the National Advisory Committee by April, 1966.

Post-Doctorate Fellowships

National Research Council post-doctorate fellowships tenable with the Geological Survey were first made available in 1956 when one fellowship was awarded. Since then a total of 24 men have held post-doctorate fellowships with the Geological Survey. An illustrated booklet describing the post-doctorate fellowships with the Department of Mines and Technical Surveys including those tenable with the Geological Survey is readily available; it is given world wide distribution by the National Research Council each year.

In 1965 the Geological Survey reviewed a total of 83 applications for N.R.C. post-doctorate fellowships in the geological sciences. From these applicants the following 4 men were offered and accepted fellowships with the Survey:

De, Anirudda, B.Sc. (Calcutta) 1949; Ph.D. (Princton) 1961;	Petrology (with Dr. C.H. Smith)
Koeppel, Victor, D.Sc. (Zuerich) 1949;	Isotope Geology (with Dr. R.K. Wanless)
Naidu, P.S., B.Sc. (Ind. Inst. Tech.) 1960; Ph.D. (U.B.C.) 1965;	Geophysics (with Dr. B.K. Bhattacharyya)
Rozkowski, A.T., M.E. (Krakow) 1950; D.Sc. (Warsaw) 1964;	Hydrogeology (with Dr. P. Meyboom)

The following completed their terms as post-doctorate fellows in 1965: Dr. Bernard Owens (February, 1965); Dr. Keiichiro Kanehira (September, 1965); Dr. Gene Laberge (August, 1965); Dr. S.K. Babu (October, 1965). The one year term of Dr. Peter Blattner has been extended from November, 1965 to November, 1966.

ADMINISTRATIVE SERVICES

LIBRARY

Mrs. N.I. Kummermann

During the year the library lost the services of Mrs. Norma Byrnes and Miss Pauline Monette, who resigned to take positions elsewhere. Mrs. L. Whitney retired, and Miss V. Vezina ended her temporary employment. Mr. A. Fisher died. Miss Mary Williams returned from library school. The library was fortunate in obtaining the services of Mr. Paul Laurendeau, Mrs. K. Nagy, Mrs. Louise Maheral (on a permanent basis), and Mrs. C.M. Wistaff.

Library statistics for the year are as follows:

Books and pamphlets acquired by purchase	1,608 of which 1,024 were for outside offices.
Canadian government publications	5,155
Canadian periodicals	2,056
Proceedings, transactions and bulletins of Societies	7,660
Foreign government publications	4,493
Foreign periodicals	2,420
Total	23,392

Other data:

Recorded loans, books, pamphlets and periodicals	40,749
Interlibrary and occasional loans	8,160
Publications borrowed from other libraries	391
Maps and charts loaned	964
Maps and charts received, before sorting for retention	3,080
Cards added to general catalogue	13,295
Items catalogued, including books, pamphlets, microfilms, monographs and analytical entries	3,905
Volumes bound	1,016
Scientific books purchased for personal use of staff members at their expense	99

PUBLICATION DISTRIBUTION OFFICE

L. Touchette

During 1965 the Publications-Information Unit continued its functions as distributor of geological publications and information for the public, government departments, and staff members.

During the year the following publications were received and made available for distribution.

Economic Geology Series	2
Memoirs	2
Bulletins (10 English and 2 French)	12
Preliminary Papers (45 English and 2 French)	47
Preliminary Papers (reprinted)	21
Miscellaneous Report Series	2
Topical Reports	9
Water Supply Papers (reprinted)	63
Misc. Reports, Brochures, Lists, etc.	16
Final Geological Maps	18
Preliminary Geological Maps (21 English and 1 French)	22
Aeromagnetic Maps (new issues)	707
Aeromagnetic Maps (reprinted)	120
Mineral Maps of Canada (French and English)	2
Map 1039-A (revised edition)	1
Indices to G.S.C. Maps (revised)	17
Indices to Aeromagnetic Maps (revised)	4

DISTRIBUTION DATA:

Maps	232,229
Reports	79,152
Indices, listings, brochures, etc.	34,335
Total Distribution	345,716

OTHER DATA:

Requests for publications, information, R. & M.	20,025
Visitors (cash sales 1,029 - others 1,151)	2,180
Notification lists	58
Total publications advertised	799

PHOTOGRAPHIC SECTION

E.C. Elliott

The photographic section is very pleased to report the recruitment of a photo librarian, which will fill a long felt need for the cataloging and filing of photographic negatives.

The work production has shown a decided drop during the past year. This can only be attributed to sickness among the staff, with loss of 143 man working days.

Production Report

Contact prints	18,828
Bromide enlargements	18,832
Photo negatives made	2,795
Photo negatives retouched	6
Photo negatives opaqued	10
Photomicrographs	270
Macrophotographs	1,201
Film positives	130
Lantern slides made	502
Lantern slides bound	264
X-ray negatives made	8
Autoradiographs	13
Photos dry mounted	368
Exposures processed (field work)	7,414
Colour transparencies made	860
Colour transparencies processed	496
Colour slides made	152
Colour slides bound	206
Colour negatives made	176
Colour prints made	656
Total	53,897

STENOGRAPHIC POOL

Mrs. M. Shanks

Summary of work executed in the Stenographic Services during 1965 is as follows:

Letters from dictaphone and stenorette	988
Letters from manuscript	3,341
Pages of reports from dictaphone and stenorette	316
Pages of reports from manuscript	10,757
Pages of Preliminary reports	5,365
Multilith masters	2,173
Tabulated pages	1,004
Long carriage tables	266
Cards	10,161
Forms	850
Total of carbon copies produced	24,316
Secretarial relief supplied - days	181
Daily average number of operators in pool	8.43) = 9.15
Daily average of personnel on secretarial relief duties	.72)
Daily time factor for assembling, elucidation of difficult manuscripts, and corrections	15% approx.

Approximate assessment of work:

Letters = 30 to 40 lines single spacing, 1 1/2" margin, including address and salutation.

Reports = 6" line, double spacing, 30/32 lines (6" x 10" approx.)

Multilith masters = include large variety of work, i.e. double and single spacing work, tables, charts, etc.

Tabulated pages = numerical statistics, correlation tables, etc.

Cards = IBM type cards, geological records, technical indices, etc.

Work in the Stenographic Pool continued in 1965 at a steady pace in much the same pattern as in past years. The big volume of typing is from October to May inclusive, but during the months June to September when secretarial relief is supplied and annual leave is taken, relatively, those remaining in the pool are kept as busy typing to meet current demands and reports left by the geologists when they leave for the field. This year 181 days (an increase of 20 over 1964) were supplied in secretarial relief and report pages were up from 14,467 to 16,122, accounted for possibly by the increase of outside publications.

These have grown to about two a week. Also letters from dictaphone and stenorette, multiliths, tabulation, long carriage, and forms all showed an increased output. Letters from manuscript, reports from dictaphone, and cards showed a decrease, the latter a considerable one. Of course some of the cards we type are considered a background job and the decrease indicates that operators were busy on more urgent work.

In previous years it was stated that approximately 15 per cent of the typists' time is spent on corrections (principally authors' changes), assembling, checking spelling and place names etc., not to mention difficulties in elucidating poor writing. This was a mental estimate made by the supervisor, but she wishes to report that for 1965 under her direction the operators kept a record of the time spent on these duties and the figure of 15 per cent is a pretty accurate statement.

We are being called on more and more to type reports containing extensive and complex equations using Greek and mathematical symbols. It is gratifying to report that the typits we obtained in the fall of 1964 to enable us to type these equations are proving most effective. It is hoped that authors are satisfied with the extra care and attention that is given these reports.

During the year two of our operators were fortunate in winning competitions in the Branch, which meant upgrading. Mrs. Murphy went to Fuels and Stratigraphy and Mrs. Yeager to G.S.C Editorial. New recruits are shaping up well.

The Supervisor would like to put on record that she deplores the dropping of Typist 3 grade. This grading, which was really only the equivalent in salary of a Steno 2, helped to recompense the experienced typists who put so much effort into mastering the complex nature of the scientific material they are called upon to type in an acceptable form.

LAPIDARY SECTION

H.W. Hay

Report of work done in Lapidary section from December 16th, 1964 to December 15th, 1965.

Thin Sections	6,437
Polished Thin Sections	181
Large Polished	110
Mounted Polished	11
Large Cut and Levelled	297
Frosted Slides	8,000
Cutting of Jade	44 hrs.
Large Cut and Polished	417 Sq. Ins.
Sections to be covered	140
Slabs-Cut-Sized - 1 x 3 x 1/4	4

INSTRUMENTAL DEVELOPMENT SHOP

G. A. Meilleur

Requests for fabrication of instruments and services has once again reached a new level during the year of 1965. Demand from all divisions has increased although not all to the same extent. Over 60 per cent of the effort has been concentrated on new developments, thus following the trend of previous years.

After 5 years of operation the Instrumental Development Shop is staffed with 3 permanent employees and was fortunate in obtaining the services of 2 students for the summer months. The third position was filled in August, 1965, with the arrival of Mr. Cregheur.

While an increase in personnel increased the shop potential, it has not been sufficient to satisfy the ever increasing demand. Hence at the end of 1965, there is a backlog of work requiring an estimated 2,400 hours of shop time. The above mentioned figures are for work orders on hand and do not include anticipated projects.

The following is a partial list of 1965 projects:

1. Miniature switch for the collector assembly of Mass Spectrometer MS-4.

2. Modification of portable diamond drill for 1" and 1 1/2" cores.

3. Vessels for high pressure studies.

4. Development of new instruments for rock sample orientation.

5. Pneumatic packer for installation of transducer in well.

6. Casing for underwater operation of transducer.

7. Development of new components for astatic magnetometer.

8. One litre counter for Radiocarbon Dating Laboratory.

Time allotted per Division was as follows:

Geophysics	30%
Petrological Sciences	27%
Economic Geology	20%
Fuels and Stratigraphy	11%
Administration	7%
Regional Geology	5%

In addition, approximately 15 per cent of the total time was contracted to commercial shops.

Activities during the past year have been very diversified and challenging, we have appreciated the cooperation of all members of the staff and hope to be able to provide ever improving services.

FIELD TELECOMMUNICATIONS

J. Blanchard

The 1966 field season will see the entry of the Department of Mines and Technical Surveys into the single side band method of radio communication. There are now 12 single side band units on order at an approximate cost of $24,000.

Because of certain technological limitations the time it will take for the transition from double side band full carrier to single side band suppressed carrier cannot be closely predicted.

The frequency of quartz crystals varies with temperature. The electrical power required to keep the crystals at a constant temperature is beyond the power capability of the dry battery pack of portable transceivers. The crystals need to be placed in a constant temperature enclosure to maintain the high degree of frequency accuracy required.

Two electronic instruments, not available commercially, have been designed, prototypes constructed and field tested. The first, a four-channel simultaneous receiver is now in field service. The second, a reference signal tuning source is being manufactured under contract.

Ninety-five per cent of radio repair and overhaul maintenance is done by commercial firms. The greater part of this maintenance is let by tender. VHF-FM, Micro-Wave, and other units of critical frequency accuracy are serviced by firms that specialize in this type of maintenance, and which have given the department satisfactory service in previous years.

New purchases this year:

HF Transceivers	70
HG Transistor receivers	37
Total number of units	373
Number of radio equipped parties	72

A number of obsolete transceivers have been turned over to Crown Assets for disposal.

This year for the first time there were enough spare transceivers for issue on temporary field assignments, to fill all requests from departmental field officers.

The rapid expansion of this position has created a work load too great to be performed by one person. A permanent technical assistant is mandatory if it is to continue to be an asset to this department.

APPENDIX I

STAFF LIST

Geological Survey of Canada

Director's Office

1 Director
Fortier, Y.O.

1 Secretary to Executive
Arscott, Mrs. M.M.

1 Chief Geologist
Lord, C.S.

1 Secretary to Executive
Derry, Miss G.E.

1 Sr. Sc. Off. 1
Hall, E.

1 Steno. 3
Morency, Miss L.S.

Special Projects

2 Chief of Division
Lang, A.H.
Stockwell, C.H.

Secretary Nat. Adv. Comm.

1 Sr. Geologist
Henderson, J.F.

Manuscripts & Cartography

1 Geologist 5
Harker, P.

Manuscripts

2 Geologist 4
Blackadar, R.G.
Jenness, S.E.

1 Clerk 4
Mahoney, Mrs. L.R.

1 Steno. 3
Yeager, Mrs. M.A.

Cartography

1 Tech. Off. 7
Daughtry, G.S.

1 Clerk 3
Lessard, Miss J.M.

1 Technician 1
McCracken, J.M.

Planning

1 Tech. Off. 6
Williams, L.A.

Editing & Contracts

1 Tech. Off. 6
McNeil, C.E.

Compiling

1 Tech. Off. 6
Nunn, E.P.

1 Drafts. 4
Leader, R.E.

2 Super. Dr. 2
Debain, P.
Dumbrell, E.A.

2 Map Comp. & Comp. 4
Daugherty, R.F.
Raddatz, Miss M.A.

6 Drafts. 3
Barbary, G.J.
Heyendal, H.A.
King, J.A.
Kovachic, Mrs. H.
Lavigne, G.H.
Nichol, H.S.

Drafting (Illustrations)

1 Drafts. 5
Gardham, F.J.

2 Drafts. 4
Finn, H.J.
Edwards, B.

5 Drafts. 3
Hayne, M.F.
Heney, F.J.
Hill, B.G.
Saffin, R.E.
Vermette, W.P. (Calg.)

5 Drafts. 2
Browne, J.A.
Corriveau, J.P.
Potvin, R.Y.
Sutcliffe, W.J.
Yelle, J.S.

Drafting (Illustrations) continued

5 Drafts. 1
Canthart, J.A.
Grenier, N.
McKenzie, N.M.
Pelletier, Miss A.E.
Sauvageau, R.

Drafting (Maps)

1 Drafts. 5
Babcock, L.W.

2 Drafts. 4
Bernard, M.G.
Gagnon, J.G.E.

10 Drafts. 3
Bencik, K.
Cooke, Miss B.J.
Hill, R.S.
Howe, K.G.
MacLachlan, L.A. (Calg.)
Mainville, B.
Romhild, R.C.
St. Pierre, M.
Thomson, J.W.
Whitman, G.S.

1 Drafts. 2
Gagne, R.M.

1 Asst. Tech. 3
Young, W.G.

Negative Engraving,
Colour Negatives

1 Drafts. 4
Williams, J.B.F.

3 Drafts. 3
Daley, L.A.
Papps, T.L.
Walter, D.J.

Negative Engraving,
Colour Negatives (Cont'd)

1 Drafts. 2
Thomson, H.A.

1 Drafts. 1
Enright, M.L.

Photo-Mech. Map Photo

1 Process Camera Operator
Buck, N.E.

1 Asst. 3 Litho or Photo
Foshay, G.N.

1 Asst. 1 Litho or Photo
Snyder, W.M.

Printing and Photostat

1 Technician 2
Major, A.C.

2 Asst. 2 Litho or Photo
Fairfield, R.D.J.
Wilson, G.B.

1 Asst. 1 Litho or Photo
Mackenzie, R.J.G.

Marine Geology - Dartmouth, N.S.

1 Geologist 4
Pelletier, B.R.

1 Sr. Sc. Off. 2
King, L.H.

2 Geologist 3
Marlowe, J.I.
Wagner, Miss F.J.E. (Ottawa)

2 Geologist 2
Bartlett, G.A.
McMullen, R.M.

Marine Geology - Dartmouth, N.S.
(Continued)

4 Sc. Off. 2
Buckley, D.E.
Grant, A.C.
Kranck, Miss K.M.
Vilks, G.

2 Technician 2
Cormier, R.
Duncan, G.A.

1 Asst. Tech. 3
Holler, A.T.

1 Technician 1
Pitcher, Miss S.S.M.

British Columbia Office

1 Geologist 5
Armstrong, J.E.

1 Sc. Off. 2
Leaming, S.F.

1 Clerk 4
Marble, Mrs. A

1 Stenographer 3
Lee, Mrs. E.K.

1 Clerk 2
Bowman, Mrs. V.C.

Whitehorse Office

1 Geologist 4
Green, L.H.

1 Clerk 3
Phillips, Mrs. E.C.

Administrative Services

1 Admin. Off. 6
Pollitt, K.

1 Admin. Off. 3
Lajoie, L.J.

1 Stenographer 3
Baker, Mrs. R.D.

Attendance

1 Typist 3
Shields, Mrs. L.

Accounts

1 Admin. Off. 1
Raymond, J.E.

2 Clerk 3
Fahey, G.O.
McNaught, Mrs. M.E.L.

Branch Registry and Messenger Service

1 Principal Clerk
Reynolds, Mrs. E.V.

1 Clerk 3
McGuire, Mrs. V.M.

1 Clerk 2
O'Dwyer, Mrs. F.

1 Clerk 1
Perron, Miss M.I.N.

1 Clerical Asst.
Patry, Miss G.M.

Geological Information

1 Supervising Clerk
Touchette, L.J.

1 Clerk 4
Letang, E.G.

1 Clerk 3
Lortie, L.H.

2 Clerk 2
Clarke, C.R.
McNabb, Mrs. S.W.A.
Vachon, D.M.

1 Typist 2
Drapeau, Mrs. G.M.

Stationery & Office Supplies

1 Clerk 4
Smith, D.D.

1 Clerk 3
Moreau, V.

1 Storeman 2
Charlebois, G.J.

1 Driver
Cayer, H.H.

Photographic

1 Technician 4
Elliott, E.C.

3 Photographer 4
Cooke, F.J.
Emslie, J.B.
Thorpe, E.

Photographic continued

2 Photographer 2
White, Miss J.I.
Skuce, C.A.

1 Tech. Off. 2
Beckstead, D.C.

2 Technician 1
Kempt, J.W.
Stafford, W.G.

Library

1 Librarian 5
Kummermann, Mrs. N.I.

2 Librarian 1
Nagy, Mrs. K.
Williams, Miss M.E.

1 Tech. Off. 3
Lindsay, Miss L.E.

1 Clerk 3
Stewart, Miss T.G.

1 Clerk 2
Maheral, Mrs. L.

1 Tech. Off. 2
Laurendeau, P.E.

1 Typist 2
Wistaff, Mrs. C.M.

Stenographic Pool

1 Clerk 4
Shanks, Mrs. M.A.

1 Clerk 3
Partington, Mrs. G.

Stenographic Pool continued

2 Typist 3
Casey, Mrs. M.
Millar, Miss M.

6 Typist 2
Ainsworth, Mrs. H.B.
Bouvier, Miss C.
Mahony, Mrs. G.I.
Richard, Mrs. B.G.
Stafford, Mrs. D.M.
Welsh, Mrs. P.P.

3 Typist 1
Goldstein, Mrs. R.S.
Lafrance, Miss P.A.
Pichette, Miss M.H.

Technical Services

1 Technical Officer 5
Jones, F.W.

Lapidary

1 Technician 3
Hay, H.W.

2 Technician 1
McEwan, W.O.
Whitehead, A.E.

1 Asst. Tech. 3
Demers, A.Y.

Equipment Office

1 Clerk 3
Rozon, R.

Instrument Shop

1 Tech. Off. 4
Meilleur, G. A.

2 Technician 2
Cregheur, A. Y.
Fournier, J. P.

Carpenter Shop

1 Carpenter
Carey, E. L.

REGIONAL GEOLOGY DIVISION

1 Chief of Division
Douglas, R. J. W.

1 Clerk 4
Paquette, Mrs. A. M.

Appalachian

1 Geologist 5
Neale, E. R. W.

3 Geologist 4
Anderson, F. D.
Kelley, D. G.
Poole, W. H.

2 Geologist 3
Benson, D. G. (Bedford)
Williams, H.

1 Geologist 2
Gillis, J. W. (Bedford)

Eastern Shield

1 Geologist 5
Duffell, S.

Eastern Shield continued

5 Geologist 4
Fahrig, W. F.
Frarey, M. J.
Goodwin, A. M.
Stevenson, I. M.
Taylor, F. C.

4 Geologist 3
Baragar, W. R. A.
Emslie, R. F.
Jackson, G. D.
Skinner, R.

Western Shield

2 Geologist 5
Wright, G. M.
Tremblay, L. P.

5 Geologist 4
Bell, C. K.
Eade, K. E.
Fraser, J. A.
Heywood, W. W.
McGlynn, J. C.

3 Geologist 3
Baer, A. J.
Bostock, H. H.
Donaldson, J. A.

1 Geologist 2
Reinhardt, E. W.

1 Sr. Sc. Off. 1
Davison, W. L.

Cordilleran

1 Geologist 5
Little, H. W. (B. C.)

Cordilleran continued

8 Geologist 4
Campbell, R.B. (B.C.)
Gabrielse, H.
Leech, G.B.
Muller, J.E. (B.C.)
Roddick, J.A. (B.C.)
Souther, J.G. (B.C.)
Tipper, H.W.
Wheeler, J.O. (B.C.)

2 Geologist 2
Blusson, S.L.
Hutchison, W.W. (B.C.)

FUELS AND STRATIGRAPHY DIVISION

1 Chief of Division
Caley, J.F.

1 Clerk 3
Riddell, Mrs. N.H.

Palaeontology

3 Geologist 5
McLaren, D.J.
Jeletzky, J.A.
Tozer, E.T.

5 Geologist 4
Bolton, T.E.
Copeland, M.J.
McGregor, D.C.
Norris, A.W.
Sinclair, G.W.

3 Geologist 3
Bamber, E.W.
Cumming, L.M.
Norford, B.S.

1 Geologist 2
Fritz, W.H.

Palaeontology continued

1 Sc. Off. 2
Uyeno, T.T.

1 Tech. Off. 3
Botte, B.J.

1 Technician 3
Callahan, J.J.

1 Technician 1
Matte, J.E.A.

2 Asst. Tech. 1
Jarvis, D.C.
Moore, G.P.

1 Steno. 3
Murphy, Mrs. F.M.

1 Clerk 2
Carbone, S.

Senior Research Palaeontologist

1 Geologist 5
Frebold, H.W.

Petroleum Geology

1 Geologist 5
Norris, D.K.

5 Geologist 4
Aitken, J.D. (Calg.)
Irish, E.J.W. (Calg.)
Liberty, B.A.
Price, R.A.
Stott, D.F. (Calg.)

3 Geologist 2
MacQueen, R.W. (Calg.)
Ollerenshaw, N.C.
Taylor, G.C.

Petroleum Geology continued

1 Sr. Sc. Off. 2
Sanford, B.V.

1 Sr. Sc. Off. 1
Latour, B.A. (Calg.)

2 Sc. Off. 3
Howie, R.D.
MacLean, B.

1 Technician 2
ter Haar Romeny, W.U.

1 Clerk 3
Wragg, Miss C.E.

2 Asst. Tech. 3
Bova, P.
Seguin, R.J.G.

1 Asst. Tech. 1
Lafontaine, J.M.

Arctic Islands

1 Geologist 5
Thorsteinsson, R. (Calg.)

1 Geologist 4
Christie, R.L.

2 Geologist 3
Kerr, J.W. (Calg.)
Trettin, H.P. (Calg.)

Western Plains Office

2 Geologist 5
Wickenden, R.T.D.
Belyea, Miss H.R.

2 Geologist 3
Burk, C.F.
Procter, R.M.

Western Plains Office continued

3 Geologist 2
Pugh, D.C.
MacKenzie, W.S.
Nassichuk, W.W.

2 Sr. Sc. Off. 1
Chamney, T.P.
Price, L.L.

1 Sc. Off. 3
Tassonyi, E.J.

2 Sc. Off. 2
Cox, R.L. (Ottawa)
Martin, H.L.

1 Tech. Off. 3
Jones, Mrs. M.

1 Tech. Off. 2
Banning, W.J.

1 Technician 1
Herron, D.L.

1 Asst. Tech. 3
Bowering, A.L.

1 Asst. Tech. 2
Heinrich, A.G.

1 Clerk 4
Brooks, Mrs. M.H.

1 Clerk 2
Penley, Miss W.L.

3 Typist 1
Dennis, Mrs. V.
Seburn, Mrs. M.A.
Walters, Miss P.L.

Coal Research

1 Geologist 5
Hacquebard, P.A.

1 Geologist 3
Cameron, A.R.

2 Sc. Off. 3
Birmingham, T.F.
Donaldson, J.R.

1 Tech. Off. 4
Barss, M.S.

ECONOMIC GEOLOGY DIVISION

1 Chief of Division
Robinson, S.C.

1 Clerk 4
Burns, Miss E.M.

Central Technical Geological Files

1 Clerk 3
Shurben, Mrs. P.K.

Geology of Mineral Deposits

1 Geologist 4
Whitmore, D.R.E.

1 Geologist 5
Kindle, E.D.

5 Geologist 4
Gross, G.A.
McCartney, W.D.
Mulligan, R.
Roscoe, S.M.
Rose, E.R.

1 Geologist 3
Chamberlain, J.A.

Geology of Mineral Deposits continued

1 Sc. Off. 2
McLeod, C.R.

1 Tech. Off. 4
Johnston, A.G.

1 Asst. Tech. 2
Burke, R.D.

Geochemistry

1 Geologist 5
Boyle, R.W.

2 Geologist 3
Cameron, E.M.
Currie, K.L.

2 Geologist 2
Fortescue, J.A.C.
Sangster, D.F.

2 Sc. Off. 3
Dyck, W.
Lynch, J.J.

1 Sc. Off. 2
Hornbrook, E.H.W.

1 Tech. Off. 2
Horton, R.E.

1 Technician 3
Lavergne, P.J.

1 Technician 2
Mihailov, G.

2 Technician 1
Durham, C.C.
Pelchat, J.C.

Pleistocene Geology

2 Geologist 5
Fyles, J.G.
Prest, V.K.

7 Geologist 4
Craig, B.G.
Gadd, N.R.
Henderson, E.P.
Hughes, O.L. (Calg.)
Lee, H.A.
Stalker, A.M.
Terasmae, J.

2 Geologist 3
Blake, W.
St. Onge, D.A.

4 Geologist 2
Fulton, R.J.
Klassen, R.W. (Calg.)
Lewis, C.M.
Rutter, N.W. (Calg.)

1 Tech. Off. 4
Mott, R.J.

1 Technician 3
Field, D.E.

1 Technician 1
Kelley, R.G.

Engineering and Groundwater Geology

1 Geologist 5
Brown, I.C.

1 Geologist 4
Meyboom, P. (Calg.)

1 Sr. Sc. Off. 2
Owen, E.B.

Engineering and Groundwater Geology

2 Sr. Sc. Off. 1
Charron, J.E.
Halstead, E.C. (Vanc.)

2 Geologist 3
Scott, J.S.
van Everdingen, R.O.

2 Geologist 2
Carr, P.A. (Bedford)
Delorme, L.D. (Calg.)

1 Sc. Off. 3
Gilliland, J.A.

3 Sc. Off. 2
Freeze, R.A.
Lissey, A.
Parsons, M.L.

1 Sc. Off. 1
Lawson, D.W.

1 Technician 2
Pearce, R.G.

Yellowknife Office

1 Sc. Off. 2
Thorpe, R.I.

1 Clerk 3
Braden, Mrs. E.

PETROLOGICAL SCIENCES DIVISION

1 Chief of Division
Smith, C.H.

1 Clerk 3
Gougeon, Mrs. C.L.

Mineralogy

1 Geologist 4
Traill, R.J.

3 Sr. Sc. Off. 1
Steacy, H.R.
Lachance, G.R.
Rimsaite, Miss J.

1 Res. Sc. 1
Aumento, F.

2 Sc. Off. 3
Jambor, J.L.
Sabina, Miss A.P.

1 Sc. Off. 1
Hunt, Miss C.M.

1 Tech. Off. 2
Delabio, R.N.

1 Asst. Tech. 2
Bartlett, Mrs. M.E.

Mineral Separation Lab.

1 Tech. Off. 3
Gauthier, C.H.R.

1 Technician 3
Paris, J.C.

1 Technician 1
Larose, J.M.

2 Asst. Tech. 3
Machin, D.B.
Turpin, J.

3 Asst. Tech. 2
Gauthier, P.J.
Houle, A.
Valenzuela, J.M.

Isotope and Nuclear Research

1 Sr. Sc. Off. 3
Wanless, R.K.

3 Sc. Off. 3
Loveridge, W.D.
Lowdon, J.A.
Stevens, J.A.

1 Technician 3
Sullivan, R.W.

1 Technician 1
Robertson, I.M.

1 Asst. Tech. 3
Bradshaw, C.D.

1 Asst. Tech. 2
Clair, J.F.

Petrology

1 Geologist 5
Reesor, J.E.

1 Res. Sc. 1
Froese, E.

1 Geologist 3
Irvine, T.N.

2 Geologist 2
Douglas, J.A.V.
Findlay, D.C.

Data Processing

1 Geologist 4
Dawson, K.R.

1 Geologist 3
Agterberg, F.P.

Analytical Chemistry

1 Sr. Sc. Off. 3
Maxwell, J.A.

Chemical Lab.

1 Sr. Sc. Off. 2
Abbey, S.

2 Sc. Off. 3
Courville, S.
Sen Gupta, J.G.

2 Technician 1
Bouvier, J.L.
Church, K.A.

2 Asst. Tech. 3
Gibson, W.A.
Watson, Mrs. F.J.

3 Asst. Tech. 2
Brewer, Miss M.A.
Brown, D.A.
Seymour, Miss L.J.

Spectrographic Lab.

1 Sr. Sc. Off. 1
Champ, W.H.

1 Tech. Off. 4
White, W.F.

1 Technician 2
Malone, J.P.

GEOPHYSICS DIVISION

1 Chief of Division
Morley, L.W.

1 Steno. 3
Goodman, Mrs. N.D.

E.M. & Resistivity

1 Sr. Sc. Off. 2
Collett, L.S.

1 Sc. Off. 3
Ahrens, R.H.

1 Sc. Off. 2
Wyder, J.E.

2 Technician 3
Gouvreau, C.
Stauffer, W.J.

1 Technician 2
Flint, T.R.

Fed/Prov. Aeromag. Surveys

1 Geologist 4
MacLaren, A.S.

1 Tech. Off. 5
Ready, E.E.

2 Map Comp. & Comp. 4
Chretien, Miss M.B.
Derouin, E.J.

1 Map Comp. & Comp. 3
Haley, E.L.

Magnetic Methods

1 Sr. Sc. Off. 2
Hood, P.J.

2 Sc. Off. 3
Bower, Miss M.E.
Sawatzky, P.

1 Tech. Off. 4
Owens, K.H.

1 Technician 4
Knapp, H.W.C.

Magnetic Methods continued

1 Technician 3
Dicaire, A.

1 Map Comp. & Comp. 4
Reveler, D.

Theoretical Geophysics

1 Sr. Sc. Off. 2
Bhattacharyya, B.K.

1 Map Comp. & Comp. Super. 1
Langlois, R.J.

1 Map Comp. & Comp. 4
Dods, S.D.

2 Map Comp. & Comp. 3
Laurin, Mrs. T.C.M.
Zieman, F.W.

1 Drafts. 1
Abbinett, D.D.

1 Map Comp. & Comp. 1
Roy, A.Y.

Rock Magnetism

1 Geologist 4
Larochelle, A.

1 Sc. Off. 3
Schwary, E.J.

1 Technician 2
Christie, K.W.

1 Technician 1
Freda, G.N.

Seismic

1 Sr. Sc. Off. 2
Hobson, G.D.

1 Sc. Off. 3
Overton, A.

1 Technician 4
MacAulay, H.A.

1 Technician 3
Hodge, R.A.

Remote Airborne Sensing

1 Geologist 4
Gregory, A.F.

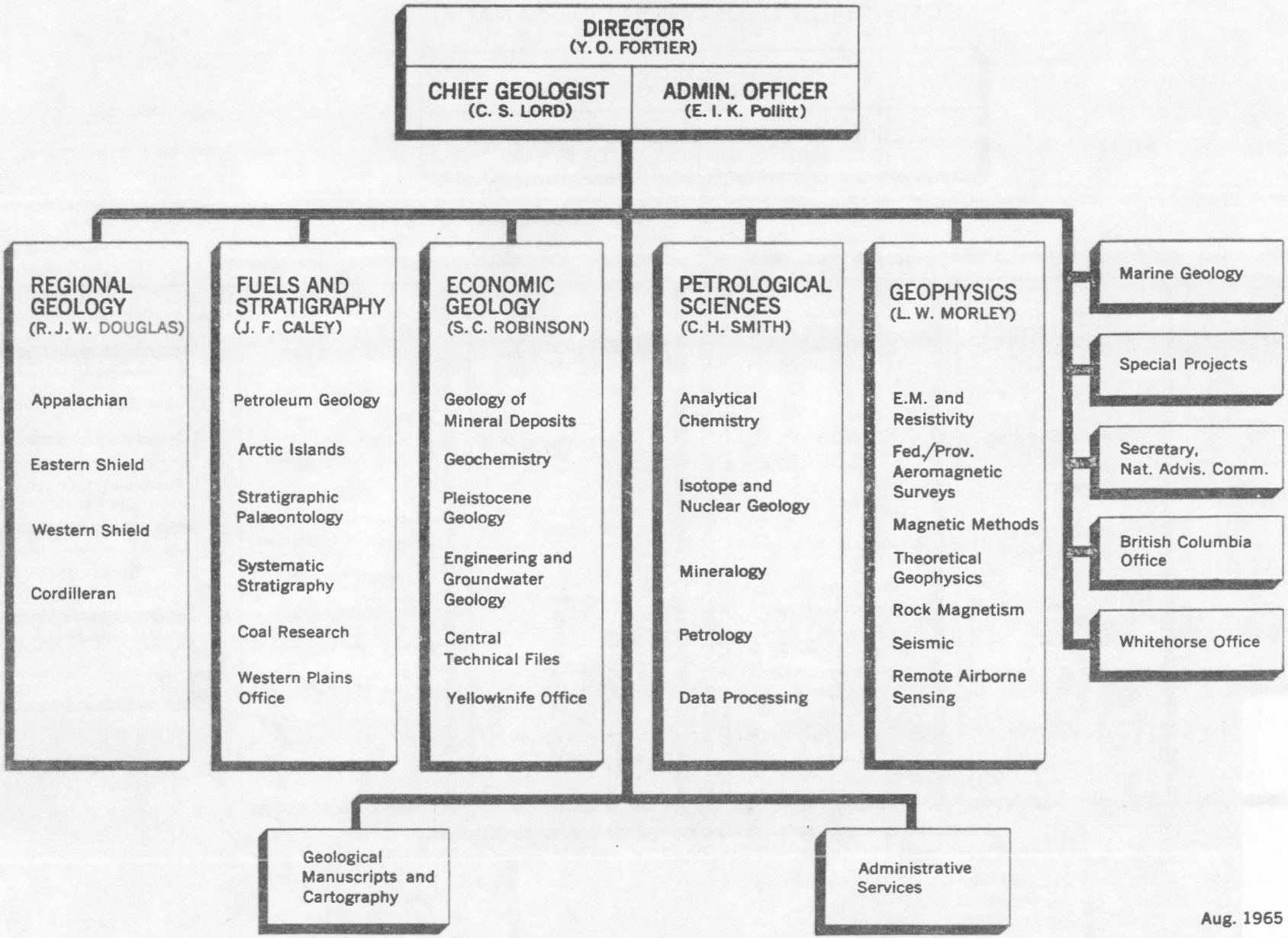
1 Geologist 2
Becker, A.

1 Tech. Off. 6
Washkurak, S.

On Loan

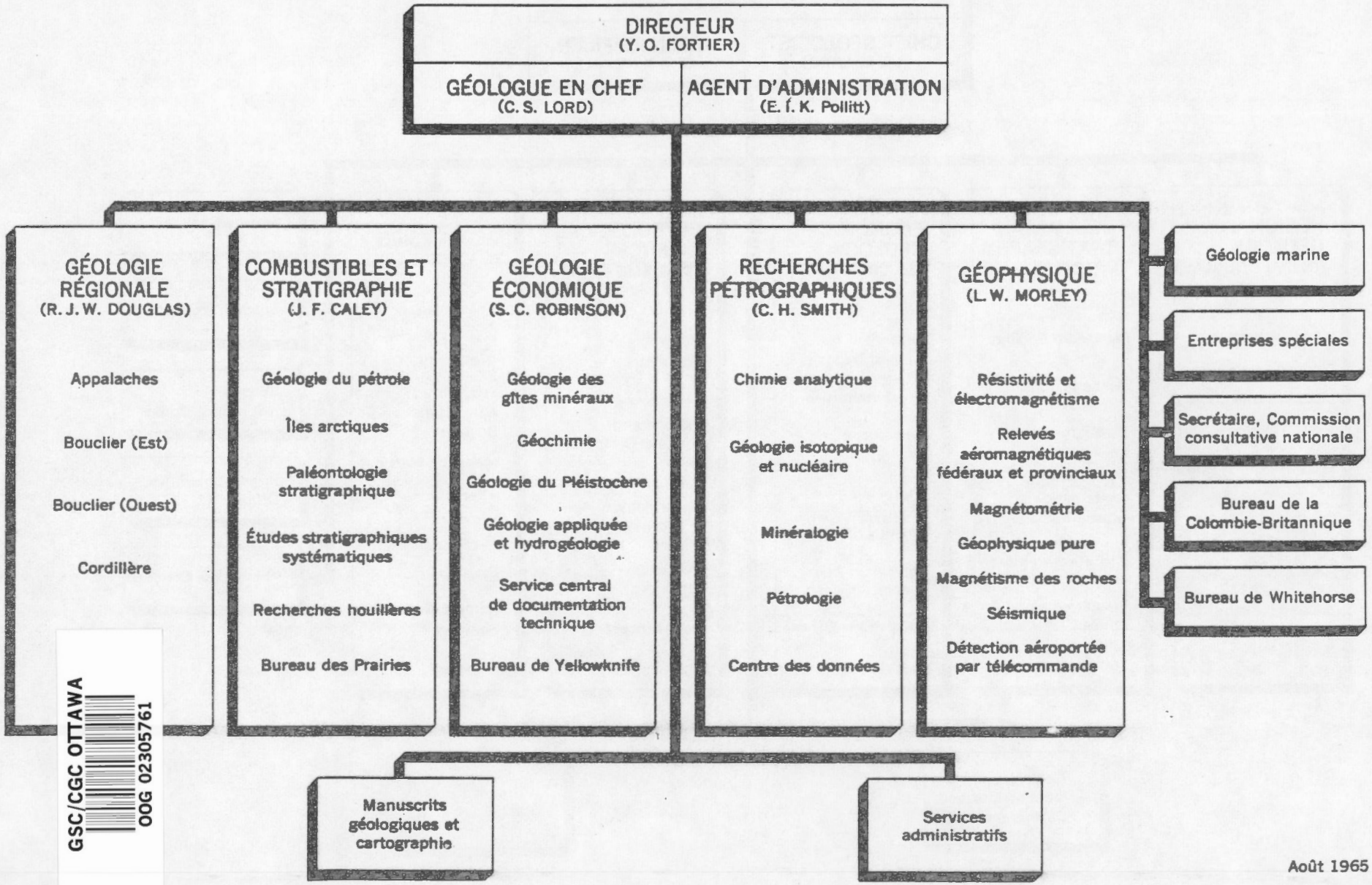
1 Technician 3
Blanchard, J.

GEOLOGICAL SURVEY OF CANADA



Aug. 1965

COMMISSION GÉOLOGIQUE DU CANADA



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Août 1965