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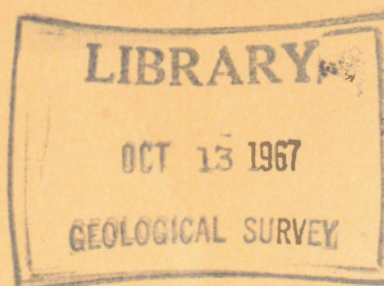
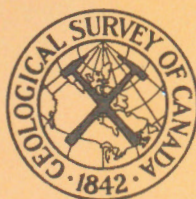
CANADA  
DEPARTMENT OF ENERGY,  
MINES AND RESOURCES

GEOLOGICAL SURVEY OF CANADA

ANNUAL REPORT

JANUARY 1, 1966 TO MARCH 31, 1967

FOR GEOLOGICAL SURVEY USE ONLY



OTTAWA

1967

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CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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GEOLOGICAL SURVEY OF CANADA

ANNUAL REPORT - JANUARY 1, 1966 to MARCH 31, 1967

Note: This report comprises data submitted for the 1966 Departmental Annual Report. For ease of reference the data have been re-arranged but have not been carefully edited. This report is intended only for Geological Survey office use and record.

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ANNUAL REPORT JANUARY 1, 1966 TO MARCH 31, 1967

GEOLOGICAL SURVEY OF CANADA

INTRODUCTION

Y.O. Fortier, Director

The Geological Survey is responsible for the continuation of systematic geological investigation of Canada, both in the field and in the laboratory. It is the major organization engaged in this field in Canada and its studies are nation wide. This systematic research is supported by research in the many aspects of geological sciences, including geochemistry, geophysics, geomorphology, mineralogy, palaeontology, petrology, and related subjects.

The main objectives of the Geological Survey are:

- to systematically investigate, describe, and explain the geology of Canada and thereby:
  - (a) determine the nation's potential mineral resources;
  - (b) provide industry and other governmental agencies with the data required for the discovery and exploration of the nation's mineral deposits;
  - (c) assist planning and development by providing data fundamental to engineering projects, land use, water supply, and to other resource fields;
- to carry on other research that will contribute to our knowledge of how and when the rocks of the earth and their contained mineral deposits were formed, thereby expanding the potentials of the science and thus enabling geologists to investigate and explain the geology of Canada more effectively; and
- to develop new instruments and methods as aids to geological investigations and as aids to the search for mineral deposits; and
- to assist in the operational and research training in the geological sciences and in the supporting techniques to meet the requirements of science and the nation's economy for qualified manpower.

In 1966 the Geological Survey sent out 102 full-time field parties and 36 short-term parties. Twenty parties were active in large scale reconnaissance studies, the remainder in more detailed mapping or in the



investigation of specific topics. No major airborne projects were carried out in 1966 but helicopters and light fixed-wing aircraft were used by many parties.

Operation Selwyn, using helicopter support, continued reconnaissance mapping in eastern Yukon and adjacent areas; helicopters were also used by parties in British Columbia and District of Mackenzie. In the latter area the aircraft was shared by several parties and was moved from south to north with the advance of spring weather conditions.

On the more detailed and topical scale the Survey's activities covered a wide spectrum and ranged from a study of the late Precambrian Dubawnt Group to a study of the eskers west of Hudson Bay; from a study of volcanic rocks in the Cordillera to an examination of Mississippian foraminifera of southwestern Alberta; from a marine seismic survey of Lake Ontario to experimental aerial photography around the western shoreline of the same lake.

Laboratory support is of increasing importance to modern geological research and within the Geological Survey development of new tools designed to assist in theoretical and applied research continued. Computer programs for the interpretation and handling of large quantities of geochemical data were written, compiled or modified. A rapid test for the on-site determination of nickel and cobalt in water was developed. Research continued towards the production of an extremely high sensitivity magnetometer suitable for installation in light twin-engined aircraft. In the field of analytical chemistry a titrimetric method for the determination of silica over the range of 30 to 80 per cent was under investigation. If successful, this method will give a procedure less subject to the hidden errors of the present method.

To stimulate geological research at Canadian universities, grants by the Geological Survey were initiated in 1951. During the period covered by this report 85 grants totalling \$150,000 were awarded to 20 universities. Support was provided for 20 Ph.D. thesis projects through summer employment with the Survey. Staff members from Ottawa and from the regional offices presented lectures to various groups on geological subjects; such talks range from popular presentations to highly technical papers presented to scientific meetings. An exchange between one of the Survey's staff geologists and a member of the Bureau of Mineral Resources, Australia, took place between March 1966 and March 1967.

The Geological Survey regularly publishes the results of its scientific activity and during the period covered by this report 6 memoirs, 22 bulletins, 52 papers, 14 preliminary maps, 6 multicoloured maps, 16 topical reports and one miscellaneous report were issued. About 390,000

copies of maps and reports were distributed, 8,218 sets of minerals and rock chips were sold, and 70 special collections representing the mineral industry of Canada were prepared for display in Canadian embassies throughout the world.

In addition to the headquarters in Ottawa, the Survey maintains offices in Calgary, Whitehorse, Yellowknife, and Vancouver. The offices in Calgary were moved in March 1967 to the Survey's new Institute of Sedimentary and Petroleum Geology building which will be officially opened in September 1967.

A Departmental decision was made to convert the Annual Report period from the calendar year to the fiscal year. In order to effect this conversion the following report, from which data are extracted for the Departmental report, covers the period January 1, 1966 to March 31, 1967.



## REGIONAL GEOLOGY DIVISION

R.J.W. Douglas, Chief

S. Duffell, Acting Chief

### INTRODUCTION

The division is responsible for geological investigation of the orogenically disturbed regions of Canada, i.e. the Canadian Precambrian Shield and the Cordilleran and Appalachian Regions. 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.

For the period covered by this report the Division comprised 45 employees including a Division Chief, 4 Section Heads, 1 Division Secretary and 39 staff geologists to which there were added during the field season a complement of 2 Post-Doctorate Fellows and 11 graduate students engaged in Ph.D. theses projects. A total of 38 geologists were involved in field research on 38 projects which involved over a month's field work, 5 geologists conducted field investigations involving less than a month's time in the field and 8 staff members stayed in the office to write reports on back projects. Full scale field projects were distributed as follows: 13 Cordilleran Section, 8 Western Shield, 9 Eastern Shield, and 8 Appalachian. During the winter months the project officers concentrated on the office and laboratory phases of their projects as well as the planning of field operations for the next season. Nearly all officers of the Division actively participated in the programs of various technical and scientific organizations by the presentation of papers, organization of meetings and service on committees.

In addition to the reports on the past season's field work contained in G.S.C. Paper 67-1, Part A, many of which are effective preliminary reports, there was submitted for publication a total of 52 manuscripts of all types. These were divided as follows: 4 Bulletins, 13 Papers, 17 maps for publication by G.S.C. and 18 papers for outside publication. Publications by members of the Division in 1966 amounted to 5 memoirs, 3 bulletins, 15 papers and 13 maps by G.S.C. and 11 papers by other organizations.

Six officers of the Division moved back to the main building at 601 Booth Street from No. 8 Temporary Building. Though this move caused some disruption in the work of the officers concerned it was offset by the benefits of having all members of the Division, in Ottawa, in the one building.



Dr. R.J.W. Douglas, Chief of Division continued with Special Projects in writing, compiling and editing the 5th edition of Geology and Economic Minerals of Canada. S. Duffell continued as Acting Division Chief, as well as Head of Eastern Shield Section.

For a period of 3 months Dr. G.M. Wright again carried on the duties of Chief Geologist during the absence of Dr. C.S. Lord.

Dr. E.R.W. Neale spent approximately six months as part time assistant to Dr. J.M. Harrison.

Dr. K.E. Eade left in March for Australia as part of an exchange program with the Australian Survey and returned in March 1967.

Dr. H.W. Little was transferred from Cordilleran Section to Economic Geology Division.

Drs. E.R.W. Neale, D.G. Kelley and W.W. Heywood served in various capacities on the Ottawa General Committee for the Annual Meeting of the C.I.M.M. held in Ottawa, March 27-29, 1967.

Two new staff members joined the Division in June. J.W.H. Monger joined the Cordilleran Section in Vancouver to work on stratigraphy and structure of the Atlin Horst, a problem involving upper Palaeozoic stratigraphic studies. Anthony Davidson joined the Western Shield Section to work on granites and metamorphism in the Ennadai orogenic belt.

In July M.J. Kennedy who had recently completed his Ph.D. at Trinity College, Dublin, came to the Division as its first Post-Doctorate Fellow. He is interested in comparing the Fleur de Lys Group rocks of Newfoundland with the Dalradian rocks of Ireland.

All geologists in the Division were reclassified to Research Scientists during the year.

## REPORTS ON SECTIONS

### CORDILLERAN SECTION

H.W. Little

The Cordilleran Section is responsible for most of the investigations of bedrock geology carried out by the Federal Government

in the Canadian Cordillera within British Columbia and Yukon Territory. This research in many areas supplements or is supplemented by related cooperative activities by geologists of other divisions of the Geological Survey of Canada and the British Columbia Department of Mines. Although current activities are mainly directed toward completion of the reconnaissance phase of regional investigations in which data and conclusions on structure and stratigraphy are integrated to develop the broad tectonic picture, other more detailed and more specialized projects are also in progress. These include volcanological, structural, stratigraphic, and metamorphic studies.

From 1961 to 1965 the section has been rather evenly divided between those stationed in Vancouver and those stationed in Ottawa, but since June 1966 three-quarters of the section has been housed in Vancouver.

Field investigations were undertaken by nearly all members of the section, but in some cases these were cut short by other commitments such as revision of "Geology and Economic Minerals of Canada". Operation Selwyn, which embraces five one-by-two degree quadrangles in Yukon, District of Mackenzie and northern British Columbia, was continued. Completion and re-examination of parts of several one-degree quadrangles in central and southern British Columbia was accomplished, and more detailed studies of structure, volcanology, and stratigraphy were undertaken or continued in a number of areas. In contrast to the 1965 field season, no university professors were engaged in field activities within the section but the number of Ph. D. candidates assigned thesis areas was maintained at four, three of whom completed their projects.

During 1966, officers of the Cordilleran Section published 3 preliminary maps, submitted for publication one preliminary map, one paper, two bulletins, and three outside papers, and gave three oral presentations.

### Activities

S.L. Blusson: completed the reconnaissance of Sekwi Mountain (105 P), Nahanni (105 I), and Frances Lake (105 H) map-areas, Yukon and Northwest Territories. These map-areas are part of Operation Selwyn (see Gabrielse). This work provided evidence of a western source for the late Proterozoic rocks, whereas Ordovician and Devonian dolomites grade southward into shales. The stratigraphy and structure have been determined and a preliminary map of Frances Lake has been submitted for publication. In May he presented for publication a paper on the "Geology and tungsten deposits near the headwaters of Flat River Yukon, and southwest District of Mackenzie" and attended the meeting of the Edmonton Geological Society.

R.B. Campbell: completed roughly 50 per cent of the study of McBride (93 H) area. The work provided much information on the Windermere and Early Cambrian stratigraphy and permitted correlation of strata of the Cariboo Mountains to those of the Rockies. In Cariboo Mountains a sequential change in the style of deformation from flow folding through shear folding to brittle fracture, and tilting of fault blocks suggests that deformation occurred on various "floors" or depth levels. The deepest level is exposed in the Premier Range in Canoe River (83 D) area. He prepared a report on McBride (93 H) for publication in G.S.C. Paper 67-1, Part A. With H.W. Tipper he completed for publication a preliminary map of Bonaparte River (92 P). The map completes the delineation of a belt of Mesozoic rocks extending north from the Nicola Group near Kamloops to and beyond Prince George thus outlining an important region for mineral exploration currently the site of much activity. He completed about 70 per cent of his part of a joint memoir (with H.W. Tipper) on Bonaparte River (92 P). At year end he began preparation of a preliminary map of Canoe River for completion early in 1967.

H. Gabrielse: continued supervision of Operation Selwyn (see also Blusson and Handfield), and was personally responsible for investigations in Watson Lake, Yukon (105 A), and Jennings River, B.C. (104 O) map-areas. Within Watson Lake area, for which a preliminary map has been submitted, there is a marked change in the stratigraphy of the Palaeozoic rocks in a northwesterly direction in the vicinity of longitude 128°30' west.

Dr. Gabrielse prepared a section on the geology of the Northern Cordillera for the revision of "Geology and Economic Minerals of Canada", a project which took the major portion of available office time during the year. In May he attended the meeting of the Edmonton Geological Society at which was presented a paper entitled "Stratigraphy of the Silurian Carbonate Rocks of the Rocky Mountains of Northern British Columbia", co-authored with B.S. Norford and G.C. Taylor. In October submitted to Canadian Journal of Earth Sciences for publication a paper entitled "Tectonic Evolution of the Northern Canadian Cordillera". He co-authored a paper with Roddick, Souther and Wheeler entitled "Age and Nature of the Canadian Part of the Circum-Pacific Orogenic Belt" which was presented by J.A. Roddick at the Eleventh Pacific Science Congress in Tokyo in August.

L.H. Green: relinquished his duties as Resident Geologist, Whitehorse, and was transferred to the Cordilleran Section in Vancouver in July, 1966. Preparation of the annual report on "Mineral Industry of Yukon" was completed prior to the move and has since been published as Paper 66-31. Since moving to Vancouver he has been occupied in preparation of a memoir covering Operation Ogilvie, the field work for which was done in 1961.

In March 1966, he gave a paper at the Second Yukon Resources Conference, Whitehorse, Yukon on the "Mineral Potential of Yukon", and with R. B. Campbell prepared a paper entitled "Geological Reconnaissance of Cordillera Progresses" which was published in the Annual Review number of the Northern Miner, November 24, 1966. He also submitted a paper for publication by the Survey entitled: "Mineral Potential of the Yukon".

H.W. Little: left the section in Vancouver, March 22, 1967 to report to the Economic Geology Division in Ottawa. J.O. Wheeler was named Acting Head of the section until further notice. In addition to administrative duties as section head he completed 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". Some time was devoted to telephone and personal calls by and to other geologists, mainly in the mining industry.

A start was made on a revision of the Nelson map-area (82 F) with J.E. Reesor, to incorporate much additional detailed work done since the original edition was prepared.

J.W.H. Monger: joined the section in June and began a study of late Palaeozoic and early Mesozoic rocks in the Atlin Horst. The season was spent in establishing the probable Permian stratigraphic succession in the French Range (parts of 104 J) and in comparing the style of deformation in these rocks with the simpler style developed in contiguous early Mesozoic rocks, immediately north of the Horst.

In addition he prepared for publication a report on early Tertiary stratified rocks in Greenwood map-area (82 E 1/2), B.C. which were investigated with H.W. Little in 1965. He presented a paper on the "Geology of Chilliwack Valley B.C." before the Geological Club of the University of B.C. He also presented for publication as a bulletin a manuscript entitled "Tertiary of the Greenwood Area".

J.E. Muller: continued investigations on Central Vancouver Island. The 1966 work was mainly concentrated on obtaining complete coverage of the Cretaceous Nanaimo Group basin and some time was spent in most parts of the outcrop area, from Port McNeill in the north to the Duncan-Gulf Islands region in the south. A report on the stratigraphy and structure of the Nanaimo Group is in preparation. It will also include a compilation of information regarding the coal mining activities in the past hundred years and the stratigraphy and structure of the coal deposits. In conjunction with J.A. Jeletzky he is revising the biostratigraphy of the Nanaimo Group. A short visit was made to the Pine Pass area (93 O) to examine in greater detail rocks within the area to be flooded by the Peace River dam and to obtain additional necessary data elsewhere in the map-area. He visited Ottawa for consultation with J.E. Muller during the week of March 21-26, 1967.



J.A. Roddick: as coordinator of the Coast Mountains Project, continued compilation and analysis of data accumulated since 1962, concentrating mainly on Douglas Channel and Hecate Strait map-areas. Based on his experience in the Coast Mountains he advised R.A. Stacey of the Dominion Observatory of the most suitable locations of lines for gravity surveys across the Coast Mountains and Continental Shelf. Preliminary preparations were made for the 1967 field operation, including a reconnaissance flight over the central Coast Mountains in October. Beginning in May, a paper on the tectonic evolution of British Columbia and Yukon Territory was prepared in collaboration with Wheeler, Gabrielse and Souther. In August he attended the Eleventh Pacific Science Congress in Tokyo where he presented the above paper at the symposium on the tectonics of the circum-Pacific belt, chaired the final session, presented a paper for J. Terasmae on Yukon palynology, represented Canada (geology) on the P.S.A. standing Committee on Geology and Geophysics, and participated in the field trip on the northern Japanese Island of Hokkaido. The paper presented to the symposium will be published in a special volume of Tectonophysics. In connection with his work on Operation Pelly he prepared and submitted a paper on the Tintina Trench to the Journal of Geology for publication in January 1967. In collaboration with Dr. Hutchison he prepared a paper on the specific gravity of plutonic rocks in the Coast Mountains and will be submitted for outside publication. A paper on the Coast Crystalline Belt (submitted in 1965) appeared during 1966 in a special volume of the C.I.M. A short report was made on the application of IBM punch cards to field work and some time was spent on revision of the IBM format and coding in light of experience on the Coast Mountains Project. In the spring a visit was made to the University of Victoria computer centre at the invitation of the director. For possible application to the Coast Mountain Project, investigations were conducted into IBM Optical Scanners, portable tape recorders, and the feasibility of electronic point-counting. During the year he critically read papers by A.J. Baer, W.W. Hutchison, J.G. Souther, F.C. Taylor and E. Schiller, and a bulletin by S.L. Blusson. Consultations (32) were held with mining exploration geologists, those from Japan being especially prominent during the fall. In preparation for the Pacific Science Congress he took an intensive refresher course in Japanese at U.B.C. He attended the G.S.A. Cordilleran Section meeting in Santa Barbara in March and presented a paper "Specific Gravity of Plutonic Rocks in Northern Coast Mountains, B.C.; co-authored with W.W. Hutchison.

J.G. Souther: continued a program of volcanological work in the Cordillera. Primary mapping of the central part of the Mt. Edziza volcanic complex was completed at a scale of 1:25,000. Detailed stratigraphic sections showing the alternation of basalt with rhyolite and trachyte have been prepared. Pulses of volcanic activity have been related to successive stages of subsidence of a graben-like structure that bounds the volcano on the west. Chemical and petrographic studies are in progress.

In conjunction with the Dominion Observatory regional heat flow program, three deep holes were drilled at various distances from Mt. Edziza volcano.

Chemical analyses have been made of 170 specimens of plateau basalt collected by H.W. Tipper in south-central B.C. This data forms the basis of a paper on the chemistry and petrology of the plateau lavas being prepared jointly by J.G. Souther and H.W. Tipper.

Dr. Souther continued as a member of the Associate Committee of Geodesy and Geophysics, Subcommittee on Volcanology and attended the October, 1966, meeting in Ottawa.

He published in the Bulletin Volcanologique a paper entitled "Acid Volcanism and its Relationships to the Tectonic History of British Columbia" and in C.I.M.M. special volume No. 8 a paper entitled "North Central Belt of the Cordillera of British Columbia".

Collaborated with Roddick, Wheeler and Gabrielse in a paper entitled "Age and Nature of the Canadian Part of the Circum-Pacific Orogenic Belt presented by Roddick at the Eleventh Pacific Science Congress at Tokyo in August.

H.W. Tipper: in the field completed reconnaissance investigation and joint studies with J.A. Jeletzky in the Taseko Lakes area, a project commenced in 1961. In addition he carried out preliminary reconnaissance in the Mt. Waddington and Hazelton areas in preparation for future work. His work with Jeletzky is providing significant new information on the stratigraphy of the Mesozoic rocks in central British Columbia.

With R.B. Campbell he completed for publication Map 66-3 a Preliminary map with marginal notes on the Bonaparte River area, B.C. The map delineates a belt of Mesozoic rocks extending north from the Nicola Group near Kamloops to and beyond Prince George which is presently under active exploration by the mineral industry. He completed the major portion of his part of a joint memoir (with R.B. Campbell) on the Bonaparte River area. He is also working with H. Frebold on a paper entitled "Stratigraphy and Palaeontology of Callovian rocks of southern British Columbia" which is expected to be published later in 1967 and collaborating with J. Souther on a paper on the chemistry and petrology of plateau basalts in south-central B.C. He presented a paper for publication by the Survey co-authored with Dr. H.W. Frebold entitled "Middle Callovian Sedimentary Rocks and Guide Ammonites from S.W. B.C."

J.O. Wheeler: spent three weeks in Rocky Mountains in the northeast part of Rogers Pass map-area (82 N W 1/2) revising earlier reconnaissance investigations to 1-mile standard, on which scale adjacent work by Operation Bow-Athabasca has been done. He prepared a section on the geology of the Southern Cordillera for the revision of the Geology and Economic Minerals of Canada. Other duties included the supervision of the Cordilleran Structure Project and organization of a field conference in Revelstoke. Collaborated with Roddick, Souther and Gabrielse in a paper entitled "Age and Nature of the Canadian Part of the Circum-Pacific Orogenic Belt" presented by Roddick at the Eleventh Pacific Science Congress, Tokyo in August.

D.J. Tempelman-Kluit: after completion of his Ph.D. at McGill University joined Operation Selwyn (see Gabrielse and Blusson) in a temporary position and subsequently occupied a temporary position in the Vancouver Office of the G.S.C. A paper describing the geology of Tombstone area, Yukon has been submitted for publication. Early in 1967 he was appointed to a permanent position in the section.

J.A. Coates: a graduate student at the University of British Columbia concluded a study of the structure and stratigraphy of the Dewdney Creek and Pasayten Groups in Manning Park, B.C. The former has been identified as flysch deposits of Jurassic age succeeded by Lower Cretaceous polymictic clastics derived from a granitic terrain. The Pasayten Group, which has been shown to be partly marine, is 17,000 feet thick and entirely Lower Cretaceous.

C.A. Giovanella: a graduate student at Stanford University, began a study of a metamorphic terrain that straddles the Rocky Mountain Trench along Canoe River Valley (83 D). The work should throw light upon the tectonic history of the Trench.

R.C. Handfield: a graduate student at Princeton University completed field work that will provide data for a biostratigraphic study of the Lower Cambrian strata of Mackenzie Mountains, N.W.T. and Yukon (95 D, L, and M; 105 I and P).

The variation in thickness of the Lower Cambrian strata of 1,200 feet and 3,200 feet between Nahanni and Sekwi Mountain areas has been determined to be due to sub-Middle Cambrian unconformity.

B.E. Lowes: A graduate student at the University of Washington (Seattle) began a stratigraphic, structural, and metamorphic study of sedimentary and volcanic assemblages and their metamorphic equivalents east of Harrison Lake, B.C. (in 92 H). This work is an attempt to extend northward the structural elements of northern Cascade Mountains.

W.J. McMillan: a graduate student at the University of British Columbia, concluded the structural and petrographic study of part of the west flank of Frenchman's Cap gneiss dome in Ratchford Creek area, B.C. (82 M/7). It was shown that early southwest plunging isoclinal folds were refolded about southeast-trending steeply dipping axial planes.

V.A. Preto: a graduate student at McGill University completed structural and petrographic investigations of the Grand Forks Group, part of the Shuswap Terrane in 82 E/1, W 1/2. The metamorphic complex is folded successively northward into an antiform, a complex synform, and a very broad anticlinal warp. These trend west-northwesterly, parallel to the dominant trend of late Palaeozoic rocks west of the Granby River fault, but there these trends are not apparent in strata of Middle Triassic and later age.

#### Personnel Notes

S.L. Blusson: visited the Vancouver office in May for consultations. Attended meeting of Edmonton Geological Society.

R.B. Campbell: spent 2 weeks in Ottawa in January 1966 working with H.W. Tipper on Bonaparte River (92 P) preliminary map and an outline for a memoir. During the field season he spent one day with J.E. Reesor inspecting gneisses along the Rocky Mountain Trench. Dr. Campbell attended the Annual Meeting of the G.S.A. in San Francisco in November.

H. Gabrielse: attended meeting of the Edmonton Geological Society in May, 1966.

L.H. Green: attended the Second Yukon Resources Conference in Whitehorse in March, and the General Meeting of the G.S.A. in San Francisco in November, the latter at his own expense. Dr. Green relinquished the position of Resident Geologist in Whitehorse in July and was transferred to the Cordilleran Section in Vancouver. In November he visited the U.S.G.S. offices and laboratories in Menlo Park for consultations.

W.W. Hutchison: visited H.C. Berg of the U.S.G.S. in southeast Alaska in August, and also visited the Menlo Park offices of the U.S.G.S. for consultations and laboratory inspections in November. He attended the General Meeting of the G.S.A. and the Yosemite field trip, both at his own expense.

- G.B. Leech: was transferred from the Cordilleran Section to Special Projects in April, 1966.
- H.W. Little: visited Victoria in March for consultations with geologists of the British Columbia Department of Mines, and Ottawa in December for consultations at headquarters. In March 1966 he attended the Second Yukon Resources Conference in Whitehorse. He had field consultations in Revelstoke in June with geologists of the Cordilleran Structure Project, and in August with Robert G. Yates of the U.S.G.S. As thesis area supervisor for the G.S.C. he visited V.A. Preto in the Grand Forks area in August.
- J.W.H. Monger: joined the staff in March 1966. Visited Ottawa in April for consultations with H. Gabrielse and others.
- J.E. Muller: attended the General Meeting of the G.S.A. in San Francisco in November.
- J.G. Souther: visited Ottawa in October for consultations and participation in the N.A.C. subcommittee meetings on volcanology and on the upper mantle. In November he was visited by Professor Kuno of the Geological Institute, University of Tokyo.
- J.A. Roddick: attended the Eleventh Pacific Science Congress in Tokyo in August.
- H.W. Tipper: visited the Vancouver office in May for consultation with other members of the section, i.e. R.B. Campbell, J.A. Roddick, and J.G. Souther.
- J.O. Wheeler: visited Ottawa for three weeks in April and May to work with colleagues on the tectonic map of Canada and a chapter on "Geology and Economic Minerals of Canada". In June Dr. Wheeler addressed the A.A.P.G. on the subject "Tectonic Evolution of the southern part of the Western Canadian Cordillera". In October he again visited Ottawa to attend the Upper Mantle committee meeting. He attended the General Meeting of the G.S.A. in San Francisco in November.



### Memberships on Committees

- H. Gabrielse - Member, American Committee on Stratigraphic Nomenclature.  
- Chairman, Isotope Age Committee; Geological Survey of Canada.
- J.G. Souther - Member of N.A.C. Subcommittee on Volcanology.
- J.O. Wheeler - Member of N.A.C. Subcommittee on Structural Geology.  
- Member of N.R.C. Canadian Upper Mantle Committee - Reporter on Tectonics.

### WESTERN SHIELD SECTION

G.M. Wright

The Western Shield Section is responsible for geological investigations in the Canadian Shield west and north of the Ontario-Manitoba border. The trend of recent years toward heavy commitment of personnel to projects in the Northwest Territories continues. All of the 9 field projects carried out in 1966 were in the Northwest Territories; 6 in the District of Mackenzie, 2 in the District of Keewatin, and 1 astride the border between the two districts.

As in recent years, a contract helicopter was shared by several parties and moved north and south to coincide with changing ice and weather conditions. This helicopter was used successively by Reinhardt and Hoffman near the East Arm of Great Slave Lake, by Bostock and Fraser in the Itchen Lake area, by Donaldson in the Dubawnt plain, and by Bostock and Baer in the Wholdaia Lake area. Heywood and Davidson, in the Ennadai-Rankin belt, shared a light, fixed-wing aircraft with Donaldson in the Dubawnt plain.

Most available staff were assigned to areas and problems of significance to geological theory and/or of importance in mineral exploration in northern Canada. Because there are only two small areas in the entire Western Shield that have not been covered by reconnaissance mapping, it is safe to say that we are now embarked, almost exclusively, on the second stage of geological studies, the unravelling of geological problems within the fundamental framework established by reconnaissance surveys over the last thirty years.

E.W. Reinhardt continued his studies in gneisses south of the East Arm of Great Slave Lake, and P.F. Hoffman, a graduate student at Johns Hopkins, commenced a thesis project in the East Arm. W.R.A. Baragar,

on loan from the Eastern Shield section, investigated the volcanic rocks of the Coppermine River Group as part of a broad study of volcanic piles in the Canadian Shield (see Eastern Shield Section). H.H. Bostock completed investigations in the Itchen Lake auriferous region, and with A.J. Baer also completed coverage of the Wholdaia Lake map-area. J.A. Fraser completed his stratigraphic and structural studies of the Epworth Group at Rocknest Lake. J.A. Donaldson completed the investigation of the internal constitution of the Dubawnt Group. W.W. Heywood and A. Davidson commenced investigation of a critical strip across the northern end of the Ennadai-Rankin orogenic belt. Hans Hofmann, who joined the Palaeontology Section in August, visited the parties of P.F. Hoffman and H.H. Bostock to see the well-displayed stromatolites in Proterozoic rocks of the East Arm, Great Slave Lake, and the Rocknest Lake area.

Summaries of the geological results of 1966 field work are contained in Geological Survey of Canada Paper 67-1 Part A, and are not, in general, repeated in this report.

These field projects involved each of the geologists concerned in several weeks of pre-season scientific studies and operational planning, and additional weeks preparing 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 for publication in outside journals, and in consultations with other scientists in government, industry and universities.

During 1966, officers of the Western Shield Section published or submitted for publication 3 memoirs, 1 bulletin, 1 final map, 3 preliminary maps with marginal notes and 8 papers by the Geological Survey, and 1 paper in an outside journal.

Three officers of the Section (Bell, Davison, Reinhardt) were moved from No. 8 Temporary Building to 601 Booth St. For the first time in many years the Section is now under one roof; supervision and control are enhanced accordingly.

#### Activities

A.J. Baer: spent most of the year in Ottawa preparing a memoir on the Bella Coola map-area in British Columbia. In August, he joined H.H. Bostock in completing coverage of the Wholdaia Lake map-area (75 A) by helicopter, and in familiarizing himself with the geology, terrain and operational problems involved in a proposed study of gneisses in the Fond-du-Lac (74 O) map-area of northern Saskatchewan to be started in 1967.

Dr. Baer submitted a preliminary map and paper on the Bella Coola and Laredo Sound map-areas.

C.K. Bell: remained in Ottawa completing a lengthy report on the Wekusko map-area (63 J), one of four 4-mile areas included in the Upper Nelson River project. He gave a paper to the Logan Club on the geological relations across the Superior-Churchill boundary in Manitoba.

R.T. Bell: was the successful candidate for the new position in the section.

H.H. Bostock: completed his field studies in the Itchen Lake map-area (76 E/W and 86 H/E) where gold occurs in amphibolites of the Yellowknife Group. For several days he played host to a team from the National Film Board engaged in making a film on the activities of the Geological Survey; the use of helicopters over break-up was the particular point of interest in this case.

Toward the end of the field season, Dr. Bostock took his helicopter south to the Wholdaia Lake area (75 A), where, with Dr. A.J. Baer, he completed coverage of the map-area in order to prepare a final map and marginal notes. He submitted the manuscript for this project in December.

Dr. Bostock also submitted a preliminary paper and map on the Itchen Lake map-area.

A. Davidson: commenced a comprehensive study of the granitic rocks and their envelopes in the Ennadai-Rankin orogenic belt. The field season of 1966 was spent in a preliminary assessment of the northern part of the region, the choice of specific targets for future studies, and some detailed investigations.

Mr. Davidson spent the autumn months working with W.W. Heywood on the preparation of a memoir on the Benjamin Lake area (75 M/2); the metamorphism of the rocks of the Yellowknife Group in this area was the subject of his Ph.D. dissertation at the University of British Columbia.

W.L. Davison: spent the year in Ottawa preparing a preliminary report and map on the Nejannilini map-area (64 P) in northern Manitoba, and doing research for his memoir on the problems of metasediments, gneisses and granulites in the Sea River area (54 NE).

He published Geological Survey of Canada Paper 65-25 on the Caribou River map-area (54 M), one of the four 4-mile map-areas included in the Seal River project.

J.A. Donaldson: completed his investigations on the stratigraphy and sedimentation of the Dubawnt Group, concentrating on the western part.

He used a helicopter for 1 month (ex Bostock) and shared a Cessna 180 with Heywood. This project has produced, in addition to a thorough study of the Dubawnt Group, data for a strip of 3 or 4 four-mile maps of Schultz Lake (66 A), Aberdeen Lake (66 B), Beverley Lake (66 C), and possibly Tammarvi River (66 D).

Dr. Donaldson was assigned in the fall to write a section on the geology of the Labrador Trough, the Cape Smith belt and the Belcher Islands for the new edition of Geology and Economic Minerals of Canada (E.G. 1).

Dr. Donaldson published a memoir (338) on the Marion Lake map-area of Quebec-Newfoundland, a preliminary map (7-1966) with marginal notes on the Schultz Lake area, District of Keewatin, and submitted a report on the rubidium-strontium age of Dubawnt volcanic rocks for publication by the Geological Survey. He also spoke to the Logan Club on the Dubawnt Group.

K.E. Eade: left Ottawa early in March 1966, en route Australia, to take up his appointment as the Geological Survey of Canada's exchange geologist with our Australian equivalent, Mr. Peter Crohn.

Dr. Eade's most interesting monthly reports indicated clearly the value of exchanging ideas on the spot on a wide variety of endeavours common to both organizations. In addition to participating fully in field work, Dr. Eade visited many key geological areas in Australia, and hopes to prepare a report comparing and contrasting Precambrian geology in Canada and Australia. He returned to Canada in March, 1967. With W.F. Fahrig and J.A.S. Adams he presented a paper for publication in Nature entitled "Abundance of radioactive elements in crystalline Shield rocks".

J.A. Fraser: spent 1 month completing studies in the Rocknest Lake area, District of Mackenzie. Most of this time was spent in measuring several sections through the Epworth Group sediments and in collecting samples for chemical studies. He used a helicopter (ex Bostock) for about 10 days.

The remainder of the year was spent in preparing a preliminary paper on the Rocknest Lake area and a memoir on the results of Operation Coppermine. Dr. Fraser also did the technical editing for two manuscripts from the Western Shield and presented the abstract of a paper "Correlation of Proterozoic Strata in northwestern Canadian Shield" which is to be given in Prague in 1968.

W.W. Heywood: carried out a preliminary survey of the geological problems within a strip of four-mile map-areas across the north end of

the Ennadai-Rankin orogenic belt, with a view to concentrating future work on parts of the area that will be most productive of answers to the many problems - structure, stratigraphy, sedimentology, volcanism, intrusion, and economic geology - that this belt contains. He was closely associated in this work by A. Davidson who has been assigned to work on the granites of the region.

Dr. Heywood also made an assessment of the whole belt in regard to logistics-operations-administration needs, should the Geological Survey decide to carry out a proposed multi-disciplinary investigation of the Ennadai-Rankin complex in the next few years. He was visited by Dr. S.M. Roscoe and Mr. V.R. Slaney for a few days each; these officers advised on problems of uraniferous Proterozoic rocks and the use of special air photos respectively.

Dr. Heywood spent the remainder of the year in preparing a memoir, with A. Davidson, on the Benjamin Lake area (75 M/2), and on another memoir dealing with the results of Operations Back River and Wager. He published G.S.C. Paper 66-10, Geological Notes on Operation Wager, Northwest Territories and Memoir 337 on the Ledge Lake Area, Manitoba and Saskatchewan. He assisted in preparations for the Annual Meeting of the C.I.M.M. held in Ottawa March 27-29, 1967.

P.F. Hoffman: a graduate student at Johns Hopkins commenced his thesis project on the stratigraphy, sedimentology and paleocurrents of the Proterozoic rocks in the East Arm of Great Slave Lake. In this first season's study much new data has been gathered on variations in thickness of several formations, on a paleocurrent directions perpendicular to the axis of the basin in the probable marine units, on the spectacular and varied algal stromatolites contained in several formations and the strong correlation of stromatolite form and paleocurrent direction, and on the evolution of the Precambrian atmosphere and sea water from various rock-types and structures contained in them. Mr. Hoffman is convinced that stromatolites can be used for stratigraphic correlation within this sedimentary basin.

It is anticipated that Mr. Hoffman's studies will require one more field season to complete.

J.C. McGlynn: spent the year in Ottawa preparing material for the chapter on Precambrian geology in the new edition of Geology and Economic Minerals of Canada. Dr. McGlynn is the chief author of this chapter, but other officers have been assigned to some parts - such as the Grenville, the Labrador Trough, etc. He relinquished the chairmanship of the Isotope Age Committee to H. Gabrielse.



E.W. Reinhardt: completed geological mapping in 75 E/12, E/13 and part of 85 H/9 in connection with his investigations of the nature and origin of the gneissic and mylonitic rocks near and south of the MacDonald Fault on the south side of the East Arm of Great Slave Lake. The project also includes a study of the pattern and movement of the major and minor faults in the area. It is anticipated that one more field season will be required to complete this project and will involve some investigations in the Simpson Island area. This last season will have to be delayed until 1968, to permit Dr. Reinhardt to participate in Operation Torngat I in northern Quebec-Labrador in 1967.

The remainder of the year was spent preparing a paper, based on his Ph.D. thesis on the cordierite gneisses of the Gananoque area, for publication in the Canadian Journal of Earth Sciences, and a preliminary map and paper on his work in the Great Slave Lake area. He was one of the authors of Geological Survey of Canada Paper 66-32, Mont Laurier and Kempt Lake map-areas, Quebec.

L.P. Tremblay: remained in Ottawa during 1966 preparing and submitting a second preliminary map on the Contwoyto Lake area (76 E/14); checking translations for the French edition of Geology and Economic Minerals of Canada (E.G. 1); preparing and submitting a paper on the Goulburn Group in the Contwoyto and Beechey Lake areas; and writing a memoir on the Beechey Lake area (76 G).

G.M. Wright: as head of the Western Shield section, prepared the interim and final field programs for 1966 and the preliminary field program for 1967, processed requests for base-maps and air photos, 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. Revising of dossiers for conversion of staff geologists to the Research Scientist classification occupied some time early in the year. A two-day seminar on the introduction of Collective Bargaining was attended late in the year; this was preceded and followed by much animated discussion of the problems involved.

Dr. Wright was directed to undertake a feasibility study for a Metamorphic Map of Canada, in connection with a proposed I.U.G.S. Map of Metamorphic Belts of the World. The G.S.C. project has already completed a pilot study in the Eastern Canadian Shield by F.C. Taylor, and from this experience conclusions will be drawn as to the objectives, methods and effort to be proposed for the overall project.

In March 1966, Dr. Wright was assigned to duties of Acting Chief Geologist for three months while Dr. Lord was on overseas assignment. The main task during this period was the preparation of the final

Field Program for 1966. During early 1967 he spent 60-75 per cent of his time assisting the Director with special projects.

Dr. Wright published two short papers (one with S. Duffell) in G.S.C. Paper 66-42, Contributions to Geological Exploration in Canada.

#### Personnel Notes

A. Davidson: joined the staff in June as a recruit for the Western Shield Section after submitting his Ph.D. thesis to the University of British Columbia.

W.L. Davison: was on sick leave from October 25 to January 3, 1967.

J.A. Donaldson: attended the meetings of the G.A.C. in Halifax in September. He presented a paper on the Stratigraphy and Sedimentology of the Dubawnt Group, and participated in a post-convention field trip in the Minas Basin.

W.W. Heywood: presented a paper on the geology of the Back River-Wager area at the Prospectors and Developers meetings in Toronto in March 1966. He also attended the meetings of the Lake Superior Institute of Geology in Sault Ste. Marie, Michigan in May 1966. He joined the post-convention field trip to the Blind River-Elliot Lake area to acquaint himself with the Huronian sediments of the area, particularly as regards any similarities with the Proterozoic Hurwitz sediments in southern District of Keewatin.

J.C. McGlynn: attended the annual meetings of the Canadian Institute of Mining and Metallurgy in Quebec City in April.

E.W. Reinhardt: presented a paper on Phase Relations of cordierite, garnet, biotite and hypersthene in high-grade pelitic gneisses of the Gananoque area, Ontario at the 47th Annual Meeting of the American Geophysical Union in Washington in April.

L.P. Tremblay: acted as outside reader and attended the oral examination at Laval University for the Ph.D. thesis of Leopold Gelinas on metamorphic rocks in the Ungava area.

G.M. Wright: attended the meetings of the Lake Superior Institute of Geology in Sault Ste. Marie, Michigan in May, and participated in the subsequent field trip to the Blind River-Elliot Lake area. Also in May, he joined a two-day field conference on metamorphic rocks in the northern Adirondacks.

#### Membership on Committees

- A.J. Baer - Member, Subcommittee on Structural Geology, National Advisory Committee on Research in the Geological Sciences.
- H.H. Bostock - Representative of Calgary Office (G.S.C.) at Advisory Council Meetings, Professional Institute of the Public Service.
- J.A. Donaldson - Member, G.S.C. Working Group on Uranium.
- J.C. McGlynn - Chairman, G.S.C. Committee on Absolute Age (to end of 1966).  
- Chairman, G.S.C. Committee on Stratigraphic Nomenclature.
- L.P. Tremblay - Member, Staff Relations Committee, Professional Institute of the Public Service.
- G.M. Wright - Chairman, G.S.C. ad hoc Committee for the Metamorphic Map of Canada.

#### EASTERN SHIELD SECTION

S. Duffell

Personnel of the Eastern Shield Section are responsible for geological investigation in that part of the Canadian Precambrian Shield lying east of the Manitoba-Ontario boundary and including Baffin Island. In all 10 projects were conducted during the 1966 field season of which 4 were in Ontario, one in Ontario and Quebec, 2 in Newfoundland-Quebec, 2 in Newfoundland-Labrador and one pertaining to the shield as a whole. No large scale air supported operation was conducted in this year's program. The projects involved detailed investigation for special studies, or for publication at a scale of 1 inch to 1 mile and reconnaissance investigation for publication at a scale of 1 inch to 4 miles. Personnel of the section

submitted for publication by the Survey 4 maps, 1 terminal report, 1 preliminary paper, 1 bulletin and 4 papers for outside publication. All officers with field projects submitted reports on field activities for inclusion in G.S.C. Paper 66-1 Part A. Many of these 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.

In Ottawa much use was made of the chemical analytical facilities of the Survey in providing data on regional and specific geological problems particularly in the study of volcanic piles, diabase dykes and anorthosite intrusions. The isotopic age dating laboratories supplied numerous dates which were helpful in providing data on regional problems.

### Activities

W.R.A. Baragar: a paper on the "Geochemistry on the Yellowknife volcanic rocks" was published in the February issue of the Canadian Journal of Earth Sciences. He served as a member of the Volcanological sub-committee of N.R.C. Associate Committee on Geodesy and Geophysics and in June participated in a field trip of the sub-committee in the lake of the Woods area, Ontario. In November he participated in the G.S.A. field trip to Hawaii to study the recent volcanoes there.

His field project for 1966 was the investigation of the stratigraphy of the volcanic rocks of the Coppermine Group in the Western Shield.

R.G. Blackadar: though no longer a formal member of the section submitted a bulletin on "The Precambrian Geology of Northwest Baffin Island" for critical reading and subsequent publication.

D.M. Carmichael: a graduate student at the University of California, Berkley, completed field work on his thesis study in the Hastings area to establish the nature of the stratigraphic sequence, deformation and metamorphism in the Hastings synclinorium. He submitted a short report for inclusion in G.S.C. Paper 67-1 Part A.

S. Duffell: continued as Acting Chief of Division throughout the year in addition to duties as Section Head. He critically read 7 papers for publication in outside journals, one bulletin and numerous reports for internal use and inclusion in 67-1 Part A.

In March 1966 he attended the C.I.M.M. Convention in Quebec City and in May the meetings of the Institute of Lake Superior Geology at Sault Ste. Marie, Michigan and participated in the field excursion to Elliot Lake. In June for inspection purposes he visited the parties of A.M.

Goodwin and R.H. Ridler near Swastika, Ontario. With Dr. Wright he published a short paper in G.S.C. Paper 66-42 "Contributions to Geological Exploration in Canada".

R.F. Emslie: returned to the Survey May 1 from his leave of absence to lecture at Queen's University during the absence of H.R. Wynne-Edwards. Since returning he has continued his field and laboratory studies of the structure, petrology, tectonic significance and origin of anorthositic intrusions in the Nain and Grenville Provinces of the Eastern Canadian Shield.

In October he presented a paper at the George H. Hudson Symposium on the "Origin of Anorthosite" held at Plattsburgh, New York entitled "Crystallization and Differentiation of the Michikamau Intrusion". The paper will be included in the Symposium publication. Also in October he participated in a field excursion conducted by Queen's University to the Sudbury area and adjacent Grenville front as background information to his commitment to E.G. 1, 5th Edition.

In December he addressed the Logan Club describing the anorthosite-quartz manganite association in the Nain and Grenville tectonic provinces.

Also in December, Bulletin 130 "The Copper Content of Canadian Shield Rocks, Red Lake-Lansdowne House area, Northwestern Ontario" co-authored with R.H.C. Holman was published by the Survey.

W.F. Fahrig: completed field work but is continuing office and laboratory investigations on the age, petrology and tectonic importance of diabase dyke swarms in the Canadian Shield. A paper co-authored with K.E. Eade and J. Maxwell entitled "Composition of Crystalline Shield Rocks and Fractionating Effects of Regional Metamorphism" was published in vol. 211 No. 5055 of Nature in September.

He acted as a member of the American Committee on Stratigraphic Nomenclature and attended a meeting of that Committee in San Francisco in November. Together with K.E. Eade and J.A.S. Adams he presented a paper for publication to "Nature" entitled "Abundance of Radioactive Elements in Crystalline Shield Rocks".

M.J. Frarey: continued his studies 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. Again associated with him in this work was Dr. R.T. Cannon an N.R.C. Post-Doctorate Fellow from McGill University. Dr. Cannon was specifically concerned with analyses of structures and rock fabrics along the Grenville front near Killarney.



In May Dr. Frarey participated in a field trip to study Adirondack geology organized by Dr. Kramer of Syracuse University. He also attended the meetings of the Institute of Lake Superior Geology and acted as guide on the field excursion to Elliot Lake.

He continued as a member of the Advisory Committee, Department of Geology, University of Western Ontario of which he is a graduate.

In the December issue of Canadian Journal of Earth Sciences he published a discussion on a previous paper by Grant M. Young on the Huronian Stratigraphy of the McGregor Bay area, Ontario.

A. M. Goodwin: as part of the study of Archaean volcanic belts commenced investigations in the Timmins, Kirkland Lake, Noranda belt which is expected to take two seasons of field work. It is expected the study will give information on the stratigraphy and composition of volcanic sequences and their relationship to mineral occurrences.

In March 1966 he presented a paper at the annual meeting of the Prospectors and Developers Association in Toronto entitled "Archaean protocontinental growth and mineralization" which was subsequently published in the May issue of the Canadian Mining Journal. He also presented abstracts of two papers, (a) "Growth and mineralization of Canadian Shield" to be presented at CIMM Annual Meeting in March and (b) "Archaean protocontinental growth and early crustal history of the Canadian Shield" to be presented at the International Geological Congress in Prague 1968. He continued in his capacity as President of the Geological Association of Canada having been elected in September 1966.

He was an active member of the Volcanological sub-committee of N.R.C. Associate Committee on Geodesy and Geophysics and in June organized and led the sub-committee's field trip to the Lake of the Woods area Ontario to study Archaean volcanic sequences.

He acted as editor of the Geological Association of Canada's Special Paper No. 3 "The Relationship of Mineralization to Precambrian Stratigraphy in Certain Mining Areas of Ontario and Quebec" which included a paper by him entitled "The Relationship of Mineralization to Stratigraphy in the Michipicoten Area, Ontario". Also published during the year by O.D.M. was M.P. No. 6 "Volcanic Studies in the Birch-Uchi Lakes Area". Also submitted for publication in the Canadian Journal of Earth Sciences is a paper, co-authored with R. Shklanka of O.D.M., entitled "Archaean Volcano-Tectonic Basins, Form and Pattern".

G.D. Jackson: in March presented a paper to the Annual Meeting of the Prospectors and Developers Association in Toronto entitled "The Geology and Mineral Possibilities of the Mary River Region, Northern Baffin

Island" which was subsequently published in the June issue of the Canadian Mining Journal. In June he moved his office from No. 8 Temporary Building to 601 Booth St. During the field season he remained in the office to work on back projects.

R. Skinner: returned to the Sioux Lookout area to study in more detail the sedimentary sequence in the volcanic-sedimentary belt between Sioux Lookout and Savant Lake. Results of this work are reported in G.S.C. Paper 67-1, Part A. For inclusion in an overall report on the Moose River project he submitted a geological map and report, the field work for which was done in 1965. He continued writing a memoir on the Tetagouche Lake area of New Brunswick which is expected to be completed shortly.

I.M. Stevenson: completed reconnaissance investigation of the relatively unknown area of Labrador, Newfoundland N.T.S. Blocks 23 A and 13 C, D, E and F. Highlights of this reconnaissance are reported in G.S.C. Paper 67-1, Part A. In March he attended the annual Meeting of the C.I.M.M. in Quebec City.

F.C. Taylor: studied some areas of flat lying undisturbed sediments in and adjacent to the area to be covered in Operation Torngat which is to commence in 1967. He prepared a 'pilot' metamorphic map of the Superior Province in the Eastern Shield as a preliminary step in the preparation of a metamorphic map of Canada. He submitted for publication in the Canadian Journal of Earth Sciences a paper co-authored with E.A. Schiller entitled "Metamorphism of the Meguma Group of Nova Scotia". He attended the annual meeting of the G.S.A. in San Francisco in November and the Annual Meeting of the Prospectors and Developers Association held in Toronto in March 1967.

R.H. Ridler: a graduate student at University of Wisconsin commenced a thesis study of the volcanic rocks at Kirkland Lake and their relationship to mineral deposition. It is expected the study will be completed in 1967. Results of this year's work are reported in G.S.C. Paper 67-1, Part A.

F.M.G. Williams: a graduate student at McGill University commenced a thesis study of the structure and metamorphic petrology of the Naskaupi and older fold belts of the Grenville and Nain tectonic provinces. It is expected the study will be completed in 1967. Results of 1966 field work are reported in G.S.C. Paper 67-1, Part A.

### Personnel Notes

- W.R.A. Baragar: participated in the G.S.A. Field Trip to Hawaii in November.
- S. Duffell: attended C.I.M.M. Annual Meeting at Quebec City in March 1966 and Institute of Lake Superior Geology at Sault Ste. Marie, Michigan in May.
- R.F. Emslie: returned to the Survey on May 1 after spending the academic year at Queen's University substituting for H.R. Wynne-Edwards. Attended Symposium on Anorthosites at Plattsburg, New York in October.
- W.F. Fahrig: attended the meeting of the American Committee on Stratigraphic Nomenclature at San Francisco in November.
- M.J. Frarey: participated in the meetings of the Institute of Lake Superior Geology at Sault Ste. Marie, Michigan in May.
- A.M. Goodwin: was elected President of the Geological Association of Canada at their annual meeting held in Halifax during September.
- G.D. Jackson: presented a paper to the Annual Meeting of the Prospectors and Developers Association in Toronto in March.
- I.M. Stevenson: attended the Annual Meeting of the C.I.M.M. at Quebec City in March, 1966.
- F.C. Taylor: attended the annual meeting of the G.S.A. at San Francisco in November.

### Membership on Committees

- W.R.A. Baragar - Member of the Volcanological Subcommittee of the N.R.C. Associate Committee on Geodesy and Geophysics.
- R.F. Emslie: - Member of Stable Isotope Committee of G.S.C.

- W.F. Fahrig - Member of the American Committee on Stratigraphic Nomenclature.
- M.J. Frarey - Member Advisory Committee, Department of Geology, University of Western Ontario.
- A.M. Goodwin Member of Volcanological Subcommittee of the N.R.C. Associate Committee on Geodesy and Geophysics.
- F.C. Taylor Member Branch Equipment Committee.  
Member ad hoc committee for the Metamorphic Map of Canada.

## 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 central New Brunswick, along the central mineral belt, a detailed study of the stratigraphy and structure of the Ordovician and Silurian strata was begun in the McKendrick Lake area. In southern New Brunswick, a detailed study of the stratigraphy, structure and mineral deposits of Ordovician to Carboniferous rocks of the St. Stephen-Pleasant Mountain area was completed; the area contains the Mount Pleasant tin-molybdenum deposit and closely approaches the St. Stephen nickel deposit. In northern Nova Scotia, detailed studies of lower Palaeozoic strata and their structure were continued in the Cobequid Mountains and completed with re-examination of key areas in the Antigonish Highlands. Regional investigations of the Ordovician and Silurian volcanic and sedimentary rocks in Red Indian Lake area, central Newfoundland, which includes the Buchans lead-zinc-copper mine, was completed, and work in the Burgeo area to the south was begun. The results of recent studies by mining company and university geologists on Burlington Peninsula, northern Newfoundland, were investigated, and a

detailed structural analysis of a key part of the area was begun by a post-doctoral fellow. Study of the lower Palaeozoic klippe rocks at the north end of the Great Northern Peninsula was continued. Summary accounts of the investigations are carried in Geological Survey Paper 67-1, Part A.

Throughout the year, geologists of the Section were consulted by earth scientists in government, universities, and by private industry.

During the period covered by this report geologists of the section published 6 short accounts in Geological Survey papers, 1 paper and 1 memoir. In scientific journals outside the Survey they published 1 abstract of a paper, 3 papers, and 1 guidebook. They submitted for publication by the Survey 2 final maps, 1 preliminary map, and 1 Upper Mantle Symposium; and for publication by scientific journals 2 abstracts of papers, 1 bibliography, and 1 short note.

#### Activities

F.D. Anderson: began a detailed stratigraphic and structural study of the Ordovician and Silurian sedimentary and volcanic rocks of the McKendrick Lake area (21 J/16), central New Brunswick. The area adjoins on the north and south previously studied areas in the central mineral belt. In the field, he tested the usefulness of a scintillometer in geological mapping. He submitted an abstract of a paper to the Geological Society of America. He continued preparation of a final account on the geology of Belleoram map-area (1 M), southern Newfoundland.

D.G. Benson: completed study of the Cape George (11 F/13) map-area and re-examined key areas in the Merigomish (11 E/9), Lochaber (11 E/8) and Hopewell (11 E/7) map-areas to study further the stratigraphy, structure, and tectonics of the pre-Carboniferous sedimentary and volcanic assemblage and associated intrusive rocks of the Antigonish Highlands. He continued evaluation of the application of SCUBA diving to geological problems by examination of a mineralized area near Georgeville and of geological features on the west side of George Bay that could possibly be traced by sparker and/or seismic methods. He continued work on a preliminary map of Merigomish, Malignant Cove, and Cape George map-areas and a memoir combining these three areas and Lochaber map-area.

He acted as treasurer of the Field Trip Committee of the G.A.C. annual meeting in Halifax in September.



J.W. Gillis: continued preparation of a final account of the pre-Carboniferous schists, gneisses, and granites and Carboniferous sediments of Port aux Basques area (11 O), southwest Newfoundland. He collected for P.J. Hood a suite of specimens around Halifax for magnetic studies. He served as a member of the Founding Committee of the Northeastern Section, Geological Society of America, and as a member of the Hotel and Registration Committee for the joint annual meeting of the Geological and Mineralogical Associations of Canada, held in Halifax. He critically read a paper on a geophysical study of the Orpheus gravity anomaly off Cape Breton Island. He participated in the field trip to southwestern Newfoundland conducted by the Geological Association of Canada.

D.G. Kelley: continued detailed investigation of the stratigraphy and structure of the pre-Carboniferous strata and of the granitic rocks in the Cobequid Mountains, northern Nova Scotia. He spent several days during the field season on final arrangements for the Geological Association of Canada field trips held in September.

He was consulted during the year by geologists engaged in or planning exploration in Nova Scotia. G.H. Eisbacher, senior assistant for the past two field seasons, completed the field phase of a detailed structural study which will form the basis of a Ph.D. thesis to be submitted to Princeton University.

Dr. Kelley published a paper and road-log on the stratigraphy of Cape Breton Island in "Guidebook, Geology of Parts of Atlantic Provinces", produced by the Geological Association of Canada, and in September conducted the field trip. With G.H. Eisbacher, he submitted a short note to Maritime Sediments on tectonic studies in the Cobequid Mountains. He completed 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 member of a standing committee of the Professional Institute, as the chairman of Field Trips Committee of the G.A.C. annual meeting in Halifax; and as a member of the Provincial Coordination Committee for the Geological and Mineralogical Associations of Canada joint annual meeting in Halifax.

M.J. Kennedy: a National Research Council post-doctorate fellow from Trinity College, Dublin began a detailed structural study of the schists and gneisses of the Fleur de Lys Group in the Fleur de Lys area (12 I/1), northern Newfoundland. With E.R.W. Neale, he examined the structural geology of the Flatwater Pond-Mic Mac Lake area (12 H E 1/2) and the stratigraphic relationship of lower Palaeozoic rocks to the older Fleur de Lys Group.

E.R.W. Neale: spent six weeks in the Burlington Peninsula (12 H E/2), northern Newfoundland, to appraise the recent studies by mining company and university geologists and to examine rock exposures produced by new road-cuts, forest fires, and pulpwood operations since he published preliminary maps of the area several years ago, in order to ascertain what future work is required to prepare final maps and reports. He conducted two informal field trips in the area with participants from Oxford, Cambridge, Yale, and Columbia Universities, and several geologists from local exploration companies. His senior assistant, R.K. Stevens, continued for six weeks the regional study of the Palaeozoic klippe rocks on Great Northern Peninsula, begun by J.W. Gillis in 1965. He participated in the field trip in southwestern Newfoundland conducted by the Geological Association of Canada.

He served as a half-time executive assistant to the Assistant Deputy Minister (Research) from April 1 to November 15, 1966.

He was appointed Program Chairman for the Geology Division of the Royal Society of Canada and is arranging a symposium on the state of the earth sciences in Canada for the Centennial Year meetings in Ottawa. He was appointed co-editor, with H. Williams, of a special Geological Association of Canada volume dedicated to the late Professor Hugh Lilly. He is convener of the publicity subcommittee for the Annual General Meeting of the Canadian Institute of Mining and Metallurgy. Also, during 1966, Neale was appointed to the Geological Committee of the Advisory Council in Engineering of Queen's University. He continues as member of the Editorial Board of the Institute of Mining and Metallurgy (London).

W.H. Poole: continued to serve as Acting Head of the Section. He continued preparation of a contribution on the stratigraphy and tectonics of the pre-Carboniferous rocks of the mainland part of the Appalachian region of Canada for the current revision of Geology and Economic Minerals of Canada (R.J.W. Douglas, editor). He participated in a field trip to southwestern Newfoundland conducted by the Geological Association of Canada, and, afterward, he joined E.R.W. Neale and others on a field examination of the lower Palaeozoic rocks of part of Burlington Peninsula, northern Newfoundland. He supervised a Ph.D. thesis study by A.A. Ruitenberg in the St. Stephen-Pleasant Mountain area, southern New Brunswick, and joined Ruitenberg in the field for an examination of the stratigraphy and structure.

He edited and published a guidebook with roadlogs to the geology of parts of the Atlantic Provinces (14 papers, 8 roadlogs, 155 pp.) used in conjunction with the field trips conducted by the Geological and Mineralogical Associations of Canada joint annual meeting in Halifax.

He published in the technical program, an abstract of a paper on the geology of the Appalachian Region of Canada which he read at the plenary session of the meetings. He published a short article on Maritime Sediments in the Appalachian Session of the Upper Mantle Workshop held in Ottawa February 1965. With H. Williams and others, he published an account in Canadian Journal of Earth Sciences on the Rb/Sr age and geological setting of the Precambrian Holyrood granite of southeast Newfoundland. He edited and submitted for publication by the Survey an International Upper Mantle symposium entitled "Continental Margins and Island Arcs"; it consists of 42 papers prepared by scientists from many countries and totals 483 pages. He prepared an addendum of 129 entries to a bibliography of research projects carried out by the Geological Survey 1965-66 in the Atlantic Provinces for the Atlantic Provinces Economic Council (APEC). He critically examined and edited a final map and notes and a preliminary map and notes, both for publication by the Survey; and two short papers for publication in scientific journals.

He served as a member of the Departmental Committee on Recent Crustal Movements and Seismic Regionalization, and as a member of the Subcommittee on Structural Geology, National Advisory Committee on Research in the Geological Sciences.

A. A. Ruitenberg: a graduate study at Leiden University, the Netherlands, began and completed the field phase of an integrated study of stratigraphy, structure, and metallogeny of the St. Stephen-Pleasant Mountain area (parts of 21 G/3, 6, 7), southern New Brunswick. The area contains nickel deposits and, notably, the Mount Pleasant tin-molybdenum deposit. He submitted a preliminary map and notes on the area to the Survey for publication. The results of the study will form the basis of a Ph.D. thesis to be submitted to Leiden University.

H. Williams: completed investigations of the Ordovician and Silurian volcanic and sedimentary rocks, which include Buchans lead-zinc-copper mine, of Red Indian Lake (East Half) area (12 A E 1/2), and began investigation in the Burgeo (East Half) area (11 P E 1/2) to the south. With F. C. Taylor, he made a brief examination of Lower Cambrian or older red beds and basalt of northern Newfoundland and southeast Labrador. He joined other geologists in brief examinations of the geology of key areas of Humber Arm, Burlington Peninsula, and Horse Islands off the north coast.

He published a final account of the geology and the mineral deposits of the Chisel Lake area in west-central Manitoba, and, with W. H. Poole and others, he published an account in Canadian Journal of Earth Sciences on the Rb/Sr age and geological setting of the Precambrian Holyrood granite of southeast Newfoundland. He submitted

for publication by the Survey a final map and notes of the Red Indian Lake (East Half) area, and a final map of the Geology of Newfoundland, scale 1:1,000,000. He is continuing preparation of a contribution on the geology of Newfoundland for the current revision of Geology and Economic Minerals of Canada (R.J.W. Douglas, editor). He was appointed co-editor with E.R.W. Neale of a special Geological Association of Canada volume dedicated to the late Professor Hugh Lilly, and is preparing a paper on the Precambrian of the Appalachian region of Canada for that volume. He critically read for a scientific journal a paper on the geology of part of northeastern Newfoundland.

### Personnel Notes

- W.H. Poole: continued as Acting Head of the Appalachian Section. He attended the joint annual meeting of the Geological and Mineralogical Associations of Canada in Halifax, at which he read a paper to the plenary session on the geology of the Appalachian region of Canada. In March the report of the International Upper Mantle Symposium on Continental Margins and Island Arcs was published which was edited by him.
- F.D. Anderson: attended the meeting of the Northeast Section, Geological Society of America at Boston, March 16-18, 1967 and presented a paper entitled "Structure of the Baie D'Espoir Group, Newfoundland".
- D.G. Benson: (Halifax) also attended the GSA meeting in Boston and presented a paper entitled "Tectonic Evolution of the Palaeozoic Rocks of Northern Nova Scotia". He also attended the joint annual meeting of the Geological and Mineralogical Associations of Canada in Halifax.
- J.W. Gillis: (Halifax) attended the joint annual meeting of the Geological and Mineralogical Associations of Canada in Halifax, at which he co-chaired a technical session. He attended the Atlantic University Geological Conference in Halifax.
- D.G. Kelley: Attended the Nova Scotia Mining Society at Ingonish, Nova Scotia, and the joint annual meeting of the Geological and Mineralogical Associations of Canada in Halifax. He served as a member of the Ottawa General Committee for the preparation and conduct of the C.I.M.M. Annual Meeting held in Ottawa, March 27-29, 1967.

M.J. Kennedy: an N.R.C. post-doctoral fellow from Trinity College, Dublin, was attached to the Section in July.

E.R.W. Neale: attended the meeting of the Royal Society of Canada in Sherbrooke and the annual meeting of the Canadian Institute of Mining and Metallurgy in Quebec. He presented a talk on organization of Commonwealth earth scientists to the Ottawa Branch of the Canadian Institute of Mining and Metallurgy, and a talk on the work of the Geological Survey to new employees of the Department. He served as convenor publicity subcommittee, Ottawa General Committee for the preparation and conduct of the CIMM Annual Meeting held in Ottawa, March 27-29 and attended a one week course on Management Grid held in Cornwall, Ontario in March, 1967.

H. Williams: attended the joint annual meeting of the Geological and Mineralogical Associations of Canada in Halifax. He attended the Prospectors and Developers Convention in Toronto in March.

#### 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.

D.G. Benson - Treasurer, Field Trips Committee, joint annual meeting of Geological and Mineralogical Associations of Canada, Halifax 1966.

J.W. Gillis - Member, Founding Committee, Northeastern Section, Geological Society of America.  
- Member, Hotel and Registration Committee, joint annual meeting of Geological and Mineralogical Associations of Canada, Halifax, 1966.

D.G. Kelley - Member, Branch Committee on Central Technical Files.  
- Chairman, Field Trips Committee, joint annual meeting of Geological and Mineralogical Associations of Canada, Halifax 1966.  
- Member, Provincial Coordination Committee, joint annual meeting of Geological and Mineralogical Associations of Canada, Halifax 1966.  
- Member, Legislation and By-Laws Committee, Professional Institute.



- E.R.W. Neale - Member, Editorial Board, Applied Science, Institute of Mining and Metallurgy (U.K.).
- Member, Program Committee, Canadian Institute of Mining and Metallurgy Meeting 1967..
  - Program Chairman, Geology Division, Royal Society of Canada, Meeting 1967..
  - Member, Advisory Council on Engineering, Queen's University.

## 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 - the fossil fuels - 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, sedimentology, 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 five sections, each having 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 determination 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.L. Christie, Acting Head

This section is 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: - B.A. Latour, Office Manager

This office is responsible for regional subsurface and surface stratigraphic studies in the western provinces, the Northwest Territories, and the 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 government 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 the Department of Indian Affairs and Northern Development and the National Energy Board.

Several members of the Petroleum Geology Section are also based at the Calgary Office.

To carry on stratigraphic studies, the scientific staff in Calgary is in three groups as follows:

Mesozoic Stratigraphy Unit: D.F. Stott, Leader

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

Devonian Stratigraphy Unit: Helen R. Belyea, Leader

## 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. The report period 35,170 samples representing 210 wells in Ontario were received and prepared for microscopic examination. Samples and cores of many of the wells drilled in Quebec and the Atlantic Provinces are also stored at Ottawa. This material was made available to visiting geologists for study, and representatives of the following companies availed themselves of this service: Imperial Oil Enterprises Ltd, British American Oil Company, Socony Mobil Oil of Canada Limited, Consumers Gas Company, Shell Canada Limited, Pan American Petroleum Corporation, Trans Canada Pipelines Limited, Texaco Exploration Company, Petropar Canada Limited, Quebec Natural Gas Company, and Texas Eastern Transmission Corporation.

Samples from wells drilled in the western provinces, and samples and cores from wells drilled in Northwest Territories, Yukon Territory, Arctic Islands, and off-shore in Eastern Canada 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 organizations through whose cooperation information and/or drilling samples and cores were received: Ontario Department of Energy Resources and Management, for samples of wells drilled in Ontario; Imperial Oil Enterprises for information on drilling on Anticosti Island, Quebec; Department of Mines and Petroleum Resources, Victoria, for samples of wells drilled in British Columbia; Oil and Gas Conservation Board, for electric logs and samples of wells drilled in Alberta; Petroleum and Natural Gas Branch, Department of Natural Resources, Regina, for well samples; Nova Scotia Department of Mines for drilling information; Department of Mines, Agriculture and Resources, St. John's, for drilling information in Newfoundland; Mines Branch, Department of Lands and Mines, Fredericton, for drilling samples in New Brunswick; Department of Mines, Quebec City, for drilling information in Quebec, 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 the time of writing is shown below:

Location	Scientists	Technicians	Clerks and Typists
OTTAWA	25	9	4
CALGARY	21	4	7

### Membership on Committees

- Caley, J.F. - Associate Editor, Eastern Canada, A.A.P.G.  
- Member, Committee for Publication, A.A.P.G.  
- Member, Permanent Council, World Petroleum Congresses  
- Representative for Eastern Canada, Basement Rocks Project, A.A.P.G.
- Frebold, H. - Representative for Canada, Sous-Commission du Jurassique, Commission de Stratigraphie. Union Internationale des Sciences Geologiques.

## PRINCIPAL RESEARCH SCIENTIST

Dr. H. Frebold

Research on the Jurassic System of Canada was concentrated on four main objectives: 1) the recently discovered Jurassic occurrences in the Manning Park area, British Columbia (in cooperation with J.A. Coates); 2) the Pliensbachian rocks in the Rocky Mountains and Foothills (in cooperation with N.C. Ollerenshaw); 3) the Jurassic stratigraphy and faunas of Taseko Lakes area, British Columbia (in cooperation with H.W. Tipper); and 4) the new occurrences of Jurassic rocks and faunas in central and northern Yukon (in cooperation with E.W. Mountjoy and D. Tempelman-Kluit). Results of these studies have added considerably to knowledge of the Jurassic faunas, stratigraphy, and palaeogeography in western and northern Canada. Some of the results are described in four reports submitted and expected to be published in 1967. One report, GSC Paper 66-27, was published.

Field work was carried out in Manning Park, British Columbia and in the Rocky Mountains and Foothills region.

In addition eight reports on fossil identifications and age determinations were prepared and of these 6 were for Survey members, 1 was for the British Columbia Department of Mines and Petroleum Resources, and 1 for Petropar Canada Limited.

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

Two manuscripts to be published as Geological Survey of Canada Papers were completed during the months of January, February and March 1967; "Middle Callovian Sedimentary Rocks and Guide Ammonites from Southwestern British Columbia" (with H.W. Tipper) and "Toarcian and Bajocian Rocks and Guide Ammonites from Southwestern British Columbia" (with H.W. Tipper and J.A. Coates).

## 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.



Nine staff members undertook field investigations in Canada's sedimentary basins during 1966. A preliminary account of their findings is published in GSC Paper 67-1, Part A. Dr. B.A. Liberty resigned to take up a teaching position at the University of Guelph, and Mr. B. MacLean transferred to the Bedford Institute of Oceanography. Dr. D.L. Gibson and Mrs. C.J. Havard joined the Section at the Calgary Office. We regret to record the accidental death of Mr. Lafontaine of the Well Sample Preparation Laboratory. His position was filled by Mr. S. Colletta.

Officers of the Section published 13 contributions to the scientific literature, 7 as publications of the Geological Survey, and 6 as contributions to internationally recognized journals. Officers were widely consulted by scientists in other government agencies as well as in universities and industry.

A summary account of research activities in the Petroleum Geology Section follows:

#### Activities

D.L. Gibson: spent approximately six weeks examining Triassic rocks of the eastern Canadian Cordillera south of Athabasca River in order to effect their correlation with stratigraphic units established by him north of the river in 1962 and 1963. He spent two weeks with Dr. E.T. Tozer visiting important Triassic sections and fossil localities in northeastern British Columbia in preparation for future lithostratigraphic investigations in that area. A GSC bulletin titled "Triassic stratigraphy and petrology between Smoky and Brazeau Rivers of Alberta"; and a paper for outside publication "Triassic stratigraphy and petrology between the Athabasca and Smoky Rivers of Alberta" are in preparation. A paper on Triassic stratigraphy between Athabasca and Brazeau Rivers for publication by the Geological Survey was completed. See résumé in G.S.C. Paper 67-1, Part A, pp. 101-102.

Mrs. C.J. Havard: after joining the Section in June, 1966, Mrs. Havard commenced a stratigraphic study of the Kneehills Tuff Member of the Upper Cretaceous Edmonton Formation in southern Alberta west of the Sweetgrass Arch. Six cross-sections have been prepared showing the subsurface configuration of the uppermost Cretaceous Formations. The Kneehills Member has been traced in the subsurface in the Calgary area and a structure contour map on the top of the unit has been prepared. This subsurface information will be combined with surface data for a

joint publication with Dr. E.J.W. Irish. Mrs. Havard made brief field trips to the Drumheller and Crowsnest Pass areas of Alberta in relation to these studies.

R.D. Howie: continued examination of wells drilled in the Atlantic Provinces with particular emphasis on the structure and stratigraphy of the Stony Creek gas and oil field, New Brunswick, and is completing detailed geological logs of Kelly's Cross No. 1 and French River No. 1 diamond drill holes, Prince Edward Island. Details of these borings will be published in due course. In addition to preparation of the annual A.A.P.G. report on developments in oil and gas exploration in Eastern Canada for 1966, he completed the revision of a paper on the Stony Creek Field for the A.A.P.G. publication titled "Gases of North America". He studied and indexed confidential reports from oil companies on file with the Department of Indian Affairs and Northern Development and assisted oil company geologists interested in the petroleum potential of the Atlantic Provinces. Mr. Howie is collaborating with H.W. van de Poll of the New Brunswick Mines Branch on comparison and duplication of Carboniferous well data on file with the GSC and with that Branch.

During the year Mr. Howie published "Catalogue of well samples from Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland at the Geological Survey of Canada, Ottawa", G.S.C., Paper 65-40; "Developments in Eastern Canada in 1965" (with J.E.S. Milne), Bull. Am. Assoc. Petrol. Geol., vol. 50, No. 6, pp. 1295-1310; and "Possible base-ment graben beneath Miramichi Bay, New Brunswick" (with L.M. Cumming), Abstract in Geological and Mineralogical Associations of Canada, Technical Program, Annual Meeting, Halifax, Nova Scotia, p. 20. The complete paper presented at Halifax will be published by the Geological Association of Canada.

E.J.W. Irish: continued his stratigraphic study of the uppermost Cretaceous formations of the southern Alberta Plains. During 1966 a detailed investigation was made of the Whitemud and Battle Formations in the Cypress Hills, Alberta and their western equivalents within the Edmonton and St. Mary River Formations. Surface exposures of these strata between latitudes 49 and 52 degrees north were mapped and samples collected from each exposure for petrographic, mechanical, chemical, and X-ray analyses. Data from this field and laboratory investigation will be combined with the subsurface correlation established by Mrs. C.J. Havard in order to effect a closer correlation of the late Upper Cretaceous formations. Dr. Irish submitted the first of a series of six maps (Oyen, 72M) to be published by the Geological Survey showing the surface geology of southern Alberta on a scale of four miles to the inch.

He completed laboratory work pertaining to his study of the Whitemud Formation, Battle Formation, Kneehills Tuff and their western equivalents. He completed his contribution to the joint report on the above formations with Mrs. C.J. Havard. Dr. Irish continued the preparation of maps (scale 1:250,000) showing the surface geology of southern Alberta and began petrographic and heavy mineral studies of the St. Mary River Formation. A preliminary map with marginal notes, Drumheller (82 P), was submitted for publication.

B.A. Liberty: spent approximately two months on stratigraphic studies of the lower Palaeozoic strata of the St. Josephs Island-Sault Ste. Marie, Ontario area and one month completing his studies of the surface geology of the Peterborough-Kingston area. He continued 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. Dr. Liberty answered enquiries relating to the industrial minerals and petroleum possibilities of Ontario.

B. MacLean: until his transfer to the Bedford Institute of Oceanography in July, 1966, 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 revision of the geological map of Canada; prepared monthly summaries of oil and gas activities in Western Canada, and continued the preparation of isopach 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 published by the Geological Survey. A paper "Petroleum and natural gas potentialities of Yukon Territory" was prepared jointly with J.F. Caley and D.K. Norris for the Yukon Northern Resources Conference, Whitehorse, March, 1966.

D.K. Norris: extended studies of structural fabrics in coal measures of the eastern Canadian Cordillera to the Anthracite fields of the northern Appalachians with a view to establishing differences or similarities in these fabrics as a function of structural position on mountain arcs and of tectonic environment. In collaboration with Dr. A. Larochelle of the Geophysics Division he carried out the field phase of magnetic fabric studies of extrusive and intrusive rocks of the Mackenzie arc in order to establish the validity of the "Alaskan orocline" and its implied relation to the westward drift of North America relative to Eurasia. Detailed lithostratigraphic investigations of the non-marine Jurassic and Lower Cretaceous rocks of the southeastern Canadian Cordillera were continued.

He devoted considerable time to scientific liaison between the Geological Survey and the National Film Board. Three manuscripts arising from research within the Division of Fuels and Stratigraphy were critically read and administrative duties were carried out.

During the year Dr. Norris spoke by invitation to the American Geophysical Union on his investigations of the fracture fabric of the anticline-syncline pair exposed along the Ottawa Queensway. He was invited to speak at the Alberta Society of Petroleum Geologists structural geology symposium on the mechanics of overturning of panels beneath thrust plates and to the Chevron Standard Company structural geology seminar on the significance of coal measure fabrics in the mechanical interpretation of mountain arcs. He delivered a paper titled "Middle Cambrian lithostratigraphy of the southeastern Canadian Cordillera", prepared jointly with Dr. R.A. Price, at the symposium on Lower Palaeozoic stratigraphy held at the University of Alberta. A paper "Petroleum and natural gas potentialities of Yukon Territory" was prepared jointly with J.F. Caley and B. MacLean for the Yukon Northern Resources Conference, Whitehorse, March. 1966.

Dr. Norris published three papers during the year: "Lower Middle Cambrian correlations in the east-central Cordillera" (jointly with W.H. Fritz), in G.S.C., Paper 66-1, pp. 105-110, 1966; "The mesoscopic fabric of rock masses about some Canadian coal mines", in Proc. First Congress, Intl. Soc. Rock Mechanics, vol. 1, pp. 191-198, 1966; and "Middle Cambrian lithostratigraphy of the southeastern Canadian Cordillera" (jointly with R.A. Price), in Bull. Can. Petrol. Geol., vol. 14, No. 4, 1966.

D.K. Norris devoted 80 per cent of his time to administrative duties within the Division of Fuels and Stratigraphy during the first three months of 1967. In addition he brought to completion his function as scientific advisor to the National Film Board for the Geological Survey film "The Continuing Past". Dr. Norris made some progress in the preparation of a paper titled "The Crowsnest Deflection of the Eastern Cordillera"; he delivered a lecture on his structural fabric studies in the Ottawa-St. Lawrence Lowlands to the faculty and graduate students of the Department of Geology of Ottawa University and he critically read two manuscripts, one for a Geological Survey paper and another for an outside publication.

N.C. Ollerenshaw: continued his studies of the structure and stratigraphy of the southern Foothills of Alberta. A geological investigation of the Foothills portions of the Lake Minnewanka East and Lake Minnewanka West areas was initiated and completed during the 1966 field season. A preliminary map with marginal notes is under preparation for the Lake

Minnewanka East area. A paper on the Panther Dome, complete with map and cross-sections is being prepared. Papers on the Blairmore Group (Ghost River to the Clearwater River) and the basal Fernie Group of the southern Foothills of Alberta (with Dr. H. Frebold) are also in preparation. A preliminary geological map of part of Limestone Mountain area was provided by request for J. Ray McDermott and Co. in 1966. A preliminary map and marginal notes for the combined Burnt Timber Creek East and Burnt Timber Creek West areas (Map 65-11) was published in 1966.

R.A. Price: completed field work on Operation-Bow Athabasca, a reconnaissance investigation of the regional geology of about 12,000 square miles of the southern Rocky Mountains in Alberta and British Columbia, involving Dr. J.D. Aitken of the Calgary office, Prof. E.W. Mountjoy of McGill University, and D.G. Cook and H.R. Balkwill, Ph.D. candidates at Queen's University and the University of Texas respectively. An outline of the regional geologic structure and other aspects of the regional geology was submitted for publication in the Report of Activities of the Geological Survey at the close of the field season. Compilation and interpretation of data gathered during 1965 were continued prior to the 1966 field season. A paper on "Cambrian stratigraphy in the southeastern Canadian Cordillera, prepared in collaboration with D.K. Norris, was presented at a symposium on lower Palaeozoic stratigraphy at the University of Alberta and published in the Bulletin of Canadian Petroleum Geology. Dr. Price supervised Ph.D. thesis projects by H.U. Bielenstein on structural analysis of the Rundle thrust sheet and by D.G. Cook on analysis of structural relations in the Main Ranges of the Rocky Mountains in the Kickinghorse Pass region. He interviewed candidates for scientific research positions with the government as a member of the Civil Service Commission recruitment team visiting Canadian universities. He served as a critical reader for two manuscripts prepared for publication by the Geological Survey and for one submitted to the Alberta Society of Petroleum Geologists.

During the year Dr. Price published "Middle Cambrian lithostratigraphy of the southeastern Canadian Cordillera" (jointly with D.K. Norris) in Bull. Can. Petrol. Geol., vol. 14, No. 4, 1966 and submitted a paper titled "The tectonic significance of mesoscopic subfabrics in the southern Rocky Mountains, Alberta and British Columbia" for publication in an outside journal.

He delivered the following talks:

Alberta Society of Petroleum Geologists symposium on Structural Geology within the Canadian Rockies, Calgary, June, 1966, "Flexural-slip folding in the southern Canadian Rockies".



Chevron Standard Company, seminar on structural geology, Calgary, June, 1966, "The tectonic significance of mesoscopic fabric elements, southern Rocky Mountains, Alberta and British Columbia".

Cordilleran Structure Project, Field Conference, Revelstoke, British Columbia, June, 1966, "Flexural-slip folding in the southern Canadian Rockies", "Operation Bow-Athabasca", and "Mesoscopic fabric elements and structural analysis in the southern Canadian Rockies".

Department of Geology, Queen's University, Kingston, Ontario, November, 1966, "Flexural-slip folding in the southern Canadian Rockies".

Department of Geology, McMaster University, Hamilton, Ontario, December, 1966, "Flexural-slip folding in the southern Canadian Rockies" and "Mesoscopic fabric elements and structural analysis in unmetamorphosed sedimentary rocks".

B.V. Sanford: continued the study of the Palaeozoic rocks of southwestern Ontario with main emphasis on the Devonian System. During the latter portion of the year, a study of the Palaeozoic rocks bordering Hudson Bay was initiated in preparation for Operation Winisk, an air-supported geological reconnaissance of the Palaeozoic formations of Hudson and James Bay region to be carried out during 1967.

During the year, GSC Paper 65-30 was published illustrating the stratigraphy, structure, and reservoir characteristics of each of the 61 Silurian oil and gas fields in Ontario.

He completed a paper entitled "Devonian Rocks of Ontario and Michigan" for publication by the International Devonian Symposium.

G.C. Taylor: spent most of the year compiling and interpreting the data collected during the field phase of Operation Liard. Considerable time was spent in the organization and preliminary planning of a future project to map, refine and revise the geology of the terrain between the areas completed by Operations Liard and Bow-Athabasca. He published jointly with W.S. MacKenzie "Devonian stratigraphy of northeast British Columbia" in G.S.C., Paper 66-2, pp. 66-67, 1966, and with H. Gabrielse and B.S. Norford "Stratigraphy of the Silurian Carbonate rocks of the Rocky Mountains in northern British Columbia" in Bull. Can. Petrol. Geol., vol. 14, No. 4, 1966.

He completed a joint paper with E.W. Bamber and R.M. Procter titled "Late Palaeozoic Stratigraphy of Northeast British Columbia" for publication with the Geological Survey. He critically read two papers to be published by the Survey.



Annual report of the Well Sample Preparation Laboratory 1966

Province	RECEIVED				PROCESSED			
	CORE		DRILL CHIPS		CORE		DRILL CHIPS	
	footage	wells	samples	wells	footage	wells	samples	wells
Manitoba	-	-	531	4	-	-	531	-
Alberta	-	-	-	-	-	-	44,995	339
British Columbia	-	-	-	-	-	-	-	-
Ontario	2424	29	35,170	210	9,438	15	35,567	164
Quebec	1805	3	9,185	150	-	-	9,195	122
New Brunswick	-	-	-	-	-	-	-	-
Nova Scotia	-	-	-	-	-	-	-	-
P.E.I.	-	-	-	-	-	-	-	-
Newfoundland	-	-	1,176	4	-	-	1,176	4
Grand total	4229	32	46,062	368	9,438	15	91,454	629
Western	-	-	531	4	-	*	46,382	340
Eastern	4229	32	45,531	364	14,269	19	51*,513	315

Operating days (Jan 1, 1966 - Dec 31, 1966): 250 days

Drill chip preparation

Core Set preparation

Related work

Leave, training etc.

Staff available throughout 1966

Total operating mandays

Manpower

1.62 Manpower

1.14 "

2.04 "

-- "

4.80 "

Mandays

404 Mandays

285 "

302 "

202 "

1193 "

Annual report of the Well Sample Preparation Laboratory 1966

Province	RE-PROCESSED				RESERVED & SHIPPED				RECEIVED UNPROCESSED		
	CORE		DRILL CHIPS		CORE		DRILL CHIPS		CORE		
	footage	wells	samples	wells	footage	wells	samples	wells	footage	wells	no of boxes
Manitoba	-	-	-	-	-	-	-	-	-	-	-
Alberta	-	-	856	1	-	-	-	-	-	-	-
British Columbia	-	-	-	-	-	-	-	-	?	1	2
Ontario	3,026	1	3,862	16	9,438	15	4,834	28	approx. 22,349	248	1,741
Quebec	1,805	3	-	-	-	-	7,311	122	172	4	9
New Brunswick	-	-	1,721	10	-	-	-	-	277	3	11
Nova Scotia	-	-	-	-	-	-	-	-	?	1	9
P.E.I.	-	-	-	-	-	-	-	-	4,790	19	324
Newfoundland	-	-	-	-	-	-	688	2	-	-	-
Grand total	4,831	4	6,539	27	9,438	15	12,833	152	27,588	275	2,096
Western	-	-	856	1	-	-	-	-	?	1	2
Eastern	4,831	4	5,683	26	9,438	15	12,833	152	27,588	275	2,094

Operating days (Jan 1, 1967 - Mar 31, 1967): 82 days

Drill chip preparation

Core set preparation

Related work

Leave, training etc.

Staff available during this period

Total operating mandays

Manpower

1.10 Manpower

0.64 "

1.96 "

-- "

3.70 "

Mandays

87.50 Mandays

55.50 "

105.00 "

75.50 "

323.50 "

\*Total wells/samples processed include "total wells/samples re-processed"

Well Sample Preparation Laboratory and Core Centre

W. U. ter Haar Romeny (in charge)

Preparators: R. J. G. Seguin

P. Bova

S. Colletta

Data for the fifteen month period covered by this report are presented in tabular form.

Reorganization of the Core Storage Centre involving the sorting, indexing and re-boxing of about 27,588 feet of core received prior to 1966 was completed.

During the summer of 1966, compilation of well data required for the updating of the Catalogue of Ontario Well Samples (GSC Paper 63-46 B. V. Sanford) was made.

A workshop and core examination was constructed by D. P. W. and dust removal apparatus installed above the slabbing equipment to reduce air pollution and so improve working conditions in this area.

Throughout the year sample and core examination facilities were made use of by several industry geologists as well as by geologists from provincial departments.

Mr. ter Haar Romeny served as program director of the Weston Club during the year and was elected to Chairman in October. As Deputy Building Emergency Officer he reorganized the emergency alarm system for Fire Warning and Shelter Protection.

Membership on Committees

- |                       |   |
|-----------------------|---|
| <u>R. D. Howie</u>    | - Chairman, Appalachian Discussion Group, Jan. - May, 1966.                               |
| <u>E. J. W. Irish</u> | - Chairman, Calgary Branch, Professional Institute of the Public Service.                 |
| <u>B. A. Liberty</u>  | - Chairman, Ottawa Geoscience Discussion Group, 1965-66.                                  |
| <u>D. K. Norris</u>   | - Member, Departmental Committee on Recent Crustal Movements and Seismic Regionalization. |

- Member, Departmental Satellite Information Committee.
- Member, Geological Survey Exhibits Committee.
- Scientific liaison between the Geological Survey and the National Film Board.

N.C. Ollerenshaw - Chairman, Geological Survey Exhibits Committee, Calgary.

- R.A. Price - Member, Geological Survey Library Committee.
- Member, Geological Survey Central Technical Files Committee.
  - Structural Geology Subcommittee of the N.A.C. on Research in the Geological Sciences.
  - N.S.F. Field Conference for Geology Professors - Committee for 1967 field conference.

- 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 203 reports were prepared by members of the Section on 3,008 lots of fossils. These lots were submitted by the following:

GSC Field Officers .....	2,038
Other Government Departments .....	42
Industry .....	645
Universities .....	273
Miscellaneous .....	10

In addition, 21 reports on 270 lots were prepared for GSC officers by outside experts at our request.

Loans totalling 103 lots other than types were made to individuals and institutions in Canada and elsewhere; a total of 107 lots of fossils, 102 plaster casts and 4 peel sections were sent as gifts or in exchange to 18 individuals or institutions throughout the world.

In Canada, and five other countries there are 52 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, such studies have resulted in three manuscripts for publication by the Survey, and 3 papers published elsewhere.

Forty-five 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 Paleontologicheskii Zhurnal for the American Geological Institute, for publication in International Geology Review. Several members of the Section are readers for the Palaeontology Society.

During the year three additional papers in the "Illustrations of Canadian Fossils" Series were published, bringing the total now published to 11. Members of the Section published 3 Bulletins, 3 Papers, and Volumes II and III of the Catalogue of Type Invertebrate Fossils. In addition, 3 Papers in outside journals, 7 abstracts and 2 reviews were published. Members of the Section completed and submitted a Chapter on Palaeontology, illustrated by 33 plates, to be published in the new edition of "Geology and Economic Minerals of Canada".

### Type Collection

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

A total of 1,398 types described in both Survey and outside publications were added to the Type Collection of the Survey in 1966. Publications in which these types were reported are as follows:

GSC Bull.	128 Jurassic ammonites and pelecypods, Arctic . . . .	98 types
	131 Permian ammonites, Arctic . . . . .	27
	133 Devonian stromatoporoids, Western Canada . . . .	
	134 Ordovician and Silurian trilobites, corals, echinoderms . . . . .	56
	135 Carboniferous corals, Western Canada . . . . .	2
	140 Silurian brachiopods, New Brunswick . . . . .	
Paper	51-16 Cretaceous forams, Alberta . . . . .	52
	65-35 U. Cretaceous-Paleocene plants, Western Canada . . . . .	67
	66-5 Silurian faunas, Ontario . . . . .	156
	66-11 Carboniferous plants, Eastern Canada . . . . .	162
	66-27 Jurassic ammonites, Alberta . . . . .	4
	66-30 Devonian spores, Eastern and Arctic Canada . . .	333

# Types in Outside Publications:

Bolton, T.E. (GSC), Palaeontology, 9:3 .....	10
Churkin, M. Jr. (USGS), Palaeontology, 9:1 .....	15
Copeland, M.J. (GSC), Proc. G.A.C., 17 .....	20
Fritz, M.A. (Univ. Toronto), Palaeo. 40:6 .....	2
Jeletzky, J.A. (GSC), Univ. Kansas Pal. Contr., Mollusca 7 .....	16
Jones, D.L. et al (USGS), Prof. Paper 503-F .....	6
Laursen, D. (Denmark), Malacologia, 3:3 .....	14
Pedder, A.E.H. (Univ. New England), Palaeontology, 8:4 .....	7
Pedder, A.E.H. (Univ. New England), Palaeontology, 9:1 .....	6
McGill, P. (Imperial Oil), Bull. Can. Petrol. Geol., 14:1 .....	64
Rasetti, F. (Johns Hopkins), Smithsonian Misc. Coll., 148:9 .....	1
Sartenaer, P. (Belgique), Bull. Inst. Roy. Sci. Nat., 41:3 .....	8

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Twenty-three loans of 145 type specimens have been made to outside specialists at their request.

## Activities

E.W. Bamber: wrote 15 reports on 222 lots of Carboniferous and Permian fossils collected by GSC field officers; did 2 weeks of field work with R.W. Macqueen near Banff, Alberta; acted as outside reader for the Journal of Palaeontology; evaluated one manuscript for the Arctic Institute of North



America and two for the International Devonian Symposium. Manuscripts were completed on the Mississippian Stratigraphy of Southwestern Alberta (with R.W. Macqueen) and on the Carboniferous and Permian Stratigraphy of Northeastern British Columbia. GSC Bulletin 135 on Lithostrotionid Corals was published. Visits were made to the Calgary Office to confer with R.W. Macqueen, G.C. Taylor, and R.M. Proctor, and to the U.S. National Museum to study type specimens and consult with officers of the U.S. Geological Survey.

W.A. Bell: (retired) wrote 15 reports on 86 lots of plant megafossils and was author of GSC Paper 66-11 published during the year.

T.E. Bolton: wrote 3 reports on 11 lots of fossils. The field season was devoted to Silurian-Ordovician biostratigraphic studies in the central and western parts of Anticosti Island, Quebec. Faunas of the Silurian rocks of Gaspé, Quebec and Arisaig, Nova Scotia, were examined with Dr. M.J. Copeland, in order to complete data that will assist in the regional correlation phase of the Anticosti studies. The investigation of trilobites and echinoderms collected from these rocks was continued; publication in a GSC Bulletin is anticipated. He attended the New York State Geological Association Annual Meeting in Buffalo, New York in June, and the September GAC-MAC meeting at Halifax, co-chairing the Palaeontology technical session during the latter programme. During the year, GSC Bulletin 134, Volumes II and III of the Catalogue of GSC Type Invertebrate Fossils, Paper 66-5 illustrating "Silurian Faunas of Ontario", and an outside paper entitled "Some Silurian Bryozoa from the Canadian Arctic Islands", were published. He worked with Drs. Copeland and Sinclair, in the preparation of plates illustrating the Ordovician faunas of Lakefield area, Ontario, for publication in an Ontario Department of Mines guidebook, and submitted a description on the Ordovician bryozoan fauna of the Braeside quarry for inclusion in a GSC Bulletin being prepared by Miss M. Steele. Fifteen manuscripts were reviewed as a member of the Programme and Publications Committee and Assistant Editor to the Geological Association of Canada. Three manuscripts were critically read for the Palaeontological Society. He was elected to the Council of the Geological Association of Canada and appointed Chairman of the Technical Abstracts and Programme Committee for the 1967 Kingston Annual Meeting.

T.P. Chamney: wrote 9 reports on 120 lots of Mesozoic and Palaeozoic microfossils. Three of these reports were for the oil industry, and one for the National Museum. He re-wrote a bulletin previously submitted for publication on the Barremian Textulariina of the Aklavik Range. Two additional manuscripts were completed and submitted for publication as co-author with E.W. Mountjoy of McGill University on the Albian of the

Yukon, and with D. Russell of the National Museum on the Upper Cretaceous of Drumheller area, Alberta. He is continuing preparation of a bulletin for systematic description and illustration of Albian Foraminiferida of the Yukon. Supporting Cretaceous service identifications for Operation Liard (D.F. Stott) and Southern Alberta Plains (E.J.W. Irish) has required disintegration, picking of microfossils and cursory examination of over 2,000 lots of rock samples. Results of this continuing project have been provided as personal communications to the respective field officers concerned. Preparation for the subsurface "schedule of wells" for the Department of Indian Affairs and Northern Development, was commenced with examination of core material from the B-A Oil Company et al. Mackenzie River Delta bore hole Reindeer D-27. Three additional wells in the Eagle Plains were examined for the same purpose. In company with J.A. Jeletzky, meetings were held with geologists of the B-A Oil Company for discussions of the Mesozoic stratigraphy pertaining to the Reindeer D-27 bore hole. Three summer seasonal university students were supervised in tasks including Carboniferous foraminiferal study by A. Petryk, a Ph.D. candidate from the University of Saskatchewan and the training of a scientific illustrator, Miss A. Haeseker from the University of Calgary. The third student from the University of British Columbia under supervision, developed a new rock disintegration technique in conjunction with his laboratory preparation assignment. A special lecture series was attended on the subject of "Continental Edge Facies" given by Dr. Van Andel in association with the University of Calgary and the American Association of Petroleum Geologists. A paper was delivered to the Palaeontological Section of the Alberta Society of Petroleum Geologists on "A Review of Foraminiferal Zonation of the Mesozoic in Arctic America". Some time this year has also been devoted to the establishment of our new G.S.C. library in Calgary as an appointed member to the Library Committee.

M.J. Copeland: wrote 20 fossil reports on 87 lots of Palaeozoic microfossils for field officers, industry, and other organizations. He spent part of a field season collecting Ordovician, Silurian, and Devonian microfossils in Nova Scotia, New Brunswick, Gaspé, and Anticosti Island, Quebec. He continued his studies of Ordovician-Silurian-Devonian Ostracoda and Eurypterida of Eastern and Arctic Canada, particularly from Anticosti Island, and other non-trilobite Arthropoda from various localities. He published a paper on "Some Leperditid Ostracoda from the Richardson Mountains, Northern Yukon Territory" in the Proceedings of the Geological Association of Canada, vol. 17. He assisted in preparing fossil plates for a forthcoming guidebook to the geology of the Peterborough area being published by the Ontario Department of Mines; identified and prepared illustrations of Ordovician Ostracoda from Braeside, Ontario, for inclusion in a Geological Survey bulletin on that area; completed and submitted manuscripts on fossil phyllopods from Cornwallis Island, Canadian Arctic, and Arkansas, U.S.A. for submission to the Journal of Palaeontology. He was appointed to

the Programme Committee of the Geological Association of Canada for the August-September, 1967 meeting of that Association in Kingston, Ontario. He edited, or critically read several manuscripts for the Survey and outside organizations.

R.L. Cox: wrote 2 reports on microfossils from a sample of Arctic Tertiary rocks. A study of organic microfossil plankton from the Cretaceous of Saskatchewan and Manitoba was started. Six weeks were spent in southwest Manitoba consulting with geologists of the Manitoba Dept. of Mines and Natural Resources, and collecting samples from every type and reference Cretaceous and Tertiary section in the province. Three weeks were spent consulting with palynologists of the Alberta Research Council, the University of Alberta and Shell Oil Company in Edmonton, and the University of Calgary, Imperial Oil Limited and Standard Oil of California. In addition, cored intervals of Cretaceous rocks from Alberta and Saskatchewan were sampled in Calgary and Regina respectively. Cretaceous samples were also taken from collections made by L.L. Price of three Saskatchewan potash shafts. Sixty-nine samples have been macerated, and 281 slides have been prepared. A preliminary study of these samples indicates an extensive, well preserved sequence of microfossil plankton assemblages is present both in the Manitoba and Saskatchewan Cretaceous marine units. An earlier project on the palynology of the Tertiary Sooke Formation of Vancouver Island is postponed until the work on the Cretaceous material has been completed.

L.M. Cumming: prepared 5 reports on 68 lots of fossils from Palaeozoic Formations in Eastern Canada. He attended the first meeting of the Northeastern Section of the Geological Society of America at the University of Pennsylvania in February. He completed a manuscript "Platform and Klippe Tectonics of Western Newfoundland - A Review". He read this paper at the Royal Society Symposium on Appalachian Tectonics at Sherbrooke in June. Field work consisted of 2 1/2 months of biostratigraphic studies in Newfoundland. An abstract summarizing this field work "St. George-Table Head Disconformity, Western Newfoundland", was submitted to the C.I.M.M. for publication and results were presented at their Annual Meeting. Jointly with R.D. Howie, he prepared for publication and presentation a paper "Basement Graben beneath Miramichi Bay, New Brunswick". He attended the G.A.C. annual meetings in Halifax and field trips to Cape Breton and northern New Brunswick. He gave assistance to Dr. P.W. Hay, New Brunswick Mines Branch, during the planning stage of a mapping project in southern New Brunswick. He acted as regional coordinator for papers concerning the northeast Appalachians for the forthcoming International Symposium on the Devonian System. He compiled data concerning the Devonian rocks of the eastern Appalachians, submitted an abstract, and completed a manuscript on "Devonian System-Canadian Appalachians and New England States", for the International

Devonian Symposium. He delivered a lecture on Stratigraphic Palaeontology to an undergraduate class at Carleton University and assisted the Ottawa Branch C.I.M.M. at their Sciences Exhibit at Careers Expo 66. In March he attended the Prospectors and Developers Mining Convention in Toronto where he also examined fossil specimens in the Royal Ontario Museum. Jointly with Dr. B.D. Erdtmann he began a study of Ordovician graptolites from Newfoundland. During the year, 7 manuscripts for outside publication were critically reviewed. In 1967 he was appointed to the Branch Equipment Committee for a 3-year period.

W.H. Fritz: wrote 31 reports on 283 lots of Cambrian fossils. Eight weeks were spent in the eastern Cordillera collecting material that can tentatively be organized toward four future papers. Lower Cambrian fossils were collected as background material for a paper now in preparation on the Lower Cambrian faunas of the Sekwi Formation, Northwest Territories. Late Middle Cambrian fossils were collected in conjunction with the project being conducted in cooperation with Professor H.B. Whittington, to collect and study material from the classical Middle Cambrian locality in the Burgess Shale of Field, B.C. Trilobites from these collections will be described and compared with material to be collected from the Stephen Formation next summer. Fossils were collected from the Albertella Zone. A representative collection of Albertella faunas is now nearly complete. Collections from the Glossopleura Zone, when added to previous collections, contain about half the representative faunas necessary for a formal description of trilobites from this zone. Classical Cambrian fossil localities were visited in Idaho, Utah, Nevada, Wisconsin, and Vermont. Types were studied and discussed at the U.S. National Museum, Washington, D.C. A manuscript on Lower and Middle Cambrian faunas from Nevada was passed by critical readers for the Palaeontology Association, London. One manuscript was critically read. One week was spent assisting in the shooting of a movie on the Geological Survey.

H.J. Hofmann: joined the Palaeontology Section at the end of July and initiated a program of systematic study of Precambrian fossils. He wrote two reports on submitted material, spent 2 weeks in August visiting and collecting Proterozoic stromatolite localities in the District of Mackenzie, and carried out a study of the occurrence of Huronian megafossils near Elliot Lake, Ontario. A preliminary paper on the latter was prepared and submitted for publication in Science. He attended the Geological Society of America Meeting at San Francisco, and participated in the Palaeontological Society field trip to the Inyo-White Mountains in California to study the Precambrian-Cambrian transition. This was followed by a visit to the Univ. of California, where he presented a talk on Precambrian fossils at a conference on the evidence of Precambrian life. He consulted with Dr. P.E. Cloud and visited several research laboratories in the Los Angeles area that are active in research on Precambrian problems.



Subsequently, 3 days were spent on a field trip to the Precambrian of the Death Valley area in the company of Drs. P. E. Cloud and L. A. Wright, and collections were made of stromatolites and microfossils. He also started preparation of a catalogue of Precambrian fossils and pseudo-fossils in Canada; presented an illustrated talk at McGill University on possible fossils from the Huronian; attended a conference on stromatolites at Johns Hopkins University; visited the Harvard Biological Laboratories and Dr. E. Barhoorn to study methods in Precambrian microbiology; read a paper to the Northeast Section of the Geological Society of America (Boston) on Precambrian fossils (?) from Elliot Lake; and reviewed two manuscripts.

J. A. Jeletzky: wrote 13 reports on 1,133 lots of Cretaceous and late Upper Jurassic marine invertebrates collected by GSC field officers and others. Three and a half months were spent in Western Canadian Cordillera and northern California studying Cretaceous and late Upper Jurassic stratigraphy and faunas, and helping mapping projects of Drs. J. E. Muller and H. W. Tipper. Preliminary results are summarized in brief reports on "Biochronology of the Lower Part of Nanaimo Group (Mid-Upper Cretaceous), Eastern Vancouver Island", and on "Stratigraphy and Palaeontology of Lower Cretaceous and Upper Jurassic rocks of Taseko Lakes and Pemberton Map-areas" appearing shortly in GSC Paper 67-1. Extensive consultations with Drs. R. W. Imlay and D. L. Jones during field work in northern California have cleared up a number of important problems of palaeontological zoning and correlation of Buchia-bearing beds of western North America. Results will be incorporated in a far advanced outside paper on "Jurassic-Cretaceous boundary beds of western Canadian Cordillera". In May he spent four days at the Survey's Calgary office and at the Calgary headquarters of various oil companies for consultation and liaison. In this connection, he gave a lecture on "Palaeontology, the Basis of Practical Geochronology of Phanerozoic Rocks", at the meeting of Alberta Society of Petroleum Geologists. In November, he attended the San Francisco meetings and field excursions of the Palaeontological Society and Geological Society of America and read a paper on: "Jurassic-Cretaceous transition beds, Pacific Slope of North America". After the meetings he spent a week studying fossil collections and consulting specialists at USGS Menlo Park office, Stanford University, California Academy of Sciences, and University of California, Berkeley. He also attended an informal seminar of the Alaskan Branch of USGS on tectonics of Alaska and acted as one of its panel speakers. He spent one week with L. L. Price advising him on faunas and biochronology of Cretaceous rocks exposed in the Potash shafts of Saskatchewan, and another with Dr. J. E. Muller performing similar services in connection with the Cretaceous of Western and Northeastern British Columbia. A joint report with Muller is in preparation. In the office he continued to work on the manuscript and illustrations of the Coleoidea volume of the Treatise on Invertebrate Palaeontology. In this connection he completed a monograph of

"Comparative Morphology, Phylogeny and Classification of Fossil Coleoidea". Two smaller papers dealing with new Coleoidea taxa are far advanced. He continued and nearly finished the pre-editing of the posthumous Cretaceous manuscript of F.H. McLearn, served as a critical reader of two Cretaceous Survey manuscripts, advised several representatives of oil industry, continued to check Russian translations of short summaries, titles, and authors names to be included in final reports of the Survey, and continued to serve as a member of the Stratigraphic Committee of U.S. National Research Council. GSC Bulletin 128 on Upper Volgian Ammonites and Buchias from Arctic Canada, was published during the year.

Jocelyn A. Legault: assisted M.J. Copeland throughout the year and also prepared and submitted for publication, a report on Silurian conodonts from Arisaig, Nova Scotia.

D.C. McGregor: wrote 22 reports on 161 lots of fossils from Palaeozoic, Mesozoic and Tertiary rocks of Eastern, Western and Arctic Canada. In the laboratory, he prepared 80 samples for microfossil analysis, prepared 180 slides and made 1340 photomicrographs of fossils. He continued his studies of the Lower Devonian spores of the eastern Gaspé Peninsula, Quebec, and Middle and Upper Devonian spores of the Arctic Islands. In June, he presented a paper entitled "Devonian spores from Eastern and Arctic Canada" at the Annual Meeting of the Canadian Botanical Association in Vancouver. He was re-elected Secretary of the Palaeobotanical Section of the Canadian Botanical Association. In August, he attended the Second International Conference on Palynology in Utrecht, the Netherlands, where he presented a paper entitled "Composition and range of some Devonian spore assemblages of Canada". This paper will be published in Volume 1, of the new journal "Review of Palaeobotany and Palynology", early in 1967. While in Utrecht, he took part in meetings of the International Committee on Microflora of the Palaeozoic, of which he is a member. He began preliminary preparations for two field excursions of which he will be joint leader in 1967, one for the International Symposium on the Devonian System in Calgary, and the other for the annual meeting of the Canadian Botanical Association in Ottawa. He continued compilation of a reference collection of slides and photographs of plant microfossils of pre-Quaternary age, and affected exchanges of material with palynologists in various parts of the world. He was critical reader for two GSC manuscripts, one manuscript for the Arctic Institute and one for the Palaeontological Society. He reviewed and wrote an abstract for one paper translated from Russian by the American Geological Institute. He was co-author with B. Owens of one GSC Paper published during the year, and was author of a review published in an outside journal. He is preparing illustrations and systematic descriptions of about 150 species of spores from the Lower Devonian



Battery Point Formation of Gaspé Peninsula, to be submitted in 1968 for publication as a GSC Bulletin. He completed a paper on Upper Devonian index spores, some previously unknown outside the U.S.S.R., which will be delivered orally at the Canadian Botanical Association and later published. A paper on Palynology and Palaeozoic biostratigraphy was presented to a Seminar on Biostratigraphy at the University of Ottawa. One manuscript was critically read for the Palaeontological Society and three for the International Devonian Symposium.

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 specialists outside the Geological Survey. He wrote 6 reports on 77 lots of fossils from Western and Arctic Canada. He continued his researches into Lower and Middle Devonian corals. 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 twice for planning meetings and discussions. He visited the British Museum (Natural History) and other research institutions in London, and took part in a Field Conference during July in Germany and Austria as a guest of the German Research Association, with members of the Committee on the Silurian-Devonian Boundary. He gave a talk in the Geology Department of McGill University. He wrote a review for the Journal of Palaeontology, acted as a reader for the Palaeontological Society and the American Geological Institute, and as a member of the advisory board of the Palaeontological Research Institute. He read 6 manuscripts for publication by the Geological Survey.

B.S. Norford: wrote 25 reports on 424 lots of fossils from Ordovician and Silurian rocks in Western and Arctic Canada. Five weeks were spent in the field, studying stratigraphic sections in northeast Ellesmere Island and the adjacent Greenland coast. GSC Paper 66-55 was completed and describes an Ordovician section in Ellesmere Island. Two papers were completed for publication in the Bulletin of Canadian Petroleum Geology. One consists of a joint revision with J.D. Aitken of the Lower Ordovician stratigraphy of southwest Alberta. The other, in collaboration with H. Gabrielse and G.C. Taylor, is a study of the Silurian Nonda Formation of northeast British Columbia. Two papers were presented at the Lower Palaeozoic Symposium held in Edmonton in May, one on the Nonda Formation, the other on the Ordovician and Silurian stratigraphy of the southern Rocky Mountains. Six Survey manuscripts and seven manuscripts for outside journals were critically read. He acted as External Examiner for a Ph.D. Examination at the University of Alberta. Three visits were made to the Calgary Office of the Survey during the year.

A.W. Norris: wrote 10 reports on 205 lots, jointly with D.J. McLaren, and 15 reports on 189 lots alone, all from Devonian rocks. With Dr. Helen R. Belyea, he visited Regina, Saskatchewan, Virden and Winnipeg, Manitoba, to log selected Devonian drill core as an aid to correlating the Devonian formations outcropping in Manitoba with the subsurface formations of Manitoba, Saskatchewan, Alberta, and southern District of Mackenzie, and with B.V. Sanford visited Calgary and Winnipeg to examine core and cuttings from wells drilled in the Hudson Bay Lowlands. He was a member of a party of five Canadians and five Russians who visited West Germany and the Austrian Alps to examine Silurian and Devonian sections. On the return trip he visited the British Museum (Natural History) to examine Devonian fossils collections. During the latter part of the summer, along with B.V. Sanford, W.L. Davison, and B.G. Craig he visited Churchill, Manitoba, and made an aerial reconnaissance by Otter of the Hudson Bay Lowlands, in Manitoba, Ontario, and Quebec, required for planning and mounting of Operation Winisk in 1967. Jointly with B.V. Sanford, he is responsible for leading this operation and is currently working full time preparing for it. He identified 200 lots of fossils out of a total of 500 collected by himself from the Manitoba Devonian outcrop belt during the early part of the year. In preparation for the International Devonian Symposium activities in September, 1967, he prepared a resume of a four-day field trip, an itinerary, a stratigraphical summary of Devonian rocks outcropping in Manitoba, a list of references, a map showing the geology and field trip route, and descriptive notes of the stops. During the year he critically read and assessed two M.Sc. theses, and critically read 10 other manuscripts on palaeontology and stratigraphy, two for Survey officers, the remainder for outside organizations. Completed manuscripts were submitted on the Devonian of northern Yukon and District of Mackenzie; they will result in papers published by the Geological Survey and in the Volume of the International Symposium on the Devonian System.

G.W. Sinclair: wrote 4 reports on 54 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. With Miss M. Steele, a detailed comprehensive report on the fossils of critical beds near Braeside, Ontario, was prepared, as well as ancillary studies of comparative material from Fourth Chute and Paquette Rapids. Work was also done on papers on the Wilderness Formations of Ontario and the Ordovician of Baffin Island. With Drs. Bolton and Copeland, fossils plates were prepared for a guide to the Geology of the Bancroft area, to be published by the Ontario Department of Mines. Memorial tributes to the late Dr. Alice Wilson were prepared for the Geological Society of America and the Royal Society of Canada.

H.M. Steele: Until May, provided assistance to E.T. Tozer, E.W. Bamber and B.S. Norford. Later, with G.W. Sinclair, she began and completed preparation of a GSC Bulletin on the Middle Ordovician fauna

from Braeside, Ontario; aided in the collection of numerous blocks of limestone from Fourth Chute, Ontario; etched these blocks and obtained from them more than 100 specimens of Eodinobolus. With B.S. Norford, a paper on the Trimerellid genus Eodinobolus from the Middle Ordovician Chaumont Formation at Fourth Chute, Ontario, was prepared. A week was spent in the field at Paquette Rapids in the Ottawa River; collected slabs of limestone to be etched for silicified Ordovician fossils.

E.T. Tozer: In November, he assumed responsibility, as Acting Head, for the administration of the Palaeontology Section. He prepared 15 reports on 83 lots of Triassic fossils from Arctic and Western Canada, submitted by officers of the Geological Survey and oil companies. Four weeks were spent in the field studying the biostratigraphy of Triassic formations in Tuchodi Lakes, Fort Nelson, and Trutch areas. In July and August, 6 weeks were spent in Europe, examining and photographing type and other specimens of Triassic Ammonoidea and Bivalvia. Geological Institutes and Museums were visited in Cambridge, Zurich, Vienna, Budapest, Milan, Basel, Stuttgart, Munich, Copenhagen, Bonn and Delft. Short field excursions, providing opportunities to collect material for comparative purposes, were made to classical Triassic localities in Salzkammergut (Austria) and northern Italy. In October and November, he visited the Riksmuseum in Stockholm and then spent 2 weeks in the U.S.S.R., again visiting museums and institutes. The following institutes were visited: in Leningrad; Geological Institute (VSEGEI), Central Geological Museum, Institute for Arctic Geology (NIIGA), Karpinsky Museum and University; in Moscow, the Palaeontological and Geological Institutes of the Academy. These visits provided opportunities to exchange data and specimens, in addition to seeing and photographing type specimens. A report on the Triassic faunal sequence in Canada, summarizing all known and new data, was completed and submitted for publication as a GSC Bulletin. A paper on the biostratigraphic classification of the Triassic of North America was also prepared, for publication outside, with Dr. N.J. Silberling of the U.S. Geological Survey. A manuscript on Anisian Ammonoidea from northeastern British Columbia, left by the late Dr. F.H. McLearn, was prepared for publication. This necessitated preparation of all illustrations. McLearn's manuscript will lead to two reports, a short preliminary paper, now published, and a GSC Bulletin. Both were submitted for publication. Preparation of a report on the Ladinian ammonoid faunas of British Columbia was started. He is a member of an international group undertaking compilation of a 1:10,000,000 Geological Map of the Arctic to be published by the Commission for the Geological Map of the World. During the year, he met the two other members of the group (Professor Berthelsen in Copenhagen; Dr. Egiazorov in Leningrad). Division of responsibility is essentially settled, and the group now awaits the base map, which will be prepared by the Commission. During the year he continued to serve as a member of the Library Committee.

T.T. Uyeno: Prepared 8 reports on 20 lots of conodont fossils submitted by officers of the Geological Survey of Canada and other organizations. He received his doctorate in August from the University of Iowa. A partial requirement of his degree was a study on the conodont biostratigraphy of the Upper Devonian Waterways Formation of Alberta; a full report is now being prepared for Survey publication, and a preliminary report has been submitted. He accompanied B.V. Sanford for four weeks to southwestern Ontario and nearby parts of Ohio and Michigan. He collected from major quarries and outcrops Lower and Middle Devonian rocks in an attempt to establish conodont zonation of these strata. A core from the Norfolk county, southern Ontario, traversing almost the entire Lower and Middle Devonian strata, is also being used as complement to surface material. In addition, a strategic core from the James Bay Lowlands is being investigated for Devonian conodonts in conjunction with the forthcoming Operation Winnisk. Very important comparative conodont materials from the German Devonian standard, and the Austrian Carnic Alps sections, were received from D.J. McLaren. Throughout the year he continued to supervise the filing and organization of reports prepared by members of the Section and assisted in other administrative matters, including answering general inquiries from the public.

#### 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

One preparator was assigned every afternoon to assist the Cambrian palaeontologist to prepare specimens for scientific study, also another preparator was assigned every second week to assist the Cretaceous palaeontologist. The substantial volume of material prepared by these workers is not included in the appended list of specimens prepared by mechanical methods.

An enclosed area in Room B-60 was transformed to a Grinding and Polishing Laboratory. This area now contains one 36" Diamond Saw and two 27" Vi-Bra Laps. With this new equipment specimens up to 34" in diameter can be sawn, and specimens with a diameter of up to 24" can be polished. One technician is assigned to this laboratory every second week.

Services performed in the general laboratory are outlined below:

1966 - 1967 Season

	Cellulose Acetate Peels	Polished Sections	Saw Cuts	Plaster Casts & Jackets	Rubber Moulds & Casts	Thin Sections	Prep. by Mechanical Methods	
Bamber, E.W.	24	8	545	88		1176	66	
Bell, W.A.				12	6			
Bolton, T.E.			24	39	17	12		
Copeland, M.J.			65	8	8	122		
Cumming, L.M.	4				4			
Frebold, H.			81	44	56			
Hofmann, H.	22				26			
Jeletzky, J.A.			257	82	13			
McLaren, D.J.	8		400	34	20	267		
Norford, B.S.			140	40	40	83		
Norris, A.W.			32	1	1	32		
Sartenaer, P.				242	120			
Sinclair, G.W.			45	27	17	30		
Steele, M.			105	70	35	70		
Thorsteinsson, R.						150		
Tozer, E.T.					51	20		4
School Collections					60	10		
Totals	32	8	1382	1010	420	2045	66	

Parcels Received ..... 408  
 Parcels Shipped ..... 164  
 Localities Catalogued ..... 7175 (Invert.)  
 Localities Catalogued ..... 380 (Plants)

Progress was made in the re-organization of basement storage. This involved re-numbering 867 three-tiered cabinets, and the curating of some 700 trays of Devonian material from Western Canada.

Approximately 300 trays of specimens were transferred from the main storage collection in B-60, 601 Booth St., to the storage depot on Laperriere Street, in order to allow adequate storage facilities for the current collections.

In the Ottawa Micropalaeontology Laboratory, a total of 431 samples were washed or disintegrated and subsequently examined and picked for microfossil content. A further 75 samples were prepared for study of the conodont fauna. J.E.A. Matte also spent considerable time preparing the new Acid Disintegration Laboratory for operation.



		Newfoundland	Nova Scotia	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Yukon	N.W.T.	Arctic	U.S.A.
14	Recent				4	4			5	1			
67	Pleistocene			6	5					6	13	137	
	Cretaceous												
5	Jurassic								5				
	Triassic												
	Permian												
2	Carboniferous		2										
42	Devonian							119	20		3		
54	Silurian			27	24								3
47	Ordovician	2		30	11	4							
	Cambrian												
31	TOTAL	2	2	63	44	8	0	119	30	7	16	137	3



In the Calgary Micropalaeontology Laboratory, a total of 1,248 samples were prepared. Microfossils were picked from 1,121 of these samples by a worker under contract.

Three technicians are presently working overtime preparing specimens for shipment to Calgary later this summer. To date about 100 hours of overtime has been used for this operation.

## ARCTIC ISLANDS SECTION

R.L. Christie, Acting Head

The Arctic Islands Section carries out reconnaissance and detailed studies in the Canadian Arctic Archipelago. The sedimentary basins north and west of the mainland and Baffin-Ellesmere areas of exposed Canadian Shield are given special attention because of the recognized petroleum potential. Studies aimed at determining the stratigraphic framework and tectonic history and style of the orogenic belts that extend through the archipelago into northern Greenland are also carried on. The islands offer unique opportunities to study the relationship between the continental and Greenland masses, and data on this problem and on the relationship between the islands and oceanic structures are obtained where practicable.

### Activities

R.L. Christie: worked principally on the logistic management and execution of Operation Grant Land, the second and final season based in 1966 at Lake Hazen, northern Ellesmere Island. A study and brief technical report on the placing of monuments in permafrost regions was completed for the Geodetic Survey program carried out in 1966 for establishing of a geodetic net to measure possible relative movement of north-west Greenland and Ellesmere Island. Geological notes on each proposed site were included. In the field, the special areas of interest included the Lake Hazen region (Mesozoic and Tertiary rocks) and Judge Daly Promontory (lower Palaeozoic and Tertiary rocks). Drafting and collating of abstract reports for the operation, which comprised 5 Canadian and 1 Danish (Greenland Geological Survey) field parties, was carried out after field work ended. Preparations were made for field work on eastern Devon Island and for continuation of work on southern Ellesmere Island. Additional duties included: general assistance to the Division as Acting Section Head and representative of the Arctic Islands Section in Ottawa (e.g. inquiries

from individuals; geological advice or notes to other departments); service as chairman of the Branch Equipment Committee; editing and critical reading of two manuscripts relating to field work of the Geological Survey; geological advice to the Northern Coordination and Research Centre (Department of Indian Affairs and Northern Development) on two translations, from Russian, of papers on northern problems.

H.P. Trettin: participated in Operation Grant Land, directed by R.L. Christie, and was responsible for the study of the pre-Mississippian eugeosynclinal rocks of northern Axel Heiberg and Ellesmere Islands. In 1966, the axis of the eugeosyncline in northeastern Ellesmere Island was delineated by a paleocurrent study on turbidites, the first investigation of this type in the Arctic Islands.

During the year, investigations were made and reports were completed or advanced towards completion on the following subjects: "Pre-Mississippian geology of northern Axel Heiberg and northwestern Ellesmere Islands" (GSC Bulletin), revised, enlarged, and re-submitted; "Lower Triassic tar sands of northwestern Melville Island (GSC Paper), revised with additional chemical, isotope, and statistical data, and re-submitted; "Studies of the Marble Canyon Formation", report prepared in 1966 and awaiting fossil data; "Eugeosynclinal rocks of northern Ellesmere Island", report for the GSC and a paper for the International Symposium on the Devonian System in preparation. Papers completed for outside publication include: "Triassic tar sands of Melville Island" (7th World Petroleum Congress); "Paleocurrent trend analysis of a delta in the Bjorne Formation (Lower Triassic) of Melville Island" (co-author with F.P. Agterberg and L.V. Hills). Short papers prepared for publication in 'GSC Reports of Activities' include: "Lower Triassic tar sands of northwestern Melville Island" (Paper 66-2); "Pre-Mississippian geology in selected areas of northern Ellesmere Island" (Paper 67-1 Part A).

J.W. Kerr: carried out research and writing directed toward publication of the results of Geological Survey field work, and in addition integrated his research with published data on fundamental geological problems such as continental drift and processes in the mantle. His immediate goal is the propounding of a new theory of continental drift using as documentation the Canadian Arctic Islands and the North Atlantic.

Dr. Kerr completed several papers for publication by the Geological Survey. Papers prepared for publication in outside journals include: "Counterclockwise rotation of North Greenland about the Wegener transform fault" (Bull. Can. Petrol. Geol.); "Continental drift in North Atlantic and Arctic Regions" (Bull. Can. Petrol. Geol.); "A foundered continental remnant" (Nature); "A new nomenclature for

Ordovician rock units of the eastern and southern Queen Elizabeth Islands" (Bull. Can. Petrol. Geol.). In addition, work was begun for a paper on "Devonian history of the Canadian Arctic Islands" for the International Symposium on the Devonian System, to be held in Calgary in September, 1967.

Dr. Kerr critically read two manuscripts by members of the Survey, and one by an outside author.

W.W. Nassichuk: was occupied with field work for three months, and during the remainder of the year was engaged in research and writing of reports. Progress on manuscripts and reports is summarized as follows: "Permian ammonoids of Arctic Canada" (GSC Bull., issued 1966), co-authored with W.M. Furnish and B.F. Glenister; "Permian biostratigraphy in the southern Sverdrup basin" (GSC Bull., draft ms. nearly complete); "Pennsylvanian ammonoids of Ellesmere Island" (GSC Bull., draft ms. nearly complete); "New occurrences of Permian ammonoids in the Canadian Northwest" (GSC Paper, in preparation). A short paper on "Studies of Permo-Carboniferous and Mesozoic strata on northern Ellesmere Island" was submitted for publication in 'Report of Activities' (GSC Paper 67-1 Part A). He also collaborated with R.L. Christie for a paper on the late Palaeozoic and Mesozoic stratigraphy of the Tanquary Fiord-Yelverton Pass region of Ellesmere Island.

Papers completed for outside publication included: "A morphologic character new to ammonoids demonstrated by Clistoceras Gen. Nov. from the Pennsylvanian of the Canadian Arctic" (J. Palaeontol. in press); "Agmoblastus in the Pennsylvanian of the Canadian Arctic" (addendum in Treatise of Palaeontology, Geol. Soc. Amer., Treatise ser.). A manuscript titled "The first occurrence of Helicoprion, a coiled symphysial tooth structure" (note for J. Palaeontol.) is in preparation. Abstracts were prepared for publication in 'Abstracts of publication in scientific journals by officers of the GSC, 1965' (Paper 66-4): "Christioceras, a new Pennsylvanian ammonoid from the Canadian Arctic" (with W.M. Furnish); and "Correlation notes on the Upper Wapanucka Limestone of southeastern Oklahoma" (with H.L. Strimple).

In addition to the manuscripts and papers noted, Dr. Nassichuk studied and reported on some 500 Permian and Carboniferous ammonoids in 6 lots for a member of the Geological Survey, for oil companies, and for scientists at universities. Two other similar reports are presently under preparation for oil companies. A manuscript relating to Geological Survey field work was critically read and advised on in the course of the year.

R. Thorsteinsson: continued his research on Devonian fossil fishes at the Naturhistoriska Riks Museet, in Stockholm, Sweden.

### Other Activities

H.P. Trettin was Chairman of the Research Committee of the Alberta Society of Petroleum Geologists. He prepared a paper for the World Petroleum Congress in Mexico and served on the A.S.P.G. committee judging theses submitted to it in 1966.

R.L. Christie completed a fourth year as Secretary of The Arctic Circle, Ottawa. He delivered a lecture to the Institute of Northern Studies, University of Saskatchewan.

J.W. Kerr presented two papers orally: "Lower Palaeozoic history, Ellesmere Island" for the Lower Palaeozoic Symposium; "Pre-Mississippian sedimentary patterns" for the Alberta Society of Petroleum Geologists.

W.W. Nassichuk attended the Alberta Society of Petroleum Geologists Continuing Education Series, lectures by L.L. Sloss, and the Structural Geology Symposium held at Calgary in Spring, 1966.

J.W. Kerr attended the Lower Palaeozoic Symposium at Edmonton, and the Geological Society of America meetings at San Francisco.

H.P. Trettin attended an A.S.P.G.-organized lecture series on sedimentation; Dr. Van Andel, lecturer.

J.W. Kerr served on the following committees: Research Committee of the Alberta Society of Petroleum Geologists; Subcommittee of the National Research Council on Research in Stratigraphy, Palaeontology, and Sedimentation; Library Committee of the Geological Survey of Canada, Calgary. Dr. Kerr was Chairman of the McConnell Club of the Geological Survey, Calgary. The Medal of Merit of the Alberta Society of Petroleum Geologists (for the best paper on geology in Canada published in 1965) was awarded to J.W. Kerr and R.L. Christie for their paper, "Tectonic history of Boothia Uplift and Cornwallis fold belt" (Amer. Assoc. Petrol. Geol.).

## 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 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 boreholes 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.

### Palaeoecological and Environmental Studies of Coal

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

From the Minto coalfield in New Brunswick, P.A. Hacquebard has examined two additional column samples of the Minto Main seam. He has also compiled a lithofacies map of the clastic sediments overlying this seam from new field data collected in 1966. Preliminary spore counts on eleven petrographic intervals of this seam have been made by M.S. Barss.

In preparation for a contribution to the 1967 Symposium on the Science and Technology of Coal, entitled "Petrography of Canadian Coals in Relation to Environment of Deposition", the following work was carried out.

From the Sydney, St. Rose-Chimney Corner, Pictou and Springhill coalfields of Nova Scotia and the Nanaimo and Telkwa fields of British Columbia, detailed cross-sections of the major coal seams have been drawn by P.A. Hacquebard. This work required the accumulation of a great number of data on coal seam sections at many locations in each field. From these cross-sections information regarding the type of coal basin and the nature of sedimentation is obtained. This information will be correlated with the petrography of the coals, and for this one major

seam from each field has been selected for a complete microscopic analysis. This includes the preparation (microscopically) of a coal log from a series of polished sections covering the entire thickness of the seam, and a maceral analysis of the petrographic subdivisions of each seam by means of grain mounts. All but one of the six coal logs used in this study had been previously prepared. However, no maceral analyses were available.

Accordingly, T.F. Birmingham has compiled the coal log of the seam from No. 4 Mine at Telkwa, for which he prepared and examined microscopically 40 polished sections. He has also prepared 26 grain mounts and determined the maceral content of each.

J.R. Donaldson has assisted with the drafting and arranging of the six diagrams resulting from this project, to publication standards.

### Coal Mine Geology and Evaluation of Coal Reserves

The contour plan of the No. 3 seam in the Syndicate Mine at Springhill, N.S., compiled in 1965, has been updated by incorporating data obtained from new workings. J.R. Donaldson has redrawn the plan in consultation with P.A. Hacquebard, who collected the new data during underground visits made in the summer of 1966. After overcoming the difficulties caused by faulting, the Syndicate Mine is now a regular producer, employing as many as 120 men.

P.A. Hacquebard wrote a report on the remaining mining reserves of the Pictou coalfield, N.S. This work was carried out by request of the Nova Scotia Department of Mines in view of the approaching depletion of mineable coal in this field. A significant factor in evaluating the reserves is the question of the relationship between the coals of the Westville and Stellarton districts. From detailed spore studies carried out by M.S. Barss it was concluded that these coals cannot be correlated, but that those of Westville are older than the coals of Stellarton.

As a result of this report two bore-holes were drilled near Stellarton with the objective of finding a block of coal in the Foord seam in which no previous mining had taken place. The coal cores, which were 44 and 47 feet thick, have been examined by P.A. Hacquebard and J.R. Donaldson in the laboratory at Ottawa. This examination was done microscopically with polished sections and megascopically by careful inspection of the coal core itself. This procedure was necessary in order to determine the variations in the quality of the coal within this great seam thickness. By this method each coal core was divided into eight intervals, and eighteen subdivisions. Ash analyses of these divisions were carried out in Halifax and revealed the presence of a



9-foot thick horizon of good quality coal at the same level in both cores. A third bore-hole has been planned to delineate the extent of this virgin block of mineable coal in the Foord seam which was hitherto not known.

### Research on Coking Coals - Crowsnest Coalfield

A.R. Cameron completed the petrographic work on the 50-foot thick Balmer seam from the Crowsnest coalfield of British Columbia. For this it was necessary to determine the microlithotype content of the petrographic intervals of one whole column sample and part of another. This required the preparation and microscopic examination of 34 grain mounts. In addition, 370 sections of the polished master column of the Balmer seam were reexamined megascopically. This was done to obtain information on the number and thickness of the vitrain and durain layers. A sieve analysis on small (200 g) samples representing twenty intervals of this column was also carried out, and the results were correlated with the petrographic data. A report was given on this study in a paper presented at the San Francisco meeting of the G.S.A. in November 1966. A complete description of the petrography of the Balmer coal along with relevant data on swelling, fluidity and chemical composition will be given in a future Survey publication. Some information was presented informally at the meeting of the North American coal petrographers held in Ottawa, March 28, 1967.

### Uranium Possibilities in Lignite

In June 1966, A.R. Cameron spent two weeks visiting lignite occurrences in North and South Dakota and in Saskatchewan. In the Dakotas visits were made to areas where commercial quantities of uranium ore are extracted from lignite. In Saskatchewan lignite exposures were checked for radioactivity in the Eastend-Shaunavon and Twelvemile Lake-St. Victor areas. Readings were taken with a scintillation counter and 16 samples were collected. These were checked with the end-window tube device in Ottawa, which indicated an approximate range of  $U_3O_8$  of 0.001 to 0.015 per cent. Attempts to obtain more accurate analyses from X-ray fluorescence were unsuccessful. For a chemical determination of the uranium content, the samples have been submitted to the Analytical Chemistry Section. Results on this are not yet available.

Review Paper for Symposium on Science and  
Technology of Coal, Ottawa, 1967

The Coal Division of the CIMM is sponsoring a series of "Centennial" review papers, one of which will deal with "The Development of Coal Petrology in North America". This review is being prepared by A.R. Cameron in cooperation with W.F. Berry of Bituminous Coal Research, Monroeville, Pa. and B.N. Nandi of the Fuels Division of the Mines Branch. During the latter part of 1966, Cameron was engaged in accumulating and reviewing a great number of articles on coal petrology for this project. A summary of the paper was presented at the CIMM Coal Division meeting on March 29, 1967.

Exhibit on Coal Science

J.R. Donaldson has prepared the design and layout of the exhibit on coal, which has been constructed by the Canadian Government Exhibition Commission for permanent display at the new Miners' Museum in Glace Bay, N.S. The exhibit consists of four panels, which portray: 1. The location, production and reserves of the coalfields of Eastern Canada; 2. The geological aspect of coal seams; 3. The four banded ingredients of bituminous coal; 4. Coal investigations by the G.S.C.

The exhibit has been placed at the Geological Survey, where it will remain for about six months, thus fulfilling the Section's commitment for a Coal Display in Logan Hall (O.P. 260).

Chronology of Coal in the Geological Survey of Canada

T.F. Birmingham compiled a detailed report on coal chronology for the purpose of assisting Dr. M. Zaslow, University of Western Ontario, in his preparation of an official history of the Geological Survey. For this report nearly all existing references pertaining to coal in Survey publications and by G.S.C. authors have been collected and arranged in a bibliography. The latter has well over 200 references, which are listed geographically by provinces, by Canada in general and in an addenda containing recent and associated publications. An historical chart on coal chronology, listing all authors, number of coal references and year of publication is included, as well as four descriptive chapters. These describe the geological aspects of coal research, its history and development within the Geological Survey, and its specialization as presently carried out in the fields of coal petrology and palynology by the Coal Research Section.

## Coal in Appalachian Region

(Chapter for Economic Geology, Series 1, Fifth Edition)

P.A. Hacquebard has composed this chapter, which deals with the ten coalfields of Eastern Canada. For each field a brief summary is given on the stratigraphy, on the number and thickness of the contained coal seams, on the geological structure and on the total production since mining first started. A chart showing this production and the remaining reserves, in graphical form, is included. Also discussed are the greatly different depositional characteristics of the Sydney and the Pictou coalfields. These differences are portrayed in two diagrams that show cross-sections through successive seams and palyno-petrographic seam profiles that are typical for each environment.

### Carboniferous Palynology

During 1966, M.S. Barss compiled 5 reports on 26 samples submitted for age determinations by G.S.C. field geologists. For the spore studies he made 95 macerations prepared 100 slides, 150 single mounts and took 300 photomicrographs. The reports mentioned, with reference to region, number of samples, geologists concerned and age determined, are as follows:

1. Nova Scotia, 12 samples, D. Benson of G.S.C.  
Age: lowermost Pennsylvanian.
2. Northwest Territories, Ellesmere Island, 1 sample,  
' H.P. Trettin of G.S.C.  
Age: Pennsylvanian.
3. Nova Scotia, 1 sample, D.G. Kelley of G.S.C.  
Age: Pennsylvanian.
4. Nova Scotia and New Brunswick, 5 samples, D.G. Kelley of G.S.C.  
Age: Pennsylvanian.
5. Nova Scotia, 7 samples, D. Benson of G.S.C.  
Age: Mississippian - Pennsylvanian.

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, as well as some sections in Northern and Western Canada: 56 of the 75 macerations mentioned were devoted to this project.

For the 1966 G.A.C.-M.A.C. meeting in Halifax, M.S. Barss and P.A. Hacquebard prepared a paper on "Age and Stratigraphy of the Pictou Group in the Maritime Provinces as Revealed by Fossil Spores". This paper is the result of an examination of 300 samples under the long range project of a study of Carboniferous sections, mentioned previously. Twenty stratigraphic sections with miospore zones show the relationships between various rock units assigned to the Pictou Group. This is illustrated with a three dimensional diagram, in which the sections are plotted in columnar fashion on a map of the Maritime Provinces at their respective localities. In each column not only the spore zones, but also the general lithology and thickness of individual units has been indicated. Publication of this paper, of which the manuscript has not yet been fully completed, is expected in 1967.

For a contribution to the G.S.C. series on Illustrations of Canadian Fossils, M.S. Barss has completed the manuscript on "Carboniferous and Permian Spores". For this it was necessary to prepare an additional 16 plates, bringing the total to 38 plates with 918 photomicrographs. They illustrate the characteristic miospores of twelve formations (or groups) belonging to the Carboniferous and Permian of Eastern, Western and Northern Canada. Publication of this volume is expected in mid-1967.

For the International Committee on the Microflora of the Palaeozoic (I.C.M.P.) specimens and photomicrographs have been supplied to the working groups on the genera Lycospora and Verrucosisporites.

### Field Activities

In June 1966, P.A. Hacquebard spent three weeks in the Maritimes, where he visited the Minto, Springhill, Pictou and St. Rose coalfields.

At Minto he measured 33 sections of strata overlying the coal seam and collected two additional column samples of this seam.

At Springhill, underground visits were made in the Syndicate Mine in order to obtain data in the newly advanced workings.

At Stellarton, a visit was made to the office of the Nova Scotia Department of Mines. The drilling for the Foord seam of the Pictou coalfield was discussed and drill sites selected.

At St. Rose an underground visit in Evan's Coal Mine was made in order to obtain a column sample of the No. 5 seam.

In June 1966, A.R. Cameron made a two week trip to the lignite deposits in North and South Dakota and in Saskatchewan. The objective was to learn more about the uranium occurrences in lignite. He collected 16 samples from two lignite areas in Saskatchewan and examined these for radioactivity.

#### Laboratory Visits and Attendance at Meetings

1. From May 1-6, 1966, J.R. Donaldson visited the coal petrology sections at the Homer Research Laboratories of the Bethlehem Steel Co. in Bethlehem, Pa. and at the Bituminous Coal Research Laboratories in Monroeville, Pa.
2. The Annual Meetings of the Geological and Mineralogical Associations of Canada, held in Halifax, N.S., from September 12-13, was attended by M.S. Barss.
3. A.R. Cameron attended the 79th Annual Meeting of the G.S.A. held in San Francisco, from November 14-16, 1966. He also participated in the pre-convention fieldtrip through the coalfields of Utah.
4. P.A. Hacquebard was present at the Chicago meeting of the American Coal Petrographers, which took place on December 15, 1966.

#### Other Activities

J.R. Donaldson has rearranged the coal files by placing more than 3000 reference samples in small plastic containers. This was necessary in order to prevent deterioration of these samples by atmospheric oxidation. Approximately another 1000 samples will have to be similarly filed to complete this task.

As a result of Donaldson's visit to two U.S. Coal Petrology Laboratories, it was decided to relocate the coal reflectance equipment into a separate room where humidity and temperature control would be possible. Arrangements for this have been made and the change-over will be completed in 1967. For greater accuracy and reliability of results a new constant current regulator and recorder have been obtained for the reflectance set-up.

T.F. Birmingham spent time training a summer assistant in the procedures of preparing coal for microscopic examination. These activities are related to the unfortunate circumstance that the Section has no permanent technician, which in nearly all instances retards scientific progress, because the preparation work is carried out by the scientific staff.

A.R. Cameron devoted some time in rewriting parts of the manuscript of his report on "Some Petrological Aspects of the Harbour Coal Seam, Sydney Coalfield, N.S.". Some new photomicrographs and diagrams were also added. This report will be published as a G.S.C. bulletin.

During the year, M.S. Barss assisted visiting palynologists by providing type sections and related materials on Carboniferous miospores of the Maritime Provinces. The visitors were:

- a) Dr. L. Hills of Shell Oil Co. of Canada Ltd., who visited the Section from April 3-16, 1966.
- b) Dr. O. Varma, post-doctorate fellow at U.N.B., whose visit took place from September 26-30, 1966.

#### Membership on Committees

- |                        |   |
|------------------------|---|
| <u>P.A. Hacquebard</u> | <ul style="list-style-type: none"><li>- Member, Nomenclature Subcommittee, International Committee on Coal Petrology.</li><li>- Member, International Committee on the Microflora of the Palaeozoic.</li><li>- Member, Canadian Advisory Committee on Coal Research.</li><li>- Member of Ottawa Organization Committee for Centennial Meetings on Science and Technology of Coal (Ottawa, March 29-30, 1967).</li><li>- Ditto for 1967 Ottawa Meetings of North American Coal Petrographers (March 28, 1967).</li></ul> |
| <u>A.R. Cameron</u>    | <ul style="list-style-type: none"><li>- Member, Canadian Advisory Committee on Coal Research.</li><li>- Member of Executive, Geologists Group, Professional Institute of the Public Service of Canada.</li><li>- Member of Ottawa Organization Committee for Centennial Meetings on Science and Technology of Coal.</li><li>- Ditto for 1967 Ottawa Meeting of North American Coal Petrographers.</li></ul>   |
| <u>M.S. Barss</u>      | <ul style="list-style-type: none"><li>- Member, International Committee on the Microflora of the Palaeozoic.</li></ul>  |



Publications and Reports (1966)

Barss, M.S., and Hacquebard, P.A.

- 1966: Age and stratigraphy of the Pictou Group in the Maritime Provinces as revealed by fossil spores - Abstract in Technical Program of Halifax Meetings of G.A.C. and M.A.C., p. 2.

Birmingham, T.F.

- 1966: Chronology of Coal in the Geological Survey of Canada - Internal Rpt., 42 pp., 1 chart.

Cameron, A.R.

- 1966: Petrography of a 50-foot thick seam, the Crowsnest coalfield, B.C., Canada - Abstract in Program of San Francisco Meetings of G.S.A., p. 34.

Cameron, A.R., and Botham, J.C.

- 1966: Petrography and carbonization characteristics of some Western Canadian coals. Printed in Coal Science, Advances in Chemistry Series 55, American Chemical Society Publication, Washington, D.C., pp. 564-576.

Hacquebard, P.A.

- 1966: Coal in Appalachian Region; chapter prepared for Ec. Geol. I, fifth edition, 1967 - manuscript copy 11 pp., 4 Figs.

Hacquebard, P.A., and Barss, M.S.

- 1966: Views on remaining mining reserves of the Pictou coalfield, N.S. - Internal Rpt., 7 pp., 4 Figs.

WESTERN PLAINS OFFICE, CALGARY

B.A. Latour, Office Manager

At the end of 1966 the total staff at Calgary numbered 40 of which 32 are members of the Fuels and Stratigraphy Division. Staff changes during the year included nine new members, one retirement, and five resignations. New members were Mrs. A. Cooper, Mrs. V. Dennis, Miss W.L. Elviss, Mrs. M. Jones, Miss J.C. Savage, Mrs. J.J. Shelton, Mrs. C.J. Havard, D.W. Gibson, and A.G. Heinrich. Resignations were received from Mrs. A. Cooper, Mrs. M.L. Hellard, Mrs. M.A. Seburn, E.J. Tassonyi, and D.L. Herron.

Of special note was the retirement of Dr. R.T.D. Wickenden after thirty-six years' service with the Geological Survey of Canada. Dr. Wickenden served as Officer-in-Charge of the Western Plains Office from its inception in 1950 until his retirement in July, 1966.

Distribution of the staff, by category, is as follows: twenty-one scientists from Fuels and Stratigraphy Division; three scientists from Economic Geology Division; six clerical; five technicians; three draftsmen; one librarian; and two vacancies (one Fuels and Stratigraphy scientist and one draftsmen).

Visitors of the office who signed the registry during the year numbered 3,953. Of these, 1,723 came to examine well logs and samples, 1,616 to purchase publications, and 614 to consult with members of the staff or to use the library facilities.

A total of \$7,620.80 was received from the sale of 12,121 items of Survey publications.

The total number of drilling samples received was 369,361. Each of the provinces showed an increase and the samples received from each were: Manitoba, 4,500; Saskatchewan, 71,243; Alberta, 202,018; British Columbia, 77,790; and Northwest Territories, 13,810.

During the year a start was made to transfer old Saskatchewan samples from inconvenient, space-taking envelopes to the more efficient glass vials. Some 220,000 samples have been transferred, leaving some 160,000 to be done.

Northwest Territories core was received in the amount of 719 boxes and an additional 338 boxes were received from off-shore drilling on the east coast.

The well files were expanded by 7,593 electric and other mechanical logs received during the year.

A great need was overcome in March when this office secured the services of a librarian, Mrs. M. Jones. As a result the usefulness of our library to the staff has been increased and there is now a feeling of confidence that the anticipated growth of this library will be guided by capable hands.

The staff of this office is looking forward with great anticipation to the move to our new building sometime in the latter part of January.

#### Devonian Stratigraphy Unit: Helen R. Belyea, Leader

##### Activities

Helen R. Belyea: continued work on various projects as follows: (1) preparation of a map, now near completion, showing distribution of Devonian reefs and banks in Alberta; (2) prepared cross-sections, maps,

analysis of facies, and part of the text of a report dealing with the Middle Devonian geology over and in the vicinity of Tathlina uplift, southern District of Mackenzie; (3) examined core and samples from new wells drilled and verified earlier cross-sections for a joint project with W.S. MacKenzie on Devonian correlations from lower Mackenzie area to northern Alberta; (4) examined cores for a joint project with A.W. Norris on correlation of late Middle Devonian from Great Slave Lake to Manitoba; and (5) examined well cuttings and core for determination of formation tops for Schedule of Wells, N.W.T., 1967 edition. Dr. Belyea spent two days in the Cadomin area examining the Frasnian-Famennian boundary and Frasnian reef-shale relationships and another three days examining Devonian outcrops in northern Washington. Also, as part of an educational program sponsored by the United Nations for Mr. E. Aizenberg, a geologist from Israel, Dr. Belyea spent two days giving him a generalized "course" on the Devonian of Western Canada which included examining cores and outcrop sections. A talk, "Distribution of Devonian reefs and banks, Arctic, northern and western Canada", was given to the Reef Symposium of the Alberta Society of Petroleum Geologists as part of the A.S.P.G. Continuing Education Program. She also gave another talk to the A.S.P.G. in the form of a report on the Field Conference in Germany and Austria, July, 1966. In conjunction with W.S. MacKenzie, a short but critical note on "Organic growth in carbonate tongues", complete with photographs was submitted for publication in GSC Paper 67-1, Report of Activities.

W.S. MacKenzie: continued his study of the Southesk Cairn carbonate complex. Dr. MacKenzie also made petrographic studies of the Devonian Ancient Wall reef complex in Jasper National Park, which led to the first North American discovery of a species of foraminifera. He reviewed the Devonian stratigraphy along Highway 16 and along the Banff-Jasper highway in preparation for the 1967 International Devonian Symposium field trips. He examined some outcrops of Devonian rocks in Washington, supervised the logging of limestone and dolomite cores in the Pine Point area, N.W.T., and picked formation tops for publication in the Schedule of Wells, N.W.T., 1967 edition.

Dr. MacKenzie submitted for publication "The Southesk Cairn carbonate complex" as a GSC Bulletin; an abstract entitled "Organic growth in carbonate tongues" in GSC Paper 67-1 (co-author is H.R. Belyea); and "Devonian stratigraphy in northeastern British Columbia" (co-author is G.C. Taylor) as a GSC Paper. He delivered a talk, "Reef margin facies, vicinity of Mountain Park, Alberta", at the Alberta Society of Petroleum Geologists Reef Symposium, Calgary, December 8th. He also submitted a paper entitled "Upper Devonian Carbonate Mounds and Lenses, vicinity of Mount MacKenzie and Cardinal Mountain, Alberta", for publication in the 1967 International Devonian Symposium Volumes.

D.C. Pugh: served as an assistant to H.R. Belyea and W.S. MacKenzie. Dr. Pugh obtained data on distribution of Upper Devonian reef fields for compilation of a reef map for H.R. Belyea. Under direction of

W.S. MacKenzie, he logged dolomite cores and recorded occurrences of limestones from Middle Devonian Presqu'île dolomite diamond drill cores in lead-zinc prospects, south of Great Slave Lake.

#### Outside Publications

W.S. MacKenzie: "Upper Devonian stratigraphy in the vicinity of Mountain Park, Alberta"; Edmonton Geological Society Guidebook, Eighth Annual Field Trip, Cadomin, Alberta.

#### Attendance at Conferences, Meetings, Field Trips, etc.

H.R. Belyea: Royal Society of Canada, Sherbrooke, Quebec, June, 1966.  
International Field Conference on the Silurian-Devonian boundary and stratigraphy of the Devonian System in Germany and Austria, July 4-21, 1966.

American Association of Petroleum Geologists Continuing Education Program, "Facies types and facies distribution of continental margins", Calgary, October 3-5, 1966.

W.S. MacKenzie: American Association of Petroleum Geologists Continuing Education Program, "Stratigraphic geology - principles and practice", Calgary, March 14-16, 1966.

Symposium on Evaporites and Related Rocks, University of Alberta Earth Sciences Conference, Banff, May 8-13, 1966.

Alberta Society of Petroleum Geologists, Symposium on Structural Geology within the Canadian Rockies, Calgary, June 7, 1966.

#### Membership on Committees

H.R. Belyea: Co-Chairman, International Symposium on the Devonian System, to be held in Calgary, September 6-8, 1967.

Member, Miller Medal Committee, Royal Society of Canada.

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

#### Activities

J.D. Aitken: completed his field studies of the Pre-Devonian stratigraphy of the southern Rocky Mountains. As well, five weeks' field work was spent

on a joint project (W. H. Fritz and H. B. Whittington) initiated this year to study the stratigraphy, paleoecology, and palaeontology of the Burgess Shale in the vicinity of Burgess Pass. Preparation of a report on Middle Cambrian stratigraphy is in progress. Considerable office time was spent in sedimentary petrology and petrography and facies studies, especially of carbonate rocks.

Dr. Aitken presented the paper "Middle Cambrian to Middle Ordovician Cyclic sedimentation, southern Rocky Mountains of Alberta" to the Edmonton Geological Society, Lower Palaeozoic Symposium, May 26-27. A half-day course on "Principles of Geology as illustrated in the Western National Parks" was prepared and given at the annual Park Warden's School in Jasper, May 17.

He completed a manuscript titled "Classification and Environmental Significance of Cryptalgal Limestones and Dolomites". It has been submitted for publication in an outside journal.

Dr. Aitken gave a talk 'Back to the Bush, or What, More Field Geology?' to the Desk and Derrick Club, Calgary, in February 1967.

R. W. Macqueen: continued his studies of Carboniferous stratigraphy and sedimentology in the Banff-Jasper area in which he was accorded logistical support from Operation Bow-Athabasca during the month of August.

A manuscript "New data on Banff - Rundle relationships (Mississippian), southern Rocky Mountains and Foothills, Alberta" with E. W. Bamber as co-author was submitted for publication.

The following talks were given: (1) "Recent carbonate sedimentation, Qatar area, Persian Gulf" to the McConnell Club in January; (2) "Ancient examples (Mississippian) of recent dolomites" at Evaporites and Related Rocks Symposium, University of Alberta Earth Sciences Conference, Banff, Alberta, May 8-13; and (3) "Penecontemporaneous dolomitization in the Qatar area, Persian Gulf" on October 13 and "Some aspects of recent carbonate sedimentation in the Persian Gulf" on October 14 to the Faculty and Students of the Department of Geological Sciences, McGill University, Montreal. In addition, a talk "Banff-Rundle stratigraphy - a new look at an old problem" was prepared jointly with E. W. Bamber to be presented to the Alberta Society of Petroleum Geologists, January 4, 1967. He is preparing a manuscript tentatively titled "Persian Gulf type sediments of the Canadian Carboniferous". He gave a talk on "Modern processes of sedimentation and diagenesis in the Persian Gulf, with some ancient examples" to the Faculty and Graduate Students of the Geology Department, University of Calgary. Dr. Macqueen critically read a paper by E. W. Bamber, G. C. Taylor, and R. M. Procter titled "Late Palaeozoic Stratigraphy of northeastern British Columbia" to be published by the Geological Survey.

H.L. Martin: commenced a study of the Mississippian formations in the Edson area, Alberta. He also started a study on the application of a computer program to present a trend surface analysis of the Mississippian System in west-central Alberta and he expects to submit a manuscript by mid-1967. A study of the Mississippian subsurface strata in the Wabamun Lake area, Alberta was started in November. Three days were spent examining Mississippian exposures in the Cadomin area, Alberta.

R.M. Procter: continued his study of the petrology and biostratigraphy of the subsurface Mississippian, Pennsylvanian and Permian formations of northeastern British Columbia with emphasis on the Late Carboniferous. Additional palaeontological support was provided by E.W. Bamber and B.L. Mamet. Two weeks in August were spent at Fort St. John examining core as well as sections along the Alaska Highway. He also continued the study of the subsurface Triassic stratigraphy of northeastern British Columbia. It has been decided to publish the results of this study in five parts, the first of which concerns the distribution, subdivision and structural configuration of the Baldonnel Formation and which was submitted and published on a reduced scale in GSC Paper 66-2. He assisted, as well, in picking formation tops for late Palaeozoic units for the Schedule of Wells, N.W.T., 1967 edition. The first three months of 1967 were devoted almost entirely to finishing the manuscript "Late Palaeozoic stratigraphy - northeastern British Columbia" authored by E.W. Bamber, R.M. Procter and G.C. Taylor. Dr. Procter attended two meetings of the Stratigraphic Nomenclature Committee of the Alberta Society of Petroleum Geologists. Approximately 3 days were spent in connection with equipment for the clay mineralogy laboratory for the new building.

#### Outside Publications

J.D. Aitken: "Middle Cambrian to Middle Ordovician cyclic sedimentation, southern Rocky Mountains, Alberta"; Bull. Can. Petrol. Geol., vol. 14, No. 4.

R.W. Macqueen: "Mississippian stratigraphy and sedimentology at Cadomin, Alberta"; Edmonton Geological Society Guidebook, Eighth Annual Field Trip, pp. 39-59.

#### Attendance at Conferences, Meetings, Field Trips, etc.

J.D. Aitken: Edmonton Geological Society, Lower Palaeozoic Symposium, May 26-27.

Served as guide for Prof. Marshall Kay, Dr. R.J.W. Douglas, and Michael Churkin (U.S.G.S.) on a two-day field trip Edmonton-Calgary, via Jasper and Banff.



American Association of Petroleum Geologists Continuing Education Program, "Facies types and facies distribution of continental margins", Calgary, October 3-5.

R.W. Macqueen: Symposium on Evaporates and Related Rocks, Univ. of Alberta Earth Sciences Conference, Banff, Alberta, May 8-13.

Edmonton Geological Society, Lower Palaeozoic Symposium, May 26-27 (at own expense).

Alberta Society Petroleum Geologists, Symposium on Structural Geology within the Canadian Rockies, Calgary, June 7.

Alberta Society of Petroleum Geologists, Symposium on Exploration for Natural Gas in Canada, Calgary, September 12-14.

Alberta Society Petroleum Geologists, Reef Symposium, Calgary, December 8.

H.L. Martin: Attended a course of 12 two-hour sessions entitled "Economics in Petroleum Exploration", sponsored by Alberta Society of Petroleum Geologists and offered by University of Calgary, Extension Department.

Combined meetings of American Association of Petroleum Geologists and Society of Economic Palaeontologists and Mineralogists, St. Louis, April 25-28, 1966.

American Association of Petroleum Geologists Continuing Education Program "Stratigraphic Geology - Principles and Practice", Calgary, March 14-16. Alberta Society of Petroleum Geologists, "Symposium on Structural Geology within the Canadian Rockies", Calgary, June 7.

Alberta Society Petroleum Geologists, Symposium on Exploration for Natural Gas in Canada, Calgary, September 12-14.

R.M. Procter: Combined meetings of American Association of Petroleum Geologists and Society of Economic Palaeontologists and Mineralogists, St. Louis, April 25-28.

Alberta Society of Petroleum Geologists, Symposium on Exploration for Natural Gas in Canada, Calgary, September 12-14.

Took part in a tour of uranium properties in Wyoming, Colorado, and Utah as guest of the United States Atomic Energy Commission, June 16-25.

### Membership on Committees

R. W. Macqueen: Member, Exhibits Committee, GSC, Calgary Office.

R. M. Procter: Member, GSC Calgary Office, Library Committee.  
Member, GSC Uranium Studies Program Committee.  
Member, Medal of Merit Committee, Alberta Society of  
Petroleum Geologists.

Mesozoic Stratigraphy Unit: D.F. Stott, Leader

### Activities

C.F. Burk, Jr.: developed, in cooperation with the Computer Sciences Division, a series of four computer programs to process basic stratigraphic data. Approximately 17,000 items from 740 control points were used to test the programs. The output is programmed to produce two printed tables, one of subsea elevations data and another of isopach values. A computer program to determine the "centre of gravity" and standard deviation of a selected rock was written.

Material presumed to be bentonite was collected from the St. Léon Formation of eastern Gaspé Peninsula, Quebec, and submitted to the Isotope Geology Section for possible radiometric age dating. As editor, Bulletin of Canadian Petroleum Geology, Dr. Burk edited and processed seven major papers totalling about 110 pages for publication in the Bulletin. He is a member, Advisory Committee of Geoscience Information Society and a member, Advisory Committee to the Editor of "Proceedings of International Symposium on the Devonian System". Dr. Burk attended meetings of the Committee on Storage and Retrieval of Geological Data in Canada; the Subcommittee on Census of Machine - Processable Geological Data Files in Canada; the Subcommittee on Mineral Deposits; and the Subcommittee on National Index to Geological Data in Canada. He took a special course on "Information Retrieval", Dept. of Continuing Education, University of Calgary.

A manuscript "Coding of geological names and terms" was submitted for publication by the National Advisory Committee on Research in the Geological Sciences. Also, a second manuscript "Geological data on fossil fuels and related economic sedimentary deposits" was submitted for publication by the National Advisory Committee on Research in the Geological Sciences.

L. L. Price: continued his supervisory duties associated with the joint project with the Saskatchewan Department of Mineral Resources. The project was expanded to include potash shafts at the Cominco, Duval, and Noranda sites as well as those previously started as Esterhazy, Lanigan,

and Allan. Purpose of the project is to record structure, lithology, and contact relationships that are briefly exposed during the shaft sinking. Fossils are collected for the Geological Survey and three sets of rock specimens, one for each agency of the joint project and one for the University of Saskatchewan. He continued his study of the "White Specks" zone of the Pasquia Hills area. A brief visit was made to the type area of the Swan River Group in west central Manitoba to observe newly exposed evidence of structure.

Two supervisory trips to the Saskatoon-Yorkton area during the winter maintained contact with field personnel and potash companies cooperating in geological studies of shaft walls.

A preliminary report on Cretaceous fossils from four mine shafts was prepared jointly with J.A. Jeletzky. Results from the study of these unique collections were applied to the stratigraphy of north-central Saskatchewan. Several new concepts are indicated.

In preparation for assisting in Operation Winišk, a considerable amount of time was spent on research of literature on the Hudson Bay area.

D.F. Stott: continued his stratigraphic studies of Cretaceous rocks of northeastern British Columbia. A summary of Jurassic and Cretaceous strata and a map showing distribution of those rocks were submitted for inclusion in a preliminary report on Operation Liard. In conjunction with this project, he continued his subsurface studies of Cretaceous and Jurassic strata in northeastern British Columbia. These studies will permit correlation of the Jurassic and Cretaceous strata from outcrop into subsurface. He initiated a new project involving stratigraphic and regional structural studies of Ellef and Amund Ringnes Islands. Supplies and equipment were requisitioned for forwarding to Resolute during the 1966 summer shipping season and preliminary studies of aerial photographs of Ellef Ringnes Islands were made to evaluate the time required for more detailed investigations. A subsurface correlation of formations of Fort St. John and Bullhead Groups in the region between Peace River in British Columbia and Upper Mackenzie River in District of Mackenzie was established. A photo-geological evaluation of Ellef Ringnes Island was undertaken and a detailed preliminary map on scale of 1 inch to 2 miles was prepared. He published "The Upper Cretaceous Smoky Group, Rocky Mountain Foothills, Alberta and British Columbia" as a Geological Survey bulletin.

#### Outside Publications

C.F. Burk, Jr.: "Collating Exploration Data", Oilweek, vol. 17, No. 39, pp. 16, 18-19 (co-author with N.M. Ediger).

"Proposed computer file for geological data on gas fields and other fossil fuels deposits" (Abstract), Oilweek, vol 17, No. 30, p. 34 (co-author with N.M. Ediger).

"Proposed computer file for geological data on fossil fuels deposits" (Abstract), Bull. Can. Inst. Mining Met., vol 59, No. 653, p. 1063.

D.F. Stott: "Cretaceous Alberta Group in the region of McLeod River, Alberta", Edmonton Geological Society, 8th Annual Field Trip Guidebook.

#### Attendance at Conferences, Meetings, Field Trips, etc.

C.F. Burk, Jr.: Meetings of the Committee on Storage and Retrieval of Geological Data in Canada; in Toronto, March 9-10; in Ottawa, August 31; in Ottawa, November 7-8.

Prospectors and Developers' Association, Toronto, March 8, 1966 (at personal expense).

Computer Society of Canada, 5th National Conference, Banff, Alberta, May 29-June 1.

Alberta Society of Petroleum Geologists - Canadian Society of Exploration Geophysicists Joint Conference, Calgary, September 12-14.

Canadian Institute of Mining and Metallurgy, Annual Western Meeting, Calgary, October 17-19.

Ontario Petroleum Institute, London, Ontario, November 1-3 (at personal expense).

Geological Society of America, Annual Meeting, San Francisco, November 13-16.

Geoscience Information Society, Annual Meeting, San Francisco, November 15.

"Evaporites and Related Rocks", National Conference on Earth Sciences (Alberta Society Petroleum Geologists - University of Alberta), Banff, May 8-13.

Workshop on coordinate indexing of geological documents directed by F. Dolan and E. V. Goodman, Imperial Oil Ltd.; Ottawa, May 16-20.

"Facies types and facies distribution of continental margins", American Association of Petroleum Geologists Continuing Education Program, Calgary, October 3-5.

L.L. Price: "Evaporites and Related Rocks", National Conference on Earth Sciences (Alberta Society of Petroleum Geologists - University of Alberta), Banff, May 8-13.

"Facies types and facies distribution of continental margins" American Association of Petroleum Geologists Continuing Education Program, Calgary, October 3-5.

D.F. Stott: Edmonton Geological Society, Field Conference, Cadomin, Alberta, August 19-21.

Geological Society of America, Annual Meeting, San Francisco, November 14-16.

Meetings of the Canadian National Committee, Seventh World Petroleum Congress, Calgary.

"Facies types and facies distribution of continental margins", American Association of Petroleum Geologists Continuing Education Program, Calgary, October 3-5.

Symposium on Structural Geology within the Canadian Rockies, Alberta Society of Petroleum Geologists, Calgary, June 7.

#### Membership on Committees

C.F. Burk, Jr.: Editor, Bulletin of Canadian Petroleum Geology, published quarterly by Alberta Society of Petroleum Geologists, Edmonton Geological Society, and Saskatchewan Geological Society.

Member, ex-officio, Executive of Alberta Society of Petroleum Geologists.

Member, Committee on Storage and Retrieval of Geological Data in Canada.

Member, Advisory Committee to Riley's Reproduction Ltd., Log digitizing project; liaison with Committee on Storage and Retrieval of Geological Data in Canada.

L.L. Price: Member, Earth Sciences Committee, Alberta Society of Petroleum Geologists.

D.F. Stott: Chairman, Calgary Library Committee.

Member, Canadian National Committee, Seventh World Petroleum Congress.

## ECONOMIC GEOLOGY DIVISION

S. C. Robinson

### INTRODUCTION

The objectives and functions of the Division are in effect the sum of the functions of its constituent sections, which were stated in the annual report for 1965. Since that time, the Groundwater Section has been transferred to the Water Research Branch with the exception of the Engineering Geology Unit which remains as part of this Division.

As currently constituted, the Division contains the Engineering Geology Unit, the Geochemistry Section, the Geology of Mineral Deposits Section and the Pleistocene (Quaternary) Geology Section. Reports of activities of each of these units follow and include titles of publications, data on personnel changes, committee memberships and attendance at meetings as well as tables showing productivity of laboratories.

In Engineering Geology, much time in the past year has been devoted to studies required by other organizations, notably evaluation of dam sites in the Yukon Territory, geological assessment of the new routes of the Welland Canal System and supervision of efforts to contain and control the flow of an artesian well in the Coldstream Valley of British Columbia.

In Geochemistry the program was mainly concerned with development and testing of methods that can be used to delineate anomalously high concentrations of metals on both reconnaissance and local scales. The immediate acceptance by industry of geochemical methods devised for location of silver-bearing veins in the Cobalt camp and the staking rush that followed release of results of geochemical surveys in the Bathurst camp are evidence of the success of this program. Preliminary results of biogeochemical projects demonstrate conditions under which these new methods are most effective. The application of computer-based clustering techniques to results of geochemical studies of trace elements in carbonate rocks has materially extended their effectiveness.

A shortage of geochemists in Canada has limited both the scope and productivity of this Section in the past year. Attempts to fill positions have had only limited success. An 'unfortunate' result of the success of the Section's program is the difficulty of competing with other organizations for the services of Survey-trained field assistants.

A symposium on Geochemical Prospecting sponsored by the National Advisory Committee on Research in the Geological Sciences was held in Ottawa in April, 1966, and members of the Section contributed



greatly to its organization. The Symposium was attended by over 250 representatives of the mining industry, universities, Provincial Governments and United States and overseas organizations. Thirty-seven papers were presented, six of these by members of the Geological Survey; the proceedings of the Symposium will be published by the National Advisory Committee.

The Pleistocene program comprises areal studies of Quaternary sedimentology, stratigraphy and geomorphology and topical projects designed to solve specific problems. The areal program is designed primarily to provide knowledge of the extent, shape, composition, history and genesis of Quaternary deposits in Canada, much of which is used by agencies concerned with forestry, agriculture, land inventory, groundwater and engineering. Several projects in the year's program were undertaken to meet specific requirements of one or more of these agencies. Topical projects included such matters as mineral exploration techniques based on studies of glacial deposits; studies of palaeoclimate and environment; correlation of geochronological methods applied to the Quaternary - vertebrate palaeontology palynology, dendrochronology and radiocarbon dating; processes of mass wasting; processes of sedimentation, etc.

The many practical applications of our knowledge of the Quaternary period tend to obscure their importance to geologists concerned with earlier periods in the earth's history. Not only does the Quaternary provide a record that is largely unaltered and therefore readily interpreted in terms of genetic processes and environment, but in its present day setting it permits geologists to study these processes as they take place. This dynamic aspect of geology may well provide direct evidence of the forces and environment under which sediments, volcanic deposits and certain mineral deposits of earlier periods were laid down. In recognition of the importance of current processes, the Pleistocene section has provided space for and close collaboration with the developing limno-geology unit of the Water Research Branch. It is hoped that this collaboration will continue when the limno-geologists move to their own institute.

The most significant accomplishment of the year in Geology of Mineral Deposits was the first publication (G.S.C. Paper 66-12) applying concepts of genesis of uranium deposits to our knowledge of the geology of Canada and so providing a direct assessment of those areas in Canada where the more important types of uranium deposits should be sought. This paper illustrates an important function of the section. The problem of recording geological data of mineral deposits in a systematic format that would permit statistical assessment of genetic factors, age, environment, provenance and other factors was reviewed in detail as a contribution to the work of the National Advisory Committee's study of storage and retrieval of geological data in Canada. Officers of the section were also active on the committee established to recommend a Branch program for study of the geology of uranium.

Work on the ad hoc Committee on Storage and Retrieval of Geological Data in Canada occupied a large part of the time of the administrative unit of the Division during the year. In addition to minutes of meetings of the main Committees, an interim report was prepared for publication (G.S.C. Paper 66-43) which gave rise to a very large volume of correspondence. Interest in the work of this Committee was further reflected in sales of the interim report which went out of print (1,500 copies) within 4 months of publication. In connection with this project, the chairman, Dr. Robinson, attended a meeting in Nancy, France, of an international committee on Data of Geochemistry and a symposium on geological data storage at which the ad hoc Committee's results were presented to the Mines Ministers' Conference during its annual meeting in St. John, New Brunswick. Papers concerning portions of the work of the Committee have been presented by members as follows:

S.C. Robinson: Storage and Retrieval of Data; The Canadian Surveyor, September 1966.

D.A. Sharp: Computer Applications in the Petroleum and Mineral Industries; C.I.M.M., Calgary, October 1966.

C.F. Burk, Jr. and N.M. Ediger: Collating Geological Data; A.S.P.G. - C.S.E.G. Joint Conference, September 1966; Oilweek, Nov. 14, 1966, p. 16.

The work of the Committee as appointed has been completed, and a final report will be presented to the National Advisory Committee in April, 1967.

## TIME STUDY

Project leaders form a majority of scientists in the Division. As such they have many duties additional or ancillary to work on their projects, that reduce the time available for research. In order to ascertain individually and collectively the amount of time devoted to their various duties, each project leader was asked to answer a questionnaire. Records of time in the field, official leave for conventions, and annual leave were obtained from official attendance records but other data had to be estimated by each project leader. The following table lists the average time devoted to various activities together with the maximum and minimum time indicated by individuals.

TIME STUDY - % of working days; average  
minimum - maximum

	Geochemistry	Mineral Deposits	Pleistocene	Engineering Geology	DIVISION
Field (incl. preparation & travel	21.0 2.8 - 46.8	14.3 0.8 - 44.8	28.3 2.4 - 51.8	36.8 33.2 - 40.4	22.8 0.8 - 51.8
Committees	4.7 0.8 - 7.2	3.0 0 - 14.0	3.9 0.4 - 12.8	- -	3.6 0 - 14.0
Meetings, trips	5.0 2.6 - 9.2	5.4 0.8 - 26.8	3.2 0 - 10.8	4.8 2.4 - 7.2	4.1 0 - 26.8
Courses	- -	1.5 0 - 5.2	- 0 - 0.2	1.2 0 - 2.4	0.5 0 - 5.2
Leave	6.1 4.0 - 8.4	5.4 0.4 - 11.2	6.0 0.4 - 12.0	4.2 0 - 8.4	6.1 0.4 - 8.4
Talks, preparation	0.9 0 - 1.6	2.6 0 - 10.4	0.5 0 - 2.0	- -	1.8 0 - 10.4
Publications, internal & outside	3.2 0.2 - 9.2	8.0 2.0 - 24.0	5.9 0.2 - 23.2	2.8 0.8 - 4.8	5.7 0.2 - 24.0
Correspondence	2.0 0.4 - 4.0	7.3 2.0 - 16.0	4.7 1.2 - 10.0	6.6 3.6 - 9.6	4.7 0.4 - 16.0
Supervision	2.0 0 - 4.0	2.6 0 - 8.0	2.4 0 - 12.0	- -	2.2 0 - 12.0
Visitors	2.3 0.4 - 4.0	3.3 1.2 - 6.0	2.2 0 - 8.0	2.2 1.2 - 3.2	2.7 0 - 8.0
Consultation with other staff	2.0 0 - 5.0	4.8 2.0 - 10.0	4.4 0.8 - 10.0	2.6 0.4 - 4.8	3.8 0 - 10.0
Group discussions	0.7 0 - 2.0	4.6 2.0 - 12.0	3.9 2.4 - 8.0	3.2 2.4 - 4.0	3.5 0 - 12.0
Reading	6.6 4.0 - 8.0	3.4 4.0 - 6.0	5.1 2.0 - 12.0	5.0 1.2 - 8.8	4.7 1.2 - 12.0
Other official duties	5.2 0 - 15.6	6.4 3.2 - 12.0	6.3 0.8 - 23.0	5.2 1.2 - 9.2	6.6 0 - 23.0
Research and preparation of GSC publications	38.0 0 - 52.0	27.6 6.8 - 75.0	23.2 10.0 - 66.0	25.4 20.8 - 30.0	27.0 0 - 75.0

### STAFF

At the end of 1966, continuing staff of the Division included 31 research scientists, 6 geologists, 2 senior scientific officers, 10 scientific officers, 2 technical officers, 7 technicians and 3 clerks. There were two scientific positions vacant and 2 officers, Drs. McCartney and Lee, were absent on special leave. During the summer 50 seasonal staff were employed in the field, 36 in the office and laboratories, and 6 seasonal employees are on staff during the winter. Three members of staff are in the Western Plains office in Calgary and two are in Yellowknife.

Mrs. K.L. Edmond joined the division as staff geologist in April and has been primarily occupied with duties as scientific secretary to the Ad Hoc Committee on Storage and Retrieval of Geological Data, with perusal of manuscripts and with other scientific staff work. Other changes in staff are recorded in the reports of sections.

### VISITING SCIENTISTS AND STUDENTS

As has become usual in the past decade, the division has again benefited from collaboration with visiting geologists in the past year.

Postdoctorate Fellows assigned by the National Research Council were:

Dr. A.T. Rozkowski a specialist in chemical hydrology from the Geological Institute of Silesia, Poland, who spent the summer with Dr. Meyboom, now of the Water Research Branch in Saskatchewan. He is now completing the office and laboratory aspects of the work assisted by his wife Mrs. A. Rozkowska who has carried out many of the chemical analyses for him, and expects to return to Poland early in June.

Dr. I. Banerjee of the University of Calcutta, who commenced his fellowship in September with a brief visit to examine Quaternary deposits of the Cochrane area in company with Dr. O.L. Hughes of the Pleistocene Section.

Captain J. LeMenestral of the French Army in collaboration with officers of the Pleistocene Section completed a geomorphological map of the area centred on Blackburn (east of Ottawa).

National delegations from West Germany and from Japan seeking information on uranium sources were formally received in the Boardroom on July 13, 1966 and September 13, 1966. Both delegations were briefed on the geology and mineral potential of uranium in Canada. This type of meeting may well become more common in the future as industrial nations seek long-term sources of minerals.

The division planned or assisted in arranging itineraries for three Soviet geologists who visited Canada under auspices of the National Research Council Exchange Agreement.

Visitors from the U.S.S.R. Academy of Sciences were as follows:

Professor F.K. Shipulin, Senior Research Fellow, Institute of Geology of Ore Deposits, Petrology, Mineralogy and Geochemistry.

Professor E.I. Semenov, Head of the Mineralogical Laboratory, Institute of Mineralogy, Geochemistry, and Crystal Chemistry of Rare Earths.

Professor F.V. Chukhrov, Director, Institute of Geology of Ore Deposits, Petrology, Mineralogy and Geochemistry.

Reception of visitors is making increasing demands upon personnel of the division, particularly visitors representing mining companies. Time spent with visitors averaged eight day per man in Mineral Deposits and six days per man in Geochemistry.

The following scientists from other institutions visited officers of the division in both the office and field, and some visited the division as a whole:

Dr. H.W. Wilson, Director, Scottish Research Reactor Centre.  
Dr. M.H. Tupas, Institute of Applied Geology, University of the Phillipines.  
Dr. A.F. Trendall, Geological Survey of Western Australia.  
Mr. T. Quinlan, Australian Bureau of Mineral Resources.  
Dr. S. Singh, Geological Survey of British Guiana.  
Dr. A. Pissart, University of Liege, Belgium.  
Dr. P. David, University of Montreal.  
Professor S.R. Brown, Queen's University, Department of Biology.  
Dr. H.W. Borns, University of Maine.  
Dr. J.L. Cutbill, Department of Geology, University of Cambridge, England.  
Dr. C. Beaumont, Mr. F.A. Spire, Mr. Delbos, Bureau des Recherches Géologiques et Minières, Paris.  
Dr. M. Stuiver, Yale University.  
Dr. K.O. Emery, Woods Hole Oceanographic Institution.  
Dr. G. Wasson, Mr. C.R. Harrington, National Museum of Canada.

The first meeting of the Quarternary Subcommittee, N.A.C.R.G.S., held in the Geological Survey of Canada, was attended by:

Dr. J.A. Elson, McGill University.  
Dr. R.H. McNeill, Acadia University.  
Dr. P.F. Karrow, Waterloo University.  
Dr. A. Dreimanis, University of Western Ontario.

Dr. L. Bayrock, Research Council of Alberta.  
Mr. L. Gray, Manitoba Conservation Authority.  
Mr. A.K. Watt, Ontario Water Resources Commission.  
Dr. W.O. Kupsch, University of Saskatchewan.  
Dr. W.D. Brueckner, Memorial University.

### SUMMARY OF ACTIVITIES

During 1966-67, staff of the Division submitted the following manuscripts for publication: 4 memoirs, 17 papers, 2 bulletins, 4 maps and 12 preliminary maps. These publications are included in the annual index to publications of the Geological Survey of Canada.

As shown in the reports of the Sections, staff of the Division attended a total of 33 meetings and field trips, embracing a wide spectrum of general and specialized geological topics and in many cases presented papers or led excursions. Of particular note were the following:

1. Participation by W. Blake Jr. in the Stockholm University Svalbard Expedition to Spitsbergen for the field season.
2. Attendance by two members of the division at the Geological Society of America annual meeting, San Francisco.
3. Presence of D.A. St-Onge at meetings of the International Geographical Commission on Slopes, Fluvial Dynamics and Applied Geomorphology in Belgium, where he presented a paper.
4. Participation by G.A. Gross in the National Research Council - U.S.S.R. Academy of Sciences Exchange Program. Dr. Gross spent seven weeks visiting laboratories and examining iron deposits in Russia, and briefly, in Sweden.
5. Invitation by the United Nations to Dr. G.A. Gross to participate in a Panel of Experts which is to update the United Nations publication, "Survey of World Iron Ore Resources - Occurrence, Appraisal and Use".

Field, office and laboratory activities of the division are described below in reports of the sections. Some highlights are:

1. Planning and establishment of the Great Lakes Limno-geology Unit of the Water Research Branch by the Pleistocene Section, and particularly Drs. Fyles and Lewis.
2. Unexpected artesian flow from a borehole in the Vernon area, B.C. was successfully controlled through the work of J.S. Scott in conjunction with a grouting consultant.



3. Organization of the symposium on Geochemical Prospecting, sponsored by N.A.C.R.G.S., by the geochemistry section.
4. Completion of the Glacial Map of Canada by V.K. Prest and the Glacial Map of Yukon Territory by O.L. Hughes.

## METALLOGENIC MAP OF CANADA

The Metallogenic Map of Canada project stems from the Geological Survey's commitment, as the Canadian member of the International Geological Congress 'Subcommission for the Metallogenic Map of the World, to develop the Canadian part of a 1 to 5 million scale metallogenic map of North America. The project is proceeding with the cooperation of the Canadian Metallogenic Map Committee set up for the purpose and which comprises representatives from nine provincial departments of Mines and Geological Survey member as chairman. The Geological Survey is responsible for integrating the provincial contributions and for the primary development of the parts covering the Territories and those provinces that find themselves unable to make compilations. In April 1966 the project was transferred to the Special Project Unit of the Geological Survey but it continues to report through the Economic Geology Division for administrative purposes.

The Canadian Metallogenic Map Committee met in April, 1966, when G.B. Leech superseded W.D. McCartney as chairman, and studied critically the legend devised in January by the North American Metallogenic Map Committee in which W.D. McCartney had represented Canada. The Canadian Committee agreed to use the legend, subject to certain amendments and clarifications it suggested and which were adopted by the North American Committee also. This complex legend is now being put to the test in trial compilations by several provinces and the Geological Survey. The Geological Survey work is proceeding, where practicable, from a 1 to 1 million base scale, as this is a useful one for later projects, but in view of the imminent deadline (a draft of the North American map is scheduled for August, 1968) it may have to proceed in part directly from a 1 to 3 1/3 million scale.

## ACKNOWLEDGMENTS

Of great importance to the work of the Division is the collaboration of other scientists in mining companies, universities and provincial and other agencies of government. Many of these collaborators are mentioned below in reports of Sections, and appreciation is here expressed to them all.

Much of the progress in the Division's work is dependent upon services rendered by laboratories in other organizations. It is a pleasure to have this opportunity of expressing 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 has greatly facilitated our developments of data processing approaches to geological problems.

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 Section. 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

Central Technical Files Committee	Chairman
<u>ad hoc</u> Committee on Storage and Retrieval of Geological Data in Canada	Chairman
Historical Committee	Chairman
Technician Appraisal Committee	Chairman
Associate Committee on Meteorites	Chairman
Training Committee	Chairman

#### ATTENDANCE AT MEETINGS

Dr. S. C. Robinson attended meetings of: the ad hoc Committee on Storage and Retrieval of Geological Data in Canada, March 1966, in Toronto, and January 1967 in Montreal; the Mineralogical Association of Canada, September 1966, in Halifax; the Canadian Institute of Mining and Metallurgy, March 1967, in Ottawa; and the Prospectors' and Developers' Association Convention, March 1967, in Toronto.

## REPORTS ON SECTIONS AND LABORATORIES

### GEOLOGY OF MINERAL DEPOSITS SECTION

D.R.E. Whitmore

Geological Survey of Canada officers within the section deal specifically with the geology of mineral deposits and the geological settings within which they occur.

During 1966, five officers worked in the field. Three examined nickel, iron, and tin deposits throughout the country. Two other concentrated their efforts in the Mackenzie District and in the Sault Ste Marie-Chibougamau District respectively studying many different types of deposits and attempting to relate them to the geology of the two regions.

Office and laboratory work based on previous field work was carried out by the remaining officers. Reports on copper in the Cordillera, vanadium in Canada, the metallogeny of the Appalachian region resulting from these studies are expected shortly.

#### Activities

J.A. Chamberlain: conducted two field projects in connection with his studies of sulphide deposits. He supervised the work of graduate student P.R. Simpson on the St. Stephen nickel deposit, New Brunswick, involving both field and mineralogical laboratory phases (62-47).

In association with Mr. Simpson he studied nickel distribution in serpentinites at Puddy Lake, Ontario. Results suggest that a relationship may be established between nickel enrichment and presence of nickel-poor magnetite in serpentinitized host rocks, and this relationship shows promise as a prospecting tool (63-37).

Dr. Chamberlain investigated nickel distribution in a peridotite sill in norite of the north rim of the Sudbury Basin, with a view to comparison between Sudbury and Muskox data.

He completed laboratory study of sulphides from the Muskox intrusion (see Papers submitted, below) (O.P. 285). Further office work involved critical reading of a paper by Kullerud and Naldrett on ore formation at the Strathcona Mine, Sudbury, Ontario (O.P. 544).

G.A. Gross: Two of Dr. Gross' field projects dealing with the geology of iron deposits were active in 1966. He visited twelve major iron mining areas in Eastern and Central Canada to examine new mine exposures, update geological information and collect specimens to support current

laboratory research (57-29). A pilot study of the stratigraphy of iron formation in part of the Labrador Trough forms a Ph.D. thesis project for I.S. Zajac. Field work begun in 1965 was completed (62-47-2).

Office and laboratory studies were pursued of material collected in 1965 from iron deposits in the Mary River area, Baffin Island. A preliminary paper appeared in the Bulletin of the C.I.M., and a G.S.C. Bulletin is being prepared for publication in 1967 (65-6).

A joint project is underway with the Geophysics Division to study the relationship between geological and geophysical parameters of a magnetite iron formation in the Kapico Range near Nakina, Ontario. Field work was done in 1964 by G.A. Gross and D.F. Sangster of this Division, and P.J. Hood of Geophysics Division, and a manuscript by Sangster covering the geological portion of a proposed Bulletin was completed this year (62-47).

He undertook preparation of a chapter on the iron ore reserves of Canada for a United Nations publication "A Survey of the Iron Ore Resources of the World". Based on a National Research Council Academy of Sciences exchange visit to Russia for seven weeks during the summer of 1966, Dr. Gross prepared several talks on the iron deposits of the Soviet Union and some of the centres of geological research in the U.S.S.R. These talks have been (or will be) presented to: the Adams Club, McGill University; Cobalt Branch, C.I.M., Ottawa Branch, C.I.M., Annual General Meeting, C.I.M.

A.G. Johnston: keeps abreast of current exploration literature and issues a monthly digest. He also provides assistance in metallogenic map compilation and bibliographic searches. Activities in 1966 included the following: Monthly newsletter on Mineral Exploration: Twelve monthly digests each containing about 20 items were prepared for circulation among professional staff members. The project was started in 1963. Developments from that time to the present are plotted on a large wall-map of Canada (O.P. 323). Mineral Map of Canada: The Map was brought up to date to include all metallic producers and past producers up to the end of 1965 (O.P. 382-4). Metallogenic Map, Silver in Canada: Considerable time was occupied re-drafting this map (O.P. 414). A map showing current activities in mineral exploration in the Yukon together with notes summarizing activities in the Vangorda area was prepared for the Director.

E.D. Kindle: is completing an Economic Geology Series Report on Copper Deposits of the Canadian Cordilleran Region. Field work was completed in 1965.

The report will summarize deposits in tabular form. Longer descriptions will be restricted to type deposits, or deposits of particular topical interest studied in greater detail. To date some 963 properties have been dealt with, in B.C., Yukon Territory, and Mackenzie Mountain

portion of the Northwest Territories. Eighteen types of deposit have been recognized, ranging in age from Precambrian to Palaeocene (60-9).

W.D. McCartney: In anticipation of his departure in September to teach Economic Geology at Queen's University Dr. McCartney devoted most of his time in 1966 to completion of his study of metallogenic studies in the Appalachians. A.G.S.C. bulletin will be prepared to describe this work.

C.R. McLeod: continued supervision of the Metallogeny laboratories during 1966. Much of his time in the early part of the year was directed to the training of R.D. Burke in ore polishing techniques so that Mr. Burke was able to take over most of this work by the year's end. Operation of the laboratory is described below.

As the year progressed Mr. McLeod devoted more of his time to direct collaboration with the Research Scientists of the Section. With W.D. McCartney he carried out heavy mineral studies directed towards definition of metallogenic provinces in the Appalachians. Using samples collected by Dr. J.A.C. Fortescue he made a preliminary mineralogical study of the sulphides of the Vangorda Creek area, Yukon. By year end he was working in close collaboration with Dr. Gross.

R. Mulligan: Two of Dr. Mulligan's projects were actively pursued in the field during the 1966 season and data on other nominally completed and published projects continued to become available, illustrating the continuing nature of many of the projects in the Section. Several actual and potential tin occurrences in the southwest Cordilleran tin belt were examined and sampled by Dr. Mulligan. Work in the Cassiar district continued to produce new information on the distribution and concentration of tin in the northwest Cordilleran tin belt (65-12). Work was continued in the tin province of southern New Brunswick in collaboration with A. Ruitenbergh, whose Ph.D. field project there was transferred for administrative purposes to the Regional Geology Division. The preliminary report on "Geology of Canadian Tin Deposits" was published in July. The first draft of an economic Geology Report on tin is scheduled for the end of 1967 (61-40). About three weeks field work on a Metallogenic study of the Beryllium-Tin province of the northern Cassiar Batholith, Yukon and British Columbia was done in 1966 in conjunction with a helicopter-equipped regional-mapping party (65-12). Publication of a preliminary report is planned to coincide with publication of a preliminary map of the Jennings River area by the Regional Geology Division, after the 1967 season. The 1967 season should complete field investigations for the project.

New information regarding beryllium concentration and distribution was assembled, mainly from spectrographic analysis of samples taken in connection with the projects described above (53-12). Some occurrences of beryllium minerals were discovered and others reexamined in the Cassiar District in 1966. The large number of occurrences discovered since Ec. Geol. Rept. No. 23 was submitted for publication will require a supplementary



paper, similar to that prepared and published for lithium in 1965, which it is hoped to have ready by the time the report is published. A partly-prepared concentration-distribution map, summarizing the spectrographic-analytical information, may be included in the same paper.

In addition to office work in support of the above field projects, several field-based studies have expanded into laboratory projects which will warrant separate publication. Preliminary investigation of tin-bearing silicates in skarn from the Cassiar District, Yukon and British Columbia continued by electron probe and related techniques as well as separation and cleaning of minerals for analysis, refractive index, and specific gravity determination. A joint paper was prepared, and presented by J. L. Jambor at the GAC-MAC meeting in September. Completion for publication awaits necessary chemical analyses. Lithium content is being studied for Canadian granites (O.P. 448), and analytical results compared for Cordilleran, Appalachian and Shield areas. A distribution-concentration map with appropriate symbols, distribution-frequency-range charts, and documentation, are partly prepared for publication but not complete owing to pressure of higher-priority work.

Collection of information on the Geology of molybdenum and tungsten continued as a matter of section policy and for necessary revision of existing Economic Geology reports, mainly in conjunction with other projects: No formal project for this has yet been established.

S. M. Roscoe: continued active field work in his Metallogenic studies in the Lake Superior-Chibougamau Region (61-33), with examinations as wide-spread as the Nipigon region in the northwest and the Otish Mountains in the east. Mineral separations for trace metal and isotopic studies are nearly completed for this project. Lead isotope studies and rock geochemical studies are nearly completed. It is hoped that analyses of 400 sulphide separates will be obtained in 1967.

Some experimental compilations of results were made, and in part presented orally at a meeting of the Institute of Lake Superior Geology, May 5, 1966. Publication of lead isotope data, data on metals present in sulphide concentrates, and some data on chemistry of archaean volcanic rocks is anticipated in 1967. Work will continue on metallogenic map presentations and explanations.

Contact was maintained with uranium mining companies and organizations engaged in uranium exploration. Representatives of most of the larger companies engaged in uranium exploration or planning exploration visited the G. S. C., as did a number of foreign delegations interested mainly in nuclear fuel supply. We have worked closely with the Mineral Resources Division and have had much cooperation from Eldorado Mining and Refining Limited. Information on uranium exploration, gained through conversations in Ottawa, field trips, correspondence and visits to company offices, has been filed in Central Technical Files.



A report was prepared in April giving recommendations of the "Uranium Study Group"; an interdivisional group formed on instructions from the Director to examine survey requirements in this field.

Roscoe acted as co-leader of an Institute of Lake Superior Geology field excursion to Elliot Lake on May 7 and showed J. A. Donaldson, Regional Geology Division Huronian geology in June. A field trip to U.S. uranium deposits was arranged in June through E. E. N. Smith of Eldorado and the U.S.A.E.C. This gave E. M. Cameron an opportunity to evaluate possibilities for uraniferous lignite deposits in southern Saskatchewan and Proctor of the Calgary office an appreciation of types of deposits that may be sought in Western Canada.

Roscoe visited W. W. Heywood's and J. A. Donaldson's Regional Geology field parties in the N. W. T. to examine Proterozoic rocks there and evaluate possibilities of uranium deposits. Laboratory studies of radioactive quartz pebble conglomerate from the Padlei area, N. W. T., were made.

An address to the American Nuclear Society and Canadian Nuclear Association on "Unexplored Uranium and Thorium Resources of Canada", Feb. 1966, was published as G.S.C. Paper 66-12.

E. R. Rose: Field work in Dr. Rose's current project on geology of vanadium in Canada (63-9), was completed in 1965. Laboratory work on material collected from the field and submitted by other officers of the Survey was carried on during 1966. A preliminary report summarizing much new information on the distribution of vanadium in Canada was submitted for publication during the year. He prepared a precis on the history of the study of geology of mineral deposits by the G.S.C. as a contribution to the forthcoming history of the Geological Survey of Canada. He also investigated the possibilities of making use of material in the Economic Geology collection of the Survey for periodic displays in the building.

D. R. E. Whitmore: did no field work during the season. Through D. J. Bachinski who completed the field phase of a study of the volcanics he was able to maintain contact with the Whalesback Mine project (64-58).

Preparations were made to bring together material for a comprehensive joint publication on the Coronation Mine Study (60-16).

In addition to administrative duties as section head he completed a chapter on "Bedrock Geology and Mineral Deposits" in a forthcoming Centennial volume on Hudson Bay (O.P. 429). With the assistance of A. G. Johnston, A. Y. Smith and B. MacLean he completed and submitted the Mineral Map of Canada on a scale of 1:5,000,000 to form part of E. G. 1. Work on External Aid, and the Depletion Allowance Income Tax Act, was relatively light during the year. At the year end he resigned as an

Associate Editor of the Canadian Journal of Earth Sciences. Throughout the year he continued to write a chapter on Economic Geology of the Canadian Shield for E.G. 1. Towards the year end Mulligan (tin, beryllium), Gross (iron) and Roscoe (uranium) were brought in as collaborators.

Assisted by R.I. Thorpe and A.G. Johnston he prepared a review of geological developments in exploration in the Northwest Territories and Yukon Territory for 1965. Jointly with Dr. J.M. Harrison he wrote a paper on Research in Mineral Exploration for presentation at the Annual General Meeting of the C.I.M.

Much of Whitmore's time has been concerned with work of the ad hoc committee on Storage and Retrieval of Geological Data in Canada, and in three of its subcommittees, particularly Subcommittee No. 5 dealing with Mineral Deposit Data of which he is chairman.

R.I. Thorpe: Including visits to Pine Point, Mr. Thorpe spent some forty-one days in the field during 1966. Much of this time and a good portion of office time is devoted to obtaining material for the monthly report on exploration activities in the Northwest Territories as well as data on the mineral deposits themselves.

Data from part of the office files have been compiled in a form which can be readily used in preparation of a series of metallogenic maps of Mackenzie District (65-50).

#### Metallogeny Laboratory

(C.R. McLeod, R.D. Burke)

Production of polished sections increased slightly (900) over 1965 (775). A second Durener polisher was put into operation during the year. Burke gradually took over the polishing by mid-year.

Polished sections were made for 26 officers of the Survey, as shown below: In addition some 20 sections of synthetic galenas were prepared for Dr. K. Lyall of the Mines Branch. Current backlog totals over 900 sections including 109 for the reference collection and 433 from Muskox drill core. Most of these are mounted ready for polishing.

Metallogenic Laboratories - 1966

A. Production of Polished Sections

Economic Geology Division

Geology of Mineral Deposits Section

Project

S. M. Roscoe	156	61-33
D. Bachinski	102	64-58
J. A. Chamberlain	92	63-37
R. I. Thorpe	34	65-50
E. R. Rose	29	63-39
C. R. McLeod	25	65-48, O. P. 432, O. P. 512
D. J. Carson	21	64-47-1
I. S. Zajac	21	62-47-2
G. A. Gross	19	62-47
W. D. McCartney	8	62-46
R. Mulligan (hand polished)	15	

Geochemistry Section

D. F. Sangster	60	65-56
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Petrological Sciences Division

T. N. Irvine	182	57-28
A. De	60	57-28
E. Froese	28	57-27-6
J. L. Jambor	15	O. P. 306
J. A. Douglas	9	O. P. 119
P. Blattner	3	57-27-6
F. Aumento	2	66-41
V. Koepfel	1	O. P. 463
R. J. Traill	1	O. P. 7
G. Lachance	1	O. P. 308
T. E. Lawrence	1	O. P. 455
S. Courville	1	O. P. 77

Regional Geology Division

H. S. Bostock	6	64-11
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Fuels and Stratigraphy Division

B. A. Liberty	3	59-21
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Mines Branch, Fuels and Mining

Practice Division

K. Lyall	20	galena study
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Total Polished Sections 915

B. Laboratory Use (man-days)

Economic Geology Division

Geology of Mineral Deposits Section

<u>Officer</u>	<u>Ore Microscopy</u>	<u>Preparation Facilities</u>	<u>Separation</u>
R.D. Burke		220	
C.R. McLeod	40	70	10
S.M. Roscoe	33	30	80
H.C. Sakrison	2		48
J.A. Chamberlain	30	2	5
R. Mulligan	30	30	1
W.D. McCartney*	20		
D. Bachinski	15		
P.R. Simpson	40	10	5
E.R. Rose			5
I.S. Zajac	3	1	

Geochemistry Section

D.F. Sangster	8	3	4
P.J. Lavergne			5
W. Dyck		1	

Petrological Sciences Division

T.N. Irvine	20	10	
V. Koepfel	10	20	
E. Froese*	8		
R.N. Delabio			3
H.R. Steacy			1
P. Blattner		1	
F. Aumento		1	
G. Lachance		1	
G. Plant		2	
J.L. Jambor		5	
S. Courville	12		

Administration

Howe\*

1

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272

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407

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167

Notes: \*1. denotes use of calculator for most or all of time indicated

2. use by students or assistants charged where applicable

3. preparation facilities includes use of hand-polishing equipment, diamond saw, rock-breaker, and plastics for mounting (especially epoxy). Also included is use of lapidary table for polishing of the piston head used in the disc preparation mold assembly for X-ray fluorescence spectroscopy.

### Outside Publications

- J.A. Chamberlain: Heazelwoodite and Awaruite in Serpentine in the Eastern Townships; Can. Mineralogist vol. 8, pt. 4, 1966.
- Sulphides in Muskox Intrusion; Can. J. Earth Sci. (in press).
- J.A. Chamberlain et al.: Nickel Distribution in Serpentinites of Puddy Lake area Ontario. Geol. Assoc. Can. (in press).
- G.A. Gross: The origin of high grade iron deposits of Baffin Island, N.W.T.; Can. Mining. J.; April 1966.
- Principal types of iron formations and derived ores; Trans. Can. Inst. Mining Met., 1966.
- G.A. Gross et al.: Relationship between geology and geophysical parameters of a magnetite iron formation; Trans. Can. Inst. Mining Met., 1966.
- W.D. McCartney et al.: Rb/Sr age and geological setting of the Holyrood granite southeast Newfoundland; Can. J. Earth Sci., 1966.
- E.R. Rose: The copper Nickel deposits of Timagami Island, Ontario; Ec. Geol. vol. 61, 1966.
- D.R.E. Whitmore et al.: Research and mineral exploration; Bull. Can. Inst. Mining Met. (in press).

### Outside Talks

- G.A. Gross
- |  |  |
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| Recent Investigations of Iron Formations | - University of Manitoba                   |
| Iron Deposits of Soviet Union            | - Ottawa C.I.M.                            |
| Iron Deposits of Soviet Union            | - Adams Club, McGill                       |
| Geology of Iron Deposits in Canada       | - U.S.S.R. Research Groups<br>(four times) |
- S.M. Roscoe
- |  |                             |
|--|-----------------------------|
| Metallogenetic considerations in Superior Province | - Inst. L. Superior Geology |
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### Meetings, Courses, Field Trips etc.

- J.A. Chamberlain Field trip to Cobalt - Mineralogical Association of Canada, Electron Probe Course, Massachusetts Institute of Technology.

G.A. Gross National Research Council - Academy of Sciences, Exchange visit, USSR, May-July. Examination of Swedish iron deposits.  
• AIME Iron Symposium, Duluth, Minnesota; Prospectors and Developers Assoc. Toronto; United Nations Committee on Iron Ores. N.Y.

W.D. McCartney Prospectors & Developers Assoc. Toronto; C.I.M., Quebec.

S.M. Roscoe Geological Survey trip to Western U.S.A. Uranium occurrences.

Drs. Whitmore, Gross, and Chamberlain attended meetings of the Canadian Institute of Mining and Metallurgy, April 1967, in Ottawa.

Dr. Gross attended the Prospectors' and Developers' Association Convention, March 1967, in Toronto.

## GEOCHEMICAL SECTION

R. W. Boyle

During 1966, research in geochemistry and geochemical prospecting was carried out in a number of field areas in Canada. These included a large geochemical prospecting research program in the Cobalt area of Ontario; an investigation of lead-zinc deposits in carbonate rocks in various parts of Canada; biogeochemical field work in Nova Scotia, Quebec, Ontario, British Columbia, and Yukon; and field work on circular structures in Quebec and Ontario.

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

Summaries of work done in the analytical laboratories are given in Tables I to V.

### Summary of Field Work

D.F. Sangster continued study of the geochemistry of lead-zinc deposits in carbonate rocks. During the 1966 field season, 15 such deposits were mapped or examined and samples collected for mineral separation and analysis.



K.L. Currie completed field work on the Manicouagan structure, Quebec with the aid of a helicopter. Samples for paleomagnetic studies were collected, and the results have been submitted as a paper to the Journal of Geophysical Research. A brief visit was made to the Brent crater and samples collected for chemical analyses.

J.A.C. Fortescue visited and planned a Quick Project at the Pecan property of Terra Nova Mines Limited in Gaspé Park, P.Q. in June. In July he travelled to Vancouver and after discussions with representatives of a number of mining companies, decided to carry out three visits to properties which might be suitable for field work during the summer of 1967. Each of these properties was visited and samples of soil and herbarium plant specimens collected. During August and September investigations were carried out at the Petawawa Forest Experiment Station involving the planning of collection of trees from an aspen stand and a provenance experiment.

E.H.W. Hornbrook planned and carried out a Pilot Project at Silvermine, Cape Breton Island, during the month of June. This involved the collection of 400 samples of plant material and 100 samples of soil material from 45 stations located at 100 foot intervals along a cut line across an undisturbed lead deposit. The Quick Project, as planned by Fortescue, was carried out by Hornbrook at the Pecan Property. During the first week in August Hornbrook planned shallow investigations at both of these properties. These investigations were carried out by staff of the Seismic Section of the Geophysical Division of the Geological Survey of Canada under the general direction of G.D. Hobson. In late August the movable biogeochemical unit was taken to the Petawawa Forest Experiment Station and set up to carry out processing and analysis of plant material collected from the aspen stand. This first full scale test of the movable biogeochemical unit in the field was successful.

R.W. Boyle supervised a large geochemical prospecting research program in the Cobalt area of Ontario during June, July, and August. A.S. Dass a graduate student from Carleton University was in charge of the field work and G. Mihailov supervised the analytical colorimetric laboratory which was set up in the Provincial Institute of Mining at Haileybury. C.C. Durham was in charge of the mobile spectrographic laboratory. During the set up period J.J. Lynch supervised the details of organizing the colorimetric and spectrographic laboratories and the training of student personnel. P.J. Lavergne set up the sample preparation laboratory and trained personnel in its operation. W. Dyck spent two weeks in the Cobalt area on the same project and carried out gamma ray surveys across a number of silver veins.

The Cobalt research program was designed to test the effectiveness of geochemical prospecting for silver veins using till, glacial clay, derived soils, groundwaters, and host rocks. Preliminary results of the research have been published in G.S.C. Paper 66-46.

### Office and Laboratory Work

W. Dyck with the assistance of J.C. Pelchat carried out experiments in coprecipitation and adsorption of silver on ferric hydroxides and diffusion of silver in aqueous solutions using radioactive silver as a tracer.

Thus far the effect of pH on the amount of silver adsorbed has been determined using hydroxides prepared in two different ways. The studies cover a pH range from 4 to 8 and a silver concentration range from 0.01 ppm to 100 ppm. Coprecipitation studies show that the amount of silver coprecipitated with iron is influenced greatly by the presence of ions which form insoluble silver salts or silver complexes.

For the determination of the diffusion constant of silver in aqueous solutions seven diffusion cells were designed and tested. The values for the diffusion constant obtained from these cells ranged from  $33 \times 10^{-5}$  to  $1.6 \times 10^{-5}$  cm<sup>2</sup>/sec. Optimum cell parameters are being determined for the "workings" designs.

The coprecipitation studies of cobalt with iron initiated in 1965 were suspended in favour of the silver studies before sufficient publishable data had accumulated..

A series of gold standards was prepared for the testing of a neutron activation method for determining traces of gold.

K.L. Currie completed a final report on work at the Carswell structure, Saskatchewan, and submitted it for publication as a GSC Bulletin. A paper reporting solubility experiments on natural rocks, and their applicability to a stock in Newfoundland was prepared in collaboration with I.F. Ermanovics and is in press in the Canadian Journal of Earth Sciences. Three years of laboratory and theoretical work are collected in a paper on the solubility of albite in supercritical water submitted to the American Journal of Science and abstracted in the Canadian Mineralogist. A note on the origin of shock metamorphism in the Carswell structure is in press in Nature. A study of the geochemistry of some Canadian craters was completed in collaboration with M. Shafiquallah. It was concluded that 'melt' rocks in the crater do not originate by melting of the wall rocks.

He completed a study of the solubility of albite in supercritical water, and studies of the solubility of microcline as well as mixtures of microcline and albite were continued. Apparatus was designed and constructed for extending the measurements to 10 kilobars. A study of the deformation of quartz during brecciation was begun using a 125 ton press. Under suitable geometries, unsupported quartz pistons can maintain pressures in excess of 20 kilobars. Modelling experiments on the formation of craters were continued. It was concluded that the morphology of craters of inflation and collapse is identical to those of hypervelocity impact.

D.F. Sangster completed the first draft of a study pertaining to a detailed geological and geophysical investigation of a magnetite iron-formation out in collaboration with Drs. G.A. Gross and P.J. Hood. This is to be a Survey publication.

He obtained samples of magnetite-bearing rock from a variety of geological environments from existing Survey collections in preparation for a study of the geochemistry of magnetite.

He critically reviewed three geological papers for publication and one geochemical textbook.

He designed a pictorial display depicting geochemical prospecting techniques used by the Geological Survey of Canada. This display was exhibited at the Symposium on Geochemical Prospecting held in Ottawa in April, 1966.

E.M. Cameron spent the greater part of the year setting up statistical and computer methods for the interpretation and handling of large quantities of geochemical data. The following programs were either written, compiled or modified and are available to other workers:

- C 40307 Printer Plot of Geochemical Data from Well Sections
- C 40308 General Statistics Program for Geochemical Data (STATS)
- C 40309 Principal Components Analysis (RFACT)
- C 40309 Principal Components Analysis (PRINCOMP)
- C 40310 X-Y Plot of Geochemical Data from Wells
- C 40311 Trend Analysis as Proportion of Log Mean
- C 40312 Trend Analysis as Running Average
- C 40313 Trend Analysis as R-Mode Factor Scores
- C 40314 Varimax Matrix Inversion (SUFMIV)
- C 40315 Factor Scores (FSCR)
- C 40316 X-Y Plot of Factor Scores
- C 40317 Multiple Regression (MULTR)
- C 40319 Varimax Criterion Rotation

The principal effort was put into applying Factor Analysis methods to geochemical data from carbonate studies. An important "statistical" finding was that if large data matrices of precisely analyzed rock samples from fairly homogeneous populations are factored, factors with eigenvalues of much less than one (the usual limit for psychometric applications of factor analysis) may be significant in terms of real processes, and may in fact reveal very subtle effects. The geological implication of this work is that it is now possible to extract a great deal more information from geochemical data with considerably less effort than was possible with conventional interpretational methods.

A long term aim of automating each stage of a geochemical project has now essentially been completed. A direct-reading spectrometer (Quantograph) provides analytical data on punched tape which is converted into per cent concentration on the departmental computer and punched onto cards. These data are then interpreted by factor analysis, trend surface, and other computerised methods. The interpreted data can then be plotted as graphs or onto maps suitable for publication by the plotter attached to the computer.

During the period January to May 1966 J.A.C. Fortescue prepared a series of papers two of which described investigations carried out in the Moose River area the previous summer, one summarized progress made in biogeochemical research at the Geological Survey of Canada during the period 1963-1966 and the fourth was concerned with the role of geochemistry in mineral exploration. From September to December 1966 he prepared the first four sections of a detailed progress report on all research carried out in the biogeochemical research program so far.

E.H.W. Hornbrook completed detailed checking of results obtained in the spectrographic laboratory the previous summer during the months of January and February 1966. He also compiled results and draft figures to be made into lantern slides which illustrated the paper given by Fortescue at the Symposium on Geochemical Prospecting held in Ottawa in April. In May Hornbrook trained one T.O. and one S.A. to process and analyze spectrochemically, samples of soil and plant material. During the course of the summer 400 samples of plant material were analyzed chemically in the trailer spectrograph laboratory in Ottawa. In addition 120 similar samples were analyzed in the same laboratory when set up in the field at Petawawa (See Table V). For the balance of the year Hornbrook assisted generally in the preparation of data for inclusion in the progress report and in particular began to compile a detailed report on the Silvermine Pilot Project.

A.Y. Smith prepared a Mineral deposits map of Canada under the direction of D.R.E. Whitmore. He also set up and modified a geochemical prospecting test for tin in soils and stream sediments. The test

has been prepared for publication in the series "Field and Laboratory Methods used by the Geological Survey of Canada in Geochemical Surveys". Smith also began work on geochemical methods of prospecting for uranium. Initial work is directed to finding suitable rapid analytical techniques for use on soil, stream sediment and water samples.

R.E. Horton and E.M. Cameron carried out further development work on a general method to determine simultaneously both major and trace elements in a variety of different rock types. The results formed the basis of a joint publication by E.M. Cameron and R.E. Horton.

C.C. Durham and R.H.C. Holman completed a manuscript on the mobile spectrograph trailer laboratory for publication as a Survey Bulletin.

J.J. Lynch implemented rapid methods of analysis for the determination of aluminum and silica in water samples from high temperature bomb experiments conducted by K.L. Currie.

J.J. Lynch with the assistance of a student assistant (Miss D. Church) developed a rapid sample site test for the determination of nickel and cobalt in water.

J.J. Lynch with the assistance of a graduate student (G. MacGillivray) installed an atomic absorption spectrophotometer and carried out preliminary tests on a number of parameters.

J.J. Lynch with the assistance of a graduate student (B. Nunn) carried out investigations of ammonium pyrrolidine dithiocarbonate as a reagent for the preconcentration of a number of trace elements in water. These included Cu, Pb, Ni, Co, Ag, and Cd.

J.J. Lynch assisted Mrs. Anna Rozkowska in devising methods of analysis for soil extracts.

C.C. Durham spent a month in the colorimetric trace element laboratory learning the techniques of this laboratory.

P.J. Lavergne spent a month in the mobile spectrographic laboratory and a month in the colorimetric trace element laboratory learning the techniques of these laboratories. He also prepared a series of standard samples from various hand-picked minerals. These standards will be used in a number of geochemical laboratories.

All members of the geochemical section spent considerable time during the months of January, February, and March organizing the Symposium on Geochemical Prospecting sponsored by the National

Advisory Committee on Research in the Geological Sciences held in Ottawa April 20, 21, and 22. This symposium attracted more than 250 participants from the mining industry, universities, provincial governments, and various United States and overseas organizations.

#### Attendance at Meetings

J.A.C. Fortescue attended the National Western Mining Conference at Denver, Colorado in February 1966 where he gave a paper on "Exploration Architecture". In April he gave a paper at the Annual Meeting of the C.I.M.M. in Quebec City. In May he attended a Canadian Botanical Association Field Trip in British Columbia led by Dr. V.J. Krajina.

E.M. Cameron took part in a Colloquium on Computer Methods in Earth Sciences held at the University of Kansas in December.

K.L. Currie presented a note on shock metamorphism to the Conference on Shock Metamorphism, Greenbelt, Md., May 16-19. He gave a paper entitled 'Solubility of albite in supercritical water' at the MAC annual meeting in Halifax.

D.F. Sangster attended the International Symposium on the origin of stratiform deposits of lead, zinc, barite, and fluorite, New York, March 3, 4, 5, and the 5-day post-convention field trip to U.S. lead-zinc deposits.

R.E. Horton attended the XIII Canadian Spectroscopy Symposium in Montreal.

R.W. Boyle attended the annual meeting of the C.I.M.M. in Quebec City in April and presented a paper on geochemical prospecting.

R.W. Boyle attended the Annual Meeting of the M.A.C. and G.A.C. in Halifax in September and gave a paper on the origin of the gold in the deposits of the Meguma series of Nova Scotia. He also gave a lecture on the Bathurst massive sulphide orebodies in Bathurst and acted as guide during the annual C.I.M.M. trip to the Bathurst-Newcastle area.

R.W. Boyle gave a lecture on geochemical prospecting to the C.I.M.M. branch at Cobalt in November.



All members of the Geochemistry Section attended the Geochemical Prospecting Symposium sponsored by the National Advisory Committee on Research in the Geological Sciences held in Ottawa April 20, 21, and 22. J.J. Lynch, C.C. Durham, C.F. Gleeson, J.A.C. Fortescue, E.H.W. Hornbrook, and R.W. Boyle gave papers at the symposium on various aspects of geochemical prospecting. E.M. Cameron is editor of the proceedings of the symposium.

Drs. Boyle and Sangster and Mr. Smith attended meetings of the Canadian Institute of Mining and Metallurgy, April, 1967, in Ottawa.

R.W. Boyle has been appointed Program General Chairman for the 1969 Special Meeting on Geochemical Exploration of the Canadian Institute of Mining and Metallurgy.

#### Membership on Committees

E.M. Cameron is convenor for the Geochemical Sessions of the XIII Colloquium Spectroscopicum Internationale.

K.L. Currie acted as secretary of the Branch isotope committee; acted on the executive committee of the M.A.C. and was chairman of the Geochemical Discussion Group in Ottawa.

R.E. Horton served as a member of the exhibits committee for the XIII International Spectroscopy Colloquium.

C.C. Durham served as a member of the exhibits committee of the International Spectroscopy Colloquium sponsored by the Canadian Association of Applied Spectroscopy.

J.J. Lynch served on both the Mines Branch and Geological Survey of Canada Technician Appraisal boards.

#### Personnel Notes

C.F. Gleeson resigned from the section in February to take up employment in geochemical exploration with Société Québécoise d'exploration Minière.

G. Mihailov resigned from the section in September to take up employment with the Department of Trade and Commerce.

Mrs. Alice Leech spent the winter months with the section working mainly on Operation Bathurst and on the Geochemical Prospecting Symposium.

Miss Susan Withers joined the section in June as a technician in the colorimetric trace elements laboratory.

Mr. A.Y. Smith joined the section in September after having served two years on an External Aid team in Uganda.

Miss Lily Usik joined the section in December as a geobotanist.

During the year the section was pleased to assist in the training of a number of geologists and geochemists on the Colombo Plan and from other geological institutions. These included A.S. Dass, Geological Survey of India; R. Darbar, Geological Survey of Uganda; and Mun Kit Lee, Malaya.

#### Outside Publications

Cameron, E.M.

1966: Evaluation of sampling and analytical methods for the Regional Geochemical study of a subsurface carbonate formation. J. Sed. Petrol. vol. 36, pp. 755-763.

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

1966: Relationships between geology and geophysical parameters of a magnetite iron-formation; Can. Inst. Mining Met. Bull. February, pp. 154-158.

Sangster, D.F.

1966: Review of R.M. Garrels and C. Christo's book "Solutions, minerals, and equilibria". Ana. Chem., March 1966.

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Trace Element Laboratory Report

J.J. Lynch

Table I. Summary of Analyses Completed in Colorimetric Trace Element Laboratory in 1966 (J.J. Lynch in charge)

A) Field - Cobalt, Ontario				
Field Geologist	Type of Samples	Metals Analyzed	No. of Samples	No. of Analyses
R.W. Boyle	Soil	Zn, Cu, Pb, As, Sb, Mo, W, Hg	270	2208
R.W. Boyle	Soil	Zn, Cu, Pb, As, Sb, Mo, Hg	100	700
R.W. Boyle	Soil	Zn, Cu, Pb, As, Sb, Hg	745	4528
R.W. Boyle	Sediment	Zn, Cu, Pb, As, Sb	47	247
R.W. Boyle	Rocks	Zn, Cu, Pb, As, Sb, Mo, W, Hg	185	1480
R.W. Boyle	Rocks	Zn, Cu, Pb, As, Sb, Mo, Hg	1056	7640
Totals			2403	16,803

B) Ottawa

Field Geologist	Project or Area	Type of Samples	Metals Analyzed	No. of Samples	No. of Analyses
C.F. Gleeson	Keno	Sediment	Pb	20	40
K.L. Currie	O.P. 265	Water	Na, K, Al, SiO <sub>2</sub> , pH, alkalinity	12	132
E. Hornbrook	Biogeochem. studies	Soil	Zn, Cu, Pb, Ni	99	396
R.W. Boyle	Walton, N.S.	Soil Rock	Zn, Cu, Pb, As, Sb, Ni, Co, Mo, W	54	380
C.F. Gleeson	Cobalt (Preliminary)	Rocks, Soils Sediment	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W, Hg	135	1407

Table I (cont'd.)

B) Ottawa

Field Geologist	Project or Area	Type of Samples	Metals Analyzed	No. of Samples	No. of Analyses
R.W. Boyle	Walton, N.S.	Minerals	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	4	56
R.W. Boyle	Walton, N.S.	Coal, Soil, Rock, Minerals	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	18	179
C.F. Gleeson	Keno	Sediment	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	16	144
H.A. Lee	Kirkland L.	Soil, Mineral	Ni	36	72
C.F. Gleeson	Keno	Mineral	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	2	18
C.F. Gleeson	Soquem	Sediment	Mo, W	58	116
T.N. Irvine	66-41	Rocks	Zn, Cu, Pb	8	48
J.A.C. Fortescue	Texas Gulf Sulphur Co. Ltd. prop- erty	Soils	Zn, Cu, Pb, Ni	252	1008
R.W. Boyle	Bathurst	Sediment	Zn, Cu, Pb	48	720
D.C. Findlay	Flin Flon Deep Bore Hole	Rock	Zn, Cu, Pb, Ni	44	308
W.D. McCartney	65-48	Mineral	Zn, Cu, Pb, Ni, Co	45	225
C.F. Gleeson	Keno	Rock	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	408	4122
W.D. McCartney		Mineral	Zn, Cu, Pb, Ni, Co	35	175
J.A.C. Fortescue	B.C. & Y.T. Mineral Dep.	Soil	Zn, Cu, Pb, Ni,	82	328
J.A.C. Fortescue	B.C. & Y.T. Mineral Dep.	Soil, Rock	Zn, Cu, Pb, Ni, Mo	77	404

Table I (cont'd.)

B), Ottawa

Field Geologist	Project or Area	Type of Samples	Metals Analyzed	No. of Samples	No. of Analyses
D.F. Sangster	65-56	Mineral	Pb, Ni	139	179
R.W. Boyle	Wallaceburg	Soil	Zn, Cu, Pb, Ni	9	90
D. Hornbrook	Biogeochem. Studies	Plant Ash	Zn, Cu, Pb, Ni	574	2329
R.W. Boyle	N.B.	Soil	Zn, Cu, Pb, Ni, Co, As, Sb, Mo, W	48	926
E.M. Cameron	Rock Standards	Rock	Mn	14	28
K.L. Currie	O.P. 46	Rock	Zn, Cu, Pb, Ni, Co, As, Sb	69	483
R.W. Boyle	Cobalt	Water	Zn, Cu, Pb, Ni, Co, As, Sb, Ag, Cd, Mn, Fe	80	1129
J.D. Ives	Geographical Branch	Soil	Zn, Cu, Pb, As, Sb, Mo, W	38	268
R.W. Boyle	Cobalt	Rock	Zn, Cu, Pb, As, Sb, Mo,	16	100
T.N. Irvine	57-28	Rock	Zn, Cu, Pb	74	222
Total				2514	16,032

C) Analyses performed by  
Anna Rozkowska

P. Meyboom	62-29	Soil Extract	Ca, Mg, Na, K, SO <sub>4</sub> , HCO <sub>3</sub> , Cl	72	424
Total				72	424
Grand Total				4989	33,259

Table II. Summary of Analyses Completed in Mobile Spectrographic Laboratory in 1966

(C.C. Durham in charge)

A) Field

Field Geologist	Project or Area	Type of Sample	Metals Analyzed	No. of Samples	No. of Analyses
R.W. Boyle	Cobalt	Soil	Mn, Bi, Cu, Ag, Ni, Co	737	4614
R.W. Boyle	Cobalt	Soil	Mn, Bi, Cu, Ag, Ni, Co, Pb	376	2800
R.W. Boyle	Cobalt	Sediment	Mn, Bi, Cu, Ag, Ni, Co	47	282
R.W. Boyle	Cobalt-	Rock	Mn, Bi, Cu, Ag, Ni, Co, Pb	1143	8001
R.W. Boyle	Cobalt	Rock	Mn, Bi, Cu, Ag, Ni, Co, Zn, Pb	98	784
R.W. Boyle	Cobalt	Rock and Mineral	Qualitative Analyses	12	120
Total				2413	16,601

B) Ottawa

C.F. Gleeson	Cobalt Prelim Sur.	Rock, Soil Sediment	Be, B, Ti, V, Cr, Mn, Sr, Zr, Ag, Sn, Ba, Au, Bi, Cd, Zn, Cu, Pb, Ni, Co, Mo	135	2740
C.F. Gleeson	Keno	Sediment	B, Mn, Mo, Sn, Cu, Ag, Ni, Co, Bi, Au	16	160
R.W. Boyle	Cobalt	Rock	Mn, Bi, Cu, Ag, Ni, Co	14	84



Table II (cont'd.)

B) Ottawa

Field Geologist	Project or Area	Type of Sample	Metals Analyzed	No. of Samples	No. of Analyses
R.W. Boyle	Cobalt	Rock	Mn, Bi, Cu, Ag, Ni, Co, Mo, Pb, As, W	2	20
R.W. Boyle	Bathurst	Mineral	B, Pt, Au, Mn, Pb, Sb, W, Ni, Bi, Be, Ti, Mo, Sn, V, Nb, Cd, Zr, Cu, Ag, Zn, La, Co, Ce, Cr, U, Ba, Sr	359	9693
K.L. Currie	O.P. 46	Rock	B, Mn, Be, Ti, V, Zr, Cu, Ni, Co, Ba, Cr	76	836
R.W. Boyle	Wallaceburg	Soil	B, Mn, Pb, Ti, V, Cu, Zr, Ni, Cr, Ba, Sr, Bi, Be, Sn, Nb, Ag, Co, Ga, Sc, Y	9	180
J.D. Ives	Geographical Branch	Soil	B, Bi, Mo, Sn, V, Zr, Cu, Ag, Ni, Co, Cr, Ba, Sr	38	520
C.F. Gleeson	Keno	Sediment	Mn, Ag, Cu, Ni	14	56
J.A.C. Fortescue	Standards	Sand	Ba, Be, B, Ge, Pb, Ti, V, Cr, Mn, Bi, Co, Ni, Cu, Zr, Mo, Ag, Sn, Sr	1	270
W. Tupper	Rock Stds.	Rock	Ba, B, Pb, Mn, Be, As, Ti, Sn, V, Zr, Cu, Ag, Zn, Ni, Co, Sr, Cr	19	1615
R.W. Boyle	Cobalt	Rock	As	60	60
R.W. Boyle	Cobalt	Mineral	Qualitative Analyses	1	27
Total				744	16,261

Table III. Summary of Samples Prepared in Geochemistry  
Preparation Laboratory, 1966  
(P. Lavergne in charge).

A) Field

Field Geologist	Area or Project	Crushing	Grinding	Sizing	Superpanner	Frantz	Ball Mill	Heavy Liquid	Hand Picking
R.W. Boyle	Cobalt	1294	1703	802			2449		
E.M. Cameron		1473	1473				1473		
D.F. Sangster	65-56	125	125		150	100	78	75	
J.A.C. Fortescue	O.P. 487	30	30	30			108		20
J.D. Ives	Geograph. Br.						38		
R.W. Boyle		250	250	250		65	300		50
C.F. Gleeson	Cobalt (Prelim)	140	140				278		
Others		40	40				70	50	
Total		2058	2058	280	150	165	2345	125	70
Grand Total		3352	3761	1082	150	165	4794	125	70

Table IV. Summary of Analyses from  
Direct Reading Spectrochemistry Laboratory

E.M. Cameron and R.E. Horton

Field Geologist	Project or Area	Type of Sample	Metals Analyzed	No. of Samples	No. of Determ.
Chisholm (Boyle)	Bathurst	Rock	Mn, Mg, Ca, Al, Si, Fe, Ti	12	84
E.M. Cameron	Geochem. of Limestone	Rock	Mn, Mg, Ca, Al, Si, Fe, Ti, Sr, Ba	1794	16,146
Y.O. Fortier for J.D. Ives	Geographical Branch	Soil and Sed.	Mn, Mg, Ca, Al, Si, Fe, Ti, Na	38	304
J.J. Lynch		Rock	Mn, Mg, Ca, Al, Si, Fe, Ti	19	133
D.K. Norris	Crows Nest Volcanics	Rock	Na	37	37
R. Martin	Bathurst	Rock	Mn, Mg, Ca, Al, Si, Fe, Ti	29	203
D.F. Sangster	Geochem. of lead and zinc deposits	Rock	Mn, Mg, Ca, Al, Si, Fe, Ti, Sr, Ba, Zn	182	1820
M. Shafiqullah	Geochem. Reconn. of Can. Craters	Rock	Mn, Mg, Ca, Al, Si, Fe, Ti	62	434
Total				2173	19,161

Table V. Summary of Processing and Spectrochemical Analysis of soil and plant samples by the Movable Biogeochemical Laboratory Unit in 1966

E.H.W. Hornbrook and J.A.C. Fortescue (in charge)

Project	Material	No. of samples Analyzed	No. of Determ. Elements
Silvermine Pilot Project	Plant	360	4680
	Humus	45	585
	Mineral Soil	100 <sup>+</sup>	13*
Petawawa Special Project	Plant	120	1560
	Humus	15 <sup>+</sup>	13*
	Mineral Soil	50 <sup>+</sup>	
Terra Nova (Pecan Property) Quick Project	Plant	240 <sup>+</sup>	
	Humus	30 <sup>+</sup>	
	Mineral Soil	100 <sup>+</sup>	
Three visits in British Columbia	Plant (Herbarium samples)	300	
	Humus	45 <sup>+</sup>	
	Mineral Soil	90 <sup>+</sup>	
	Rock (drill cuttings)	15 <sup>+</sup>	
Three visits in Yukon	Plant (Herbarium samples)	300	
	Plant	150 <sup>+</sup>	
	Humus	45 <sup>+</sup>	
	Ash layer	40 <sup>+</sup>	
	Mineral soil	45 <sup>+</sup>	
Total		2090	6825 **

Notes \*Thirteen elements determined in each sample (Zn, Mn, Cu, Mo, Ba, Sr, Ti, Pb, Ni, Co, Cr, and Ag) and a small amount of In as reference standard.

\*\*This number includes 7 per cent reference standard determinations

+Samples collected and processed but not analyzed by biogeochemical spectrograph.

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

<u>Laboratory</u>	<u>Seasonal Personnel</u>
Trace Element (Ottawa)	D. Ackroyd (Miss)
Trace Element (Ottawa)	P. Kelly
Trace Element (Ottawa)	G. MacGillivray
Trace Element (Ottawa)	L. Morisset (Miss)
Trace Element (Ottawa)	B. Nunn
Trace Element (Field)	L. Akister (Miss)
Trace Element (Field)	D. Vézina (Miss)
Trace Element (Field)	T. Walsh
Mobile Spectrograph (Field)	G. Rankin (Miss)
Sample Preparation	A. Potworowski
Quantograph	R. Fletcher (Miss)
Quantograph	E. Lewicki (Miss)
Quantograph	C. Marquardt (Miss)
Quantograph	C. Meeds

## ENGINEERING GEOLOGY

J.S. Scott

In April 1966 groundwater personnel of the former Engineering Geology Section left the Geological Survey to join the newly formed Inland Waters Branch. Engineering geologists E.B. Owen and J.S. Scott of the former section remained with the Geological Survey of Canada to form the nucleus of an Engineering Geology Section.

Responsibilities of this section consist of research on the aspects of geology that affect the engineering behaviour of geological materials and geological investigations of specific engineering sites or problems in response to requests from other Government agencies.

Most of the projects undertaken were directed either toward the solution of specific engineering problems or in answer to requests for information by various government agencies. Several projects required substantial field activity while others were completed on the basis of existing information.

A program of engineering geological mapping was started in the Welland Canal area to complement engineering geological information required by the St. Lawrence Seaway Authority.

Further field trials of a transducer piezometer equipped for continuous recording were carried out in Saskatchewan and Prince Edward Island to assess the responsibility of the instrument under a variety of hydrogeological conditions.

Artesian flow from a bore hole in the Vernon area, B.C. was successfully controlled through the installation of 150 feet of 30 inch casing and the consolidation of surrounding surficial materials with portland cement grout.

### Summary of Field and Office Activities

E.B. Owen, at the request of the Water Resources Branch, Department of Energy, Mines and Resources, mapped the geology at three potential dam-sites in the Yukon River drainage basin and at one site in the Pacific Coast drainage area. About one third of Mr. Owen's field season was spent in consultation with the Northern Canada Power Commission regarding potential hydroelectric power sources near Ross River, Y.T. and with the St. Lawrence Seaway Authority regarding subsurface investigations required for the Welland Canal project. He also began a program of engineering geological mapping in the Welland Canal area at a scale of 1:25,000. He



also spent considerable time replying to requests for engineering geology and groundwater information from individuals, consultants and government agencies and prepared a paper on the history of the growth and development of groundwater and engineering geology studies in the Geological Survey for Professor M. Zaslow, official Survey historian.

J. S. Scott continued field trials of a transducer piezometer equipped for continuous recording. The results of these trials will be presented in an outside paper. Dr. Scott, in conjunction with a grouting consultant, spent considerable time in the preparation of a flow control program for an artesian well near Vernon, B. C. and in the field supervision of the flow control project. He continued to provide advice and assistance on the groundwater aspects of the Red River Floodway. He also provided advice to the Defence Research Board, Suffield Experimental Station, on the possible use of transducer piezometers in monitoring blast-generated porewater pressures.

#### Membership on Committees

- |                    |  |
|--------------------|--|
| <u>J. S. Scott</u> | <ul style="list-style-type: none"><li>- Member, N. R. C. Associate Committee on Geotechnical Research.</li><li>- Chairman, Till Characterization Committee (<u>ad hoc</u>) of the Subcommittee on Pleistocene Geology, National Advisory Committee on Research in the Geological Sciences.</li><li>- Chairman, Ottawa Geotechnical Group</li><li>- Associate editor, Canadian Geotechnical Journal</li></ul> |
|--------------------|--|

#### Attendance at Meetings

- |                    |   |
|--------------------|---|
| <u>E. B. Owen</u>  | <ul style="list-style-type: none"><li>- Conference on Economic Geology in Massachusetts, Amherst, Mass.</li></ul>   |
| <u>J. S. Scott</u> | <ul style="list-style-type: none"><li>- Conference on Economic Geology in Massachusetts, Amherst, Mass.</li><li>- N. R. C. Research Seminar on Swelling Soils, Saskatoon, Sask.</li><li>- Geological Society of America, Annual Meeting, San Francisco.</li></ul> <p>41st meeting of the Associate Committee on Geotechnical research of the National Research Council, March 1967.</p> |

### Outside Papers Submitted

- J.S. Scott - A Transducer Piezometer for Clay Shales (with E. W. Brooker, and P. Ali, University of Alberta), Geotechnique.

### Internal Reports

- E.B. Owen - Report on a potential rock slide area at Pine Tree Lookout, Gatineau Parkway (for N.C.C.).
- J.S. Scott - Report on Research Seminar on Swelling Soils.  
- Report on Geological Society of America Annual Meeting.

### Topical Reports

- E.B. Owen - No. 112 - Conference on Economic Geology in Massachusetts (with J.S. Scott)  
No. 113 - Detour Dam Site, Pelly River, Yukon Territory  
No. 114 - Granite Canyon Dam Site, Pelly River, Yukon Territory  
No. 117 - Lower Seaplane Dam Site, Flat River, N.W.T.  
No. 118 - Upper Seaplane Dam Site, Flat River, N.W.T.  
No. 119 - Caribou Dam Site, Flat River, N.W.T.  
No. 120 - Lower Direction Dam Site, Flat River, N.W.T.  
No. 121 - Upper Direction Dam Site, Flat River, N.W.T.
- J.S. Scott - No. 112 - Conference on Economic Geology in Massachusetts (with E.B. Owen)

## PLEISTOCENE GEOLOGY SECTION

J.G. Fyles

During 1966, the Pleistocene Section continued geological investigations of Quaternary stratigraphy, sedimentology, and geomorphology throughout Canada. These investigations are concerned with unconsolidated (surficial) deposits and associated organic remains, constructional and erosional landforms, and geological processes of the present as well as the past.

Projects of an areal nature, designed to provide knowledge of deposits, geomorphology, and Quaternary history, constitute the major part of the program of the section. Projects of this type provide data applicable in a number of fields, and several current projects are designed

specifically to meet requests for information for forestry, agriculture, land inventory (ARDA), groundwater, and engineering agencies. Other projects are topical (as opposed to areal) and deal with such subjects as glacial mineral exploration techniques; relative movement of land and sea and land uplift; recent climate change; problems of Quaternary chronology or environment; processes of mass wasting, sedimentation, etc.

Field projects were undertaken during the year by fifteen officers of the section, two professors, and two Ph.D. candidates in eight provinces, Yukon, and Northwest Territories. A third Ph.D. project was carried out by a sub-party, and three additional professors were engaged as consultants in the field. Accounts of objectives and results of field projects are given in Geological Survey of Canada Paper 67-1. Seismic surveys in support of Pleistocene projects were carried out by the Geophysics Division of the Geological Survey of Canada. Logistic support in specific field areas was provided by the Marine Sciences Branch (Lake Ontario) and the Polar Continental Shelf Project (Melville Island) of the Department of Energy Mines and Resources.

Investigations supporting 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 of Canada. 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.

Developments of particular interest during the year include (1) completion of the new Glacial Map of Canada and text on the Quaternary of Canada by V. K. Prest; (2) initiation of dendrochronological investigations, on an experimental basis, as an outgrowth of the program on Quaternary palynology; and (3) expansion of sedimentological investigations including projects in Upper Arrow Lake and in Lake Ontario (cooperatively with Water Research Branch), study of structure of varved sediments by post-doctoral fellow I. Banerjee; and establishment of the Great Lakes "Limnogeology Unit" of the Water Research Branch.

#### Field and Office Activities

I. Banerjee lecturer in geology of Calcutta University joined us as a N.R.C. Post-Doctorate Fellow in September. He is investigating sedimentary structures of varved clays and is comparing Pleistocene varves with varvites that he has investigated in India. Banerjee spent a week studying varved deposits in the Cochrane area of northern Ontario with O. L. Hughes and has visited varve localities in the Ottawa and Kingston areas with N. R. Gadd and E. P. Henderson.

W. Blake, Jr. was on educational leave for three months during the summer to join the Stockholm University Svalbard Expedition, 1966. Participation in this international expedition, with other members from Sweden, Finland, the U.S.S.R., and Switzerland, gave Blake a chance to continue his work, begun in 1957-1958, on raised beaches and glacial history in the north-eastern part of the Spitsbergen archipelago. A preliminary report on the end moraines and deglaciation chronology of southern Baffin Island ("Operation Amadjuak") was prepared and published during 1966. Blake also shared in the preparation of "Geological Survey of Canada Radiocarbon Dates VII". In December two days were spent at the Dartmouth College Museum, Hanover, New Hampshire, studying low level air photographs of the east side of Hudson Bay. The photographs, taken with panchromatic, infra-red, colour, and camouflage-detection films in an attempt to detect archaeological sites (Prof. Elmer Harp, Jr. will carry out field work in the area in 1967), were examined to determine their relative value for Pleistocene Geology.

B.G. Craig is preparing for a reconnaissance study in 1967 of the Quaternary geology of the Hudson Bay Lowland as part of "Operation Winisk". During the 1966 field season he took part in a trip through the lowlands, made a brief study of raised marine features at Churchill, Manitoba, and accompanied J.G. Fyles on a reconnaissance of eskers in the Dubawnt-Thelon area west of Hudson Bay. Craig is preparing a memoir on the surficial geology of northwest Baffin Island. During the summer he served as acting section head; throughout the year he assisted with a variety of official correspondence and critically read several manuscripts.

A. Dreimanis of the Department of Geology, University of Western Ontario spent a few days in the field as a consultant with each of the following: R.J. Fulton, C.F.M. Lewis, E.P. Henderson, B.C. McDonald and J. Terasmae. These visits provided a valuable interchange of ideas.

R.J. Fulton continued investigations of Quaternary geology in the Columbia River valley in areas to be affected by the Columbia Treaty dams. Much of the work this year was concentrated on the Duncan Dam area (head of Kootenay Lake). M.J. Pullen, a graduate student, completed field work for a study of sedimentation at the head of Upper Arrow Lake and G.W. Smith began a Ph.D. thesis project in the Mable Lake-Shuswap River area to tie Quaternary studies in the Columbia to Fulton's earlier work to the west. Seismic investigation of drift thickness in valleys in the southern interior of British Columbia has been undertaken through the Geophysics Division in support of Fulton's program. Fulton has continued petrographic investigation of volcanic ash samples from the southern Cordillera, has submitted final maps of the Vernon area for publication, has completed a paper on interglacial stratigraphy at the Duncan Dam and is preparing a memoir on the Vernon and Nicola areas.

J.G. Fyles continued Quaternary stratigraphic studies in the Mackenzie Delta-Arctic coast region (N.W.T. and Yukon Territory), made a brief study of the Winter Harbour moraine, Melville Island, N.W.T., with logistic support from the Polar Continental Shelf Project, and jointly with B.G. Craig carried out a preliminary reconnaissance of eskers in the Dubawnt-Thelon area west of Hudson Bay. En route from the field he visited D.A. St-Onge in the Whitecourt area, the Research Council of Alberta and the Alberta Department of Lands and Forests in Edmonton, and spent several days in the Calgary office. Fyles also carried out section administrative duties, organized the radiocarbon dating program, took part in preparation of Geological Survey of Canada Radiocarbon Dates VI, assisted in organization of the Great Lakes "Limnogeology Unit" of the Water Research Branch, and was involved in the establishment of a new N.R.C. Associate Committee on Quaternary Research.

N.R. Gadd has completed the selection and editing of parts of an unpublished memoir manuscript by J.W. Goldthwait for inclusion as an appendix in his memoir on the St. Lawrence Valley, and is preparing a memoir on the surficial geology of the Ottawa area. During the year he critically read three manuscripts, and spent considerable time on his duties as a member of the department Equipment Committee.

D.R. Grant began a Ph.D. project dealing with coastal submergence in Nova Scotia and Prince Edward Island under the supervision of V.K. Prest.

E.P. Henderson continued investigation of surficial geology in the Gananoque-Brockville area, Ontario. His map of the surficial geology of Gananoque-Wolfe Island was published during the year as Map 13-1965. He has submitted a map on the Westport area and a memoir on the surficial geology of the Avalon Peninsula, Newfoundland.

O.L. Hughes continued investigation of the limits of successive glaciations and other aspects of Quaternary geology in the southwest Yukon, in 1966 concentrating on the Aishihik Lake map-area. In addition, he supervised the Ph.D. thesis project of V. Rampton in the Snag area, and made brief investigations of stratigraphic sections, mass wasting phenomena, and Quaternary vertebrate sites (with R. Harington, National Museum of Canada), in central Yukon. Hughes also made a brief examination of an archaeological site at Fisherman Lake, near Fort Liard, N.W.T. In September he visited Ottawa and spent a week in the Cochrane area of northern Ontario to familiarize post-doctorate fellow Dr. I. Banerjee with the varved clays of that area. At the beginning of 1966, Hughes visited the Vancouver office to confer with officers of the Cordilleran Section regarding the Glacial Map of the Yukon, which has been virtually completed during the year.

Hughes leads the three-man Pleistocene group in the Calgary office and is involved in official correspondence and program planning in this connection. He has also critically read several manuscripts.



P. F. Karrow of the Department of Earth Sciences, University of Waterloo, continued study and mapping of the surficial geology of the Stratford-Conestogo area of southern Ontario. This work will provide background data for detailed soils mapping of Waterloo County. He was also associated with J. Terasmae in connection with stratigraphic drilling of interglacial deposits at Woodbridge, southern Ontario.

R. W. Klassen continued investigations of the Quaternary history of the Assiniboine River valley and its tributaries in Manitoba and Saskatchewan. The side-wall sampler, which was built for the Geological Survey of Canada (Geophysics Division) this year by the Saskatchewan Research Council, provided valuable stratigraphic information in conjunction with drilling undertaken for this project. Klassen submitted a preliminary map and report on the Waterhen-Grandrapids area, in connection with a study of the Manitoba Interlake area undertaken at the request of ARDA, and also completed a paper on interglacial stratigraphy and palaeontology on the Roaring River, Manitoba (jointly with D. Delorme and R. J. Mott). Klassen is attached to the Calgary office.

S. F. Leaming of the Vancouver office commenced an inventory of surficial deposits and landforms in the Prince George area, British Columbia, to meet a request from the British Columbia ARDA Committee. This work is under the supervision of J. E. Armstrong.

H. A. Lee continued investigation of glacial mineral exploration techniques, concentrating this year on distribution of mineral indicators in an esker in the Kirkland Lake district, Ontario. He completed a report on the Quaternary history of the Hudson Bay region for the centennial volume on Hudson Bay. He also prepared a note on the "Tyrrell Sea" for inclusion in the Reinhold Encyclopedia of Earth Sciences. During the latter part of 1966 he was occupied full-time with a French course.

Captain J. LeMenestrel of the Scientific and Technical Unit of the French Military Service was associated with the Geological Survey of Canada during the early part of the year and completed a geomorphological map of Blackburn, Ontario and Quebec, covering the eastern part of Ottawa. This map was displayed at the I. G. U. Commission on Slopes, Fluvial Dynamics, and Applied Geomorphology at Liège-Louvain, Belgium.

C. F. M. Lewis continued study of tilt and lake level change during the last few thousand years in the northern part of the Lake Huron basin. Throughout the year, he has been concerned with planning geological aspects of the Departmental Great Lakes program. To gain a preliminary appraisal of sediments and sedimentation in Lake Ontario he set up a ship-board bottom-sampling program throughout the lake. Collection and analysis of the samples has been carried out jointly by Lewis and by N. Rukavina of the Water Research Branch. The sediment program has been complemented by a Sparker survey organized by the Geophysics Division. During the



field season R. McNeely carried out a study of chemical properties of organic sediments in small lakes, in conjunction with the programs of Lewis and Terasmae. Following the field season, Lewis became responsible for supervision of the Sedimentology Laboratory.

B. C. McDonald completed his doctorate at Yale University and joined the staff of the Geological Survey of Canada before the summer. As a sequel to his Ph.D. thesis project in the Richmond-Sherbrooke area, Quebec, he commenced a new areal study of deglaciation and Quaternary geology in the adjoining area to the east. This project includes detailed mapping of the Eaton River basin to meet a request of the Quebec Department of Natural Resources in connection with the International Hydrological Decade. A short paper by McDonald on auriferous till in the eastern townships has been published in Paper 66-2, and preliminary maps illustrating his investigations on the Richmond-Sherbrooke area have been published as Geological Survey of Canada maps 4-1966 and 5-1966.

R. J. Mott completed field work involved in a palynological program in Saskatchewan designed to provide information on late-glacial and post-glacial vegetation and climate change. He also continued his varied duties in the palynology laboratory and in support of the research programs of J. Terasmae. During the year he completed a paper on palynological sampling and coring techniques and coauthored (with R. W. Klassen and D. Delorme) a paper on stratigraphy and palaeontology of interglacial deposits at Roaring River, Manitoba.

V. K. Prest continued preparation of the new Glacial Map of Canada and the account of the Quaternary geology of Canada for "Geology and Economic Minerals of Canada". With the assistance of D. R. Grant, he completed the Glacial map of Canada before the summer and cartographic work on the map was commenced at that time. The text on Quaternary geology of Canada approached its final form at the end of the year. As an outgrowth of the above-mentioned projects, Prest prepared a series of sketches of ice-frontal positions and glacial lakes in the Great Lakes area which are being produced by the National Film Board for the Ontario High School Projectual Series. He also prepared a series of maps showing stages of glacial retreat for inclusion in the National Film Board film on the Geological Survey of Canada. During a short period in the field, he supervised the Ph.D. thesis work of D. R. Grant in Nova Scotia, conferred with D. Benson on Quaternary geology in the Meregonish area, Nova Scotia, and made localized investigations in various parts of the Maritime Provinces relative to his regional compilation.

V. Rampton continued investigation of Quaternary Geology in the Snag area, Yukon Territory, involving a transect from the present glacier terminus to the all-time limit of glaciation. This study, under the supervision of O. L. Hughes is part of Hughes' overall project in the southwest Yukon and will be used by Rampton for a Ph.D. thesis at the University of Minnesota.

S. H. Richard came to the Geological Survey of Canada by transfer during the summer. His principal task, to date, has been airphoto interpretation of glacial land forms of the Hudson Bay lowland in preparation for Operation Winisk.

N. W. Rutter, who joined the Geological Survey of Canada at Calgary late in 1965, commenced a reconnaissance Quaternary geology study of the Peace, Parsnip, and Finlay Valleys, British Columbia. (Peace River Dam and Reservoir area.) The project, which has been timed to salvage information in advance of flooding, also deals with Tertiary deposits in the Rocky Mountain Trench. Rutter also continued glacial geology studies along the Bow River Valley, Alberta, between Banff and Calgary as a sequel to investigations under the auspices of the Department of Forestry. In the early part of the year Rutter spent two weeks in Ottawa on preliminary planning and airphoto interpretation for the Peace River project and also visited Vancouver and Victoria in the same connection. He is preparing a revised draft of his doctoral thesis on the glacial geology of the Banff area for publication by the Geological Survey of Canada. At the end of November, Rutter took part in a workshop at Pullman, Washington on Tephrochronology, dealing with techniques for identification and correlation of volcanic ash.

D. A. St-Onge continued investigation of surficial deposits and geomorphology in the Iosegun area, Alberta, and extended this study eastward into the Whitecourt area. These projects have been undertaken to meet a request of the Alberta Department of Lands and Forests. As part of the Whitecourt project, a geomorphological map is being prepared of an area in the Swan Hills. During the Spring, St-Onge carried out airphoto interpretation studies of part of the Dubawnt-Thelon area west of Hudson Bay in preparation for a field study of eskers (see under J. G. Fyles). He has submitted a preliminary map of the Iosegun area, Alberta, for publication by the Geological Survey of Canada, a note on geomorphological maps for the Reinhold Encyclopedia of Earth Sciences, and a report on the Cypress Hills to be published by the University of Liège.

A. M. Stalker, in conjunction with C. S. Churcher, Department of Zoology, University of Toronto, continued investigation of Quaternary stratigraphy and vertebrate faunas of selected sites in southern Alberta and Saskatchewan and particularly in the Medicine Hat area. J. C. Ritchie of Trent University serves as palaeobotanical consultant in connection with the deposits of Medicine Hat. In addition, Stalker supervised students in detailed stratigraphic analysis of post-glacial deposits at the McLeod Buffalo Jump archaeological site, in cooperation with the Glenbow Foundation. During the year, he completed a major memoir on the Drumheller area, Alberta and is preparing papers on the surficial geology of the Kananaskis Forestry Station, Alberta, and on Saskatchewan gravels and sands. Papers in joint preparation with C. S. Churcher deal with the Bow River terraces at Cochrane, Alberta, and mid-Wisconsin early man at Medicine Hat.

## 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, A. A. Berti and M. Ouellet during the summer season. Reports were prepared on materials submitted for analysis and identification by officers of the Geological Survey of Canada, and upon requests from other scientific organizations. The laboratory continued to provide technical assistance as well as introductory training in palynology and paleoecology on a short-term basis for several geology and botany students from the universities.

### Research Activities

Terasmae and Mott collected samples for palynological studies and radiocarbon dating in connection with various programs of the Geological Survey of Canada. Of particular note, bottom sediments from ten lakes were cored for geochronological studies in the North Bay and Kingston areas, Ontario, in support of G. S. C. mapping projects by C. F. M. Lewis and E. P. Henderson.

A study of modern pollen deposition in relation to present vegetation was continued in south-central interior British Columbia, and in northern Saskatchewan.

Terasmae continued investigation of post-glacial climatic trends in the Great Lakes region by means of ecological-sedimentological-palynological studies of bog, pond and lake deposits.

Stratigraphic drilling of deposits occupying the buried St. David's Gorge at Niagara Falls, Ontario, was completed in the spring of 1966. Plant-bearing beds were cored beneath glacial deposits in the gorge.

A similar drilling project was completed at Woodbridge, Ontario, in the fall of 1966. Plant-bearing beds were cored beneath two, or possibly four glacial till layers. This drilling, furthermore, revealed unconsolidated Quaternary sediments beneath what is known to be the oldest known glacial till in the Toronto region.

In March 1966, bottom sediments in three lakes were cored through ice in the Trenton-Belleville area, Ontario, and the drilling was extended into the underlying glacial deposits. This project was undertaken to obtain further data on the age of the Glacial Lake Iroquois stage in the Lake Ontario basin. Preliminary results indicate the successful attainment of this objective.

A dendroclimatological study was initiated in the arid region of south-central British Columbia (Kamloops-Vernon area) with the assistance of Dr. H. C. Fritts from the laboratory of Tree-Ring Research, University of Arizona. Preliminary results have proven very encouraging and warrant an extension of this investigation.

Samples for a similar study were collected in central Yukon Territory by O. L. Hughes of the Geological Survey of Canada and further preliminary samples have been obtained from a northern tree-line location east of Great Slave Lake in the Northwest Territories. It is hoped that data from this study can be related to and correlated with available weather records and will then provide a climate-chronological sequence extending several hundred years before the present.

### Sedimentology Laboratory

Analyses of a wide range of samples of unconsolidated materials was carried out in this laboratory by D. E. Field (in charge) and R. G. Kelly, assisted during the summer by two students. The work load facing the laboratory has increased considerably through the requirements for grain-size analyses for sedimentological projects in Upper Arrow Lake and Lake Ontario. The analyses completed during the year are tabulated below.

P. F. Karrow	102	2	239	102	
R. J. Fulton	281	2			
D. A. St-Onge	24	1			
A. Rozkowski	20				
R. O. van Everdingen	6				
R. A. Freeze	16				
B. C. McDonald	12			50	46
J. S. Scott		3			
<hr/>					
<u>Totals</u>					
Winter	307	4	188	101	46
Summer	154	2	51	51	
<hr/>					
1966 Total	461	6	239	152	46
1965 Total	182	65	113	52	-

Following the field season, direction of the laboratory was taken over by C. F. M. Lewis. He is currently reviewing the laboratory procedures in terms of the following:

1. Comparison of pipette and hydrometer methods of size analysis.
2. Adoption of hydrometer method of size analyses for some routine work.
3. Development of computer programs for size analysis in order to: reduce observational data to coordinates of cumulative size distribution curves; interpolate these coordinates where necessary; compute various statistical parameters; and machine-plot relative and cumulative frequency curves.
4. Use of magnetic stirrer in place of conventional milk-shake mixer for dispersing suspensions of cohesive soils.
5. Computer reduction and display of calcite-dolomite analysis data.
6. Introduction of additional facility: organic-matter determination using the Walkley-Black method.

### Radiocarbon Dating Program

As in former years, samples for age determination in the Radiocarbon Dating Laboratory were selected by an informal committee. Currently the committee includes W. Blake, Jr., J.G. Fyles (Chairman), and J.A. Lowdon, together with other members of the staff as appropriate to the samples under consideration. During the year 204 age determinations were made on 168 samples applying to a wide range of Quaternary chronological problems (in addition to geochemical determinations originating within the laboratory). This total includes 11 archeological dates for the National Museum of Canada.

### Attendance at Meetings, etc.

W. Blake, Jr. contributed to a discussion on possible refugia in Pearyland, North Greenland, at one of the monthly meetings of biologists from various governmental departments in Ottawa. He gave a talk on his 1966 work in Spitsbergen at the University of Stockholm.

J.G. Fyles attended the meeting of the Canadian Association of Geographers at Sherbrooke, Quebec in May in connection with a meeting of the National Advisory Committee on Geographical Research. He also attended the Conference on Environmental studies of the Glacial Lake Agassiz Region, November 3-6 at the University of Manitoba and the A. A. A. S. symposium on the Atlantic Coastal Plain December 29-30 at Washington, D.C. In March he gave a talk on "The Last Million Years" in the National Museum evening lecture series.

N. R. Gadd conducted a field trip for Grade 11 geography classes at Brookfield High School, Ottawa during the autumn. In early May he acted on the Ph.D. examination board of B. C. McDonald at Yale University and presented a talk to Yale faculty and graduate students on "The Pattern of Deglaciation of southeast Quebec".



O. L. Hughes attended the annual meeting of the Geological Society of America in San Francisco during November where he served as a Geological Survey representative at the meeting of the American Commission on Stratigraphic Nomenclature.

R. W. Klassen attended the Pacific Northwest Pleistocene Conference in the Seattle area in September and the Conference on Environmental Studies of the Glacial Lake Agassiz Region at Winnipeg in November.

H. A. Lee attended meetings of the Canadian Institute of Mining and Metallurgy, March, 1967, Ottawa.

B. C. McDonald attended the New England Intercollegiate Geological Conference Mount Katahdin, Maine at the end of September.

V. K. Prest took part in the Geological Association of Canada Pleistocene Field trip in Western Nova Scotia in September.

S. H. Richard attended the A. C. F. A. S. meeting in November at Quebec.

N. W. Rutter attended the Pacific Northwest Pleistocene field conference in Seattle area in September and the Lake Agassiz Conference at Winnipeg in November. During October, he lead a field trip on the Surficial Geology of the Banff area for the McConnell Club (Calgary Office) and while in Ottawa during the spring he addressed the Pleistocene Discussion Group on the same subject.

D. A. St-Onge presented a paper on "La Geomorphologie Appliquée" at the May meeting of the Canadian Association of Geographers in Sherbrooke, Quebec and gave three talks at the A. C. F. A. S. meeting in November at Quebec. In June he attended the I. G. U., Commission on Slopes, Fluvial Dynamics, and Applied Geomorphology at Liège-Louvain, Belgium where he presented a paper entitled "Formes de ravins dans les regions d'Isachsen et de Lancer".

J. Terasmae attended the Ninth Conference on Great Lakes Research, Chicago, Illinois in March; gave an invited lecture at the University of Manitoba on Muskeg Research in Canada; attended meetings of the Paleobotanical Section of the Canadian Botanical Association in Vancouver took part in a workshop on dendrochronology, University of Arizona, Tucson and gave a talk on "A review of Dendroclimatological studies made in Canada and suggestions for future research"; and attended the Conference on Environmental Studies of the Glacial Lake Agassiz Region at the University of Manitoba, where he talked on "Paleoecology, a practical viewpoint". Terasmae also presented invited written contributions to the 2nd International Conference on Palynology, Utrecht (Recent Pollen Deposition in the North-eastern District of Mackenzie) and to the 11th Pacific Science Congress at Tokyo (Notes on Quaternary Paleoecological problems in the Yukon Territory and adjacent regions).



Membership on Committees

- W. Blake, Jr. - Subcommittee on Glaciers, Associate Committee on Geodesy and Geophysics, N. R. C.  
- Geological Survey Radiocarbon Dating Committee.
- B. G. Craig - Canadian Air Photo Interpretation Committee  
- Subcommittee for Pleistocene Shoreline for the American International Shoreline Commission, INQUA  
- Geological Survey Radiocarbon Dating Committee.
- J. G. Fyles - Geological Survey Radiocarbon Dating Committee  
- National Advisory Committee on Geographical Research  
- Subcommittee on Research Grants, National Advisory Committee on Geographical Research  
- National Committee on Forest Land  
- Subcommittee on Permafrost, Associate Committee on Soil and Snow Mechanics, N. R. C.  
- Associate Committee on Quaternary Research (Chairman)  
- Departmental Committee on Seismic Regionalization and Recent Crustal Movements
- N. R. Gadd - Geological Survey Equipment Committee
- O. L. Hughes - Library Committee (Calgary Office)  
- Secretary, McConnell Club (Calgary Office)
- V. K. Prest - Royal Society of Canada, Geology Membership Committee
- D. A. St-Onge - Corresponding Member, Commission on Periglacial Studies, I. G. U.  
- Corresponding Member, Subcommission on Geomorphological Mapping, I. G. U.  
- Special Committee, I. G. U., Legends for medium scale geomorphological maps.
- A. M. Stalker - Subcommittee on Quaternary Geology, National Advisory Committee on Research in the Geological Sciences.
- J. Terasmae - Subcommittee on Muskeg, Associate Committee on Soil and Snow Mechanics, N. R. C.  
- Advisory Committee on Geology, Toronto Rapid Transit Subway Extension  
- Paleobotanical Section, Canadian Botanical Association (Chairman)  
- International Working Group of Palynologists (a Committee in preparation for an international association of palynologists).

Outside Publications

Anderson, T.W., and Terasmae, J.

1966: Palynological study of bottom sediments in Georgian Bay, Lake Huron; Proc. 9th Conf on Great Lakes Research, Great Lakes Res. Div., University of Michigan, Ann Arbor, Pub. No. 15.

Dreimanis, A., Terasmae, J., and Mackenzie, G.A.

1966: The Port Talbot Interstade of Wisconsin Glaciation; Can. J. Earth Sci., vol. 3, pp. 305-325.

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

1966: Geological Survey of Canada Radiocarbon Dates V; Radiocarbon, vol. 8, pp. 97-127.

Hopkins, D.M., and Fyles, J.G.

1966: Proceedings Permafrost International Conference, Lafayette Indiana, November 1963; Moderators' Report, Geomorphology pp. 551-552.

Lewis, C.F.M., Anderson, T.W., and Berti, A.A.

1966: Geological and Palynological studies of Early Lake Erie deposits; Proc. 9th Conf. on Great Lakes Research, Great Lakes Res. Div., University of Michigan, Ann Arbor, Publ. No. 15, pp. 176-191.

Rutter, N.W.

1966: Glacial history of the Bow River Valley, Banff Area, Alberta; Scientific section, Can. Alpine J., vol. 49, pp. 157-173.

St-Onge, D.A.

1966: Geomorphology of the Lancer area, Saskatchewan, Revue Geographie Montreal, vol. 20, No. 1-2, pp. 27-45.

Terasmae, J., and Hughes, O.L.

1966: Late-Wisconsin chronology and history of Vegetation in the Ogilvie Mountains, Yukon Territory, Canada; Paleobotanist, vol. 15, No. 1-2, p. 235.

Terasmae, J., Webber, P.J., and Andrews, J.T.

1966: A study of late Quaternary plant-bearing beds in north-central Baffin Island, Canada; Arctic, vol. 19.

Tovell, W.M., Lewis, C.F.M., and Deane, R.E.

1966: Recent investigations of raised shorelines, east shore of Lake Superior and the Sault Ste. Marie area; Program Inst. of Lake Superior Geology, Michigan Tech. Univ., Sault Ste. Marie, Michigan, May 6-7.

## GEOPHYSICS DIVISION

L. W. Morley

### INTRODUCTION

In spite of many changes and organizational disruptions, the report period was a productive year for the Geophysics Division - perhaps more in terms of papers and reports completed than in terms of new projects started.

Although some valuable members resigned from the Division several vigorous and well-qualified new people joined and are now reasonably well settled. We look forward to an even more productive year for the Centennial. Although responsibility for groundwater and limnological geophysics was transferred to the new Water Research Branch, positions and staff were seconded back to the Geophysics Division for a few years until they become a viable group.

The Palaeomagnetic Section, having successfully passed through a phase of developing instruments and techniques, is now, with the aid of two additional scientists, entering a more productive phase in terms of application of the method to geology.

The Electromagnetic Section's efforts for a few years now have leaned towards the development of new instruments and methods: high frequency magneto-telluric probing; an U. L. F. resistivity probing device for Pleistocene and aquifer mapping; automation of airborne INPUT data and the patenting of a new concept in airborne e.m. mapping are portents for the future of this very important field. This section at present is limited to the development of instruments and methods.

In the Theoretical Geophysics Section, a majority of the time was spent in exploiting the methods developed over the past 3 years. Thus aeromagnetic data for large areas in the Arctic, northern Ontario and the Yukon were analysed and interpreted. Such a quantitative approach to the interpretation of regional aeromagnetic data is long overdue.

The Remote Sensing Section is starting up strongly again after Dr. Gregory's departure. Good progress has already been made in the fields of airborne gamma-ray spectrometry and experimental photogeology and airborne I. R. scanning. Much of this work like that of the E. M. and Resistivity Section is preparation for the future or relatively long-term research and development.

The Magnetic Methods Section, while making great progress in attempting to adapt the Rubidium Vapour Airborne magnetometer into a practical and economical survey instrument, has at the same time managed to obtain ocean basin data over the Labrador Sea and North Atlantic Oceans which is of great scientific interest and importance in relation to modern theories on ocean floor spreading and continental drift.

The Federal/Provincial Aeromagnetic Survey Section has continued to provide invaluable service in the inspection and correction of large numbers of aeromagnetic maps submitted by the survey companies. Specifications of improved design for several new aeromagnetic contracts were written in 1966. The qualitative interpretation of large scale regional surveys in the Western Shield and in the drift covered area of northern Ontario by the section has turned up important large scale structures which were hitherto unknown.

The Seismic Section continues to make a relatively large impact (for the size of the staff) on the geology of Canada from British Columbia to the Atlantic Continental Shelf. This work is reported in G.S.C. Report 67-1, Part A. The results of last year's important work in Hudson Bay were interpreted and submitted for publication.

#### FOREIGN AID

L. W. Morley, at the request of the Economic Commission for Africa, was sent by the Department to serve on a 3-man mission in Africa to inspect proposed sites for regional training centres and operational centres for specialized services in photogrammetry and aerogeophysics. Meetings were held with senior officials of 10 countries which offered sites and facilities. The report was tabled at the Lagos meeting of the E. C. A. in March, 1967.

#### LUNAR SAMPLE ANALYSIS PROGRAM

Dr. Larochelle and Mr. Collett are among the scientists from the United States and six other countries who have been selected as principal investigators by the U.S. National Aeronautics and Space Administration to conduct experiments on the first samples from the moon's surface to be brought back by U.S. astronauts. Dr. Larochelle, with Dr. Schwarz, will conduct thermomagnetic, magnetic susceptibility and remanent magnetism studies; Mr. Collett, with Dr. Becker, will determine the electrical conductivity of the samples.

## CHANGES IN PERSONNEL

Dr. A.G. Darnley:- joined the staff in October as head of the Remote Sensing Section. He had been Principal Geologist with the Geological Survey of Great Britain.

Mr. V.R. Slaney:- a photogeologist, joined the Remote Sensing Section in July, 1966. He was formerly with the National Coal Board of Great Britain.

Mr. D. Abbinett:- joined the Theoretical Geophysics Section as map compiler and computer.

Mr. R.M. Gagne:- joined the Seismic Section March 1, 1966. He was previously with the Cartography unit.

Mr. J. Frechette:- joined the EM and Resistivity Section in July.

Dr. D.T.A. Symons:- joined the Rock Magnetism Section in October as a paleomagnetist.

Mr. G.W. Pearce:- joined the Rock Magnetism Section in January 1967 as a paleomagnetist.

Mrs. Pauline Moyd:- joined the Division in June, as staff geologist, Assistant to the Division Chief, a new position.

Dr. B. Raychaudhuri, Mr. I. Crain and Mr. Brian Charbonneau are working as winter seasonals, Raychaudhuri and Crain in the Theoretical Geophysics Section, and Charbonneau in the Federal/Provincial Aeromagnetic Surveys Section.

Mr. W.J. Stauffer:- was transferred to the Administrative Services.

Mr. D.N. Skibo:- joined the Theoretical Geophysics Section in March 1967.

Mrs. Betty Thomas:- resigned her position as Division Secretary in March 1966 and was replaced by Mrs. N.D. Goodman.

Dr. A.F. Gregory:- resigned in July to join the staff of the Geology Department of Carleton University.

Mr. Leslie Kornik:- left in September to return to University.

Dr. E.H.S. Gaucher:- left in January 1966 to do geophysical exploration for a private company.

Mr. J.E. Wyder:- has been transferred from the G.S.C. to Inland Waters Branch.

## ATTENDANCE AT CONVENTIONS

Prospectors and Developers Association, Toronto, March 1966

A. S. MacLaren presented a paper "Aeromagnetic Study of the Churchill-Superior Boundary in Northern Manitoba".

Remote Sensing Symposium, Ann Arbor, Michigan, April, 1966

A. F. Gregory.

Institute of Lake Superior Geology, Sault Ste. Marie, Mich. May 1966

A. S. MacLaren presented a paper "The Moose River Magnetic Belt, Northern Ontario".

American Geophysical Union, Washington, D.C. August, 1966

A. Larochelle

E. J. Schwarz presented a paper "Dependence of Magnetic Properties on the Thermal History of Pyrrhotite from the Noranda District, Canada".

Joint meeting of Geological Association of Canada - Mineralogical Association of Canada, Halifax, N.S. September, 1966.

P. J. Hood presented the results of the 1962 Scotian Shelf MAD survey in a paper "Aeromagnetic Survey of the Scotian Shelf southeast of Halifax, Nova Scotia". (M. E. Bower, co-author).

Joint Alberta Society of Petroleum Geologists - Canadian Society of Exploration Geophysicists Conference on Exploration for Natural Gas in Canada, Calgary, September 1966.

G. D. Hobson presented a paper "Seismic evidence defining geology in the Gulf of St. Lawrence".

Society of Exploration Geophysicists, Houston, Texas, November 1966

P. J. Hood presented a paper "Magnetic Surveys of the Continental Shelf South of Nova Scotia" (M. E. Bower co-author).

A. Becker  
L. S. Collett  
G. D. Hobson  
B. K. Bhattacharyya  
A. Overton.



Prospectors and Developers Association, Toronto, March 1967

A. G. Darnley

Second Symposium on Air Photo Interpretation, Ottawa, March 1967

V. R. Slaney, H. Gross and L. W. Morley presented a paper:  
"Airborne Infra-red Scanning Survey along the Shore Lines  
of the Lower Great Lakes".

Canadian Institute of Mining and Metallurgy, Ottawa, March 1967

A. G. Darnley  
A. S. MacLaren  
L. W. Morley  
P. Moyd  
V. R. Slaney.

### SPECIAL TALKS

G. D. Hobson -

Canadian Society of Exploration Geophysicists (Calgary):  
"Seismic exploration in Hudson Bay".

Regina Geophysical Society:  
"Seismic exploration in Hudson Bay".

Canadian Committee on Oceanography, Ottawa:  
"Seismic exploration in Hudson Bay".

On board C. N. A. V. Sackville:  
"Marine seismic program in Gulf of St. Lawrence".

P. J. Hood -

During a recruiting tour of the Universities for the Civil Service Commission, Hood gave talks at the geological science departments of McGill (Jan. 28, 1966), Saskatchewan (Feb. 2, 1966), Manitoba (Feb. 3, 1966), Michigan (Feb. 15, 1966), and the Geophysical and Polar Research Institute at Wisconsin (Feb. 10, 1966), on recent advances in magnetic prospecting techniques. The universities of Illinois and Minnesota were also visited during the recruiting tour.

A talk entitled "Flemish Cap, Galicia Bank, and Continental Drift" was given to the GSC Appalachian Discussion Group on April 4, 1966.

A. Becker and T.R. Flint -

A paper entitled "A portable microvoltmeter for the measurement of 8 HZ telluric currents" was presented by Dr. Becker at the Electrical and Electronic Measurement and Test Instrument Conference (EEMTIC) January 9, 10 and 11, 1967, Ottawa.

B.K. Bhattacharyya -

Lectured at University of California, March 25, 1967 "Spectral analysis of geophysical data and potential theory".

A talk entitled "Semi-automatic method for treatment of aeromagnetic data with emphasis on crustal studies" was given to the Regional Geophysics Branch of the U.S.G.S. at Menlo Park, California, on March 28, 1967.

P.J. Hood, G.D. Hobson, A.F. Gregory and L.S. Collett -

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

The following lectures were presented at the Department of Geological Sciences at Ecole Polytechnique, Montreal:

<u>A. Becker:</u>	Self Potential Methods
<u>P.J. Hood:</u>	Magnetic Methods
<u>A.G. Darnley:</u>	Radioactivity and X-ray spectrometry
<u>G.D. Hobson:</u>	Seismic Methods
<u>L.W. Morley:</u>	The future of Mining Geophysics in Canada.

MEMBERSHIP ON COMMITTEES

<u>A.F. Gregory:</u>	G.S.C. Uranium Studies Committee G.S.C. Library Committee Interdepartmental Committee on Aerial Surveys (I.C.A.S.)
<u>G.D. Hobson:</u>	Member, Subcommittee on Seismology of N.R.C. Associate Committee on Geodesy and Geophysics Liaison Officer, N.R.C. Industrial Research Assistance program Representative at Large - Society of Exploration Geophysicists Chairman, Translations Committee - Canadian Centennial Conference on Mining and Groundwater Geophysics Member, Program Committee - CCCMGG

- P. J. Hood: Member, Subcommittee on Geomagnetism, N. R. C.  
Associate Committee on Geodesy and Geophysics  
Member, Subcommittee on the Upper Mantle Project,  
N. R. C. Associate Committee on Geodesy and Geophysics  
Liaison Officer, N. R. C. Industrial Research Assistance  
Member, DEMR Satellite Committee  
Member, GSC Library Committee  
Member, Advisory Council, Professional Institute  
Co-Chairman, Special Delegates Seminar CCCMGG  
Member, Program Committee CCCMGG.
- A. Larochelle: Executive of Professional Institute  
Subcommittee on Geomagnetism, N. R. C. Associate  
Committee on Geodesy and Geophysics.
- A. S. MacLaren: Member, Annual Meeting Committee, Canadian Institute  
of Mining and Metallurgy  
Member, Ottawa Branch Committee, CIMM  
Member, Centenary Committee, CIMM  
Member, GSC Exhibits Committee  
Co-chairman, Exhibits Committee, Canadian Centennial  
Conference on Mining and Groundwater Geophysics.
- L. W. Morley: Chairman, Subcommittee on Exploration Geophysics of  
the Associate Committee on Geodesy and Geophysics  
General Chairman, Canadian Centennial Conference on  
Mining and Groundwater Geophysics  
Member, Working Group on Geomagnetic Anomalies,  
International Association of Geomagnetism and  
Aeronomy  
Defence Research Board - MAD Committee.
- P. Moyd: Member, Nominating Committee, Society of Mining  
Engineers of AIME  
Member, Education Committee, Society of Mining  
Engineers  
Chairman, Distinguished Lecturer Committee,  
Industrial Minerals Division, AIME  
Secretary, Organizing Committee, CCCMGG.
- V. R. Slaney: Member, Subcommittee on Technical Requirements of  
the Interdepartmental Committee on Aerial  
Surveying.

## REPORTS OF SECTIONS

### ELECTROMAGNETIC AND RESISTIVITY SECTION

L.S. Collett

#### Functions of the Section

The function of the section is to carry out electromagnetic, resistivity and magnetotelluric surveys to aid in the mapping of surficial and bedrock formations in Canada. Current research work aims at the development of new survey methods, new measuring apparatus and interpretation techniques. The section advises other divisions of the G.S.C., N.R.C., United Nations and private companies in matters relating to electrical methods. A stock of electronic components, test instruments and an electronic technical library is maintained by the section.

#### Introduction to the year's work

The work of the section during the report period was confined to a continuing study of airborne INPUT electromagnetic mapping work that was done in 1965 and further development of the AC resistivity equipment. The results of the DC resistivity and drilling work in southeastern Saskatchewan is being analyzed and written up in a Ph.D. thesis. A good start has been made on the instrumentation in the sub-audio magnetotelluric method and some field tests were carried out. Some measurements were also made using VLF energy. An investigation was started on the non-contact method of measuring resistivity of unconsolidated samples in the laboratory. The sidewall sampler was successfully field tested this summer.

#### Report by Projects

OP 255: Electrical rock properties - Low frequency resistivity equipment:  
- R Ahrens, C. Gauvreau and L.S. Collett.

Design and construction continued during the year on AC resistivity equipment. The frequency range is from 1 to 1000 HZ. A sweeping of the frequencies has been added for the measurement of amplitude and phase of the received signals. The system will be ready for bench testing early in 1967.

OP 255: Electrical rock properties - Non-contact resistivity measurement:  
- W.J. Scott (summer student)

A preliminary study was made into a non-contact method of measuring the resistivity and dielectric constant of cylindrical specimens. Measurements were made of the potential distribution in a disk-shaped sample (0.1N NaCl solution) in a uniform magnetic field at right angles to the surface of the disk. Conclusion is that with a magnetometer capable of measuring a magnetic field of the order of 10 microgammas and with a suitably designed and constructed set of Helmholtz coils, measurements of resistivity by inductive means at low frequencies should be possible for specimens with resistivities up to 10 ohm-metres.

OP 494: Magneto-telluric method for mapping of surficial deposits (aquifers) and sulphide conductors:

- A. Becker, T.R. Flint and J. Slankis (summer student)

A portable microvoltmeter for the measurement of 8 HZ telluric currents has been designed. Two instruments were constructed and tested. The microvoltmeter has a 50 db dynamic range with a FET input stage, a six section 8 HZ  $\pm$  2 HZ band-pass filter, a linear rectifier and a true integrator. It is battery powered, consumes 2 watts and weighs 15 pounds. These instruments as well as Geonics EM-16 VLF receiver were used successfully in the field (Project 66-45) this past summer over a pyritic sulphide body in Bartouille tp., P.Q., the Gloucester Fault near Ottawa and the Winkler aquifer, Manitoba. A two-dimensional model of the Bartouille tp. Quebec, deposit has been constructed in the laboratory for the interpretation of the telluric measurements. A sensing coil for measuring natural 8 HZ magnetic fields has been constructed. The sensitivity is about 1 milligram.

Field Project 66-43: Instrument development and survey using INPUT electromagnetic system (Contract No. 60559).

- L.S. Collett

A contract has been made with Barringer Research Limited to digitize the INPUT data and record on magnetic tape 12 channels of information plus altimeter recording. This is a two-year contract in which the instrument development will be spread over 1966 and 1967 and a survey done in 1967. Several inspections have been made of the progress on this development work and many discussions have been held on the direction that is to be taken in this contract.

Field Project 66-44: Drilling and testing of sidewall sampler on Winkler aquifer, Manitoba.

- J.E. Wyder and L.S. Collett

Five diamond drill holes totalling 1,476 feet were located on sites of INPUT anomalies on the flanks of the Winkler aquifer. E-logs were run in each hole. The sidewall sampler, which was designed and constructed by the Saskatchewan Research Council, was tested in these holes this summer. The sampler is capable of extracting from the side of a drill-hole a sample approximately 2" long by 3/4" diameter with a position in-the-hole accuracy of  $\pm 1/2$  foot. The sampler is capable of sampling to a depth of 1,000 feet. All the holes entered bedrock which confirms the geological information on the maps accompanying GSC Memoir 239 by R.T.D. Wickenden. Mr. Wyder also supervised the sidewall sampler in conjunction with Dr. R. Klassen's field project.

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

- J.E. Wyder

The resistivity and drilling in southeastern Saskatchewan was completed in 1965. The results are being analyzed and will form part of Mr. Wyder's Ph.D. thesis at the University of Saskatchewan.

Courses:

R.H. Ahrens attended a DRB course on Integrated Circuitry.

FEDERAL/PROVINCIAL AEROMAGNETIC SURVEYS

A.S. MacLaren

Federal/Provincial Aeromagnetic Surveys - Scale 1:63,360

Sheets Checked and Published - March 31, 1967

Northwest Territories	72
Yukon	155
B.C.	4
Saskatchewan-Manitoba	4
Manitoba	82
Ontario	58
Manitoba-Ontario	26
Saskatchewan	10
Total	411 sheets



Composite Maps Edited and Published - 1966 - scale 1:253,440

Northwest Territories	10
Saskatchewan	8
Quebec	<u>18</u>
Total	36

Data for approximately 447 map-sheets were checked, processed and edited up to March 31, 1967.

Three Year Federal/Provincial Contracts

Three three-year Federal/Provincial aeromagnetic contracts were drawn up and let for certain areas in Quebec, Saskatchewan and British Columbia. A two-year contract for Baffin Island has been drafted and will be sent out for tenders in April. One three-year contract in the District of Mackenzie and one three-year contract in the Yukon Territory has been drafted and will be submitted for bids during the summer.

There are now nine different areas under contract for aeromagnetic surveys in various provinces and territories in the country. These are in Newfoundland, Quebec, Ontario, Manitoba, Saskatchewan, British Columbia, Yukon Territory, Northwest Territories, Baffin Island and the Polar Continental Shelf.

Field inspections were carried out in the District of Mackenzie, Saskatchewan, Newfoundland, Baffin Island and Yukon Territory.

Aeromagnetic and Ship Magnetometer Surveys

Sixty-nine one-mile sheets over the Scotian Shelf were submitted for final drafting and reproduction to an outside contractor and published. Five 4-mile composite maps over the Scotian Shelf were compiled and checked prior to final printing.

Completed re-compilation of 41 one-mile maps in central Newfoundland. These maps are now ready for final drafting and reproduction.

A contract for the drafting of the remainder of the ship magnetometer surveys, as shown on aeromagnetic index No. 1, has been prepared and is ready for tenders.

### Qualitative Aeromagnetic Interpretation

Over 1200 1-mile aeromagnetic maps surrounding Hudson Bay were contoured at 200 gamma intervals and interpreted on a scale of 35 miles to an inch. This work forms part of the Centennial volume on Hudson Bay.

This work has now been extended to eastern Alberta and to the northwest of Great Slave Lake. Its value is in tectonic analysis using both geological and aeromagnetic data over a broad area.

Four-mile aeromagnetic maps, gravity data and age determinations were studied along the Churchill-Superior boundary and a paper published on its suggested relocation.

### MAGNETIC METHODS SECTION

P.J. Hood

#### Co-operative High Sensitivity Aeromagnetic Project with The National Aeronautical Establishment

- A. Field Work: P.J. Hood, P. Sawatzky, M.E. Bower,  
A. Dicaire and H.W.C. Knapp:

The co-operative aeromagnetic project with the National Aeronautical Establishment of NRC was continued during 1966. High-sensitivity aeromagnetic survey work was carried out in the following areas:

1. Labrador Sea
2. Davis Strait and southern Baffin Bay
3. North Atlantic Ocean between Newfoundland, Iceland and Scotland, and also in the Denmark Strait area.

A more detailed description of the foregoing surveys will be found in GSC Paper 66-58.

4. Alberta, over the following areas:
  - a. Redwater and Morinville
  - b. Bashaw Reef Complex
  - c. Turner Valley
  - d. Rainbow Lake

B. Instrumentation: P. Sawatzky, A. Dicaire and H.W.C. Knapp

The above named were engaged in a program the eventual goal of which is to equip a light twin engined aircraft with an extremely high-sensitivity magnetometer. The pertinent data will be recorded in digital form, using an industry-compatible format.

The above objectives have already been implemented in the present magnetometer installation in the National Aeronautical Establishment's (NAE) North Star aircraft with the exception that the present system is too heavy and bulky to be fitted into a smaller aircraft. Moreover, the recording format in use at present is not industry compatible and will have to be substantially modified.

The present system was designed to utilize conventional off-the-shelf components as much as possible. This had the advantage that a whole system could be designed and built in a relatively short time, but it also had the disadvantage of being heavy and bulky. This system was first used during the summer of 1965, then redesigned, rebuilt and used again during the 1966 field season.

To eliminate the drawbacks mentioned above, the present system is being redesigned. Integrated circuits are to be used extensively to reduce the power requirements and also to reduce the size and weight of the equipment to the point where it can be installed in a light aircraft.

To maintain a high figure-of-merit for the aircraft compensation and high sensitivity it was essential that any faults that might occur should be detected and dealt with in flight. This required that besides the digital data being recorded on magnetic tape, an analogue strip-chart recorder also had to be operated. The analogue voltage for the strip-chart recorder was obtained from a frequency-to-analogue converter which also was an off-the-shelf item. Although the unit was one of the best commercially available it was only capable of 0.1 gamma resolution. A considerable amount of effort went into improving the performance to the point where the system is capable of a resolution of 0.005 gamma.

C. Data Compilation and Analysis: Miss M.E. Bower

During 1966 efforts have been directed toward developing new analysis techniques and streamlining methods of data processing. Because the primary purpose of this report is the improvement of data acquisition systems, the recording format has differed in almost every project. In order to process these records, it has been necessary to write such a multiplicity of computer programs that there remained little time to do anything else. To alleviate this problem, a program is now in use which

converts the data into a standard machine language, allows for the correction of error points, and outputs a new magnetic tape. This standardized, edited record may then be used for whatever compilation or analysis is required.

Experiments in data analysis have been mainly concerned with the programming and application of various types of digital filters (see GSC Paper 66-2). Band-pass filters of several different frequency ranges have been used to separate low amplitude, high frequency anomalies from the main magnetic field. These anomalies are commonly of near-surface geologic origin, but may also be due to time-varying noise. First- and second-derivative filters have also been used, and appear to be useful in the study of deeper magnetic sources. Some caution is required when interpreting the output of these filters, as the filter takes the derivative only in the lower part of the frequency range; higher frequencies are enhanced or attenuated to varying degrees.

Initial compilation of the Hudson Bay survey has been completed, and the total magnetic field data contoured. With the exception of the control grid and contouring, the Bendix G-15 and PB-250 computers were used to duplicate the work usually done by map compilers. This required a total of 20 computer programs, all of which were prepared by Mr. H.N.C. Lyster of the National Aeronautical Establishment. Although the computers can do many tasks rapidly and efficiently, it is difficult to program them to simulate human judgment, and, as in the past, a large measure of this commodity is still necessary. Improvements to the digital and navigational systems will eliminate the need for some of these programs, but it still appears that an entirely different approach to the problem should be taken. A rather unsuccessful attempt was made to produce a vertical magnetic gradient map, using the difference between the bird and interpolated boom magnetometer readings. The main problem seems to be the lateral displacement of the two magnetometers; the bird winch is well out on the starboard wing. Thus the gradient measured was not truly vertical, and over anomalous areas there was a noticeable horizontal component. No usable results were obtained in magnetically flat areas.

Scale-adjusted profiles have been plotted for all the ocean trips flown during the past year. These include the traverses over the Flemish Cap, Labrador Sea, Davis Strait, Baffin Bay, Denmark Strait and flights between Greenland, Iceland and Scotland. Data from all of these projects will have to be put through the editing program before any analysis can be attempted. Because of the lack of compilation staff, there will be some delay in completing these projects.

### Overhauser Magnetometer

S. Washkurak

The electronic units for two complete Overhauser spin precession magnetometers have been constructed, and final adjustments to the systems are in progress. A vacuum system to properly de-gas a proton sample using a freeze-thaw technique has been assembled. An apparatus to measure the amount of dynamic nuclear polarization obtained by saturating an electron resonance line (Overhauser effect) in the earth's field is also being assembled. The search for a stable free radical with sufficient enhancement is continuing.

### Sea Magnetometer Map Compilation

D. Reveler

An area covering parts of four-mile map areas 10 K, 10 L, all of 10 M, the west part of 10 N, the west part of 11 C, part of 11 D and part of 11 F was published in June, 1966 at a scale of 1 inch = 1 mile (see aeromagnetic index sheet No. 1, August 1, 1966). The 69 maps showed the magnetic contours overprinted in red on a grey background which included 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 survey aircraft. Five 4-mile composite maps were also published in the two-colour format - 10 K, 10 L, 10 M, 11 D and 11 F. The west halves of 10 N and 11 C will be published at a later date when the eastern halves are available. The tender for the drafting of these maps showing ship magnetometer data, between 55° W and 61° W (see index sheet No. 1) is now being written up by E. Ready and it is expected that the final maps will be delivered by June 30, 1967. These maps will also show the magnetic contours overprinted in red on the bathymetric and Decca lattice information. Ship magnetometer data in map areas 20/0 and 1 G, 1 J, 1 O and 1 P are also ready for publication and will be included in the above-mentioned tender. This will eliminate the backlog of ship magnetometer data for the Scotian Shelf area.

### Hudson Bay 1965 Sea Magnetometer Data

D. Reveler and K.H. Owens

This sea magnetometer data was obtained by personnel of the Marine Geophysics Group at BIO on the CSS Hudson during the 1965 oceanographic project in Hudson Bay. Due to the relatively wide spacing of the ship's track the resultant total field data will be presented in the

form of residual profiles with only the regional gradient removed. Most of the compilation has now been carried out, and the profiles will be integrated with those obtained during the 1961 cruise of M.V. Theta in Hudson Bay for subsequent publication.

### Vertical Magnetic Gradient Studies

P.J. Hood

During the summer months P.A. Camfield carried out theoretical studies on the vertical gradient of the total field over a sloping sill. A number of computer programs were devised which included a program to calculate the effect of varying the angle  $\alpha$  with fixed thickness of the sill depth ratio where  $\alpha$  = sum of the angle of dip of the sloping face plus the inclinations of the earth's field and magnetization vector, and a program to calculate the effect of varying thickness/depth ratio with a fixed angle  $\alpha$ . Plotting programs were also devised so that type curves could be plotted on the Calcomp 563 Plotter in the Departmental Computer Centre.

The dipping dyke case is presently being tackled by D.N. Skibo taking account of both remanent and induced magnetization. A program for the total field and the horizontal and vertical derivatives of the total field anomaly over the dipping dyke has been written. A program to determine the maxima and minima of the gradient curves over the dipping dyke has also been devised. The value of Eulers factor  $n$ , the fall-off exponent which appears in his well-known differential equation, is also being investigated. This index also appears to hold promise in determining second derivative values.

### Magnetic Properties

H. Gross

#### Field Susceptibility Meter

A new type of in situ field susceptibility meter was designed and built, using two orthogonal coils. Field tests were conducted in October in the Bancroft area and encouraging results obtained. On the basis of the experience gained in the Bancroft test, modifications are being made to the instrument. The final unit shows promise of being lighter and smaller compared to the presently commercially-available equipment. Patents are under process.



### Laboratory Susceptibility Anisotropy Meter

Work was completed on the prototype unit, and analysis of data is nearing completion. Preparations are under way for publication. Computer programs were also set up for use with the meter. A new unit is being built using experience gained with the prototype. Patents are also under process.

### Special Projects

During 1966 P.J. Hood prepared the following briefs for the Director:

1. "Study of the Canadian Upper Atmosphere and Space Research Program and Activities of the Geological Survey of Canada in that Domain".

This brief was incorporated into a Departmental brief by R. E. Moore of the Surveys and Mapping Branch and presented to the Upper Atmosphere and Space Study Committee of the Science Secretariat of the Privy Council in the East Block of the Parliament Buildings on August 25th.

2. GSC brief on "Physics of the Earth" in Canada.

This was forwarded to Dr. J.H. Hodgson on October 18th for inclusion in a Physics of the Earth section, which is one of twelve comprising a report on the state of physics research in Canada being prepared by the Canadian Association of Physicists for the Science Secretariat of the Privy Council.

A review of new geophysical, geochemical, drilling, data recording, and compilation techniques which appeared during 1965 was prepared and published by the Canadian Mining Journal in its Annual Review issue in February. The highlights of 84 articles of interest to those engaged in mineral exploration were also summarized. The article received world-wide distribution.

## REMOTE SENSING SECTION

A.G. Darnley

### 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

Arising from the major change in permanent staff in the middle of the year, only a limited program of work has been possible. Dr. Gregory left the section at the end of June and was replaced by Dr. Darnley who joined at the beginning of October. Mr. Slaney who arrived in July replaced Dr. Anderson who left during 1965. Mr. Washkurak was concerned throughout the year with the development of the Overhauser Magnetometer for the Magnetic Methods Section. Some progress has been made in all fields of current activity, namely gamma-ray spectrometry, I.R. scanning and aerial photography, but inevitably much time has been required for the new staff to become familiar with existing commitments and to make plans for expanded activities in 1967. As a preliminary to drawing up a specification for an airborne gamma-ray spectrometry system suitable for regional surveying, experiments have been undertaken using a car-mounted spectrometer. This has been carried out with the co-operation of the Commercial Products Division of Atomic Energy of Canada Ltd. The results are considered to be sufficiently encouraging to justify the construction of a car-borne system for regular use.

Mr. Gross of the Water Research Branch has spent an increasing proportion of his time since April working in the section on infra-red instrumentation problems, and has visited the laboratories of H.R.B.-Singer Inc.

Steps have been taken to obtain portable radioisotope X-ray fluorescence equipment for demonstration, test and ultimately development purposes. Many details of electronic design and detector systems are common to both X- and gamma radiation, and operational problems of field and bore-hole instruments are similar.

### Project Reports

#### Beaverlodge Lake Experimental Airborne Gamma-ray Spectrometer Survey -

Under contract to G.S.C., Barringer Research Limited carried out an airborne survey covering approximately 90 square miles in the vicinity of Beaverlodge Lake, Saskatchewan. The flying was undertaken

during the first part of October using a Bell G-2 helicopter with a gamma-ray spectrometer system designed by Barringer Research Limited. Due to the staff changes it was not possible for any GSC personnel to be present whilst the survey was in progress. Data from the survey were due for delivery at the end of December.

#### Ground Gamma-Ray Spectrometer Survey - P.G. Killeen (Graduate Student)

Work in the Elliot Lake area which commenced in 1965 was continued using the G.S.C. portable gamma-ray spectrometer. This will provide ground data for a test airborne survey in 1967. Samples were collected for laboratory analysis to correlate with in situ readings, and a calibration line for airborne measurements was made with over 600 in situ analyses of U, Th and K. 106 calibration samples have been sent to Rice University, Houston, Texas, for analysis.

#### Airborne Infrared Imagery - V.R. Slaney

H.R.B.-Singer Incorporated have completed the greater part of a contract for the production of infrared imagery of the shorelines of Lakes Erie and Ontario. Ektachrome infrared film was also exposed. The imagery will be handed over to the Geological Survey early in 1967.

The imagery from an earlier contract with H.R.B.-Singer, completed in 1965, was delivered in November. It has not yet been assessed.

The imagery itself, and all persons working with the imagery, are still subject to military security regulations.

#### Aerial Photography in the Ennadai-Rankin Area, N.W.T. - V.R. Slaney

Aerial photographs of the Ennadai-Rankin area were examined for their usefulness in geological interpretation.

One third of the contract area is still to be photographed. Recommendations have been made to improve the image quality of the area not yet photographed.

#### 70 mm Aerial Photography of Western Lake Ontario - V.R. Slaney

Aerial photographs of portions of the shoreline of Lake Ontario between Oshawa and Niagara were obtained from a light aircraft using a Vinten 70 mm camera. Colour, colour-infrared and infrared films were exposed at altitudes between 2,000 and 5,000 feet.

The photography was designed to investigate the usefulness of various types of film for locating near shore sources of effluent, tracing the movement of effluent material, delineating concentrations of phytoplankton and for locating buried river channels.

The photography is still being studied.

### Special Projects -

Dr. A.F. Gregory was a co-author of the Confidential Report: "Uranium Studies Committee - Recommendations for the G.S.C. Uranium Geology Activities" May, 1966.

## ROCK MAGNETISM SECTION

A. Larochelle

### Palaeomagnetism

Field projects carried out during the summer of 1966 included a collection of oriented samples from the diabase dykes and sills of Northern British Columbia, Northwest Territories and Yukon for the purpose of studying the structural history of the part of the Cordillera in this area. Oriented samples were also collected from the Sudbury irruptive for a similar purpose. Samples were also obtained from the Manicouagan area in Northern Quebec for the purpose of determining a reliable Triassic pole position from this region and with other objectives in mind.

Laboratory work included the measurement and testing of the palaeomagnetism of dykes from the Val d'Or - Noranda and from the Sudbury area. Results of this work have been or are about to be published. Another study was carried out on samples from a dyke in southern Nova Scotia. The results of this study were recently published. A study on the palaeomagnetism of the Manicouagan area was recently completed and a paper on the subject has been submitted for publication. An investigation on the magnetic properties of sulphides is in progress and the results obtained so far in this work are being put together in the form of a paper. A study of the magnetization of potsherds from southwestern Ontario has shown that the earth's field intensity varied in this area over the past 5,000 years approximately the same way as in Europe and Japan. Other studies are presently in progress.

Laboratory facilities have been improved over the past year. The 3-magnet astatic magnetometer sensitivity has been increased by an order of magnitude while its range is now readily adjustable to measure rocks with intensities of  $10^{-2}$  to  $10^{-7}$  c.g.s. units/cc. A paper describing this instrument is in preparation.

A nearly completed automatic Curie Balance will soon allow systematic determination of Curie points for mineral and rock specimens. A ballistic magnetometer was also completed over the year as well as an automatically recording anisotropy susceptibility meter. Computer programmes have been developed to perform statistical tests on palaeomagnetic data and to plot directions of magnetization, ellipses of confidence, etc. on either stereographic or equal area projections.

## SEISMIC SECTION

G.D. Hobson

The activities of this section are largely reported in G.S.C. Paper 67-1, Part A. These consisted of seismic projects undertaken in Gulf of St. Lawrence, Lake Ontario, Flin Flon Manitoba, Good Spirit Lake and Canora, Saskatchewan, Rocky Mountain Trench and Okanagan Valley, British Columbia, Elliot Lake, Ontario, Cape Breton Island, Newfoundland and Gaspe. An interpretation of the crustal data recorded during the Hudson Bay program of 1965 was also completed by two graduate assistants and permanent staff.

## THEORETICAL GEOPHYSICS SECTION

B.K. Bhattacharyya

### Function

This Section was formed to perform the following functions:

- (a) to undertake research on quantitative methods of interpretation of various kinds of geophysical data;
- (b) to do analysis of available data for obtaining geophysical and geological information;

- (c) to help and encourage geologists and geophysicists in quantitative methods of interpretation for treatment of data.

### Aeromagnetic Map of Canada

Considerable progress has been made during 1966 in this project, the primary purpose of which is to delineate deep crustal magnetic sources from the available aeromagnetic data in Canada. This project involves the following processes of operation: (a) digitizing and storing the total field values at every 150" interval along longitude lines and every 100" interval along latitude lines; (b) application of filtering techniques to the residual data in order to remove the effects of near-surface, high amplitude magnetic sources; (c) analysis of suitable anomalies to determine horizontal and vertical extents and the state of magnetization of crustal magnetized bodies.

Interpretation of aeromagnetic data over New Brunswick, Nova Scotia, Gulf of St. Lawrence and a large segment of Yukon territory has been practically finished. Reports on these studies which are expected to be published shortly, will contain some interesting geological observations.

Work has also recently started on the available aeromagnetic data in central Canada covering the northern part of Alberta, Saskatchewan and Manitoba.

### Aeromagnetic Data over the Arctic Islands and Polar Continental Shelf

In early 1966 a project was undertaken to do quantitative interpretation of aeromagnetic data over the northwestern part of the Queen Elizabeth Islands, Polar Continental Shelf and a segment of the Arctic Ocean. The maps of the residual field and the continuation field up to a level of 1.6 kms from the flight elevation have revealed some major geological features in this area. The whole section of the project area under the Arctic Ocean is a seat of highly intense magnetic activity suggesting widespread folding and faulting of the volcanic rocks. This study will be completed by early 1967.

### Methods for Treatment and Interpretation of Data

Research is being carried out at present to develop an accurate and reliable method for treating non-uniformly spaced data. The objective of this study is to do, in the near future, digitizing of the aeromagnetic data only along flight lines. If successful in this study, it will be possible to eliminate the random error in interpolation between flight lines.



Some progress has also been made in the development of a method for calculating complex Fourier spectrum of two-dimensional data.

A method has been developed for treatment of data at irregular control-point spacing along linear profiles.

### Travel

B.K. Bhattacharyya spent about six weeks visiting various geophysical research centres in Paris, Stockholm, Helsinki, Moscow, Leningrad, Novosibirsk, Hyderabad and Calcutta.

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## PETROLOGICAL SCIENCES DIVISION

C.H. Smith, Chief

### INTRODUCTION

The Petrological Sciences Division is responsible for research, development and services in the fields of isotope geology, analytical chemistry, mineralogy, petrology and data processing to complement and support the program of the Geological Survey. The Division is composed of the Isotope Geology, Analytical Chemistry, Mineralogy and Petrology Sections and a Data Processing Unit. Their specific functions are defined in the introduction to each sectional report.

The Division has a staff of 58, including 29 scientists, 24 technicians and 2 post-doctoral fellows. In addition, 25 part-time assistants were employed.

During the first three months of 1967 the Division administration has been completely involved in the new systems of research scientist appraisal, preparation of the program for 1968-69, and planning for the proposed reorganization of the Geological Survey. Some time has been given to the preparation of field instructions for the 1967 field season, and completion of the annual report. The need to schedule these activities in the future was never more apparent.

There are a number of debatable standards that can be used to measure the productivity of the Division. These include the completion of certain units of work, including publications and manuscripts, chemical analyses mineral identifications, mineral separations, K/Ar ages, Rb/Sr isochrons, letters to the public and so forth. This productivity is documented in the reports of the sections which follow. Certain factors are hindering its immediate advancement. These include the large amount of time that senior personnel spend on training courses, rating boards,

reclassifications, working on standards and other matters which allow little time for planning and proper local management. A second factor is the difficulty of recruiting and retaining trained technicians. There is a flow of trained technicians into more attractive administrative positions. These are challenges to future growth in effectiveness and are being met where possible by changes in organization and the introduction of improved systems of project reporting and management.

Some highlights of the year's activities include -

Collection of rock and mineral samples and consultations on the design of exhibits for Expo '67 and the Centennial Caravan.

Planning for Departmental studies on lunar surface material recovered by NASA.

Start on the development of a national reporting system for K/Ar and Rb/Sr age data.

Collection and study of rock samples from the Mid-Atlantic ridge which provide valuable new information on the nature of the ocean floor (with B.I.O.).

Growing interest in the usefulness of mineral sets in education, resulting in the preparation of special collections for all schools in the N.W.T. and Yukon; insertion of CIM career pamphlets, and descriptive guides to minerals and rocks in the Prospector's sets.

Logging and study of rock cores and chips from a 10,000 foot drill-hole in the Precambrian Shield near Flin Flon. This is the deepest drill-hole in the Shield.

Study of 9 new minerals.

Organization of a successful workshop on Chemical Analysis of Geological Materials for the National Advisory Committee on Research in the Geological Sciences.

Installation of a new M.A.C. electron probe column and power supplies for use with the Elion probe beam scanning system and X-ray readouts. Effective use of the new instrument has been made on studies of silicate minerals.

Divisional coordination and management is carried out by the Chief of Division with a staff of one. In September the staff was increased two, with the addition of Mrs. F.C. Davies as a staff geologist. Planning and coordination was improved by the formation of a Divisional committee

of Section Heads and the Chief of Division which meets weekly. C.H. Smith attended the Senior Course in Public Administration at Carleton Place from January to April 1966 and J.A. Maxwell was Acting Division Chief during this period.

Apart from the regular duties of Divisional management, C.H. Smith carried out obligations to the International Upper Mantle Project (reported separately below), and organized a 2-day GSC-NB Dept. of Resources (Mines Division) session on geological studies in New Brunswick.

Three members of the Division were appointed Principal Investigators for the NASA Lunar Sample Analysis Program. They are J.A. Maxwell, R.K. Wanless and J.A.V. Douglas. Co-investigators include Dr. Traill, Dr. Currie, Mr. Lachance and Mr. Abbey. The samples are expected to be recovered by the Apollo program in 1970.

The Barlow Medal of the C.I.M. was awarded to J. Jambor (and R.W. Boyle) for their paper published in the CIM Bulletin.

#### (GS 62-11) INTERNATIONAL UPPER MANTLE PROJECT

The Divisional office acts as the Secretariat for the Canadian Upper Mantle Committee. C.H. Smith is Chairman of the Canadian Committee (a committee of NRC) and Deputy Secretary General of the International Upper Mantle Committee (a committee of the IUGG and IUGS).

During 1966, the Canadian report was completed for inclusion in Upper Mantle Project Report No. 3 issued by the IUMC Secretariat in April, 1966. Publication of the 3 Symposia reports arising from the September, 1965, meetings of the IUMC in Ottawa proceeded well. The volume Drilling for Scientific Purposes was issued (Paper 66-13). The World Rift System (Paper 66-14) appeared in January, 1967, and Continental Margins and Island Arcs (Paper 66-15) was issued in March 1967.

A registry of Canadian Contributions to the Upper Mantle Project is maintained, numbers being issued to authors on request. There are now 152 entries. The submission of Canadian Upper Mantle contributions to World Data Center A (Lamont) and World Data Center B (Moscow) continued. WDC-A reported that Canada has been its second largest supporter (after the USSR and followed by the USA).

Requests for information on Canadian Upper Mantle studies from foreign scientists and the public average 5 per week. During the first half of 1966, C.H. Smith substituted for Prof. L. Knopoff (UCLA)



as Secretary General of the IUMC and dealt with matters involved in the organization of a Symposium on Non-Elastic Processes, Newcastle, England, and meetings at the Pacific Science Congress, Tokyo. Current activities involve the preparation of the Canadian Upper Mantle report in cooperation with members of the Upper Mantle Committee for presentation at the IUGG Assembly in Zurich, Sept. 1967; participation in the preparation of a monograph on the upper mantle by the IUMC; and planning of upper mantle symposia for the International Geological Congress, Prague, 1968.

## PERSONNEL

The Division has had a large turnover of staff. The sudden death in April of Mr. W.F. White, a valued member of the staff of the spectrographic laboratory since 1953, and of the Department since 1926, was a serious loss to the laboratory. Mr. K.A. Church has very capably taken over, in an acting capacity, much of the responsibility for sample analysis previously held by Mr. White. Mr. J.P. Malone, a member of the spectrographic laboratory since 1955, transferred to the Administrative Training Section in June. His leaving, coupled with the loss of Mr. White, seriously reduced the work potential of the spectrographic laboratory. At the end of 1966 only two members of the Sample Preparation and Mineral Separations laboratory had been on the staff more than a year.

During the summer twenty university students were employed in offices and on field parties of the Division. Four students of the Eastern Ontario Institute of Technology joined the Chemistry Section staff from May to September and gave very satisfactory assistance.

### Professional Staff

Mr. D.E. Lawrence joined the staff of the Petrology Section in July to assume responsibility for the operation of the Petrology Laboratory.

Mrs. M. Pun from the University of British Columbia, joined the staff of the Analytical Chemistry Section in September as Chemist in charge of the Isotope Chemistry Laboratory.

Mrs. F. Davies joined the permanent staff in August filling the new position of Staff Geologist to the Division.

Dr. D.C. Findlay transferred to the Regional Office in Whitehorse in June.

### Trainees

Mr. Solomon A. Armaquaye, a Colombo Plan trainee from Ghana, spent January and February in the X-ray laboratory to learn techniques of X-ray diffraction and fluorescence analysis.

Mr. L. Chaperon, a technician from the National Museum of Canada received three weeks training in the use of X-ray diffraction techniques in August.

Dr. V.S. Papezik, Associate Professor of Geology, Memorial University of Newfoundland spent three weeks of June in the X-ray laboratory in order to gain practical experience with techniques of X-ray fluorescence analysis.

Mr. R. Darbar, a Colombo Plan trainee from Uganda, worked in the chemical laboratories from February to September. He rejoined the Analytical Chemistry Section in February, 1967 to work in the spectrographic laboratory.

### Technical staff

#### Losses

Mrs. M.E. Bartlet	X-ray lab.		to emigrate to U.S.A.
Mr. C.D. Bradshaw	Isotope	Sept.	to study at EOIT
Miss M.A. Brewer	Chem.	Sept.	returned to University
Mr. J.E. Clair	Isotope	Aug.	returned to University
Mr. P. Gauthier	Min. Separation		to continue his education
Mr. W.A. Gibson	Chem.	July	Air Material Command, D.N.D.
Mr. A. Houle	Min. Sets prep.	June	Mineral Resources Div.
Mr. J.P. Malone	Spec. lab.	June	Administration Training Div.
Miss P. LaRiviere	Isotope	Jan.	
Mr. C. Schieman	Min. Separation		Surveys & Mapping Br.
Mr. J. Valenzuela	Min. Separation	Sept.	Anal. Chem. Section

#### New technical staff

Miss N.J. Andrews	Chem.	Sept.	
Dr. M. Bonardi	Spec. lab.	Oct.	Temporary
Miss S.M. Cooper	Data Processing		to operate the key punch
Mr. J.L. MacRae	Isotope	Aug.	
Mr. F.B. Quigg	Isotope	Oct.	from Geophysics
Mr. T.R. Racine	Min. Sets Prep.	July	replacing Mr. Houle
Mrs. M. Radmore	Min. Separation		

New technical staff (cont'd)

Mr. C.S. Skiba	Isotope	June	argon extraction
Mr. D. Smith	Min. Separation		
Miss Melinda Swerdfager	Isotope	Aug.	
Miss Sylvia Zylstra	X-ray lab.		replacing Mrs. Bartlet

C.J. Dodds, D.G. Fong, and H.P. Klassen temporarily joined the staff as winter seasonals.

Post-Doctoral Fellows

Dr. George Plant from the University of Bristol, joined the Mineralogy Section in November. He is studying techniques and applications of analyses of silicate minerals using the electron probe microanalyzer.

Dr. P.B. Blattner, from Switzerland, completed a petrochemical study of the core zone veined gneisses in Thor-Odin gneiss dome. His fellowship ended in January 1967.

Dr. Victor Koeppel, from Zurich, Switzerland, completed an isotopic study of the uraniferous deposits at Goldfields, Saskatchewan and his report is undergoing final editing. Late in 1966 he returned to Zurich to take a position with the Institut for Kristallographic und Petrographie, ETH, in Zurich.

Dr. A. De from Calcutta, India is carrying on a study of the petrology of dykes emplaced in the ultramafic rocks of the asbestos mining areas of the Eastern Townships of Quebec with special reference to the modification in their chemical and mineralogical composition.

MEMBERSHIP ON COMMITTEES

<u>S. Abbey</u>	- Member, Editorial Board, Chemistry in Canada. - Member, Analytical Chemistry Division Executive, Chemical Institute of Canada.
<u>W.H. Champ</u>	- Member, Non-metallic Standards Committee, Canadian Association for Applied Spectroscopy.
<u>K.R. Dawson</u>	- Member, Departmental Electronic Data Processing Committee Branch Library Committee.

- J.A.V. Douglas - Member, Secretary - NRC Associate Committee on Meteorites.  
- MAC representative on the International Mineralogical Association Commission on Cosmic Mineralogy.

- J.A.V. Douglas and J.A. Maxwell and R.K. Wanless -  
- Principal Investigators for the NASA Lunar Sample Analysis Program.

- T.N. Irvine - Member, Branch Library Committee.  
- Member, Branch Stable Isotope Committee.  
- Member, Subcommittee for Volcanology of the Association Committee on Geodesy and Geophysics, NRC.

- G.R. Lachance - X-ray Convenor - Program Committee, XIII Colloquium Spectroscopum Internationale.

- J.A. Maxwell - Chairman, Branch Technical Appraisal Committee.  
- Member, Associate Committee on Meteorites, National Research Council.  
- Member, Standards Committee, Geochemical Society.  
- Branch representative, Departmental Committee on Bilingualism and Biculturalism.

- J.E. Reesor - Member, Branch 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.  
- Chairman, Logan Club.

- A.P. Sabina - Treasurer, Mineralogical Association of Canada.

- J.G. Sen Gupta - Vice-chairman, Chemists Group of the Professional Institute.

- C.H. Smith - Chairman, Committee on the Upper Mantle Project, International Union of Geological Sciences; Member, Planning Committee for Upper Mantle Symposia at IGC, Prague, 1968.  
- Deputy Secretary General, International Upper Mantle Committee of International Union of Geodesy and Geophysics.

- Chairman, Canadian Upper Mantle Committee of Associate Committee on Geodesy and Geophysics of NRC.
- Member, Committee on Research; Lindgren Awards Committee, Society of Economic Geologists.
- Member, Advisory Committee on Science and Medicine, Expo '67.
- Member, Associate Committee on Geodesy and Geophysics.
- Member, Canadian Section, Pan American Institute of Geography and History.
- Member, Departmental Advisory Committee on Crustal Seismic Studies.
- Member, Editorial and Advisory Board, Journal of Petrology.
- Member, Advisory Board, Mineralium Deposits.
- Member, Editorial Board, Economic Geology.
- Associate Editor, American Journal of Science.
- Member, Departmental Advisory Council, Princeton University.

H.R. Steacy

- Member, Branch Exhibits Committee.
- Member, Branch Working Group on Uranium.
- Chairman, Nominating Committee, Mineralogical Association of Canada.
- Member, Finance Committee, Mineralogical Association of Canada.
- Member, Ottawa General Committee, C.I.M.

R.J. Traill

- Member (for Canada), Commission on New Minerals and Mineral names, International Mineralogical Association.
- Member, Branch Technician Appraisal Committee.
- Member, Branch Committee on Central Technical Files.

R.J. Traill, K.L. Currie, G.R. Lachance and S. Abbey, Co-investigators

R.K. Wanless

- Secretary, Subcommittee on Isotopic Studies and Geochronology, Associate Committee on Geodesy and Geophysics of NRC.
- Member, Branch Age Determination Committee.
- Member, Branch Isotope Committee.
- Chairman, Branch United Appeal Committee.

ATTENDANCE AT MEETINGS

Senior Course in Public Administration, Kemptville, January-April,  
C.H. Smith

Study of I.O.L. "CAT" system, Calgary, Alta., Feb. 1-4 and Workshop,  
May 23-27

K.R. Dawson

Pert Course, Ottawa, March 7-11

K.R. Dawson

Management Science Appreciation Course, Ottawa, March 28-30.

K.R. Dawson

6th Annual Conference on Computers in Mineral Industries, Pennsylvania  
State University, State College, April 17-23.

F.P. Agterberg

National Conference on Electron Probe Microanalysis, College Park  
Maryland, May 4-6.

G.R. Lachance

American Geophysical Union, Washington, April 19-22.

E. Froese

T.N. Irvine

W.D. Loveridge

Annual Conference of the Chemical Institute of Canada, Saskatoon (also  
visited the Research Council of Alberta, Edmonton, in June).

S. Abbey

Royal Society of Canada, Sherbrooke, Que., June 6-8.

C.H. Smith

Eleventh Pacific Science Congress, Tokyo, Japan, Aug. 17-Sept. 3.

C.H. Smith (as delegate  
of International Union of  
Geological Sciences)

International Mineralogical Association meeting in Cambridge, England  
(while overseas on a business and holiday trip during which  
he visited 14 institutions concerned with silicate analysis).

J.A. Maxwell

152nd National Meeting of the American Chemical Society, New York,  
September.

J.G. Sen Gupta



Mineralogical Association of Canada, Annual Meeting, Halifax, September 12-14.

J.L. Jambor  
J. Rimsaite  
Ann Sabina

Advanced Seminar on Spectral Analysis of Time Series, University of Wisconsin, Madison, October 3-5.

F.P. Agterberg

Clay Minerals Society, Third Annual Meeting, Pittsburgh, October 10-13.

J. Rimsaite

Canadian Electron Probe Users Group, Ottawa, October 19.

G.R. Lachance  
R.J. Traill

Subcommittee on Isotopic Studies and Geochronology, Ottawa, October 25.

R.K. Wanless

Spectroscopy Symposium of the Canadian Association for Applied Spectroscopy, Montreal, October.

W.H. Champ  
K.A. Church

Seminar on Mass Spectrometric Analysis by the Surface Immersion Technique State College, Pennsylvania, Oct. 31-Nov. 3.

W.D. Loveridge

Meteoritical Society, Washington, November 3-5.

J.A.V. Douglas

Society of Economic Geologists, San Francisco, Nov. 12-13.

T.N. Irvine

Geological Society of America, San Francisco, November 14-17.

J.E. Reesor  
T.N. Irvine

Intermediate Course in Public Administration, Kemptville, Nov. 27-Dec. 15.

R.K. Wanless

GSC-N.B. Mines Division Joint Meeting on Geological Studies in N.B., Ottawa, Dec. 6-7.

C.H. Smith  
F. Davies

Computer Applications in the Earth Sciences, Colloquium, University of Kansas, Lawrence, December 15-16.

F.P. Agterberg

Editorial Board, Chemistry in Canada, Ottawa, January.

S. Abbey

Executive meeting, Analytical Chemistry Division, The Chemical Institute of Canada, Ottawa, January.

S. Abbey

Prospectors and Developers Convention, Toronto, March 5-8, 1967.

C.H. Smith

Managerial Grid Seminar, Cornwall, March 12-17, 1967.

J.A. Maxwell

Canadian Institute of Mining and Metallurgy, Ottawa, March 26-30, 1967.

C.H. Smith

#### OUTSIDE LECTURES

T.N. Irvine - "The Muskox Intrusion", McMaster University and University of Toronto, February, 1967.

F. Aumento - "Theory, techniques and uses of X-ray diffraction and spectroscopy in geological investigations", a series of lectures to the staff of Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Jan. 5-7, 1966.

J.L. Jambor and R.W. Mulligan - "Tin-bearing silicates from skaarn, Cassiar district, British Columbia", G.A.C. - M.A.C. Annual Meeting, Halifax, September.

J.L. Jambor - "Re-examination of yukonite", G.A.C. - M.A.C. Annual Meeting, Halifax, September.

J.Y.H. Rimsaite - "Biotites intermediate between dioctahedral and trioctahedral micas", Third Annual Meeting of the Clay Minerals Society, Pittsburgh, October 13.

J.E. Reesor - "Structural evolution in Thor-Odin gneiss dome", McGill University, January 1966.

- E. Froese - "Significance of some common opaque minerals in metamorphic rocks", Geochemical Discussion Group - Carleton University December 12, 1966.
- T.N. Irvine - "Crystallization history of the Muskox Intrusion", M.I.T. - Lecture - Seminar, May 4-5, 1966.
- "Oxide minerals in the Muskox Intrusion", S.E.G. Symposium on Magmatic Ore Deposits, Stanford, Calif., November 14-16, 1966.
- J.A.V. Douglas - "Investigation of Recent Fireballs", Ottawa Centre of the Royal Astronomical Society of Canada, December 9, 1966.
- R.K. Wanless - "Rb/Sr age determination studies at the G.S.C.", University of Toronto, April 4, 1966.
- J.G. Sen Gupta - "Determination of the abundance of the platinum metals in iron and stony meteorites". Am. Chem. Soc. New York. "Arsenaza III as a sensitive and selective reagent for palladium and its application to the determination of palladium and thorium in iron and stony meteorites". Am. Chem. Soc., New York, September 15, 1966.

#### PUBLICATIONS

Abbey, Sydney

1966: Analytical Workshop at the Geological Survey. Chemistry in Canada 18, (6), 52b (June).

(with Forman, S., and Kodama, H.J.)

(inpress) A re-examination of Xanthophyllite (Clinotonite) from the type locality. Canadian Mineralogist.

(inpress) The determination of feldspars by flame photometry. Short Communication, Mineralogical Mag.

Agterberg, F.P.

1966: Two-dimensional weighted moving average trend surfaces for ore valuation, a contribution to discussion of paper by D.G. Krige. Proc. Symposium on Mathematical Statistics and Computer Applications in Ore Valuation, Johannesburg, S. Africa, No. 2, pp. 27-33.

Agterberg, F.P. (cont'd)

- 1966: Trend surfaces with autocorrelated residuals. Proc. Computer Symposium at Pennsylvania State University, April 1966, vol. I, pp. H1-19.
- 1966: Markov schemes for multivariate well data. Proc. Computer Symposium at Pennsylvania State University, April 1966, vol. II, pp. Y1-18.
- 1966: The use of multivariate Markov schemes in petrology. J. Geol., vol. 74, pp. 764-785.

Aumento, F.

- 1966: Thermal transformations of stilbite. Can. J. Earth Sci., vol. 3, pp. 351-366.
- 1966: Stability, lattice parameters, and thermal expansion of beta-cristobalite. Am. Mineral., vol. 51, pp. 1167-76.
- 1966: Zeolite minerals, Nova Scotia. Guidebook, Geology of Parts of Atlantic Provinces, G.A.C., M.A.C. Annual Meeting, Halifax.
- (inpress) Zeolites, Encyclopedia of Earth Sciences, Reinholds Publications.

Cabri, L.J. and Traill, R.J.

- (inpress) New Palladium Minerals from Noril'sk, Western Siberia. Can. Mineral., vol. 8.

Dawson, K.R.

- 1966: A comprehensive study of the Preissac-Lacorne batholith, Abitibi county, Quebec. Geol. Surv. Can. Bull. 142.

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

- 1966: Geological Survey of Canada radiocarbon dates V. Radio-carbon, vol. 8, pp. 96-127 and Geol. Surv. Can. Paper 66-48.

Findlay, D.C. and Smith, C.H. (ed.)

- 1966: Drilling for Scientific Purposes, Report of IUM Symposium 1965. Geol. Surv. Can. Paper 66-13.

Froese, E. and Winkler, H.G.F.

- (inpress) The system  $\text{CaCO}_3\text{-SrCO}_3$  at high pressures and 500-700 °C. Can. Mineral.

Irvine, T.N. and Smith, C.H.

(inpress) The ultramafic rocks of the MuskoX Intrusion, Northwest Territories, Canada in Wiley, P.J. (Editor), Ultramafic and related rocks. Wiley Book Co.

Irvine, T.N. (ed.)

1966: The world rift system. Report of IUM Symposium 1965. Geol. Surv. Can. Paper 66-14.

Irvine, T.N.

(inpress) The Duke Island ultramafic complex, Southeastern Alaska in Wiley, P.J. (Editor), Ultramafic and related rocks. Wiley Book Co.

Irvine, T.N.

(inpress) Chromian spinel as a petrogenetic indicator, Part 2. Petrologic Applications. Can. J. Earth Sci., vol. 3.

Jambor, J.L.

1966: Constituents of cacoclasite. Can. Mineral., vol. 8, pp. 527-9.

(with R.W. Boyle)

1966: Mineralogy, geochemistry and origin of the Magnet Cove barite-sulphide deposit, Walton, Nova Scotia. Trans. Can. Inst. Mining Met., vol. LXIX, pp. 394-413 and Can. Inst. Mining Met., vol. 59, pp. 1209-1228.

Lachance, G.R. and Traill, R.J.

1966: A practical solution to the matrix problem in X-ray analysis. Part 1, Method. Can. Spect. vol. 11, p. 47.

Larochelle, A. and Wanless, R.K.

1966: The palaeomagnetism of a Triassic diabase dyke in Nova Scotia. J. Geoph. Res., vol. 71, No. 20, pp. 4949-4953.

Maxwell, J.A. (with Eade, K.E., and Fahrig, W.F.)

1966: Composition of crystalline Shield rocks and fractionation effects or regional metamorphism. Nature, vol. 211, No. 5055, pp. 1245-49.

(with Forman, S.A., and Kodama, H.)

(inpress) The trioctahedral brittle micas. Am. Mineral.

McCartney, W.D., Poole, W.N., Wanless, R.K., Williams, H., and Loveridge, W.D.

1966: Rb/Sr age and geological setting of the Holyrood granite, south-east Newfoundland. Can. J. Earth Sci., vol. 3, pp. 947-957.

Reesor, J.E.

1966: Structural evolution and plutonism in Valhalla gneiss complex, British Columbia. Geol. Surv. Can. Bull. 129.

Rimsaite, J.Y.H.

1967: Studies of rock-forming micas; Geol. Surv. Can. Bull. 149.

(in press) Optical heterogeneity of feldspars observed in diverse Canadian rocks. Feldspar Volume, Swiss Min. and Petr. Soc.

(in press) Biotites intermediate between dioctahedral and trioctahedral micas. Clays and Clay Minerals, Proceedings of the Fifteenth North American Clay Minerals Conference.

Sen Gupta, J.G.

(in press) Arsenazo III as a sensitive and selective reagent for the spectrophotometric determination of palladium in iron and stony meteorites. Anal. Chem., vol. 39, pp. 18-22.

Smith, C.H. (with Findlay, D.C.)

1966: Drilling for scientific purposes in Canada. Tectonophysics, vol. 2, No. 4, pp. 247-257.

Skinner, B.J., Jambor, J.L. and Ross, M.

(in press) Mckinstryite, a new copper-silver sulphide. Ec. Geol.

Traill, R.J. and Lachance, G.R.

1966: A practical solution to the matrix problem in X-ray Analyses. Part 2; Application to a multicomponent alloy system. Can. Spect., vol. 11, p. 63.

#### VISITORS

Mrs. D. Mah, Carleton University, visited for 2 1/2 days in June to study methods and equipment in atomic absorption spectroscopy.

Dr. Michel Delaloye, University of Geneva, Switzerland, spent 3 days in April studying analytical methods in general, particularly those involving X-ray fluorescence spectroscopy.



Mr. E. Gur and Mr. J.-C. Dumesnils, from Ecole Polytechnique, Montreal, were with the Analytical Chemistry Section for two weeks in July to gain experience in methods for the determination of ferrous iron, fluorine, magnesium (atomic absorption spectroscopy), sulphur, carbon dioxide and water.

Mr. M. Quintin, Laboratoire de Géologie Appliquée, Paris, France, visited the various laboratories of the Analytical Chemistry Section in October, to study current analytical methods.

Mr. G.J. Noel, Fuels and Mining Practice Division, Mines Branch, was shown the method in use for the conversion of the sulphur in precipitated barium sulphate (to silver sulphide). He made recoveries of sulphur from bituminous material previously treated by the hydriodic-hydrobromic acid method.

Dr. M.H. Hey, British Museum (Natural History), London, visited the Analytical Chemistry & Mineralogy laboratories in October.

Dr. W. Compston, Australian National University, spent 2 days in October conducting a seminar in the Australian program of Precambrian stratigraphic dating.

Dr. B. Hogg, University of Manitoba, Dr. R. Doig, McGill, Dr. R.M. Farquhar, University of Toronto, spent 1/2 day visiting the Isotope Geology Labs. in October.

Dr. Tupas, Phillipines Geological Survey, visited the Division laboratories.

Dr. H.W. Wilson, Scottish Research Reactor Centre visited the Isotope Geology Section in July.

Dr. R.T. Pidgeon, Cal Tech, on tour from Australia, spent 1 day in July in the Isotope Geology Section. He was interested in zircon dating.

Dr. Sato, U. of Alberta, visited the Isotope Geology Section, interested in S-work.

Prof. G. Springer, Technische-Hochschule in Aachen, Germany, visited the Mineralogy Section in October.

Prof. F.V. Chukhrov, Correspondent Member of Academy of Science, Moscow, visited the mineralogy and geochemical sections in October and November.

Prof. J. Willemse, Head of the Geology Dept., University of Pretoria, Pretoria, South Africa visited the Division in December to discuss petrological studies on layered intrusions.

Messrs. Laakso, Campbell, Vijan and Smith, Laboratories Branch, Ontario Department of Mines, visited the Division in January to discuss X-ray fluorescence and atomic absorption methods.

Dr. C. Beaumont, Directeur Général, Dr. F. Spire and M. Nicolas of the Bureau de Recherche Géologique et Minière in Paris, visited the Division laboratories in February. Their main interest was in data processing.

Dr. A.N. Mariano of Kennicott Copper Corp, New Jersey, visited to discuss economic minerals in alkaline rock occurrences in Canada.

## REPORTS ON SECTIONS

### ISOTOPE GEOLOGY SECTION

R.K. Wanless

#### Introduction

The functions of the Isotope Geology Section are: (i) to determine the age of rocks, minerals and carbonaceous materials using methods based on the radioactive decay of naturally occurring nuclides. (ii) To investigate stable isotopic variations in nature and interpret the fundamental physical and chemical phenomena responsible for the observed trends. (iii) 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 biochemical and geological environments. (iv) To develop instrumental, chemical and physical techniques in isotopic geology.

During the report period the major emphasis was placed on the refinement of Rb/Sr age determination techniques and on the adaptation of a small commercial mass spectrometer for K/Ar age determination work. A relatively small number of sulphur, lead and uranium samples were processed. Substantial advances were made toward the automatic recording of peak heights. Several one litre proportional counters for radiocarbon measurement were fabricated and assembled, but to date, it has proven to be impossible to obtain a sufficiently low background counting rate.

The Geological Survey Age Committee met on May 10th to consider requests for Rb/Sr and K/Ar age determinations. The following Rb/Sr isochron projects were recommended: age of granite cutting ultramafic rocks in Eastern Townships, Quebec; age of pre-Hurwitz basement rocks, District of Keewatin; and the age of post-Hurwitz granite, District of Keewatin. The following projects were tentatively approved if suitable material could be obtained; Harbour Main volcanics, southeastern Newfoundland and age relationships in the Grenville Front area of north-western Ontario. In addition, work was recommended on 39 samples selected from a total of 119 submitted for K/Ar age measurement.

As a consequence of a recommendation of the N.R.C. sub-committee on Isotope Studies and Geochronology, the Geological Survey has assumed responsibility for the development of a national system of recording for all Canadian isotopic age data, as a service to the public, to earth scientists, and to members of the mineral industry. The reporting format is currently being developed and when complete, will be forwarded to all potential contributing laboratories for comment.

In the course of K/Ar reconnaissance age studies micaceous samples possessing anomalously high radiogenic argon contents have been encountered. An understanding of the phenomena responsible for the observed isotopic distributions will be most valuable to geologists interpreting age determination results obtained in shield areas. In order to obtain more material and to study the field relationships of the rocks in detail, one such area adjacent to the Superior-Grenville boundary south of Chibougamau, Quebec, was visited during the 1966 field season. Rb/Sr and K/Ar analyses are now being carried out on samples selected on this field trip.

A number of aspects of the sectional activities have developed during the first three months of 1967. The low level lead laboratory is now nearing design operational level and experience has shown that the laboratory background is low enough to permit measurement of the age of zircons. Rb/Sr isochron studies have been extended to include projects in British Columbia, Quebec and Nova Scotia. At the same time plans for a larger (15" radius) mass spectrometer have been developed and the majority of the components have been ordered.

The format to be used for the national system of reporting of isotopic data has been developed and distributed to a number of interested laboratory workers. The final scheme will be presented to the Geochronology Commission of the I.U.G.S. in Edmonton in June 1967.

The adaptation of the small commercial mass spectrometer (A.E.I. M.S. 10) for argon analyses is now nearing completion. The resolution of the instrument has been increased and the high voltage

supply has been modified to permit rapid sequential switching between masses, thereby facilitating the use of digital recording of ion currents. Preliminary experiments indicate that the instrument, when operated in the static mode, is approximately 50 times more sensitive than the instrument currently employed.

### Age determination program

#### K<sup>40</sup>-Ar<sup>40</sup> Age Measurements (O.P. 28)

As a consequence of the loss of experienced technical staff and the difficulty encountered in finding replacements, the output of the laboratory in 1966 was somewhat lower than during the corresponding period of 1965. However, a total of 135 K/Ar age determinations were completed and at the same time considerable progress was made with three long term plans designed to make the laboratory operation more efficient.

The first major modification to the experimental procedures involved the assembly of a glass high vacuum line designed to permit the simultaneous filling of 180 argon-38 spike tubes at the same pressure, thereby reducing the number of calibration operations and mass spectrometric analyses required. Unfortunately, practical considerations forced the reduction of the number of tubes handled at one time from 180 to 70. The modified apparatus has now been used to prepare two batches of 70 spikes on which pressure calibrations have been successfully completed.

Secondly, a small (2" radius) commercial mass spectrometer (Associated Electrical Industries, M.S. 10) has been purchased and is to be used exclusively for argon analyses. Various electronic units and a vac-ion pumping system have been adapted for use with the apparatus and vacuum tests have been successfully completed. One of the internal slits of the source assembly has been modified in order to increase the resolving power of the instrument to ensure complete resolution of mass 38 and 40. An all metal sample inlet line embodying a variable leak valve has been fabricated and attached to the mass spectrometer. The assembly will become completely operational with the incorporation of a mass selector and switching unit within the high voltage supply of the instrument. This modification will permit rapid switching from peak top to peak top thereby facilitating the use of automatic peak height measuring equipment.

The third major modification embodies the adaption of an integrating digital voltmeter to measure the intensity of all ion currents thereby eliminating the laborious, time-consuming task of measuring recorder charts.

The first of the major modifications is now fully operational and the advantages are being realized. With the completion of the modifications to the M.S. 10 and the final incorporation of the automatic measuring apparatus additional savings in time and personnel will be realized.

The geographical distribution of K/Ar age measurements remains very much the same as in previous years with samples from the Precambrian Shield accounting for 51%, Cordillera 35%, Appalachian province 9% and miscellaneous sources 5% (including measurements required for special mica studies and determinations carried out on materials obtained from the Mid-Atlantic Ridge). The individual measurements and geological comments will be published in the annual G.S.C. isotopic age determination report. The 1966 version of this report was prepared using an off-line printer and while several difficulties were encountered this year, use of the method should make it possible to have the 1967 edition published earlier in the year than previously.

When possible, both biotite and hornblende concentrates have been prepared from the same rock in order to provide an independent check on biotite ages. In a large proportion of the cases studied we have encountered hornblende results from 10-20 per cent lower than that determined for the associated biotite. The reason for the discrepancy is not clear but in order to check one possible cause (high potassium analyses) the decision was taken to use isotope dilution techniques to determine the hornblende potassium contents. The results of this study, which is now well in hand, will assist in calibration of our X-ray apparatus in the low potassium range encountered in hornblende samples.

#### Rb/Sr Age Determinations (O.P. 28)

Experimental techniques for the preparation of rubidium and strontium samples have been firmly established and the background contamination levels have been routinely maintained below  $1 \times 10^{-9}$  g for Rb and  $12 \times 10^{-9}$  g for Sr per extraction. This accomplishment is outstanding in view of the fact that technical staff assumed responsibility for this phase of the operation on short notice late in 1965, and at the same time continued to process samples required for the K/Ar age program. Late in 1966 a new  $\text{Sr}^{84}$  spike solution was prepared and calibrated. This spike replaces the double spike referred to in last year's report and permits a more accurate estimation of the  $\text{Sr}^{87}/\text{Sr}^{86}$  ratio in spiked strontium analyses.

The following isochron studies were undertaken:

<u>Project</u>	<u>Status</u>
Preissac-Lacorne Batholith, Quebec	Whole-rock & pegmatitic mineral isochrons completed
Pre-Acadian Granites, N.B.	Whole-rock & mineral isochrons completed
Brisbane Lake Stock, N.W.T.	Completed
Timiskaming rocks, Ontario	Completed
Pre-Timiskaming rocks, Ontario	Completed
Dubawnt Volcanics, N.W.T.	Completed
Yellowknife Volcanics, N.W.T.	Preliminary investigation completed
Muskox Intrusion, N.W.T.	Whole-rock and mineral determinations complete
Pre-Hurwitz rocks, N.W.T.	Completed
Post-Hurwitz rocks, N.W.T.	Completed
Beaverlodge Area, N.W.T.	Completed
Granite, Thetford Mines, Quebec	In progress
Milkish Head granite, N.B.	In progress
Chibougamau-Grenville Front, Quebec	In progress
Miscellaneous samples	
Thor-Odin gneiss, B.C.	Completed
Deep bore-hole, Manitoba	Completed.

The results of the isochron projects are being prepared for publication in a G.S.C. report and/or outside publications. It is anticipated that the first annual release of Rb/Sr results will be ready for publication in 1967.

All Rb/Sr isochron results are now computed using a program prepared by D. York, University of Toronto, and modified for use on the departmental computer. This program provides the best-fit line, the age and error limits, the intercept, and the error limits associated with the intercept.

The time required to clean solid source filament assemblies between analyses was considerably reduced through the use of a Vibrodyne cleaning unit. Tests have shown that source assemblies processed in this way have no rubidium and strontium background.



### U-Th-Pb Age Determinations (O.P. 463)

The majority of the lead and uranium analyses were carried out by Dr. V. Koeppel for his study of the age of pitchblende deposits in the Goldfields, Saskatchewan area. Six galena specimens were analyzed in order to provide inter-laboratory control for specimens being analyzed in commercial laboratories.

The preparation of the lead and uranium samples was only possible through the kind assistance of Mr. W.A. Smith (formerly of our staff) who consented to work overtime on Saturdays in order to carry out the extractions and to familiarize our technical staff with the experimental techniques.

Dr. Koeppel has now completed his study of the region and has submitted his report for publication. He has returned to Switzerland where he has taken a position in the mass spectrometry section of the Institute of Crystallography and Petrography in Zurich.

The techniques employed for the work outlined above are essentially the same as those required when processing zircon samples for age determination. Late in 1966 a chemist (Mrs. Pun) was appointed to the Analytical Chemistry Section to carry out this aspect of our work and we look forward to increased emphasis on this phase of the age determination program.

### Radiocarbon Dating Laboratory (O.P. 457; 338)

The majority of the samples processed were selected to provide data for current research projects in the field of Quaternary chronology and related glacial events; to shed light on crustal movement as evidenced by shore level changes; and to provide information on the rates of geological processes such as sedimentation. The remainder comprise archeological and geochemical samples. All sample selections were made by the G.S.C. Committee on Radiocarbon Dating.

One sample of wood selected from a carved figure of historical interest was dated for the National Gallery of Canada. The analysis served to confirm the anticipated antiquity of the object.

Both the two litre and the five litre counters were operated routinely to process a total of 265 samples. One hundred and fifty-six of these determinations have been submitted for publication in Radiocarbon, volume 9. A series of analyses were compared with those carried out on identical materials by commercial laboratories. The agreement between the laboratories was in general good although a variation in the results for

one specimen remains unresolved. The details of this work will be published in a forthcoming age list in Radiocarbon. The counter background levels were maintained for both counters although a slight seasonal fluctuation was again observed.

The  $C^{14}$  concentration in leaves from the Champlain Lookout and the Dominion Experimental Farm in Ottawa was found to be the same. The level has continued to drop from the high value observed in 1964.

Considerable difficulty has been encountered in assembling a one litre proportioned counter. In all, four different assemblies have been prepared but the lowest background obtained was 1.2 c/m which is unfortunately about twice as high as it should be. The search for better materials is continuing.

### Stable Isotope Studies

#### Sulphur Isotope Determinations (O.P. 62)

The investigation of the sulphur isotopic distribution in mineral deposits and associated host rocks may provide valuable information regarding the chemical and physical processes responsible for ore formation, migration and deposition. The laboratories are equipped with the vacuum extraction and purification apparatus required for the preparation of sulphur dioxide for isotopic analysis and with a sensitive mass spectrometer. During 1966 activities in this field were, however, curtailed due to the pressure of the requirements of the age determination program and the loss of trained technical staff. However, a series of analyses were completed for the G.S.C. officers listed below. No meetings of the Stable Isotope Committee were called during 1966.

H. Trettin	Melville Island, N.W.T.	14 samples
J.A. Chamberlain	St. Stephen, N.B.	25 "
R.W. Boyle	Keno Hill, Yukon	70 "
R.W. Boyle	Walton, N.S.	10 "
C.H. Smith	Sudbury, Ontario	17 "
Total		136 samples

### Statistics

#### Mass Spectrometer Analyses

##### A) Samples in gaseous form

Extracted argon samples .....	211
Argon - 38 calibrations .....	53
Linde atmospheric argon .....	2
Zurich argon - 38 .....	12
Sulphur dioxide .....	<u>154</u>

Total 432

b) Samples in solid form

Rubidium .....	130
Strontium .....	260
Potassium .....	36
Lead .....	91
Uranium .....	<u>21</u>

Total 538

Total analyses 970

c) K/Ar Age Determinations .....	186
d) Rb/Sr Isochron studies .....	13
e) Radiocarbon age determinations .....	265

## ANALYTICAL CHEMISTRY SECTION

J.A. Maxwell

### Introduction

The functions of the Analytical Chemistry Section are:

- (i) To provide chemical and instrumental analyses of rocks, minerals and related terrestrial and extraterrestrial materials for the solution of geological problems.
- (ii) To adapt, develop and publish methods and techniques for the analysis of geological materials.
- (iii) To advise Branch geologists on the use of chemical theory, analytical techniques and data for the solution of geological problems.

- (iv) To compile and publish chemical data on geological materials.
- (v) To train scientists and technicians from Canada and abroad in methods of analysis of geological materials.

The volume of work handled by the Section in the report period is given at the end of this section, and 1966 data are compared with similar data for 1965.

A two-day Workshop on the Chemical Analysis of Geological Materials was held in February, 1966. It was organized by members of the Analytical Chemistry Section and sponsored by the Subcommittee on Mineralogy, Petrology and Geochemistry of the National Advisory Committee on Research in the Geological Sciences. Thirty-seven participants representing 19 agencies, including Provincial Mines Departments, Universities and Research Councils from Newfoundland to British Columbia, were shown in detail the methods of analysis used in the Section, and much useful information was exchanged during the demonstrations and discussions.

National Film Board Staff members spent several days in the laboratories of the Section in August shooting material for use in the Geological Survey film. Several Section members actively participated in the sequences.

J.A. Maxwell served as Acting Division Chief from February-May 1966, and intermittently during June and July. During August and September he visited fourteen institutions in Norway and England engaged in silicate and related analysis, to discuss analytical methods and techniques; much information of potential present and future benefit to the work of the Section was obtained.

#### Personnel

Mr. F.C. Hill joined the staff of the Spectrographic Laboratory in January, 1967 to assist in method development work.

Dr. Peter Blattner, NRC Postdoctorate Fellow from Basel, Switzerland, left in February, 1967 to take a post with D.S.I.R., Petone, New Zealand.

#### Chemical Laboratories

The chemical laboratories of the Section provide both detailed and partial rock and mineral analyses for use in geological studies. The majority of the samples submitted are analyzed by rapid methods, consisting of the determination by X-ray fluorescence spectroscopy of Si, Al,

Fe, Ca, Mg, K, Mn and Ti and the chemical determination of Fe (II), Na (flame photometer), P, CO<sub>2</sub> and H<sub>2</sub>O. Minerals and special samples, as well as some rocks, are analyzed by a variety of modified classical and instrumental methods; among the latter are flame emission and absorption photometry, spectrophotometry, potentiometry and fluorimetry. The chemical extraction and purification of small quantities of Pb, U and Th from rocks and minerals for isotope studies is done for the Isotope Geology Section.

During January, 1967 a major overhaul and cleaning of the X-ray fluorescence spectrometer was undertaken, and necessary replacements were made. Because of the difficulty in obtaining some needed parts, the instrument was out of action for most of the month.

A successful extraction was made of the lead from the BIO basalt and a mass spectrometric analysis was done. A repeat extraction, to verify the previous findings, was also carried out.

A large part of the analytical facilities of the Section has been devoted to the analysis, by classical, rapid chemical and X-ray fluorescent, atomic absorption and flame emission spectroscopic, and optical emission spectrographic methods, of 144 micas and associated rocks for Dr. J. Y. H. Rimsaite.

### X-ray Fluorescence Spectroscopy

During the year rather more than the usual instrumental troubles were encountered, leading to lengthy and frustrating delays in the routine work. Instrumental malfunctioning in the Applied Research Laboratories VXQ Spectrometer began in January and reached its peak in May with the complete breakdown of the high-voltage transformer, putting the instrument out of action for over two months while fruitless efforts were made to obtain a replacement unit. The spectrometer became operational again in July, by which time a sizeable backlog of samples awaiting analysis had accumulated. Further difficulties occurred in October and November with the detector assembly for aluminium, and 10 working days were lost while repairs were attempted. A suitable replacement has yet to be obtained.

Emphasis was placed on the development of a non-fusion general method for silicate rocks, which would materially decrease the time required for the rapid analyses, compared with the fusion procedure in routine use. At the same time a more rigorous fusion procedure was investigated; it was hoped that this would provide a means for obtaining results having an accuracy closely approaching that of the classical methods but in much less time than by the latter. The uncorrected values

obtained by the non-fusion method are suitable for studies of a reconnaissance nature involving large numbers of samples, and for reducing such large numbers to a residue on which further analytical work is justified. Studies are continuing on the improvement of the attainable accuracy by such means as the application of corrections for mass absorption effects and the use of more closely-related reference samples in the preparation of the analytical working curves. The improvement in the accuracy of the values obtained by the amplified fusion procedure was not as great as expected but this must be attributed in part to instrumental difficulties which 'clouded' the experimental results. Further efforts are being made to achieve the desired objective.

A digital voltmeter and paper tape print-out, replacing the pen-chart intensity recorder, were installed during the enforced shut-down of the spectrometer and are now in routine use.

### "Other" Chemical Analysis

The number of samples submitted (683) during 1966 was almost double that received in 1965, as was the number completed (613). In addition to detailed classical analyses made on a variety of rocks and minerals, partial analyses were made on a large number of samples, ranging from sulphides to plant ash. Important developments in this area of Section Activity are as follows:

#### (a) Atomic absorption spectroscopy

Atomic absorption spectroscopy has been applied in several areas. Magnesium can be determined simply and rapidly with no chemical separations, and this has been useful in those materials where low magnesium content has resulted in unreliable X-ray fluorescence results. Traces of lithium have been determined in rocks, down to 2-3 parts per million, without chemical separations, and with better sensitivity than is possible by emission flame photometry. Similarly, traces of zinc have been determined, the method being singularly free of interference effects. Further, magnesium and iron have been determined with good precision in biotites and other materials containing relatively high concentrations of these elements, using a single solution representing only a few milligrams of sample.

#### (b) Determination of fluorine

The reliable determination of fluorine in silicates remains a problem. Two non-distillation methods were examined in some detail but the results were not satisfactory, and the distillation method, with both a titrimetric and a colorimetric finish, continues to be used.



(c) Fluorimetric laboratory

The installation of a new laboratory for the fluorimetric determination of uranium was completed in May and applied during the summer months to composite samples representative of the Canadian Shield (thorium was also determined on these samples by a colorimetric method).

(d) Platinum metals in meteorites

A study of the distribution of the platinum metals in both stony and iron meteorites has been completed. In the course of this work a new spectrophotometric method for the determination of palladium, using Arsenazo III, was developed (see Outside Lectures).

(e) Analysis of reference standards

Work continued intermittently on the analysis of proposed standard samples, both internal (spectrographic, picrite, Q-series) and external (U.S. Geological Survey, U.S.S.R. nepheline syenite, University of Toronto granite), and the accumulated data are being evaluated.

(f) Titrimetric determination of  $\text{SiO}_2$

A titrimetric method for the determination of silica over the range 30-80 per cent  $\text{SiO}_2$  is under investigation as a possible alternative method for routine use. The method, involving the NaOH titration of precipitated potassium fluoro-silicate, is about as rapid as the colorimetric procedure and less subject to hidden error.

Isotope Chemistry Laboratory

The work of this laboratory was seriously curtailed by the delay in securing a replacement for Mr. C. Peters, the chemist in charge of the laboratory, who left in September, 1965. Staff members of the Isotope Geology Section carried out necessary preparations and analytical work until the arrival of Mrs. Mina Pun to take charge in September, 1966. Since then the laboratory has been restored to its former state, new supplies of special reagents have been prepared and Mrs. Pun has familiarized herself with the methods, procedures and problems peculiar to the laboratory.

Spectrographic Laboratories

The Spectrographic laboratories of the Section provide quantitative, semiquantitative and qualitative trace element analyses for use in geological studies, chiefly on aluminosilicates. About 50 elements are

determined with a photographic recording spectrograph; a direct-reading spectrograph is being put into operation.

There was a considerable decrease in the total number of samples submitted (to about one-third of the total submitted in 1965). Because of this, and in spite of the reduced output of the laboratory in terms of samples completed, the backlog carried into 1967 was much smaller than that carried into 1966. The volume of work, in terms of total number of determinations made, is slightly greater, however, than that of 1965, indicating that generally more determinations were made on each sample than in the previous year. The sharp drop in the total number of quantitative determinations made is balanced by significant increases in the totals for the qualitative and semiquantitative determinations. The changes in laboratory staff and the priority requirements of sample analysis made it necessary to restrict analytical development work to the minimum needed to maintain existing methods in satisfactory condition.

### General

The processing of photographic plates was greatly complicated by irregular temperature control and poor water quality during most of the year. New water-regulating equipment was installed in the darkroom in November.

Drs. P. Blattner and A. De, Postdoctorate Fellows with the Division, were accorded the use, under supervision, of our analytical facilities to do work on their own samples.

### Photographic Methods Development

Establishment of working curves for trace elements in rocks by our revised air-jet controlled D.C. arc method was resumed at the end of 1965 and continued into early 1966. Sixteen curves were completed or extended and eleven new curves were provisionally set up. The method as it is now in use covers 37 elements determinable quantitatively as traces in common rock types.

Analytical data are now being accumulated by this and other methods on a number of internationally available reference samples which will lead to improvement in the accuracy of our trace element determinations.

### Direct-Reading Method Development

Analytical programming to establish working curves on the direct reader was begun late in 1965 and carried on into the Spring of 1966. However, the staff situation has not permitted putting the instrument into service and it is being held in standby condition until programming can be resumed.

Minor mechanical and electronic modifications were made to the instrument for operational convenience. Optical stability and electron readout reproducibility proved excellent after improved air-conditioning equipment was put into service in June of 1966.

### Office Projects

- O.P. 119 Study of meteorites. Descriptions of four Canadian meteorites (Belly River, Dresden, Holman Island and Benton) are being prepared for publication. Chemical and X-ray fluorescence analyses were made on a very small sample of the Revelstoke carbonaceous chondrite and the results are being prepared for publication jointly with the University of Alberta.
- O.P. 121 Compilation of Canadian rock and mineral analysis. The use of data processing methods for further publications similar to GSC Bulletin 115 is still being investigated.
- O.P. 280 Preparation of an ultrabasic rock sample for analytical reference. Data have been accumulated for the major, minor and trace elements in this sample and a paper describing its preparation and analysis is in preparation. The reference sample is intended for internal use only.
- O.P. 288 Composition of the Canadian Shield. A paper giving the data and conclusions for collection points in New Quebec has been published (Eade, Fahrig and Maxwell).
- O.P. 397 Platinum metals in meteorites. This project is now completed. A paper describing the use of Arsenazo III as a reagent for the determination of palladium is in press (Sen Gupta). A final paper on the separation, determination and significance of the platinum metals in stony and iron meteorites is in preparation.

- O.P. 411 Analysis of proposed reference rock powders prepared by U.S. Geological Survey. Chemical and spectrographic data have been obtained for the major, minor and trace constituents of these six samples (granite-peridotite) and a final statement of results is in preparation.
- O.P. 474 Study of field sampling errors. Chemical and emission spectrographic analyses have been completed for three bulk samples of the Westport syenite, taken by three geologists, and the data are being evaluated.
- O.P. 480 Collaborative analysis of nepheline syenite. Chemical and emission spectrographic data have been obtained on this sample supplied by Professor Khoukarenko, U.S.S.R., and a final statement of the results is in preparation.

## STATISTICS

### A. Samples Received and Completed

	<u>Chemical &amp; XRF</u>	<u>Spectrographic</u>
Carried from 1965	549	1,006
Received, 1966-Mar. 31/67	<u>3,332</u>	<u>1,271</u>
	3,881	2,277
Completed, 1966-Mar. 31/67	<u>2,244</u>	<u>1,959</u>
Withdrawals, etc.	<u>114</u>	<u>1</u>
Carried to 1967-1968	1,523	317

Note: A Divisional distribution of samples in the backlog at the end of March 1967 is as follows:

	<u>Chemical &amp; XRF</u>	<u>Spectrographic</u>
Economic Geology	123	202
Petrological Sciences	301	102
Regional Geology	1,067	11
Outside	11	2
Whitehorse	<u>21</u>	<u>0</u>
	1,523	317

B. Summary and Comparison of 1966 and 1965.

	<u>1965</u>	<u>1966</u>
Samples Received		
Chemical and XRF	1,863	2,655
Spectrographic	3,074	1,021
Samples Completed		
Chemical and XRF	2,185	1,919
Spectrographic	2,564	1,789
Analyses and Preparations Reported		
Chemical and XRF	2,185	1,919
Spectrographic		
Qualitative	425	221
Semiquantitative	253	397
Quantitative	2,256	1,507
Backlog at year end		
Chemical and XRF	549	1,177
Spectrographic	1,006	237
Determinations Made		
Chemical (including development)	7,176	9,250
X-ray Fluorescence (including cali- brations, rechecks, etc.)	34,342	26,454
Spectrographic		
Total	33,474	33,807
Qualitative	6,375	9,945
Semiquantitative	3,092	8,645
Quantitative	24,007	15,217
Spectrographic Exposures		
Analytical	3,663	2,417
Development	1,244	1,155

## MINERALOGY SECTION

R.J. Traill

### Introduction

The functions of the Mineralogy Section are:

- (i) 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.
- (ii) to develop X-ray, electron beam, and other techniques for use in producing analytical results of geological significance.
- (iii) to provide mineralogical data to staff geologists for use in solving geologic problems.
- (iv) to compile and publish data on Canadian mineral localities.
- (v) to catalogue the National Mineral Collection and to develop, extend and study the Systematic Reference Series of the Collection.
- (vi) to mechanically concentrate geological materials for use in analytical laboratories of the Geological Survey.
- (vii) to collect bulk mineral and rock samples in order to assemble and sell collections to the Canadian public.
- (viii) to identify mineral and rock samples as a public service and deal with public queries in this regard.

### Field Activities

- GS. 64-48: Miss A.P. Sabina studied mineral and rock collecting localities along the north shore of the St. Lawrence River between Kingston, Ontario and Lac St-Jean, Quebec. Descriptions of these localities will be published as a guide book for mineral collectors.
- O.P. 6: C.H.R. Gauthier accompanied by J.M. Larose visited about 85 localities in New Brunswick, Nova Scotia, Ontario and Quebec. Approximately 23 tons of minerals and rocks were collected for the preparation of educational sets for sale to



the Canadian public. At the same time, 44 large specimens were collected and shipped to the Expo '67 site for the Geology Court of the Canadian Government Pavilion.

- GS 66-40: J.L. Jambor examined various mining properties in the Cobalt, Ontario area during two weeks in July. Specimens of vein material and alteration zones were collected in order to study the mineralogy of primary haloes. An X-ray study of the vein carbonates will also be made in order to establish the composition and distribution of these minerals.
- GS 66-63: F. Aumento spent four weeks on the G.S.C. Hudson in charge of deep sea dredging operations with the B.I.O. Mid-Atlantic Ridge Geophysical Cruise No. 19-66. Basalts were collected from the Median Rift Valley and adjacent mountains, and large hauls of anomalous granitic and gneissic rocks were taken from an isolated seamount. Detailed petrological, chemical, magnetic and isotopic studies are underway and will be completed in 1967.
- O.P. 101: H.R. Steacy spent 24 days in the field on collecting trips to seven localities in Ontario and Quebec. Most trips were made in collaboration with Louis Moyd, Curator of Mineralogy at the National Museum of Canada. A large volume of useful material was collected, including more than a ton of selected specimens from the Madoc occurrence where eight new sulpho-salt minerals were identified by J.L. Jambor.

### Laboratory Activities

#### Preparation of collections of Canadian rocks, minerals, and fuels (O.P. 6)

Sales of prospector's sets of mineral and rock chips increased slightly (10%) over the 1965 sales. Comparative figures for the two years are as follows:

<u>Location</u>	<u>1965</u>	<u>Jan/1966-Mar. 31/1967</u>
Ontario	2,239	2,838
British Columbia	942	1,661
Alberta	452	648
Saskatchewan	447	682
Yukon	200	404
Quebec	384	411
Manitoba	127	296
Nova Scotia	166	216

<u>Location</u>	<u>1965</u>	<u>Jan/1966-Mar. 31/1967</u>
Northwest Territories	17	87
New Brunswick	42	193
Newfoundland	1	6
Prince Edward Island	3	15
Labrador	3	0
Ottawa Office	1,107	761
	<u>6,130</u>	<u>8,218</u>

The educational value of the prospector's sets has been improved by the inclusion of identification tables, a list of selected Government publications and, through the courtesy of the Canadian Institute of Mining and Metallurgy, a booklet on Careers in the Mineral Industry.

Sales of the 120 specimen collection representing the raw materials of Canada's mineral industry amounted to 146.

The task of preparing specimens for 70 special collections of the 120 specimen set representing Canada's mineral industry neared completion with the preparation of 4,455 specimens. These sets are to be displayed at Canadian Embassies throughout the world. The unit also prepared the following special specimens and collections:

- (1) 8000 specimens for the Ottawa Secondary School Fair.
- (2) 1440 specimens for the National Film Board educational film strips.
- (3) 100 specimens 6" x 8" x 4" for the Centennial Caravans.
- (4) 274 hand specimens for Expo '67.
- (5) 96 ore specimens 4" x 6" x 4" for display in U.S.A.
- (6) 25 specimens 6" x 6" x 4" for exchange with U.S.S.R.
- (7) 2 tons of rock chips for construction of a mosaic map of Canada for display at Expo '67.
- (8) 100 collections of 6 specimens for Dr. W. Neale for students.
- (9) 4 each of rocks and mineral sets in wooden boxes for Regional Offices.
- (10) 12 sets of 17 specimens for student class given by Dr. Rimsaite.

#### Examination of mineral and rock samples (O.P. 7)

R.N. Delabio and J.L. Jambor provided mineralogical assistance to officers of the G.S.C. through preparation and identification of 2,924 X-ray powder patterns of minerals; 189 determinations of chemical composition from X-ray diffraction measurements; 26 measurements of unit cell constants from X-ray patterns; and 44 clay mineral analyses.

R.N. Delabio and C.H.R. Gauthier examined 1,608 samples of rocks and minerals as a free service to the public. The results were communicated to the submitters orally and in 231 letters.

Miss Ann P. Sabina replied by letter to 54 enquiries from the public regarding Canadian mineral localities. Most of the enquiries came from tourists and mineral collectors.

#### Reference collection of X-ray powder patterns (O.P. 15)

Work on the catalogue of X-ray patterns was at a standstill for most of the year and only 32 new patterns were added to the collection.

#### Age determinations of rocks and minerals (O.P. 28)

Examination of mineral concentrates and rocks submitted for age determination was continued by Mrs. C. Edmonds. During the period covered by this report the age determination committee approved 284 analyses. Concentrates of 203 minerals were examined and forwarded to the Isotope Geology Section. The work involved 203 X-ray diffraction analyses, and optical study of 199 concentrates and 30 thin sections.

#### Systematic Reference Series, National Mineral Collection and G.S.C. Ore Collection (O.P. 101)

The Systematic Reference Series is the research portion of the National Mineral Collection. The most significant development in 1966 was the completion of the reorganization of the Series to Dana's new system. Begun in 1965 this reorganization has been a major task, involving the regrouping and reindexing of 7,500 specimens representing about two-thirds of all known minerals. In its new format the Series will become a more efficient working arm of the Mineralogy Section.

The Series acquired 385 specimens or groups of similar specimens: by purchase (211), gift (102), exchange (65) and collection (7). They included 73 minerals new to the Series, raising the total number of recognized species and varieties on file to 1,460. Twenty-five requests were met, varying from the loan of individual specimens to the provision of 19 minerals for the preparation of geochemical standards. In all, 276 specimens were supplied in response to the requests. Seven exchanges were completed during the year with sources in Australia, Canada, Finland, France and New Zealand.

Grateful acknowledgment is made to the following persons for gifts of specimens to the Series: G. Chao, J.-P. Drolet, B.A. Edmond, R.B. Ferguson, S.A. Forman, E.A. Goranson, D.D. Hogarth, H.H. Bostock, R.W. Boyle, R.L. Christie, J. Fortescue, M.J. Frarey, C.H. Gauthier, J. Jambor, E.D. Kindle, A.S. McLaren, J.E. Reesor, S.C. Robinson, A.P. Sabina, R.I. Thorpe and R.J. Traill; R. Buchan, K.L. Currie, G.H. Faye.

Mr. Steacy was active in preparations for the Centennial year. He acted as a consultant in the planning of the Geology Court at the Canadian Pavilion, Expo '67, assisted in the procurement of large blocks of minerals, rocks and ores for the Court, and assembled nine suites of display specimens for the Centennial Caravans. To try and stimulate an interest in determinative mineralogy a series of mineral quizzes was placed in Logan Hall, but they were greeted with little enthusiasm and subsequently discontinued.

Although used only infrequently the G.S.C. Ore Collection is not dormant and material is continually added to it. The collection was improved by the addition of four suites of specimens from mines in the Cobalt camp, a suite of specimens from the Kirkland Lake camp, a suite of ore specimens obtained on exchange from the U.S.S.R., and specimens from Gortdrum Mines Limited, Ireland and from the Canada Tungsten Mining Corporation. For the latter two specimens we are indebted to J.-P. Drolet and F.E. Hall, President, Canada Tungsten Mining Corporation Limited. One of the Cobalt suites was kindly donated by S.C. Robinson; the other three were collected by H.R. Steacy and Louis Moyd. The Kirkland Lake suite is the gift of R.W. Boyle.

#### Catalogue of Canadian Mineral Occurrences (O.P. 160)

Completion of this project was delayed due to pressure of other duties. The manuscript is well advanced and should be completed in 1967.

#### Studies of New and Rare Minerals (O.P. 306)

a) Sulfosalts from Madoc, Ontario. This study is essentially completed. Most of the effort in the past year was directed toward determinations of the paragenetic sequence of the sulfosalts by ore microscopy, and determination of the reflectivities of the new minerals. The depositional sequence of the Madoc suite is unique in that the sulfosalts follow a trend of decreasing  $As_2S_3$  content rather than the usual increase in S activity. Several weeks were spent at the Mines Branch in the spring using their reflectivity apparatus. Results were not considered satisfactory because of insufficient stability of the photomultiplier tube.

This defect has now been corrected and the measurement of the reflectivities of the new minerals is currently in progress.

Most of the remaining work on the Madoc suite consists of checking some of the single crystal symmetries. Part I of the manuscript has been completed for submission to the Canadian Mineralogist.

(b) "Muskowite". Several weeks of Weissenberg and Precession camera time were spent in attempts to obtain the cell dimensions of this new hydrous magnesium-iron oxide mineral. The mineral gives only a few diffuse diffraction spots and further complications arise from the razor-thin platy habit accompanied by complex twinning. Electron diffraction patterns have been obtained, but the large cell required to index the very few lines appearing in the powder pattern makes the 3-dimensional parameters rather tenuous.

(c) Yukonite. The original material collected by J.B. Tyrrell has been studied and a preliminary paper showing its identity to arseniosiderite was prepared. Revision of the manuscript to a quality suitable for publication has not yet been undertaken.

(d) Mckinstryite. Work on this new Ag-Cu sulfide from Cobalt, Ontario consisted of the examination of about sixty specimens for Cobalt and the collection of additional ore samples from the type locality. A few polished sections were also examined in order to ascertain the mineral textures, associations, and paragenesis. A manuscript entitled "Mckinstryite, a new copper-silver sulphide" by Skinder, Jambor and Ross is in press in Economic Geology.

(e) Tin-bearing silicates. J.L. Jambor prepared an internal report on the results of a study of the distribution of tin within co-existing silicate minerals in two tin-rich skaarns that occur in northern British Columbia. These results are to be combined with additional studies, including chemical analyses and geology and published jointly by Mulligan, Jambor and Maxwell.

#### Studies of Chlorites

Mr. D. Fong, a graduate student from Queen's, undertook during the summer a study of chlorites using X-ray diffraction techniques. The purpose of the study was (1) to provide the X-ray lab with powder patterns suitable for use as standards for routine identification of the chlorite minerals, and (2) to evaluate the effectiveness of routine X-ray powder patterns as a means of distinguishing among the various known chlorite polytypes. A report has been prepared by Mr. Fong for internal use.

### Applications of X-ray Spectrography (O.P. 307)

a) An investigation was carried out on the possibility of using a fusion method for the determination of potassium in micas (for age determinations of minerals) where the amount of sample is too small for analysis by the conventional method. It was found that the reproducibility of the pelletized bead is poor and the method will not meet the precision required for age determinations.

b) The first 5 months of 1966 were spent evaluating a direct method for the analysis of rocks by X-ray fluorescence. Precision and instrumental stability were assessed and general working curves derived for the eight constituents  $MgO$ ,  $Al_2O_3$ ,  $SiO_2$ ,  $K_2O$ ,  $CaO$ ,  $TiO_2$ ,  $MnO$  and total Fe as  $Fe_2O_3$ . The possibility of applying interelement corrections is currently being investigated on a part time basis.

c) A total of 2,555 quantitative analyses were made on rock and mineral samples, in addition to 170 complete qualitative analyses and 716 partial qualitative analyses.

### Electron probe microanalysis (O.P. 308)

Up to the end of May the electron probe (Elion) was in operation for only 14 days, all devoted to the analysis of mineral samples. During this time G.R. Lachance was on loan to the Analytical Chemistry Section to assist with the development of a more rapid method of analysis for rocks by X-ray fluorescence. In early June, the Materials Analysis Company (MAC) electron probe column was delivered and since then the new probe has been in operation 67 days, mainly on calibration and verification of operating parameters. Investigations were carried out on mineral samples submitted by

Dr. V. Koeppel - (P.D.) Pet. Sci.  
Mr. P. Simpson - Econ. Geol.  
Mr. R. McLeod - Econ. Geol.  
Dr. P. Blattner (P.D.) Pet. Sci.  
Dr. J. Jambor - Pet. Sci.  
Dr. J. Douglas - Pet. Sci.  
Dr. H. Bostock - Reg. Geol.  
Dr. Sakrison -  
Dr. S. Roscoe - Ec. Geol.  
Miss A. Sabina - Pet. Sci.

Work continued on a systematic comparison of all proposed methods of correction for quantitative analysis by electron probe.



A versatile method of preparing standards was developed by G.R. Lachance and G. Plant and a note submitted for outside publication.

A series of standard reference minerals was acquired to calibrate the probe for silicate mineral work. The series now includes 26 silicate minerals.

#### Studies of rock-forming micas (O.P. 309)

Research was continued on mineralogical studies of micas and petrological studies of host rocks. The petrographic studies led to the preparation of a paper describing nine types of optically heterogeneous feldspars and their distribution in about two hundred rocks of diverse origin and history. The mineralogical studies were concentrated on the physical and chemical changes that take place on weathering, in particular on the processes of oxidation of iron and dehydration of biotites. Results of this study were presented in a paper given at the 15th North American Clay Minerals Conference and submitted for publication in the Proceedings. The scope of these studies extended beyond the laboratory facilities of the G.S.C. and we are grateful to officers of the Mines Branch for assistance with dehydration studies, absorption studies in the infrared and visible ranges, and electron microscopy.

#### Investigation of relative argon retentivity in suites of primary potassium-bearing minerals and associated alteration products (O.P. 422)

Three concentrates were prepared by hand-picking to check the lowest and highest K/Ar ages previously obtained on micaceous minerals from the Blue Mountain nepheline deposit. The lowest age (294 m.y.) was confirmed on the hand-picked hydronepheline ( $281 \pm 12$  m.y.) the highest age ( $1480 \pm 50$  m.y.) obtained on biotite is now being checked in the Isotope Geology Section.

#### Serpentine mineralogy (GS 66-41)

Systematic investigation of serpentine minerals of the National Mineral Collection of Canada by X-ray diffraction and electron microscopy techniques resulted in the discovery of a new serpentine polymorph exhibiting diverse strain relief mechanisms. The new polymorph has been described in detail in a paper submitted to the Canadian Mineralogist. Techniques for semi-quantitative identification of the components in mixtures of polymorphs of serpentine have been evaluated and are now being used to study the distribution of serpentine minerals in ultrabasic intrusions.

Rock and mineral sets for schools in northern Canada (O.P. 483)

A project to provide approximately 100 teaching collections of rocks and minerals to schools in northern Canada was initiated in 1966 for completion in 1967. The schools concerned are those in the Northwest Territories and Arctic Quebec under the jurisdiction of the Department of Indian Affairs and Northern Development and those in the Yukon Territory under the jurisdiction of the Yukon Territorial Government. Each collection will consist of some 80 hand specimens and will be complemented by a selection of appropriate literature. A prototype collection is on display on the 7th floor of the G.S.C. building.

Sample preparation and mineral separations (J.C. Paris)

At the year's end the laboratory staff consisted of J.C. Paris, B. Machin, Mrs. M. Radmore, D. Smith and B. Murthag. The laboratory continues to be hampered by a large turnover in staff, so that only Paris and Machin have more than one year's experience. In an attempt to improve quality control, a system was introduced whereby on receipt of samples and requisition, the unit head provides the submitter with a summary of the work to be performed and the anticipated date of completion of the work; on completion of the work, the submitter is asked to acknowledge receipt of the completed samples and to state whether or not the work was satisfactory. The changes in locations of equipment noted in the annual report for 1965 were not completed by the Department of Public Works until late summer, 1966.

A summary of activities:

Samples on hand, Dec. 1, 1965 .....	847	
Samples received to Mar. 31, 1967 .....	<u>9,344</u>	10,191
Samples processed to Mar. 31, 1967 .....	<u>9,432</u>	
Samples on hand, Mar. 31, 1967 .....		759

Samples crushed and ground and forwarded to:

Rock analysis laboratory .....	1,977	
Gold Assays .....	555	
Fuels and Stratigraphy .....	3,348	
Retained for mineral operations .....	<u>724</u>	6,604

Mineral separation operations:

Carpco separator .....	2,207	
Frantz separator .....	4,942	
Electrostatic separations .....	785	
Heavy liquid separators .....	4,087	
Superpanner separators .....	702	
Wilfley table separations .....	45	12,768

Mineral concentrates prepared: 2,076

PETROLOGY SECTION

J.E. Reesor

Introduction

The functions of the Petrology Section are:

- (i) 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.
- (ii) 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.
- (iii) To conduct studies on extraterrestrial materials such as meteorites and to maintain the National Meteorite Collection.
- (iv) To consult with Government agencies and the public concerning petrographic problems.
- (v) 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 study of granite continued to be directed toward the elucidation of problems of plutonism and migmatization in a well-defined mountain belt in southern British Columbia.

The status of studies currently being undertaken is as follows:

1. Thor-Odin - A joint bulletin by J.M. Moore (Carleton University) and J.E. Reesor is being completed on this project. E. Froese is currently undertaking a chemical study of Thor-Odin gneisses aimed at understanding migmatization in parts of the gneiss complex. He is also undertaking a related study of the opaque minerals of some assemblages in the complex.
2. N.R.C. Post-doctorate fellow, P.B. Blattner, completed a petrochemical study of the core zone veined gneisses in the Thor-Odin gneiss dome. His term ended in January 1967.
3. P.B. Read's study of the eastern contact zone of the Kuskanox batholith is completed and his thesis accepted by the University of California at Berkeley. It is currently being prepared for presentation as a G.S.C. Bulletin.
4. D.B. Craig's thesis study of the area south of Revelstoke is completed and his thesis accepted by the University of Wisconsin. It is currently being rewritten for presentation as a G.S.C. publication.
5. Prof. G. Mursky's study of the mineralogy and chemistry of the White Creek batholith has progressed to the following stage:
  - a) Feldspars completed. The paper deals with chemical, compositional, structural and thermal data of plagioclase and potassium feldspars.
  - b) Mafic minerals - 75 per cent completed.
  - c) Whole rock mineralogy, chemistry, etc., essentially completed.
  - d) Distribution and partitioning of trace elements between coexisting minerals - all calculations completed, including reduction of a vast number of figures into usable and meaningful forms.

6. P.E. Fox has completed his thesis for Carleton University on the Petrology of the Adamant Pluton, and an edited copy has been accepted for a G.S.C. bulletin.

(G.S. 57-28) Study of Ultramafic Rocks in Canada

T.N. Irvine continued the petrologic study of the Muskox intrusion. This work has involved further collection, compilation and interpretation of petrographic and chemical data on the rocks and minerals of the intrusion in order to define the crystallization history, trends in the composition of the magma, and parameters such as temperature and fugacities of oxygen and water. A first attempt was made to analyze the minerals of the intrusion on a large scale, by means of the electron microprobe. In this project, carried out at the University of Minnesota before the new Branch probe was purchased, analyses were obtained for 5 elements in chromites from 60 samples. With the new probe the Survey will now be able to continue this type of study. A number of chemically analyzed minerals have been collected for standards, and several mineral concentrates which may be suitable for this purpose have been prepared for chemical analysis.

A mathematical evaluation of the heat flow from the Muskox intrusion has been initiated, and preliminary estimates have been obtained for the length of time over which it crystallized.

Dr. Irvine also commenced laboratory studies of the specimen material collected during 1965 from the Aiken Lake and Axelgold Range intrusions in north-central British Columbia. About 75 samples have been prepared and submitted for chemical analysis; concentrates of olivine, pyroxene, chromite, biotite and hornblende are being prepared for chemical analysis and age determinations of olivine composition are in progress.

A paper on the oxide minerals of the Muskox intrusion was presented by T.N. Irvine and C.H. Smith at a symposium on magmatic ore deposits held at Stanford University in November under the sponsorship of the Society of Economic Geologists. The paper is to be included in a symposium volume published by Economic Geology. Dr. Irvine completed the second part of a paper on the use of chromium-bearing spinel as a petrogenetic indicator in which he makes preliminary applications of the theoretical analyses reported last year. It appears that chromites will be very useful for estimating the temperatures and oxygen fugacities under which ultramafic rocks were formed.

D.C. Findlay transferred to Whitehorse, Yukon and assumed the duties of Resident Geologist in June. He visited ultramafic localities in the Yukon and northern British Columbia during the course of his new duties, to collect data for classification of their chemical properties and their association with economic deposits.

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. Preliminary paper published (GSC Paper 64-48). Manuscript awaiting final editing.

#### Drilling for Scientific Purposes

D.C. Findlay completed his assignment as consultant to the Department of National Defence in the drilling of a 10,000-foot hole near Flin Flon, Manitoba. The hole was successfully completed in April. A total of 13 cores, 3 1/2 inches in diameter and ranging from 1.0 to 5.5 feet in length were recovered. Cores and chips were logged at the site and then shipped to the Geological Survey in Ottawa for further study. Geophysical logs were run and also stored in Ottawa. Studies on the core samples are underway at the Geological Survey, the U.S. Geological Survey, MIT, McMaster University and the University of Saskatchewan. A preliminary report has been completed for publication.

#### (O.P. 455) Petrography Laboratory

J.A.V. Douglas and D.E. Lawrence

The Petrography Laboratory provides special petrographic services and is responsible for the 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 rocks, feldspar determinations by fusion, mineral staining in thin sections and rock slices, special petrographic studies, certain optical properties of minerals and the assessment and development of new petrographic techniques.



Mr. D.E. Lawrence joined the staff in July, filling a new position with responsibility for the operation of this laboratory.

Collections:

The Representative Rock Collection is designed to bring together 80-100 specimens for each half of 4-mile map areas, or a similar number from more detailed mapping. Thin sections, where available, are stored in the same tray and an index map and IBM catalogue are kept on file. The following suites were submitted during the year:-

86 B/4	Balser Lake, Dist. of Mackenzie, N.W.T.	P.H. Smith
75, 85	Slave River, Lockhart River, District of Mackenzie, N.W.T.	I.C. Brown

Judging from the number of requests to use this collection its usefulness may be questioned: of a total of three requests, two donors used the collection only in its capacity as a convenient storage area for their past collections; and for the third, the collection was of limited use in preparing the geological map for Expo '67.

The Thin Section Collection contains about 40,000 sections, which are catalogued with accession numbers and the donor's name. There were two requests for material from this collection.

The small Type-Rock Collection incorporated some early collections and received material by donation and exchange. This collection has proved useful for comparisons.

The Canadian National Meteorite Collection received four additions in exchange for samples of the Abee, Alberta enstatite chondrite:

Atwood	chondrite	35 g
Grassland	"	15 g
Harrisonville	"	67 g
Woolgorong	"	76 g

Laboratory Services and Utilization:

Work performed:	Pet. Sci	Ec. Geol.	Reg. Geol.	F&S	Totals	
					1966-67	1965
Specific gravity, rocks	17				17	1000
Mineral staining	40	50	111		591	364
	(90)	(300)				
Refractive Indices	62				152	
	(90)					
Modes	2	18			300	672
		(215)	(65)			
Petrofabric analyses, axis			(1500)		1500	-
Petrographic descriptions	30	1	5	2	646	306
		(355)	(253)	-		
Sample preparation	-				60	80
-hand picking	(60)					
-heavy liquids	-	-	-			
	(35)	(5)	(5)		45	-
Pseudometeorites identified					185	236

Note: Unbracketed numbers indicate work performed on request.  
Bracketed numbers indicate work performed by others using facilities.

Dr. D.C. Foote of McGill University submitted over 100 rocks and minerals samples from eastern Baffin Island for identification. The information will be used in his report of the economic survey of the area.

Collections:

The following suites were added to the Representative Rock Collection:

Sutton Map Sheet, Quebec	W.H. Poole and T.H. Clarke, McGill U.
Tombstone Creek, Yukon	D.J. Templeman-Kluit

A data processing system for cataloguing rock collections was reviewed and evaluated.

(O.P. 119) Study of Meteorites

J.A.V. Douglas

Meteorite falls are announced by bright fireballs and accompanying acoustic phenomena. Three such events occurred in Eastern Canada during the year. These were investigated in detail but unfortunately no meteorites

were recovered. Since graphical reduction of visual sighting data is prone to subjectivity a more objective method, using a computer was developed for calculating the elements of a fireball trajectory. The method was applied to two of the recent fireballs resulting in papers on the fireball of April 25, 1966 (B.A. McIntosh and J.A.V. Douglas) and the fireball of December 9, 1965 (J.A.V. Douglas and H. Lee).

Laboratory investigation of Canadian meteorites were continued. In particular, the Revelstoke, a Type I carbonaceous chondrite, was compared with two classic examples of this type, Orgueil and Alais. The Dresden and Belly River, both olivine bronzite chondrites, show extensive evidence of shock metamorphism. The Garden Head, iron, previously classified as a nickel-rich ataxite, now appears to be an octahedrite of high nickel content because it retains an octahedral arrangement of the nickel-iron phases.

#### DATA PROCESSING UNIT

K.R. Dawson and F.P. Agterberg

The functions of the 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 Computer Sciences Division on matters concerning computer programming, EDP system development and uses of the Departmental computing and unit record facilities for geological purposes.
- (iv) to advise Survey officers and others on the applications of EDP and mathematical techniques to their studies.

The unit, established in 1965, is staffed by Dr. K.R. Dawson, Dr. F.P. Agterberg, Mr. L.H. Boutet and Miss S.M. Cooper who joined the staff during the year.

Geomathematical Research - F.P. Agterberg

a) Two dimensional Spectral analysis

This method was adapted for the study of textures in thin sections. The preferred periodicity in the arrangement of grains of a mineral may show up as a peak in the directional relative variance-frequency spectrum. The method was applied to specimens from the Muskox layered intrusion.

b) Statistical studies of the distribution of copper

Statistical studies of the distribution of copper in the Whalesback Pond ore deposit near Springdale, Newfoundland, is part of the Comprehensive Studies of Canadian Sulphide Deposits coordinated by D.R.E. Whitmore. Preliminary reports were published as a contribution to discussion of a paper by D.G. Krige (Ore valuation Symposium, Johannesburg) and in the proceedings of the 6th Annual Computer Conference held at the Pennsylvania State University. Further work will be reported at the C.I.M.M. Conference on Ore Reserves Estimation and Grade Control at L'Esterel, September 1967.

A good deal of time has been spent on the development of mathematical models for mine evaluation. Each assay value consists of three components: trend, signal and white noise. The trend or large scale variations can be resolved by the method of least squares although the method was first developed for the combination of a trend-noise model. The method will require further modification because of the signal effect which describes the numerous local but gradational fluctuations in concentration. It can be extracted from the autocovariance function for trend-free data and is assumed to be independent of position in the mineral deposit. Data from the Whalesback Newfoundland Mine is being used for this research.

A paper entitled "Mathematical Models in Ore Evaluation" will be presented at the Canadian Operational Research Society. A second paper entitled "Application of Trend Analysis in the Evaluation of the Whalesback Mine, Newfoundland" will be read at the forthcoming CIMM conference at L'Esterel, Quebec in September.

c) Directional Features

In cooperation with H.P. Trettin, Calgary Office, and L.V. Hills, University of Alberta, a manuscript entitled "Palaeocurrent trend analysis of a delta in the Bjorne Formation (Lower Triassic) of northwestern Melville Island, Arctic Archipelago" was prepared which will be submitted for publication.

d) Multivariate Markov Schemes

This technique was applied to chemical determinations of oil well samples provided by E.M. Cameron. The results were presented at the 6th Annual Computer Conference held at Pennsylvania State University. The method was extended to include the case of cyclicity in a multivariate system. A computer program for the extended method was compiled in cooperation with G.D. Cameron, Computer Sciences Division, and the program with a theoretical introduction and operational instructions was submitted for publication as a G.S.C. Paper.

e) Computer Techniques in Geology

A review paper entitled "Computer technique in geology" will be printed in an early edition of "Earth Science Reviews". Dr. Agterberg was also invited to participate in an oral discussion of the subject "Geology and Geostatistics of the Lorraine Mine" at the Annual Meeting of the CIMM in March.

E.D.P. Services and Systems Development - K.R. Dawson

O.P. 504 E.D.P. system to produce K-Ar reports

A study of the annual K/Ar reports indicated that an EDP procedure could improve the efficiency of the manuscript preparation. During the last six months a unit record procedure has been developed that will print the masters for photolithography. The system produced the masters for 6,000 lines (approximately 120 pages) of text by the end of December 1966.

O.P. 507 E.D.P. production of a G.S.C. negative file catalogue

The Photography Section added a photolibrarian to staff who will be responsible for the operation of the 3" x 5" card catalogue for the Branch black and white negatives. The backlog of uncatalogued negatives that extends back several years poses a large typing job. A proposal was made to apply an EDP procedure to process current accessions and gradually reduce the backlog using available staff and equipment. This was accepted and development of a unit record system is nearly complete. The regular negative title report form has been modified, the depth of cross-referencing has been increased by the introduction of concepts, and file space will be saved by the use of book catalogues updated annually instead of 3" x 5" cards.

The photograph negative index proposal came in for some debate late in 1966 and early in 1967. This is attributed in part to the simultaneous

effort to call in all outstanding field photograph captions. A Manual to explain coding procedure was written, critically read by Drs. J.A. Donaldson and C.F. Buck, modified and a few hundred copies were printed and circulated. The Index for 1966 was printed and supplied to the photography division. It is proposed to print a quarterly supplement and update it fully once a year.

O.P. 426 Development of GEODAT-G.S.C. Index to Geological Data

Phase I of the GEODAT System was turned over to the Department in July and immediate steps were taken to sequence the 250k card file in readiness for writing the master tape. This has made the card file an inconvenient source of data. Three Departmental programmers, who have been hampered by both hardware and software problems not promptly corrected by the computer manufacturer, have been working on Phase I. Approximately 180k cards were written on magnetic tape by the end of 1966.

A study was made of the Branch forms from which GEODAT cards are currently being punched. Among the defects observed are the illogical distribution of the data, a lack of essential data, poor legibility, and a combination of intermediate calculations and final results. Consequently, manual and punch transcription are unnecessarily error prone and cause extra clerical work. The inexperienced student or punch operator may miss data entered in an obscure position, while the punch operator in particular finds the card production rate much below average. Proposals were drafted for a general requisition form, laboratory report forms, and specialized requisition forms but acceptance was delayed by uncertainty as to the possible effect of reorganization on the formats.

Geodat file is still a matter of concern. Program modifications continue to delay the conversion to the magnetic tape system. The volume of enquiries for data from the file is growing slowly mainly to supply input for a variety of petrological computations. Enquiries have been received from the English Universities of Cambridge and Durham, the B.R.G.M. in Paris and INCO at Copper Cliff. The only written description available was the requisition form manual that did not describe the treatment of the data in the file. Recently a description of the file as a card oriented system was compiled, a few copies were xeroxed and sent to the above mentioned agencies.

A request was received from the Newmount Mining and Exploration Company for the 23,000 IBM card Bathurst N.B. geochemical file. Production costs were estimated and the file was duplicated, interpreted and shipped to the Company's office.



Appraisal reports of DATATEXT and a system for the automated production of the index to GSC reports were made by the C.S.D. DATATEXT involves installation of a remote terminal hooked to the IBM 1460 computer in the Laurier Avenue office of the Company. It offers a means by which reports might be written, edited and prepared for multilith or lithographic production, but there is not enough cost information available on the procedure to justify it at the present. The index to GSC reports was turned down for the same reason.

### Other Projects

A manual describing the GSC programs for computing petrological norms was written, edited, and submitted for publication.

Preliminary discussions were held with Dr. R.K. Wanless to explore the possibility of a National Index to Isotopic Measurements produced by mass spectrograph laboratories across Canada. Specifications have been drawn up for the contents, codes and report forms for the file and these are to be discussed with laboratory personnel in Universities across Canada.

Development of the petrological computations for the White Creek Batholith Project was terminated in January. Dr. Mursky was able to complete arrangements to have the work done at the University of Wisconsin.

Thirty computations were requisitioned by Drs. Roddick and Hutchison of the Vancouver Office for the Coast Range Batholith Project. The mathematics is quite elementary but the data for the individual computations must be read from as many as three different cards. This requires unit record treatment of the file before each computation combined with a new computer program and has proven time consuming and tedious. One program that required the use of the Calcomp plotter has been written by G. Cameron of the C.S.D. The work is one-third done.

Mr. H.L. Martin of the Calgary Office submitted a file of oil well data to be run using the Subsea Tops program written for Dr. Burk. The computation was completed.

Late in 1966 Dr. E. Cameron of Economic Geology Division requisitioned a paper tape punch for "on line" installation on their quantograph. The requisition was seriously delayed in the C.S.D. and early in January a series of involved negotiations were entered into that resulted in modification of the requisition from an "on line" papertape to card punch. They provided an opportunity to place the D.P.U. 026 punch on the quantograph and obtain an 029 punch as a replacement. The IBM Company agreed to lease an 024 punch for temporary installation until the 029 could be supplied late in 1967.

The NACRGS which set up an ad hoc committee to study the proposal to implement an EDP National Index to Geological Data, asked the C.P.U. to study the "CAT" system developed by Imperial Oil Ltd. Early in February a week was spent studying the system in the Company library at Calgary and in May a workshop was held in Ottawa under the direction of Company staff. Several persons from the GSC and three students were trained in the use of the system. Two students worked full time during the summer indexing GSC file documents and a sample of publications. The spreadsheets were punched and sent to Calgary where they were run on the Imperial Oil computer. The resulting book catalogues were circulated to members of the committee for study and comment.

### Operating Procedures

A delivery service with two deliveries per day was commenced between the Departmental C.S.D. and the Branch, D.P.U. This has been working well and turn around time on computations has been 24 hours when all equipment is functioning well.

Agreement was reached with the C.S.D. regarding the procedure for requisitioning system analyses and program development. The No. 332 form is completed and signed by the originator, his Division Chief, the Chief Geologist and then goes via the Branch D.P.U. to the C.S.D. The system works well and provides statistics on program development as a byproduct.

Program card decks for production computations are being filed with the D.P.U. along with the necessary documentation to describe their use. The input decks are punched at the Branch, matched with the program deck and forwarded directly to the reception room of the G.S.C. C14 Ages, K/Ar Ages, Indexray, Latitude and Longitude to UTM Conversions and Norm Computations are among the programs being treated in this manner.

Express punching coupled with visual verification is being supplied to Branch computer users and K. Shimizu of the Geographical Branch. Approximately 5,000 cards are punched per month in this program. The turn around time on 100 cards varies from 1 to 2 hours. The value of the service is clearly demonstrated by the statistics.

### D.P.U. Computer Programming

Several programs have been written to reformat existing card files from a variety of projects into the format of the GEODAT file. This replaces a manual conversion job and takes advantage of the speed and accuracy of the machine operation.

Programs have been written to convert coordinates of arbitrarily chosen grids to UTM coordinates and these have been used successfully. Such programs also replace the customary manual operation.

Programs are being developed to convert the output of direct reading analytical instruments into the conventional weight per cent. Such programs can print laboratory reports and punch IBM cards in a format compatible to GEØDAT. This is being done for the multi-channel XRF equipment of the Analytical Chemistry Section.

Periodic enquiries for information regarding the computer programs developed for GSC personnel demonstrated the need for a more conveniently located file of program decks and documentation. Consequently, a collection is being made of the program decks and copies of the documentation and these are being filed in the D.P.U.

Statistics

CARDS PUNCHED BY D.P.U. in 1966

	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>
<u>Petrological Sciences</u>											
Agterberg	1,500	100	480		870	2,425	1,155	2,115	145	475	
Aumento											
Irvine							240	400	60	10	
Jambor											7
Lowdon						45	50	100	45	45	42
Reesor						50	30				
Wanless-Stevens						1,365	660	1,110	320	1,055	528
<u>Geophysics</u>											
Camfield								425	85		
Crain											
Gross										35	
Larochelle				1,320	100	280		195	635	675	656
Symons											116
<u>Regional Geology</u>											
Baragar					500						
Carson										380	110
Fahrig											
Handfield										50	26
Smith								55	65		

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	
<u>Economic Geology</u>												
Cameron					1,600	810		505	185	460	167	
Currie											69	
Ermanovics								85	120			
Fortescue									260			
Sangster											34	
Stewart										885	360	
<u>Fuels and Stratigraphy</u>												
Christie											36	
Norris	500	200	250				45					
Price											5,915	
Calgary Office			2,500							38	726	
<u>Others</u>												
GEØDAT file										3,440	2,475	
Photo Cat.			2,250	3,530	1,974					3,160	3,000	
D.P.U.										950	3,210	
K/Ar Rept								6,000	405	825	332	
Geog. Branch					100	900	65	2,255	255	450	1,444	
Nat Index							1,705					
Ground Water		700	250		10						50	
Totals										16,295	16,160	

The table is incomplete because of changes in numbers reported during the year as report format was altered to increase its significance. The volume of cards punched during the year approaches 200,000.

Statistics

CARDS PUNCHED by D.P.U. Jan-Mar 1967

	Jan.	Feb.	Mar.
<u>Petrological Sciences</u>			
Agterberg	1, 156	1, 237	663
Aumento	64		
Douglas	43		
Irvine	33	16	
Jambor	3	7	6
Lachance			199
Lowdon	95	10	62
Plant		29	
Reesor	220	300	
Wanless-Stevens	306		440
<u>Geophysics</u>			
Christie			167
Flint		5	
Gross	108	156	52
Larochelle	627	269	252
Pearce		68	88
Schwartz			203
Skibo	161	43	302
Symons	403	476	24
<u>Economic Geology</u>			
Cameron	895	1, 900	1, 555
Fulton	187		
Horton		728	346
Stewart	642	706	504
Whitmore	16	113	
<u>Fuels and Stratigraphy</u>			
Norris	1, 115		
Price	110	110	
<u>Regional Geology</u>			
Baragar	129	572	641
Ermanovics		20	
Goodwin	28	654	195
<u>Calgary Office</u>			
Martin	20		
Geodat	2, 330	880	925
D.P.U.	1, 174	1, 704	1, 723
Photo Div.		800	1, 783
Geographical	5, 936	4, 488	2, 650
Dominion Observatory		40	
TOTAL	16, 050	16, 211	12, 780



JOBS SENT TO C.S.D. in 1966

	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>
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Petrological Sciences

Agterberg	8	23	22	22	1
Aumento				1	
Irvine	10	5	3	5	
Jambor					8
Lowdon	2	2	1	1	1
Reesor	1			6	
Wanless-Stevens	9	5	4	4	1
Mursky		3			

Geophysics

Gross			1	1	
Larochelle			6	8	17

Regional Geology

Baragar				3	
Carson		1	1		
Fahrig				1	1
Handfield		1	2		
Smith				1	

Economic Geology

Cameron			2		3
Currie					1
Ermanovics			2		
Fortescue				2	
Lewis			1		
Sangster					1
Stuart				2	

Fuels and Stratigraphy

Price					1
Calgary Office			1		

Others

GEODAT	23				1
Photo Div.		3	9	3	1
D.P.U.		19	12	25	68
K/Ar Report			3	1	2
Nat. Index	2	5			
Groundwater Br.					3
Geographical Br.					1

Totals	55	67	70	86	111
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JOBS SENT TO C.S.D. Jan.-Mar. 1967

	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>
<u>Petrological Sciences</u>			
Agterberg	3	8	11
Aumento	4		
Douglas			2
Irvine	2	5	5
Jambor	1	3	2
Lowdon	2	5	1
Plant		1	
Reesor		2	4
Wanless-Stevens	3		2
<u>Geophysics</u>			
Christie			5
Flint		2	1
Gross	4	5	9
Larochelle	3	9	5
MacLaren			1
Pearce		3	7
Symons	2	4	1
<u>Economic Geology</u>			
Cameron		6	0
Currie		1	
Horton		2	3
Lewis			3
Roscoe		1	2
Whitmore	2	1	
<u>Fuels and Stratigraphy</u>			
Price		2	
<u>Regional Geology</u>			
Baragar	3	6	8
Ermanovics	2	3	
Goodwin	6	16	4
<u>Calgary Office</u>			
Burk	1		
Martin	1	3	1
<u>B.C. Office</u>			
Hutchison	2	6	7
<u>Geodat</u>			
D.P.U.	66	53	13
<u>Photo Div.</u>			
	1	4	1
Total	109	152	96

ACCESSIONS TO GEØDAT, 1966

	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>
Control cards	79	342	6	595	694	296	384	449	156	289
Cat. cards	79	342	6	595	694	296	284	449	156	289
Oxide Anal. (PS)	8	155	53	10	281	210	238	218	271	331
Element Anal. (PS)			361	138	248	165	70	218	52	120
Sed. Size Anal.		55		169	55	204	38	95	31	41
C <sub>14</sub> Age	19	17	15	20	18	19	18	23		20
K/Ar Age	6	10	3	2			20		61	
Totals	191	921	444	1,529	1,990	1,190	1,152	1,452	727	1,090

REQUESTS FROM GEØDAT.

	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>
Oxide Analyses	1		1		9	4	6	19	9

ACCESSIONS TO GEODAT, Jan.-Mar. 1967

	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>
Control cards	182	504	7
Catalogue cards	182	504	7
Oxide Anal. (PS)	39	88	24
Element Anal. (PS)	9	8	80
Element Anal. (EG)	83		
Sed. Size	57	33	
C <sub>14</sub> Age	12		13
K/A Age	<u>14</u>	<u>5</u>	<u>8</u>
TOTAL	578	1,142	137

REQUESTS FROM GEODAT

200	Catalogue	Jan.
335	RMO	
1,300	RMO	Feb.
2,000	RMO	March

BRITISH COLUMBIA OFFICE

J.E. Armstrong

GENERAL

The British Columbia office is under the supervision of J.E. Armstrong, S.F. Leaming and a clerical and stenographic staff of three complete the personnel. One clerk was absent on account of illness for more than 4 months in 1966 and a temporary replacement was employed most of this time. Mrs. V. Bowman resigned during the year and Miss

S. Taylor was added to the staff as a replacement. One student assistant was attached to the office for a period of four months during the summer. Labourers were employed on a casual basis for shore periods.

Then geologists in the Regional Geology Division (Cordilleran Section) are attached to the office. During the year L.H. Green was transferred from Whitehorse to Vancouver and J. Monger was taken on the staff. One technical officer employed on a temporary basis completes the personnel of the Cordilleran Section staff. Also attached to the office are one hydrogeologist of the Inland Waters Branch and one Explosives inspector. The B.C. office provides space, clerical and stenographic service, and telephone service for the 13 people listed above. In March H.W. Little was transferred to Ottawa.

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 12,500 books and periodicals are in the library; this includes all the publications of the Geological Survey and B.C. Department of Mines and Petroleum Resources.

1966 was by far the busiest year ever recorded in the British Columbia office; 12,140 visitors registered and 39,521 publications of various kinds were sold. 1096 rock and mineral collections were also sold. The total sales amounted to \$23,513.09. A comparison of the years, 1953, 1956, 1965, and 1966 is given below:

	<u>Registered Visitors</u>	<u>Publications sold or distributed</u>	<u>Cash Receipts</u>
1953	2,968	5,968	no charge at this time
1956	7,260	15,655	\$ 6,706.40
1965	10,210	27,863	17,306.95
1966	12,140	39,521	23,513.09

These figures do not include the publications distributed on behalf of the B.C. Department of Mines and Petroleum Resources. In 1966, 1,786 reports were sold for them, valued at \$1,806.35. Approximately 6000 letters and requests by telephone were answered by the staff. The typing of geological manuscripts increased by at least 50 per cent over 1965.

MONTHLY REPORT

	Visitors	Publications Distributed	B.C. Mines Dept	Rocks	Minerals	\$25.00 sets	Ottawa Mines Branch	SALES
Dec, 1965	720	2721	108	14	19	1	20	\$ 1,683.10
Jan, 1966	910	2006	211	22	21	1	7	1,284.15
Feb.	880	3762	169	30	78	1	14	2,275.15
Mar.	1010	3263	117	34	44	1	5	2,062.40
Apr.	1120	3990	184	36	45	1	4	2,390.80
May	1100	3925	106	25	29	1	10	2,232.20
June	1100	3603	164	16	37	3	4	2,177.20
July	1050	3410	176	62	63	1	19	2,056.16
Aug.	1050	2878	50	19	20	3	14	1,778.03
Sept.	1100	2894	200	41	44	-	22	1,637.70
Oct.	1050	3540	144	99	115	1	5	2,000.45
Nov.	1050	3529	157	78	87	1	13	1,935.75
	<u>12,140</u>	<u>39,521</u>	<u>1,786*</u>	<u>476</u>	<u>602</u>	<u>15</u>	<u>137</u>	<u>\$23,513.09</u>

\* This figure not included in total. We also turned over \$1,806.35 to the B.C. Dept. of Mines and Petroleum Resources for the 1789 reports sold.



During the period Dec. 1st, 1966 to March 31, 1967 the office continued to be exceptionally busy as outlined in the table below.

	Visitors	Publications Distributed	B.C. Mines Dept	G.S.C. Rocks Sets	Minerals	\$25.00 Mineral Sets	Ottawa Mines Branch	SALES
Dec. 1966	775	2532	148*	41	69	1	7	\$ 1,331.75
Jan. 1967	910	5029	162*	23	25	1	14	2,644.45
Feb.	920	3195	110*	30	29	1	14	1,679.35
Mar.	1050	3689	159*	32	55	1	10	2,094.35
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
Totals	3655	14,436	579* value \$741.40	126	178	4	45	\$ 7,749.90 + B.C. Dept. sales 741.40 <hr/> \$ 8,491.30

\*not included in total.

### ACTIVITIES

#### ACTIVITIES JAN 1, 1966 - MAR 31, 1967 - S.F. LEAMING

S.F. Leaming spent 3 months in the field studying the surficial deposits of the Prince George map-area. In addition, two weeks were spent by him studying lapidary mineral occurrences and in collecting minerals (jade and perlite) for the curator of the National Mineral Collection.

He identified about 880 rocks and minerals for the general public and was consulted by approximately 1,650 people in connection with geology, minerals and related subjects. This involved a total of about 90 working days.

A talk was given by him to the Lapidary Club of Vancouver on the value of G.S.C. maps and reports for rockhound use. He published a short article on Rhodonite in British Columbia in the Canadian Rockhound, February 1966.

His manuscript on Sand and Gravel has been accepted for publication as a GSC Paper.

A talk was given by Leaming to the North Shore Rock Club on the subject Rock and Mineral Collecting in British Columbia.

Leaming also conducted Mr. Peter Crohn of the Australian Bureau of Mineral Resources and Geology on a four-day field trip to Bethlehem, Boss Mountain and Craigmont Mines.

#### ACTIVITIES JAN 1, 1966 - MAR 31, 1967 - J.E. ARMSTRONG

Armstrong did 62 days field work in 1966. The time was spent as follows:

- 1) 45 days in the Prince George area investigating the surficial deposits in cooperation with S.F. Leaming.
- 2) 3 days in the Mount Kobau area making a reconnaissance geological investigation in the vicinity of the observatory. A brief report was prepared for J.M. Harrison.
- 3) 3 days collecting perlite in the Francois Lake area for the "Court of Rocks" at Expo '67. S.F. Leaming and Armstrong did this jointly; 3 pieces of perlite weighing about a ton were shipped.

- 4) 11 days in the Prince George, Fort Fraser, McLeod Lake, Williams Lake and Okanagan areas in cooperation with the ARDA Soils studies.

Armstrong conducted the following geological field trips during the year:

- 1) He took about 40 members of the Vancouver Natural History Society on a Saturday field trip to the Hope-Princeton slide area.
- 2) He took about 25 members of the Vancouver Natural History Society on a Saturday field trip to the Skagit River valley of Washington State.
- 3) He took about 50 members of the B.C. Nature Council on a Sunday field trip up the southern Okanagan valley.

Armstrong attended the following meetings and field trips during the year:

- 1) Royal Society of Canada Council meeting in Ottawa in February.
- 2) Royal Society of Canada Annual meeting and geological field trip in Sherbrooke, Quebec in June.
- 3) C.I.M.M. Meeting of B.C. Section in Victoria in October.
- 4) Annual meeting of the Geological Society of America in San Francisco in November. This included a 2-day field trip in the Sacramento Valley and Southern Coast Range prior to the meeting and a 5-day trip to Hawaii following the meeting. While in San Francisco he attended a meeting of the G.S.A. Associate Editors.

Armstrong gave the following public talks during the year:

- 1) Geology as a career; Gladstone and John Oliver high schools, Vancouver. Two talks given in March, about 25 students attended each.
- 2) Pleistocene Geology of the Fraser Lowland, B.C. Two talks presented to the geomorphology class at the University of British Columbia. About 30 students present at each.
- 3) Geology and Physiography of the Hawaiian Islands: a talk presented to geography students at Vancouver City College. About 300 present.
- 4) A geologist's view of Canadian and U.S.A. Mountain Parks; a talk to the Vancouver Natural History Society. About 400 present.

Armstrong took the geomorphology class of Vancouver City College on a one day field trip of the Howe Sound area. About 75 attended.

Armstrong had 3 papers published during the year:

- 1) Tectonics and Mercury Deposits in British Columbia; special volume No. 8 of C.I.M.M.
- 2) Tectonic Framework of North Central British Columbia by J.G. Souther and J.E. Armstrong; special volume No. 8 of C.I.M.M.
- 3) Glaciation along a major fiord valley in the Coast Mountains of British Columbia; abstract in program for G.S.A. annual meeting in 1966.

During the period Armstrong interviewed about 800 people, the average interview lasting about 20 minutes; the total time involved equalled at least 35 working days. In addition he identified about 100 mineral and rock specimens, answered several hundred letters and processed about 2000 telephone calls.

He did the scientific editing of a major paper, 200 + pages, for the editorial section of the G.S.C. This took at least 25 working days including many interruptions. He did the scientific editing on S.F. Leaming's revised final paper on Geology of Gravel Deposits in the Strait of Georgia area.

Armstrong held office in the following societies during the past year:

- 1) In March he was elected vice-chairman elect of the geology division of the C.I.M.M. This means he will become chairman in March, 1968.

He was treasurer of the B.C. Section of the C.I.M.M. From January to July he was chairman of a special committee established to set up and prepare special volume 8 of the C.I.M.M. This volume was published in September.

- 2) He was an associate editor for the Geological Society of America and was responsible for finding critical readers for papers on the geology of the Pacific Northwest. He processed 5 papers in 1966.
- 3) He was convener of the Geology Subject Division of Section 3 of the Royal Society of Canada. As such he chaired the geology meetings in Sherbrooke.

- 4) He was a director of the Vancouver Natural History Society.
- 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 member of the ARDA Soils subcommittee for B.C.

In March 1967 Armstrong attended the Annual Meeting of the C.I.M.M. in Ottawa. As vice-chairman elect of the Geology Division he attended the business sessions of this Division. In addition he acted as a chairman at one of the technical sessions. He was elected vice-chairman of the Geology Division for the year 1967-68. He chaired the Barlow Medal Committee of the C.I.M.M.

He chaired the nominations committee of the Geology Subject Division of the Royal Society of Canada.

### WHITEHORSE OFFICE REPORT

D.C. Findlay

The Whitehorse office of the Geological Survey provides technical assistance to those engaged in mineral exploration in the Yukon, and distributes geological and topographic publications of the Geological Survey and the Surveys and Mapping Branch. The staff consists of a Resident Geologist and a clerk.

Office statistics for 1966-March 31, 1967 reflect the general increase in tempo of mineral exploration in the Yukon during the past fifteen months. Visitors signatures recorded (to March 31, 1967 ) were 3,084 (up from 2,006 in 1965); distribution of Geological Survey publications - 4,387\* (up from 1,351 in 1965) and; distribution of topographic publications - 7,969\*\* (up from 4,464 in 1965). Total dollar value of publication sales was \$5,825.99 (\$2,483.15 in 1965). Of this total \$2,408.89 was received for G.S.C. publications (\$983.15 in 1965) and \$3,417.10 for topographic publications (\$1,500.00 in 1965).

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\* Includes 92 publications distributed free of charge to government departments.

\*\*Includes 1,202 publications distributed free of charge to government departments.

Other office services included supplying geological information and advice to prospectors, exploration geologists, other government departments, and the general public. During the summer, the clerk handles numerous requests for topographic and geographic information from tourists, itinerant scientists and weekend prospectors.

In 1966 the Resident Geologist made about 60 visits to operating lode mines, lode exploration prospects and placer operations in the Yukon Territory and southwestern District of Mackenzie, N.W.T. Information obtained from these visits, as well as from discussion and correspondence with companies and individuals engaged in mineral exploration in the Territory is published by the Geological Survey as an annual report entitled Mineral Industry of the Yukon Territory and southwestern District of Mackenzie. Other field work by the Resident Geologist included commencement of studies of ultramafic and mafic rocks of the Yukon Territory.

Technical meetings attended by the Resident Geologist during 1966 were the Alaska Science Conference, Anchorage (August 30-Sept. 1) and the Geological Society of America, San Francisco (November 14-16).

Other duties of the Resident Geologist include participation in a number of governmental activities administered by the Department of Indian Affairs and Northern Development and the Yukon Territorial Government. These include the Prospectors Assistance Program, the Tote Trail Assistance program and technical assessment of representation work on mining claims submitted by companies and individuals to the Mining Recorder's offices.

### 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 the summer a senior assistant and an office assistant provided seasonal assistance.

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" collection are available for purchase. From December 1st, 1965 to November 30th, 1966, 263 aeromagnetic maps, 1330 other geological publications and 69 rock and mineral kits and 8 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 Indian Affairs and Northern Development. 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. Responsibility for the distribution of topographic maps and hydrographic charts was taken over from the Indian Affairs and Northern Development in February, 1966. From that date to November 30th, 1966, 1414 topographic and aeronautical maps and 66 hydrographic charts were sold and 754 of these maps were distributed free to Government personnel.

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 the six producing mines in Mackenzie District. Brief accounts of these visits have been given in interim reports and further information will be contained in a report published by the Geological Survey. The senior assistant was employed in logging diamond drill core and collecting information on exploration activities in the Pine Point area. The collection of information on current activities in Mackenzie District continues and these will be summarized in a report on the Mineral Industry of the Northwest Territories.

The Resident Geologist co-operated with the Department of Indian Affairs and Northern Development by reviewing and approving, as to technical content, all geological, geophysical, and engineering evaluation 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 seasonal office assistant assisted in arranging the accumulation of reports and drill logs according to the N.T.S. system, for easier retrieval. The Resident Geologist also assisted in the administration of the Prospectors Assistance Program of the Department of Indian Affairs and Northern Development. He served on

the screening and review 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 a number of the prospectors aided by the program were visited in the field.

The compilation of data for preparation of a metallogenic map of the Northwest Territories has been started. It will require much concentrated effort to bring the project to completion.

A report on the Mineral Industry of the Northwest Territories (Geol. Surv. Can. Paper 66-52) was published in December.

### SPECIAL PROJECTS

#### REPORT ON ACTIVITIES

C.H. Stockwell

#### TECTONIC MAP OF CANADA

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. The manuscript map for the whole of Canada will be completed in early 1967. A preliminary Tectonic Map of the Canadian Shield was published in 1965 (G.S.C. Map 4-1965).

The Tectonic Map of Canada will also serve as Canada's contribution toward the preparation of a World Tectonic Map to be completed and published by the International Geological Congress. Our contribution will be submitted to the Congress through the Vice-President of the North American Subcommittee 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, Subcommittee on the Tectonic Map of the World.

Member, Editorial Committee, Tectonic Map of the World.

Member, Subcommission of Precambrian Stratigraphy,  
International Union of Geological Sciences.

Chairman, Committee on the Tectonic Map of Canada.

### REPORT ON ACTIVITIES

R.J.W. Douglas

During the year considerable progress was made in the preparation of the text and accompanying charts and maps for Geology and Economic Minerals of Canada. Most chapters have been brought to the draft manuscript stage and seven have reached a final stage. Translation of the manuscript under the guidance of Dr. L.P. Tremblay is continuing so that early publication of an edition in French is anticipated.

Manuscript for the Geological Map of Canada at scale of 1:5,000,000 was submitted for publication.

### REPORT ON ACTIVITIES

A.H. Lang

The first part of the year was spent on compilation of geological maps on the scale of 1 to 1,000,000. None was completed but six done earlier await processing (O.P. 232).

On May 1 preparation of a 4th Ed. of "Prospecting in Canada" was begun. By year end this was about 60 per cent done. Of this, about 75 per cent is completely rewritten and the rest changed in many places. To keep the price as low as possible an attempt is being made not to increase the text more than 10 per cent and to use almost all the diagrams from the 3rd Ed. Several photos have been substituted and added. This is important because some better ones are available, and if too many old photos are seen readers will think the edition has not been changed much, whereas it will be up to date and much changed. The work included a good deal of correspondence with provincial departments and persons who conduct courses for which this is the text, and discussions with various authorities. Drafts of several sections were given to authorities on and apart from the G.S.C. for critical reading. (O.P. 492)

Some time was also spent preparing a paper on "100 years of prospecting in Canada" requested by the Prospectors and Developers Association.

### OUTSIDE PUBLICATION

Discovery of Post-1955 New Producers; Can. Min. Jour., Jan. 1967.

### 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 (expired June 30).
3. Working Group on Geological and Petrographical Symbols, International Organization for Standardization.
4. Member, Committee for History of G.S.C.

### 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.

Although the delay in publishing reports leaves no ground for complacency, the number of reports awaiting scientific editing is down from previous years. To some extent this means that backlogs have been transferred elsewhere; a considerable residue remains at the EM&R Editorial Division. For part of the year three production editors were wholly employed on GSC work, but unfortunately one accepted a position with another department and some difficulty was experienced in filling this vacant position. In the meantime the manuscripts piled up.

The number of GSC papers published has increased, and the total number that will eventually appear with the 66- designation will be an all time high. To relieve cartography pressure we have accepted author's figures for publication that would have been professionally redrafted in easier times. We cannot expect all geologists to be draftsmen but in some instances a little more care and thought in preparing manuscript figures and sketches so that they can be used for direct-reproduction may considerably reduce publication time.

Printing time for final publications is still excessive in spite of strenuous follow-up action by the section and EM&R Q.P. liaison staff. On the other hand, we have had very cooperative and prompt service with the Q.P. sub-units for offset printing of GSC papers.

In addition to processing manuscripts, the staff of the section have acted as compilers of several recurring publications in the Paper series, including a new publication giving abstracts of papers published by officers of the GSC in scientific journals.

S.E. Jenness resigned after seven years with the section and has accepted a position as scientific editor with the Canadian Journals of Research, N.R.C. His contribution to the work of the section will be greatly missed.

The scientific editors have, as in the past acted in a consulting and advisory capacity on a wide range of matters covering science, philology, printing and production and even matters of protocol. This all assists in good relations with the scientific staff, but at times is rather time consuming.

#### Membership on Committees

##### G.S. Daughtry

- Member, E.M.&R. Advisory Board on Draftsmen and Compilers.
- Chairman, G.S.C. Advisory Committee on Draftsmen and Compilers.

##### P. Harker

- Chairman, American Commission on Stratigraphic Nomenclature.
- Exhibits Committee.
- G.S.C. Advisory Committee on Draftsmen and Compilers.

##### C.E. McNeil

- Member of G.S.C. Exhibits Committee.

E.P. Nunn

- Member, E.M.&R. Suggestion Awards Committee.
- Chairman, Cartography Suggestion Awards Subcommittee.

J.B.F. Williams

- Secretary, Cartography Suggestion Awards Subcommittee.

Attendance at Conventions, etc.

P. Harker

- American Commission on Stratigraphic Nomenclature and GSA, San Francisco, November 1966.

S.E. Jenness

- Second George H. Hudson Symposium "Origin of Anorthosite", at State University College, Plattsburgh, N.Y., October 6-9, 1966.



STATUS OF GEOLOGICAL MANUSCRIPTS ON MAR. 31, 1967  
WITH COMPARABLE FIGURES FOR 1964 AND 1965.

Type of Report	In process						Published during year			Total Active during year		
	Scientific Editing			Cartography and EM&R Ed. Div. & Q.P.								
	1966-67	1965	1964	1966-67	1965	1964	1966-67	1965	1964	1966-67	1965	1964
Memoirs	0	6	15	21	23	19	6	3	6	27	32	40
Bulletins	5	20	39	36	37	38	22	12	14	63	69	91
Econ. Geol. Repts.	0	0	3	5	5	3	0	2	0	5	7	6
Misc. Repts. etc.	0	2	1	2	0	6	1	2	1	3	4	8
Multicolour maps <sup>1</sup>	0	7	4	44	38	39	6	7	11	50	52	54
P.S. Papers	3	14	16	47	31	32	52	45	44	102	90	92
P.S. Maps <sup>1</sup>	0	5	5	13	6	3	14	5	20	27	11	28
Topical Repts.	1			0	1		16	15	17	17	16	

<sup>1</sup> 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 or returned to author for revision; these are as follows: - Memoirs 9, Bulletins 16, Multicolour Maps 6, P.S. Papers 14.

## GEOLOGICAL CARTOGRAPHY UNIT

G.S. Daughtry

The year 1966 was one involving considerable change for the Cartography Unit. Due to re-allocation of office space the entire drafting group of thirty-two was moved to the City Centre. L.A. Williams is in charge of the drafting staff in their new quarters. The files of drawings and map manuscripts were also transferred to storage space at City Centre. Remaining at 601 Booth Street are the planning and compiling group, the negative group, and the photo-mechanical services.

The upset of routines caused by the move, and an abnormal turnover of staff have had some effect on production of maps and illustrations.

At the end of the year the staff was involved in the reclassification program leading toward collective bargaining.

### CONTRACTS AND DISPLAYS

Twenty-three individual contracts were entered into with private drafting firms. These included 1 map and 52 figures for G.S.C. publications, 57 illustrations for outside publications (including 18 figures for Calgary office), and 9 slides for Calgary.

The Cartography Unit was involved in the preparation of the following displays:

1. Seventh Annual Field Salon in Logan Hall.
2. Geochemical Prospecting Symposium, Ottawa.
3. CIMM Display, Quebec City (1966).
4. Ontario Chartered Cartographers Symposium, Ottawa.
5. CIMM Display, Ottawa (1967).

### PERSONNEL

F.J. Gardham, a senior supervisor, retired for medical reasons in March, 1967 after twenty-two years' service.

Miss J. Lessard was transferred to the Fuels and Stratigraphy Division, and Mrs. H. Ainsworth assumed the secretarial duties in the Cartography Unit.

Due to recruiting by several departments that are expanding their mapping programs, the Unit lost the services of six experienced employees; one supervisor, B. Edwards, four draftsmen, M.F. Hayne, G.S. Whitman, W.J. Sutcliffe and R.C. Romhild, and an assistant, Photo and Litho, K.S. Sidock. Two other draftsmen resigned, Miss A. Pelletier to return to school, and M. Auger to accept a position in Quebec. R. Gagne transferred to the Geophysics Division, and a recruit in Calgary, Mrs. H. Cooper also resigned. A new drafting position was added to the establishment in Calgary.

All vacancies but one have been filled, six by experienced draftsmen, G. Young, G.J. Crepin, G. Fouchard, F. Yeager, and D. Brown in Ottawa, and Mrs. J. Shelton in Calgary, and three recruits, R. Monette, G. Charbonneau, and R. Perron. Mr. Auger rejoined the staff at the end of March.

At the end of March, 1967 the total strength of the Unit was sixty-five, including one vacant position.

## PRODUCTION DATA

Maps and figure illustrations prepared by the Cartography Unit during the period from January 1, 1966 to March 31, 1967 comprised the following:

Multicoloured geological maps .....	21
Multicoloured geological maps reprinted .....	1
Preliminary geological maps .....	50
Preliminary geological maps reprinted (lithographed) .....	2
Preliminary geological maps reprinted (blue-line) .....	4
Aeromagnetic maps .....	28
Aeromagnetic maps reprinted (lithographed) .....	23
Aeromagnetic maps reprinted (blue-line) .....	100
Figure illustrations (lithographed) .....	62
Figure illustrations reprinted (lithographed) .....	9
Figure illustrations (zinc cut) .....	338
Water Supply Paper maps reprinted (blue line) .....	85
Miscellaneous (Index maps, etc.) .....	16

Miscellaneous drafting consisted of 202 items comprising 692 pieces, including drafting illustrations for scientific papers, colouring lantern slides, preparing displays, and other general drafting services.

Maps, etc. at Surveys and Mapping Branch for printing at March 31, 1967

Multicoloured geological maps .....	5
Figure illustrations .....	1

Figure illustrations completed and held in unit at March 31, 1967  
totalled 131 for 18 reports.

Maps and Illustrations in progress at March 31, 1967

Multicoloured geological maps.....	46
Preliminary geological maps .....	23
Figure illustrations .....	311

Work completed in photo-mechanical section

Mapping camera

Film negatives and positives .....	6,133
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Contact processes

Film negatives and positives .....	7,835
Colour keys on film .....	1,196
Peelcoats .....	116
Scribe-etch .....	69
Colour proofs .....	73
Vandyke prints .....	6,583
Blue-line map prints .....	16,155
White prints .....	3,306
Photostat prints .....	1,726
Xerox prints .....	267,686

Typesetting

Map names, titles, etc. were set up and printed for all maps and illustrations being drafted. Covers, etc. printed totalled 566 impressions of 68 items. Typesetting for the Mineral Resources Division involved 37 hours' work.

Manuscripts received

Multicoloured geological maps .....	24
Preliminary geological maps .....	34
Aeromagnetic maps .....	7
Figure illustrations .....	496

Back-log of maps and illustrations in Cartography Unit

	<u>Mar. 31, 1967</u>	<u>Dec. 31, 1965</u>
Multicoloured geological maps	16	19
Preliminary geological maps	1	13
Aeromagnetic maps	0	4
Figure illustrations	339	387

STUDENT PROGRAM 1966

E. Hall

Graduate Assistants

Due to transfer of the Groundwater Section to the new Water Research Branch the Geological Survey establishment of Graduate Assistants was cut to 122. The continuing decrease in the number of qualified graduate applicants is cause for concern and projection of these figures indicate that we will be unable to fill our requirements in the 1967 field season. A record total of twenty-two Graduate Assistants were employed to carry out new and continuing theses projects. As last year eight graduates refused after accepting employment with us.

Technical Officers 11

This year only seven of our establishment of twelve T.O. 11 positions were filled by professors. These ranged in grade from T.O. 5 to T.O. 9.

Student Assistants

Our establishment of Student Assistants was reduced by five to 179 to make provision for students in groundwater work. Though there was a slight increase in the number of third year students that accepted employment with us, only nineteen had previous geological experience. The policy of hiring technical school students started in 1965 was successful and this year nine such persons were employed in student assistant positions. The increasing diversification of the work of the Survey is reflected in the fact that thirty-six student assistant positions were filled by other than geology students.

Table 1

## Recruiting of Geology Students

		1966		1965		1964		1963		1962	1961
		Can.	non- Can.	Can.	non- Can.	Can.	non- Can.	Can.	non- Can.		
Graduate Assistants	Applications	86	40	128	42						
	Offered	83	36	117	37						
	Accepted	59	18	67	18						
	% "	70%	50%	57%	48%						
T.O. 3	Applications					67	11	60	7	72	66
	Offered					63	9	58	4	71	64
	Accepted					46	3	44	2	54	39
	% "					73%	33%	76%	50%	76%	61%
T.O. 2	Applications					48	16	64	12	68	67
	Offered					47	7	63	8	58	63
	Accepted					29	4	38	1	33	42
	% "					62%	57%	60%	12%	57%	67%
T.O. 1	Applications					48	3	21	3	17	44
	Offered					26	0	19	2	3	10
	Accepted					11	0	8	0	2	7
	% "					42%	0	42%	0	66%	70%
TOTAL	Applications	86	40	128	42	163	30	145	22	157	177
	Offered	83	36	117	37	136	16	140	14	132	137
	Accepted	59	18	67	18	86	7	90	3	89	88
	% "	70%	50%	57%	48%	63%	44%	64%	21%	67%	64%

NOTE: These figures include five of the eight assistants hired for other Branches.



Table 1A

## Recruiting of Geology Students

		1966		1965		1964		1963		1962	1961
		Can.	non- Can.	Can.	non- Can.	Can.	non- Can.	Can.	non- Can.		
S.A. 3rd year	Applications	91	13	104	5	98	11	110	7	96	128
	Offered	81	1	81	0	83	0	104	0	94	123
	Accepted	38	0	31	0	52	0	56	0	49	75
	% "	47%		38%		63%		54%		53%	61%
S.A. 2nd year	Applications	162	16	128	12	213	14	247	16	213	139
	Offered	130	2	122	1	128	1	154	0	192	132
	Accepted	52	1	73	1	66	1	78	0	77	84
	% "	40%		59.8%		51%		50%		40%	64%
S.A. 1st year	Applications	311	21	246	13	269	19	279	16	230	144
	Offered	143	0	120	0	79	0	88	0	40	13
	Accepted	62	0	60	0	38	0	35	0	24	4
	% "	43%		50%		48%		40%		58%	31%
TOTAL S.A.	Applications	564	50	478	30	579	44	647	40	558	411
	Offered	354	3	323	1	290	1	356	0	357	268
	Accepted	152	1	163	1	156	1	175	0	165	163
	% "	43%		50%		54%		49%		47%	61%

NOTE: These figures include ten student assistants hired for other Branches.

Table 2

Actual Employment 1966

	G.A.		S.A.	
	Field	Office	Field	Office
RG	32	4	53	3
EG	19	16	27	15
PS	0	7	1	18
G	8	5	6	2
FS	11	4	21	8
A	0	2	0	3
MG	2	3	6	5
	<hr/> 72	<hr/> 41	<hr/> 114	<hr/> 54

NOTE: This table includes the following personnel not included in Tables 1 and 3.

7	T.O.'s	professors
13	T.O.'s	winter seasonal
3	G.A.'s	special cases
1	G.A.	geography
4	G.A.'s	chemistry
1	G.A.	statistician
7	G.A.'s	geophysics and electrical engineering
1	G.A.	botany
15	S.A.'s	chemistry
2	S.A.'s	winter seasonal
6	S.A.'s	geophysics and electrical engineering
1	S.A.	botany
5	S.A.'s	special cases
9	A.T.'s	technical school students occupying SA positions.

Table 3

Distribution of geology students 1966

University	G.A.			S.A.		
	Total Offers	Refused After Accept.	Final Accept.	Total Offers	Refused After Accept.	Final Accept.
MEMORIAL	3	1	1	9		3
ACADIA				3		2
DALHOUSIE	3			8	1	5
ST. FRANCIS X.				6	1	3
ST. MARY'S				1	1	
MT. ALLISON				1		1
ST. THOMAS				1	1	
MONCTON				1	1	
U. NEW BRUNSWICK	1			14	5	5
LAVAL	1			21	2	7
LOYOLA				3		
McGILL	11	2	9	11		4
MONTREAL U.	1		1	20	1	4
ECOLE POLY.				5		1
BROCK				2		1
CARLETON U.	12	1	9	39	2	24
GUELPH	1			1		1
McMASTER				13		3
OTTAWA U.	4		3	11	1	8
QUEEN'S	13		10	34	1	14
TORONTO	4		3	24		13
WESTERN	2		1	16	1	6
WATERLOO				8		3
MANITOBA	3	1	1	22	1	12
BRANDON	1		1	2		1
SASKATCHEWAN	4		4	18	1	2
ALBERTA	3		1	11	1	4
CALGARY	2		2	14	1	8
BRITISH COLUMBIA	3		3	31		15
U.S.	43	3	28	3		1
OTHER	1		1	4	1	1

NATIONAL ADVISORY COMMITTEE ON RESEARCH  
IN THE GEOLOGICAL SCIENCES

J.F. Henderson

The Geological Survey publishes on behalf of the National Advisory Committee on Research in the Geological Sciences their annual report and certain other reports of the Committee. The annual report for 1964-65 was published in February 1965 in two volumes, Part I being an account of the work of the Committee and its Subcommittees over the year and Part II the annual survey of current research in the geological and related sciences for 1964-65. The National Advisory Committee also had published the Interim Report of the Committee on Storage and Retrieval of Geological Data in Canada (Geol. Surv. Can., Paper 66-43, 1966).

The annual report of the National Advisory Committee for 1965-66 will be published early in 1967. It gives a summary of the work of the Committee over the period September 1, 1965 to August 31, 1966, and includes the reports of the subcommittees that cover the different fields of the geological sciences which record developments in their fields over the year and suggest further problems for study. An appendix lists the research grants for 1966-67 awarded by the Geological Survey of Canada to Canadian universities. Other publications of the National Advisory Committee in 1967 will include the Survey of Current Research in the Geological Sciences in Canada (Geol. Surv. Can., Paper 66-53, 1967) and the Symposium on Geochemical Prospecting (Geol. Surv. Can., Paper 66-54, 1967).

The Geological Survey is involved directly or indirectly 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 to stimulate and support geological research in Canadian universities. Applications from staff members of universities 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 Committees recommendations.

For 1966-67, 98 applications were received (compared with 92 in 1965-66) and the total of the grants applied for was \$309,292 (compared with \$264,263 in 1965-66). Eighty-five grants totalling \$150,000 were awarded to 20 universities. The names of the recipients, the titles of the projects and the amounts awarded are listed in the Sixteenth Annual Report of the National Advisory Committee for 1965-66.

Because the grant applications for 1966-67 totalled \$309,292 or more than double the funds available, some were rejected with no support and in nearly all cases the grants to the remainder are substantially less than the amounts requested. The National Advisory Committee has recommended to the Geological Survey that the amount to be provided for grants-in-aid to the universities in 1967-68 be increased from \$150,000 to \$185,000.

#### COMPREHENSIVE STUDIES OF CANADIAN SULPHIDE DEPOSITS

The cooperative, comprehensive study of the Coronation cupriferous pyrite orebody southeast of Flin Flon, Manitoba has been completed and a final report is in preparation. This report will be a symposium type volume made up of papers written by those who carried out the different projects. Dr. D.R.E. Whitmore, the coordinator of the project since its inception will be responsible for assembling and coordinating the many contributions. He will also be the author of a final paper which will summarize, integrate and assess the whole undertaking. The report will be a publication of the National Advisory Committee.

#### STORAGE AND RETRIEVAL OF GEOLOGICAL DATA

In 1964 at the request of the National Advisory Committee, Dr. S.C. Robinson, Geological Survey of Canada, prepared an Interim Report on Possible Applications of Data Processing Techniques to Storage and Retrieval of Geological Data which was published by the Geological Survey for limited distribution. As a consequence of this report the National Advisory Committee set up an Ad Hoc Committee under the Chairmanship of Dr. S.C. Robinson to develop a National System for the storage and retrieval of geological data in Canada and to prepare a report on this system for presentation to the National Advisory Committee in April 1966. (Interim Report of the Committee on Storage and Retrieval of Geological Data in Canada, National Advisory Committee on Research in the Geological Sciences, Geol. Surv. Can., Paper 66-43, 1966.)

The National Advisory Committee accepted this interim report and recommended that the Ad Hoc Committee be retained for an additional year to:

- (1) to assist and advise in establishment of the National index;
- (2) to carry forward the design of spread sheets for those files for which there is current demand in Canada, and to seek advice of such consultants as may be necessary to implement related programs;
- (3) to act as the clearing house for Canadian representation on International Committees in this field;
- (4) to provide representatives of geology on National Committees concerned with storage of data in the environmental sciences;
- (5) to advise on and encourage the application of computer (quantitative) methods to geological data in Canada; and to promote the training of Canadian geologists in the assembly and utilization of machine-processable files; and
- (6) to bring in a final report to the National Advisory Committee in April, 1967.

#### GEOCHEMICAL PROSPECTING SYMPOSIUM

Prompted by the suggestion of its Subcommittee on Mineral Deposits, the National Advisory Committee sponsored a symposium on Geochemical Prospecting in Ottawa from April 20-22, 1966. The Geological Survey of Canada was host to the symposium which attracted 250 scientists, including many from outside Canada. Some 38 papers were presented nearly all of which were concerned with the application of geochemical methods to exploration for mineral deposits. The papers of authors submitting manuscripts and the abstracts of all papers presented will be published in a symposium volume (Symposium on Geochemical Prospecting, Ottawa, 1966, National Advisory Committee on Research in the Geological Sciences, Geol. Surv. Can., Paper 66-54, 1966.

#### POST-DOCTORATE FELLOWSHIPS

National Research Council post-doctoral fellowships tenable with the Geological Survey were first made available in 1956 when one fellowship was awarded. Since then a total of 27 men have held fellowships with the Geological Survey. A booklet describing the post-doctorate fellowships tenable with the Department of Energy, Mines and Resources is readily available; it is given world wide distribution each year by the National Research Council.



In 1966 the Geological Survey reviewed a total of 56 applications for N.R.C. post-doctorate fellowships in the geological sciences. From these applications the following 3 men were offered and accepted, fellowships with the Survey:

Indranil Banerjee India	Pleistocene Geology (with Dr. J.G. Fyles)
Michael John Kennedy Ireland	Structural Geology (with Dr. E.R.W. Neale)
Anthony George Plant England	Mineralogy (with Dr. R.J. Traill)

The following completed their terms as post-doctorate fellows in 1966:

Dr. Victor Koeppel	July, 1966
Dr. Peter Blattner	December, 1966
Dr. P.S. Naidu	July, 1966

The one year terms of Dr. A. De and Dr. A.T. Rozkowski have been extended to November, 1967 and April, 1967 respectively.

In January 1967 Mr. E. Hall took over administrative responsibility for post-doctorate fellows within the Geological Survey.

### ADMINISTRATIVE SERVICES

#### LIBRARY

Mrs. D.M. Sutherland

In September 1966, Mrs. Kummerman retired from the Public Service and her position was filled by Mrs. Sutherland. The only other staff change was the appointment of Mr. E. Rail in September to take the place of Mr. Fisher. The Library had three summer students.

During November the library began to provide Xerox copies of articles to other libraries, and individuals outside of Ottawa, instead of sending the whole periodical issue on loan. It was decided to limit this service to articles of twenty pages or less. This procedure has

saved library staff time in recording the loans, has enabled the periodicals to circulate more quickly to GSC staff, and has eliminated possible loss.

The statistics for the fiscal year 1966/67 are as follows:

I. Acquisitions:

Books and pamphlets received by purchase	687
Serials	26,438
Maps	3,537
Total	30,662

Items purchased for outside offices:

Institute of Sedimentary and Petroleum Geology, Calgary*	594
British Columbia office	29
Whitehorse office	2
Yellowknife office	1
Total	626

\*This library only purchased publications for the Calgary office to May 24, 1966.

Subscriptions to periodicals	(number of titles)
Ottawa	551
Institute of Sedimentary and Petroleum Geology, Calgary	142
British Columbia office	45
Whitehorse office	16
Yellowknife office	18
	772

II. CIRCULATION

Loans to GSC staff	50,040
Interlibrary loans and those to other individuals	9,860
Publications borrowed from other libraries	532
Maps loaned	742
Total	61,174

III. CATALOGUING

Books, pamphlets, analytics	3,498
Maps	626
Serials	188
Total	4,312

Cards typed - 12,467

#### IV. BINDING

Number of volumes - 1,030

#### V. SCIENTIFIC BOOKS PURCHASED FOR PERSONAL USE OF STAFF MEMBERS AT THEIR EXPENSE - 135

### PUBLICATION DISTRIBUTION OFFICE

L. Touchette

During 1966 the Publications-Information Office continued its functions as distributor of geological publications and information to the general public, government departments, and staff members.

During the year the following publications were received and made available for distribution.

Economic Geology Series (E.G. 1 French) .....	1
Memoirs .....	6
Bulletins .....	22
Preliminary Papers .....	62
Preliminary Papers (reprinted) .....	7
Misc. Report Series (reprinted) .....	2
Topical Reports .....	14
Water Supply Papers (reprinted) .....	53
Misc. Reports, Brochures, Lists, etc. ....	14
Preliminary Geological Maps (15 English and 1 French) .....	17
Final Geological Map .....	18
Aeromagnetic Maps (new issues) .....	528
Aeromagnetic Maps (reprinted) .....	154
Mineral Map of Canada .....	3
Map 1044-A Oil & Gas (revised) .....	2
Indices to G.S.C. Maps (revised) .....	1
Indices to Aeromagnetic Maps (new issue) .....	1
Indices to Aeromagnetic Maps (revised) .....	1
Departmental Annual Reports (English & French) .....	2

#### DISTRIBUTION DATA:

Maps .....	239,354
Reports .....	115,032
Indices, listings, brochures, etc. ....	<u>35,562</u>
Total distribution .....	389,948

OTHER DATA:

Requests for publications, information, R.&M. ....	24,345
Visitors (cash sales 1,053- others 1,019) .....	2,938
Notification lists .....	60
Total publications advertised .....	692

STENOGRAPHIC POOL

Mrs. M. Shanks

Summary of work executed in the Stenographic Services for the period January 1, 1966 to March 31, 1967:

Letters from dictaphone and stenorette .....	762
Letters from manuscript .....	4,725
Pages of reports from dictaphone and stenorette .....	379
Pages of reports from manuscript .....	14,431
Pages of Preliminary reports .....	9,115
Multilith masters .....	1,612
Tabulated pages .....	1,280
Long carriage tables .....	313
Cards .....	10,369
Forms .....	1,753
Total of carbon copies produced .....	31,192
Secretarial relief supplied - days .....	116
Daily average number of operators in pool .....	8.24)
Daily average of personnel on secretarial relief duties .....	.36) = 8.60
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.

Supervising the Steno Pool during this period has been quite a challenge due to the many changes in personnel which have taken place. By mid-summer we had almost a complete turnover of staff and at times had to resort to engaging casual help, as the G.S.C. simply had not the operators to send us. On 1st September Mrs. Gertrude Partington, who had been assistant supervisor for a number of years, left us and went to Marine Sciences Branch and her position has now been filled by Mrs. Beverly Richard. The changes have occurred for various reasons; most found upgradings, one retired, and two decided to stay home due to family needs.

These changes are mentioned because it is gratifying to observe from the record of work that we continued to meet the typing needs of the Geological Survey. Since June, among those we have recruited are at least six young girls direct from High School and all of them have shown diligence and are mastering the difficulties of the scientific terms and special formats required. This result of course requires training and patience on the part of the Supervisor and her assistant and I trust that my personal satisfaction in our accomplishments in the Pool this year is shared alike by Administration and the Scientific officers. We certainly have met with cooperation and courtesy from both these areas.

### LAPIDARY SECTION

A.E. Whitehead

The lapidary section went along as usual for the first half of 1966 with the normal output of thin sections and other side jobs. The second half of the year the pace quickened and incentive rose in the laboratory considerably. We re-arranged the lab in small ways to the advantage of the work and the man. We did some painting and cleaning up. We made a special plaque to be presented to Dr. McCartney on leaving the Survey and a regular plaque for Mr. Elliott. There were other jobs like cutting a special specimen for Dr. Hofman, cutting all the specimens for the Mid-Atlantic Display for Dr. Aumento, polishing and grinding a thin section to a special circular shape for Dr. Ermanovics, cutting hundreds of pieces of jade for Mr. Gauthier for his Economic Collections and considerable time was spent with Mr. Dyck on his chemical apparatus for research purposes.

Mr. McEwan and myself discovered that we could cut a section by a diamond blade after being mounted, without it flying off, thus cutting down considerably our time for lapping both by hand and by micro-matic machine which are the slow steps in the job. This is really an advantage with the fractured sections which have to be cut heavy in order to handle

and mount. We have been doing this by hand but for safety purposes we are in the process of developing a holder.

Our section was very pleased with the results obtained by Mr. Demers on a large coal section for Mr. Donaldson which is now on display in Logan Hall at G.S.C. but is to be placed in a museum in Eastern Canada at a later date.

Mr. McEwan and I had three very bad orders of pure mud on 1st December 1966, from Dr. Banerjee, Dr. Rose and Mr. R.D. Stevens. We cut all specimens dry and boiled them all in balsam for a considerable time and processed them in oil at all the different stages. The finished product was marvelous and we were well pleased with the results of the effort and time spent on them.

We are all in the process of cutting down or eliminating entirely the problem we have of picking which occurs in certain sections.

The months of January, February, and March of 1967 have been filled with work. The cutting of Dr. Hofmann's large specimens and the making of large thin sections to obtain the right results for him presented quite a challenge. Then there were Mr. P. Lavergne's ceramic cartridges to be cut to a specific size for his work, and shortly after that Dr. Aumento presented a problem of making several thin sections from lava which we did successfully. Right after that Dr. Jambor came in with his 13 large specimens to be slabbed and then the following month he presented us with 72 specimens to be levelled and polished. Mixed up with all of this we had Dr. Banerjee's soluble material for thin sections every month and we succeeded in obtaining a better section covering it successfully. We have tried a new impregnation which shows promise that we can process these sections in water.

In March we polished a nice large slab of silver for Mr. H. Steacy to be presented to the Glen Lake Mining Co. in appreciation of a larger slab which was donated by them to be used in several different museums.

This lab has a three man staff consisting of A. Whitehead, O. McEwan and Y. Demers.

Our output for the period consisted of the following:

Standard thin sections .....	6,622
Large and small specimens cut and levelled .....	219
Large and small specimens cut, levelled and polished .....	45
Thin sections covered only .....	117



Polished thin sections .....	154
Standard slides frosted .....	3,325
Jobs requiring man hours .....	142 hours
Slab Saw hours for 1966 .....	78 1/2 hours
Soluble sections for 1966 covered, uncovered and orientated were 41 with a total of 40 hours to complete	

### PHOTOGRAPHIC SECTION

Mr. J.B. Emslie (Acting Chief)

In preparation for the retirement of Mr. E.C. Elliott, the photographic section has been under the direction of Mr. J.B. Emslie for the past year. Mr. Elliott's retirement became official on the 6 September, 1966.

Some reorganization of the Section has resulted in the establishment of an extra processing darkroom, under the control and care of Mr. J.W. Kempt. This is being principally used for processing all films received from the field, as well as many other processing tasks including a limited amount of colour process work.

Mr. D.C. Beckstead our Photo-Librarian, has the care of the complete collection of Survey Negatives. These have been removed from the basement, and are now under much improved storage conditions with the installation of new negative filing cabinets in room 510.

Working under the guidance of, and in close cooperation with Dr. Ken Dawson, a new E.D.P. system of cataloguing negatives with picture titles has been developed and recently launched. It is confidently expected that this system will efficiently eliminate the massive back-log of cataloguing that has grown over the years. Some imperfections are likely to show initially that will need smoothing out, we therefore hope that all who use the system will cooperate in helping to achieve success.

Production totals for 1966 show a definite increase over previous years, and it is hoped that this trend will continue together with improved quality of service. However, although this increase may be due in part to improved facilities, there is still a need for added junior grade support to ease certain areas of pressure.

PHOTOGRAPHIC PRODUCTION TOTALS January 1966-March 1967

Negatives Produced

General black & white negatives .....	3,059
General colour negatives .....	20
Fossil and microfossil negatives .....	4,804
Macrophotograph negatives .....	1,779
Microphotograph negatives B/W .....	862
Microphotograph negatives colour .....	30
Autoradiographs .....	33
Total	10,587

Prints and Positives Produced

Standard contact prints .....	28,198
Logetronic prints .....	948
Black and white enlargements .....	40,218
Colour enlargements .....	104
B/W positive transparencies .....	53
Colour positive transparencies .....	163
B/W projection slides .....	1,019
Colour projection slides .....	784
Total	71,487

Grand Production Total 82,074

MISCELLANEOUS JOB TOTALS

Processing and Photo-Finishing

FIELD WORK

B/W negative exposures processed .....	8,067
Colour transparency exposures processed .....	372

SECTION WORK

B/W negatives processed .....	10,537
Colour negatives processed .....	71
Colour transparencies processed .....	460
Colour prints processed .....	100
Colour print-films processed .....	35
Negatives retouched or opaqued .....	4,535
Prints retouched, B/W and colour .....	574
Prints mounted .....	2,047
Projection slides bound, B/W and colour .....	2,117
Total	28,915

### MISCELLANEOUS TIME:

Time spent on negative cataloguing and filing	417 Man Days
Time spent on projection of slides and movies	229 Man Hours
Time spent on filing printers blocks etc.	27 1/2 Man Hours

### INSTRUMENTAL DEVELOPMENT SHOP

G.A. Meilleur

#### Function

During the report-period the function of the Instrumental Development Shop has, to some extent, developed new trends due to an increased number of requisitions requesting services on existing equipment.

The fabrication of spare parts to be made available for emergency and repair, and also the maintenance of existing equipment, are two items which are expected to increase constantly and, therefore, absorb more time from the shop. The figure of 15% given in last year's report as representing the portion of work sent out to commercial enterprises is likely to reach 25% during 1967. By doing so we hope to keep our shop working on projects which are related to its purpose of existence.

#### Outside Activities

Visits to manufacturers of diamond bits which are used by the Geological Survey for sampling rocks, have contributed greatly to its development. More work remains to be accomplished on this project if we are to improve its operation and also reduce costs.

#### Time Distribution

Petrological Sciences	35.2 per cent
Geophysics	31.4
Economic Geology	16.4
Fuels and Stratigraphy	.6
Regional Geology	.4
Administration	16.

This time distribution is based on work requested under normal requisitions.

## FIELD TELECOMMUNICATIONS

J.B. Blanchard

In 1966 the Geological Survey used VHF-FM radio telephones for the first time. These units are ideal for short ranges of thirty miles or less, over comparatively open or rolling terrain (more over water). At these short ranges use of conventional amplitude modulated (A M) is virtually impossible except at power-consuming low frequencies.

The performance of single-side-band (S.S.B.) radio telephone equipment during the 1966 field season has more than justified its greater cost over that of conventional A.M. The results of field conducted comparison tests between standard A.M. and S.S.B. equipment are startling according to reports from our field officers. Tests were successfully carried out at over 900 miles and several at distances of 400 miles or less. Although more complex to set up, these units offered no difficulty once the new concept of S.S.B. was mastered. The use of this equipment has two major disadvantages. The first being its unavailability in portable form, the second, its absence as standard equipment in aircraft. Department of Transport attributes the latter to a lack of a market in Canada for this equipment rather than to any technical difficulties.

The telecommunications section has been assigned the responsibility of licencing all departmental radio-telephone equipment. As of mid-February five hundred active radio licences had been issued to this department. These licences are issued for periods of one, three and five years. They must be kept current by submitting amendments to the Department of Transport whenever there is a change in area or frequency.

The cost of radio-telephone equipment used by departmental field officers is in excess of 200,000 dollars. Included in this cost are the transportables and portables, but not distance measuring equipment, navigational equipment or the multitude of transistor-type radio receivers.

This year for the first time, a transistorized version of the very popular PRT-20B model is available. Several of these units are to be purchased and placed in the field for purposes of evaluation during 1967.

As in 1965, a number of obsolete radio telephones were disposed of through Crown Assets. This concludes all large scale disposal of old radio equipment purchased during the latter half of the 1950s.

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 Geologist 5  
Henderson, J.F.

Manuscripts & Cartography

- 1 Geologist 5  
Harker, P.

Manuscripts

- 1 Geologist 4  
Blackadar, R.G.
- 1 Clerk 4  
Mahoney, Mrs. L.R.
- 1 Steno. 4  
Yeager, Mrs. M.A.

Cartography

- 1 Tech. Off. 7  
Daughtry, G.S.
- 1 ST 4  
Ainsworth, Mrs. H.B.
- 1 Technician 1  
McCracken, J.M.

Planning

- 1 Tech. Off. 6  
McNeil, C.E.

Compiling

- 1 Tech. Off. 6  
Nunn, E.P.
- 1 Drafts. 4  
Leader, R.E.

Compiling (Cont'd)

- 2 Super. Dr. 2  
Debain, P.  
Dumbrell, E.A.
- 8 Map Comp. & Comp. 4  
Barbary, G.J.  
Hill, R.S.  
Howe, K.G.  
King, J.A.  
Lavigne, G.H.  
Mainville, B.  
Raddatz, Miss M.A.  
Thomson, J.W.

Drafting (Illustrations)

- 1 Tech. Off. 6  
Williams, L.A.
- 2 Drafts. 4  
Finn, H.J.  
Gagnon, J.G.E.
- 4 Drafts. 3  
Heney, F.J.  
Saffin, R.E.  
Vermette, W.P. (Calg.)  
Yeager, F.S.
- 4 Drafts. 2  
Browne, J.A.  
Potvin, R.Y.  
Shelton, Mrs. J. (Calg.)  
Yelle, J.S.
- 5 Drafts. 1  
Coulthart, L.A.  
Grenier, N.  
Enright, M.L.  
Perron, R.  
Sauvageau, R.
- 1 Tech. 1  
Crepin, G.J.

Drafting (Maps)

- 1 Drafts. 5  
Babcock, L.W.
  - 2 Drafts. 4  
Bernard, M.G.  
Daugherty, R.F.
  - 10 Drafts. 3  
Bencik, K.  
Brown, D.G.  
Cooke, Miss B.J.  
Corriveau, J.P.  
Heyendal, H.A.  
Hill, B.G.  
Kovachic, Mrs. H.  
MacLachlan, L.A. (Calg.)  
Nichol, H.S.  
St. Pierre, M.
  - 1 Drafts. 2  
Young, W.G.
  - 1 Drafts. 1  
McKenzie, N.M.
- Negative Engraving,  
Colour Negatives
- 1 Drafts. 4  
Williams, J.B.F.
  - 3 Drafts. 3  
Daley, L.A.  
Papps, T.L.  
Walter, D.J.
  - 1 Drafts. 2  
Thomson, H.A.
  - 1 Asst. 3 (L or Ph)  
Fairfield, R.D.J.



Photo-Mech. Map Photo

- 1 Tech. 4  
Buck, N.E.
- 1 Asst. 3 Litho or Photo  
Foshay, G.N.
- 1 Asst. 2 Litho or Photo  
Snyder, W.M.

Printing and Photostat

- 1 Technician 2  
Major, A.C.
- 1 Asst. 3 Litho or Photo  
Wilson, G.B.
- 1 Asst. 1 Litho or Photo  
Mackenzie, R.J.G.
- 1 Lr Litho or Photo  
Monette, R.B.

British Columbia Office

- 1 Res. Sc. 3  
Armstrong, J.E.
- 1 Sc. Off. 2  
Leaming, S.F.
- 1 CR 4  
Marble, Mrs. A
- 1 ST 4  
Lee, Mrs. E.K.
- 1 CR 1  
Taylor, Mrs. S.I.

Whitehorse Office

- 1 Res. Sc. 1  
Finlay, D.C.
- 1 CR 3  
Phillips, Mrs. E.C.

Administrative Services

- 1 AS 5  
Pollitt, K.
- 1 AS 3  
Lajoie, L.J.
- 1 ST 4  
Baker, Mrs. R.D.

Attendance

- 1 CR 3  
Shields, Mrs. L.

Accounts

- 1 CR 5  
Blace, W.L.
- 1 CR 4  
Going, Mrs. M.I.

Branch Registry and  
Messenger Service

- 1 CR 5  
Reynolds, Mrs. E.V.
- 2 CR 3  
McGuire, Mrs. V.M.  
Wragg, Miss C.R.

Branch Registry and  
Messenger Service (Cont'd)

- 1 CR 2  
O'Dwyer, Mrs. F.
- 1 CR 1  
Gravelle, Mrs. N.
- 1 Clerical Asst.  
Bégin, Mrs. G.M.

Geological Information

- 1 CR 6  
Touchette, L.J.
- 1 CR 4  
Letang, E.G.
- 1 CR 3  
McNabb, Mrs. S.W.
- 2 CR 2  
Clarke, C.R.  
Murphy, B.F.
- 1 ST 2  
Drapeau, Mrs. G.M.
- 1 Storeman 2  
Vachon, D.M.

Purchasing & Supplies

- 1 CR 4  
Smith, D.D.
- 1 CR 3  
Moreau, V.
- 1 CR 2  
Lisle, Mrs. A.E.
- 1 Storeman 2  
Charlebois, G.J.
- 1 Driver  
Cayer, H.H.

Photographic

- 1 Tech. Off. 2  
Beckstead, D.C.
- 3 Photographer 4  
Cooke, F.J.  
Emslie, J.B.  
Thorpe, E.
- 2 Photographer 2  
White, Miss J.I.  
Skuce, C.A.
- 1 Technician 1  
Stafford, W.G.
- 1 Asst. Litho or Photo 3  
Kempt, J.W.

Library

- 1 Librarian 5  
Sutherland, Mrs. D.M.
- 2 Librarian 2  
Nagy, Mrs. K.  
Williams, Miss M.E.
- 1 Tech. Off. 3  
Lindsay, Miss L.E.
- 1 CR 3  
Stewart, Miss T.G.
- 2 CR 2  
Maheral, Mrs. L.  
Wistaff, Mrs. C.M.
- 1 Tech. Off. 2  
Laurendeau, P.E.
- 1 Packer & Helper  
Rail, E.J.

Stenographic Pool

- 1 CR 4  
Shanks, Mrs. M.A.

Stenographic Pool (Cont'd)

- 1 CR 3  
Richard, Mrs. B.G.
- 4 ST 2  
Blackman, Mrs. C.L.  
Blanchard, Miss L.S.  
McMillan, Miss J.M.  
Welsh, Mrs. P.P.
- 3 ST 1  
Jackson, Miss C.G.  
Kapusto, Miss E.I.  
Paquette, Miss M.J.C.

Technical Services

- 1 Technical Officer 5  
Jones, F.W.
- 1 Technician 3  
Stauffer, W.J.

Lapidary

- 1 Technician 2  
Whitehead, A.E.
- 2 Technician 1  
Demers, A.Y.  
McEwan, W.O.

Equipment Office

- 1 CR 3  
Rozon, R.

Instrument Shop

- 1 Tech. Off. 4  
Meilleur, G.A.
- 2 Technician 2  
Gregheur, A.Y.  
Fournier, J.P.

REGIONAL GEOLOGY DIVISION

- 1 Chief of Division  
Douglas, R.J.W.
- 1 Clerk 4  
Paquette, Mrs. A.M.

Appalachian

- 1 Res. Sc. 3  
Neale, E.R.W.
- 5 Res. Sc. 2  
Anderson, F.D.  
Benson, D.G. (Bedford)  
Kelley, D.G.  
Poole, W.H.  
Williams, H.
- 1 Res. Sc. 1  
Gillis, J.W. (Bedford)

Eastern Shield

- 1 Res. Sc. 3  
Duffell, S.
- 9 Res. 2  
Baragar, W.R.A.  
Emslie, R.F.  
Fahrig, W.F.  
Frarey, M.J.  
Goodwin, A.M.  
Jackson, G.D.  
Skinner, R.  
Stevenson, I.M.  
Taylor, F.C.

Western Shield

- 2 Res. Sc. 3  
Wright, G.M.  
Tremblay, L.P.
- 9 Res. Sc. 2  
Baer, A.J.  
Bell, C.K.  
Bostock, H.H.  
Davison, W.L.  
Donaldson, J.A.  
Eade, K.E.  
Fraser, J.A.  
Heywood, W.W.  
McGlynn, J.C.
- 1 Res. Sc. 1  
Reinhardt, E.W.

Western Shield (Cont'd)

- 1 SO 2  
Davidson, A.

Cordilleran

- 1 Res. Sc. 3  
Little, H.W.
- 9 Res. Sc. 2  
Campbell, R.B. (B.C.)  
Gabrielse, H.  
Green, L.H. (B.C.)  
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 Res. Sc. 1  
Blusson, S.L.  
Hutchinson, W.W. (B.C.)
- 1 Geol. 2  
Monger, J.W.H. (B.C.)

FUELS AND STRATIGRAPHY DIVISION

- 1 Chief of Division  
Caley, J.F.
- 1 ST 5  
Lessard, Miss J.M.

Palaeontology

- 3 Res. Sc. 3  
McLaren, D.J.  
Jeletzky, J.A.  
Tozer, E.T.
- 9 Res. Sc. 2  
Bamber, E.W.  
Bolton, T.E.

Palaeontology (Cont'd)

- Copeland, M.J.  
Cumming, L.M.  
Fritz, W.H.  
McGregor, D.C.  
Norford, B.S.  
Norris, A.W.  
Sinclair, G.W.
- 1 SSO 1  
Chamney, T.P.
- 1 Geol. 3  
Hofmann, H.J.
- 2 Sc. Off. 2  
Cox, R.L.  
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. 2  
Jarvis, D.C.  
Moore, G.P.
- 1 ST 4  
Murphy, Mrs. F.M.
- 1 CR 2  
Carbone, S.
- Senior Research  
Palaeontologist
- 1 Res. Sc. 4  
Frebold, H.W.

Petroleum Geology

- 1 Res. Sc. 3  
Norris, D.K.
- 4 Res. Sc. 2  
Irish, E.J.W. (Calg.)  
Price, R.A.  
Sanford, B.V.  
Taylor, G.C. (Calg.)
- 1 Res. Sc. 1  
Ollerenshaw, N.C. (Calg.)
- 1 Sc. Off. 3  
Howie, R.D.
- 1 S.O. 1  
Ibbatson, Miss C.J. (Calg.)
- 1 Technician 2  
ter Haar Romeny, W.U.
- 1 Technician 1  
Seguin, R.J.G.
- 1 Asst. Tech. 1  
Colleto, S.P.F.

Arctic Islands

- 1 Res. Sc. 3  
Thorsteinsson, R. (Calg.)
- 3 Res. Sc. 2  
Christie, R.L.  
Kerr, J.W. (Calg.)  
Trettin, H.P. (Calg.)
- 1 Res. Sc. 1  
Nassichuk, W.W. (Calg.)

Western Plains Office -  
Administration

- 1 Sr. Sc. Off. 1  
Latour, B.A.

Western Plains Office -  
Administration (Cont'd)

- 1 Tech. Off. 3  
Jones, Mrs. M.
- 1 Tech. Off. 2  
Banning, W.J.
- 2 Technician 1  
Bowering, A.L.  
Herron, D.L.
- 1 Asst. Tech. 2  
Heinrich, A.G.
- 1 CR 4  
Brooks, Mrs. M.H.
- 1 CR 3  
Penley, Miss W.L.
- 1 ST 2  
Watters, Miss P.L.
- 3 ST 1  
Dennis, Mrs. V.  
Elviss, Miss W.L.  
Savage, Miss J.C.

Systematic Stratigraphy  
Devonian

- 1 Res. Sc. 3  
Belyea, Miss H.R.
- 1 Geol. 2  
Pugh, D.C.
- 1 Res. Sc. 1  
MacKenzie, W.J.

Mesozoic Stratigraphy

- 2 Res. Sc. 2  
Burk, C.F.  
Stott, D.F.

Mesozoic Stratigraphy (Cont'd)

1 Sr. Sc. Off. 1  
Price, L.L.

1 Geol. 2  
Gibson, D.W.

Lower and Upper  
Palaeozoic Stratigraphy

2 Res. Sc. 2  
Aitken, J.D.  
Procter, R.M.

1 Res. Sc. 1  
Macqueen, R.W.

1 Sc. Off. 3  
Martin, W.L.

Coal Research

1 Res. Sc. 3  
Hacquebard, P.A.

1 Res. Sc. 2  
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 M.E.

Central Technical Geological Files

1 CR 3  
Shurben, Mrs. P.K.

Geology of Mineral Deposits

1 Geologist 4  
Whitmore, D.R.E.

1 Res. Sc. 3  
Kindle, E.D.

6 Res. Sc. 2  
Chamberlain, J.A.  
Gross, G.A.  
McCartney, W.D.  
Mulligan, R.  
Roscoe, S.M.  
Rose, E.R.

1 Sc. Off. 2  
McLeod, C.R.

1 Tech. Off. 4  
Johnston, A.G.

1 Asst. Tech. 2  
Burke, R.D.

Geochemistry

1 Res. Sc. 3  
Boyle, R.W.

4 Res. Sc. 2  
Cameron, E.M.  
Currie, K.L.  
Dyck, W.  
Fortescue, J.A.

1 Res. Sc. 1  
Sangster, D.F.



Geochemistry (Cont'd)

- 1 Geol. 2  
Usik, L.
- 1 SO 3  
Smith, A.Y.
- 1 SSO 1  
Lynch, J.J.
- 1 Sc. Off. 2  
Hornbrook, E.H.W.
- 1 Tech. Off. 3  
Horton, R.E.
- 1 Technician 3  
Lavergne, P.J.
- 1 Technician 2  
Durham, C.C.
- 1 Technician 1  
Pelchat, J.C.
- 1 Asst. Tech. 1  
Watters, Miss S.K.

Pleistocene Geology

- 1 Geologist 5  
Fyles, J.G.
- 1 Res. Sc. 3  
Prest, V.K.
- 9 Res. Sc. 2  
Blake, W.  
Craig, B.G.  
Gadd, N.R.  
Henderson, E.P.  
Hughes, O.L. (Calg.)  
Lee, H.A.  
St. Onge, D.A.  
Stalker, A.M.  
Terasmae, J.

Pleistocene Geology (Cont'd)

- 4 Res. Sc. 1  
Fulton, R.J.  
Klassen, R.W. (Calg.)  
Lewis, C.M.  
Rutter, N.W. (Calg.)
- 1 Geographer  
Richard, S.H.
- 1 TO 4  
Mott, R.J.
- 1 Geol. 2  
McDonald, B.C.
- 1 Technician 3  
Field, D.E.
- 1 Technician 2  
Kelley, R.G.

Engineering Geology

- 1 Sr. Sc. Off. 2  
Owen, E.B.
- 1 Res. Sc. 2  
Scott, J.S.

Yellowknife Office

- 1 Sc. Off. 2  
Thorpe, R.I.
- 1 CR 3  
Braden, Mrs. E.

PETROLOGICAL SCIENCES  
DIVISION

- 1 Chief of Division  
Smith, C.H.

PETROLOGICAL SCIENCES  
DIVISION (Cont'd)

1 ST 5  
Gougeon, Mrs. C.L.

1 TO 2  
Davies, Mrs. F.C.

Mineralogy

1 Sr. Sc. Off. 3  
Traill, R.J.

1 Sr. Sc. Off. 1  
Steacy, H.R.

2 Res. Sc. 2  
Lachance, G.R.  
Rimsaite, Miss J.

2 Res. Sc. 1  
Aumento, F.  
Jambor, J.L.

1 Sc. Off. 3  
Sabina, Miss A.P.

1 Sc. Off. 2  
Edmonds, Mrs. C.M.

1 Tech. Off. 3  
Delabio, R.N.

1 Asst. Tech. 1  
Zylstra, Miss S.

Mineral Separation Lab.

1 Technician 4  
Paris, J.C.

1 Technician 1  
Machin, D.B.

Mineral Separation Lab. (Cont'd)

2 Asst. Tech. 1  
Radmore, Mrs. M.H.  
Smith, D.E.

Mineral and Rock Sets

1 Tech. Off. 4  
Gauthier, P.J.

1 Tech. 1  
Larose, J.M.

1 Asst. Tech. 3  
Turpin, J.

1 CR Level A  
Racine, T.H.

Isotope and Nuclear Research

1 Res. Sc. 3  
Wanless, R.K.

3 Sr. Sc. Off. 1  
Loveridge, W.D.  
Lowdon, J.A.  
Stevens, R.D.

1 Technician 3  
Sullivan, R.W.

1 Technician 2  
Robertson, I.M.

1 Technician 1  
Skiba, C.J.

1 Asst. Tech. 2  
Quigg, F.B.

2 Asst. Tech. 1  
MacRae, J.L.  
Sweedfager, Miss M.J.

Petrology

1 Geologist 5  
Reesor, J.E.

1 Res. Sc. 2  
Irvine, T.N.

2 Res. Sc. 1  
Douglas, J.A.V.  
Froese, E.

1 Sc. Off. 2  
Lawrence, D.E.

Data Processing

2 Res. Sc. 2  
Dawson, K.R.  
Agterberg, F.P.

1 DA 1  
Cooper, Miss S.M.

1 CR 3  
Boutet, L.H.J.

Analytical Chemistry

1 Res. Sc. 3  
Maxwell, J.A.

Chemical Lab.

1 Res. Sc. 2  
Abbey, S.

1 Sr. Sc. Off. 1  
Sen Gupta, J.G.

1 Sc. Off. 3  
Courville, S.

Chemical Lab. (Cont'd)

1 Technician 3  
Bouvier, J.L.

1 Technician 2  
Church, K.A.

1 Technician 1  
Seymour, Miss L.J.

2 Asst. Tech. 3  
Gibson, W.A.  
Watson, Mrs. F.J.

2 Asst. Tech. 2  
Brown, D.A.  
Valenzuela, J.M.

1 Asst. Tech. 1  
Andrews, Miss M.J.

Spectrographic Lab.

1 Sr. Sc. Off. 1  
Champ, W.H.

GEOPHYSICS DIVISION

1 Chief of Division  
Morley, L.W.

1 ST 5  
Goodman, Mrs. N.D.

1 SO 2  
Moyd, Mrs. P.

E.M. & Resistivity

1 Res. Sc. 2  
Collett, L.S.

E.M. & Resistivity (Cont'd)

2 Res. Sc. 1  
Ahrens, R.H.  
Becker, A.

1 Technician 3  
Gauvreau, C.

1 Technician 1  
Frechette, J.P.

1 Tech. Off. 3  
Flint, T.R.

Fed/Prov. Aeromag. Surveys

1 Res. Sc. 2  
MacLaren, A.S.

1 Tech. Off. 6  
Ready, E.E.

3 Map Comp. & Comp. 4  
Chretien, Miss M.B.  
Derouin, E.J.  
Haley, E.L.

Magnetic Methods

1 Res. Sc. 2  
Hood, P.J.

2 Res. Sc. 1  
Bower, Miss M.E.  
Sawatzky, P.

1 Tech. Off. 4  
Owens, K.H.

1 Technician 4  
Knapp, H.W.C.

Magnetic Methods (Cont'd)

1 Technician 3  
Dicaire, A.

1 Map Comp. & Comp. 4  
Reveler, D.

Theoretical Geophysics

1 Res. Sc. 2  
Bhattacharyya, B.K.

1 Map Comp. & Comp. Super. 1  
Langlois, R.J.

2 Map Comp. & Comp. 4  
Dods, S.D.  
Zieman, F.W.

1 Map Comp. & Comp. 3  
Laurin, Mrs. T.C.M.

1 Drafts. 1  
Abbinett, D.D.

1 Map Comp. & Comp. 2  
Roy, A.Y.

Rock Magnetism

1 Res. Sc. 2  
Larochelle, A.

1 Geol. 2  
Symmons, D.T.A.

1 Res. Sc. 1  
Schwartz, E.J.

2 Sc. Off. 2  
Christie, K.W.  
Pearce, G.A.

Rock Magnetism (Cont'd)

- 1 Technician 1  
Freda, G.N.

Seismic

- 1 Res. Sc. 2  
Hobson, G.D.
- 1 Sc. Off. 3  
Overton, A.
- 1 Tech. Off. 4  
MacAulay, H.A.
- 1 Technician 4  
Hodge, R.A.
- 1 Drafts. 3  
Gagne, R.M.

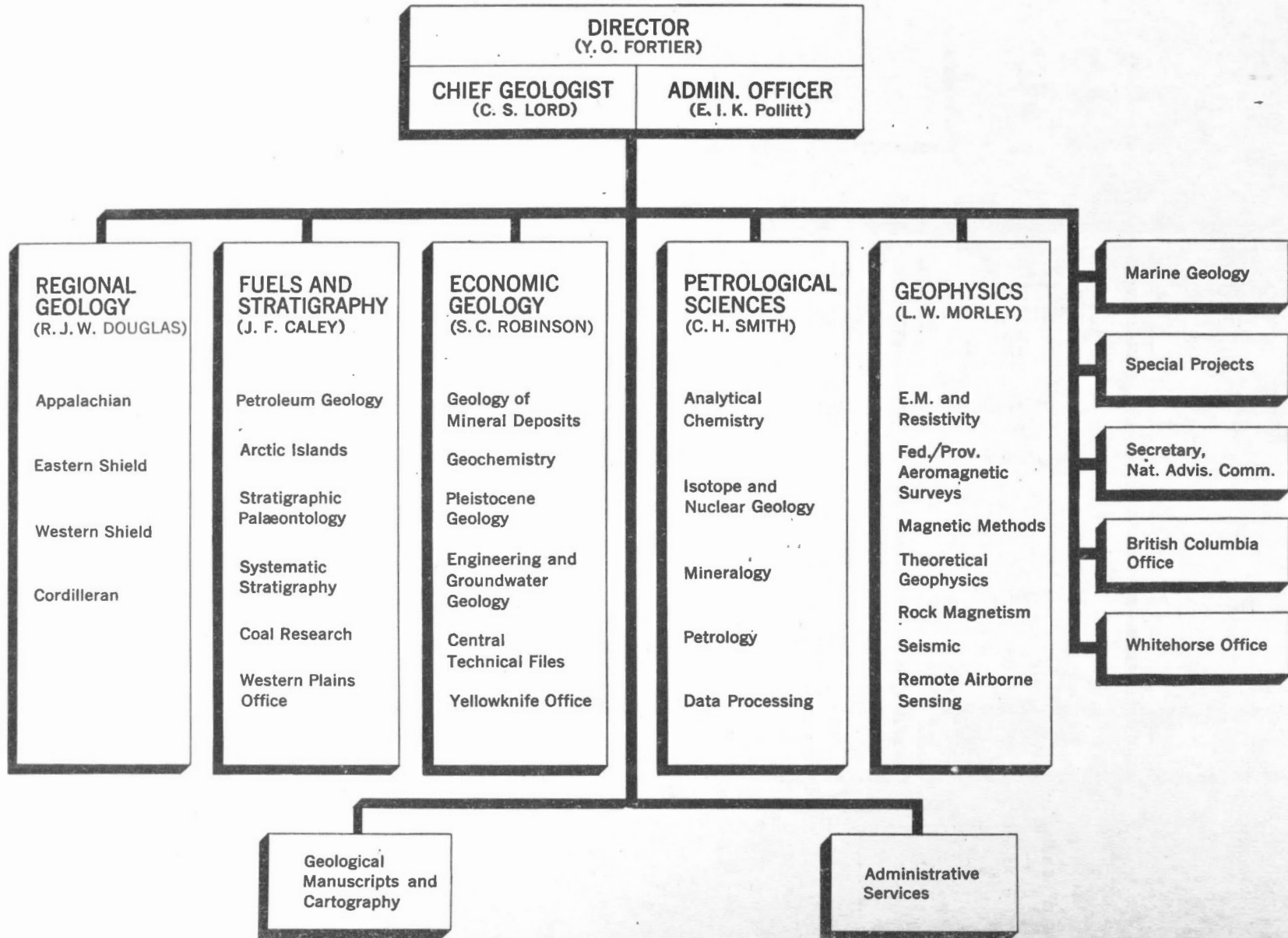
Remote Airborne Sensing

- 1 Geol. 4  
Darnley, A.G.
- 1 Tech. Off. 7  
Washkurak, S.
- 1 Sc. Off. 3  
Slaney, V.R.
- 1 Sc. Off. 2  
Gross, H.

On Loan

- 1 Technician 3  
Blanchard, J.

# GEOLOGICAL SURVEY OF CANADA





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