CANADA

ANNUAL REPORT

CALENDAR YEAR

1961

Department of

MINES AND TECHNICAL SURVEYS

annual report

Calendar Year 1961

Department of Mines and Technical Surveys

60462-9—1

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OTTAWA, 1962

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To His Excellency Major-General Georges P. Vanier, D.S.O., M.C., C.D., Governor General and Commander-in-Chief of Canada.

MAY IT PLEASE YOUR EXCELLENCY:

The undersigned has the honor to lay before Your Excellency the Annual Report of the Department of Mines and Technical Surveys for the calendar year 1961.

Respectfully submitted,

PAUL MARTINEAU

Minister of Mines and Technical Surveys

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The Honorable Paul Martineau,
Minister of Mines and Technical Surveys,
Ottawa.

SIR:

I have the honor to submit the Annual Report of the Department of Mines and Technical Surveys, covering the calendar year 1961.

MARC BOYER
Deputy Minister

Senior Personnel of the Department
as at December 31, 1961

MINISTER

THE HONORABLE JACQUES FLYNN

DEPUTY MINISTER

DR. MARC BOYER

Director General of Scientific Services .....DR. W. E. VAN STEENBURGH

Director, Surveys and Mapping Branch .....S. G. GAMBLE

Director, Geological Survey of Canada .....DR. J. M. HARRISON

Director, Mines Branch .....DR. JOHN CONVEY

Dominion Astronomer .....DR. C. S. BEALS

Director, Geographical Branch .....DR. N. L. NICHOLSON

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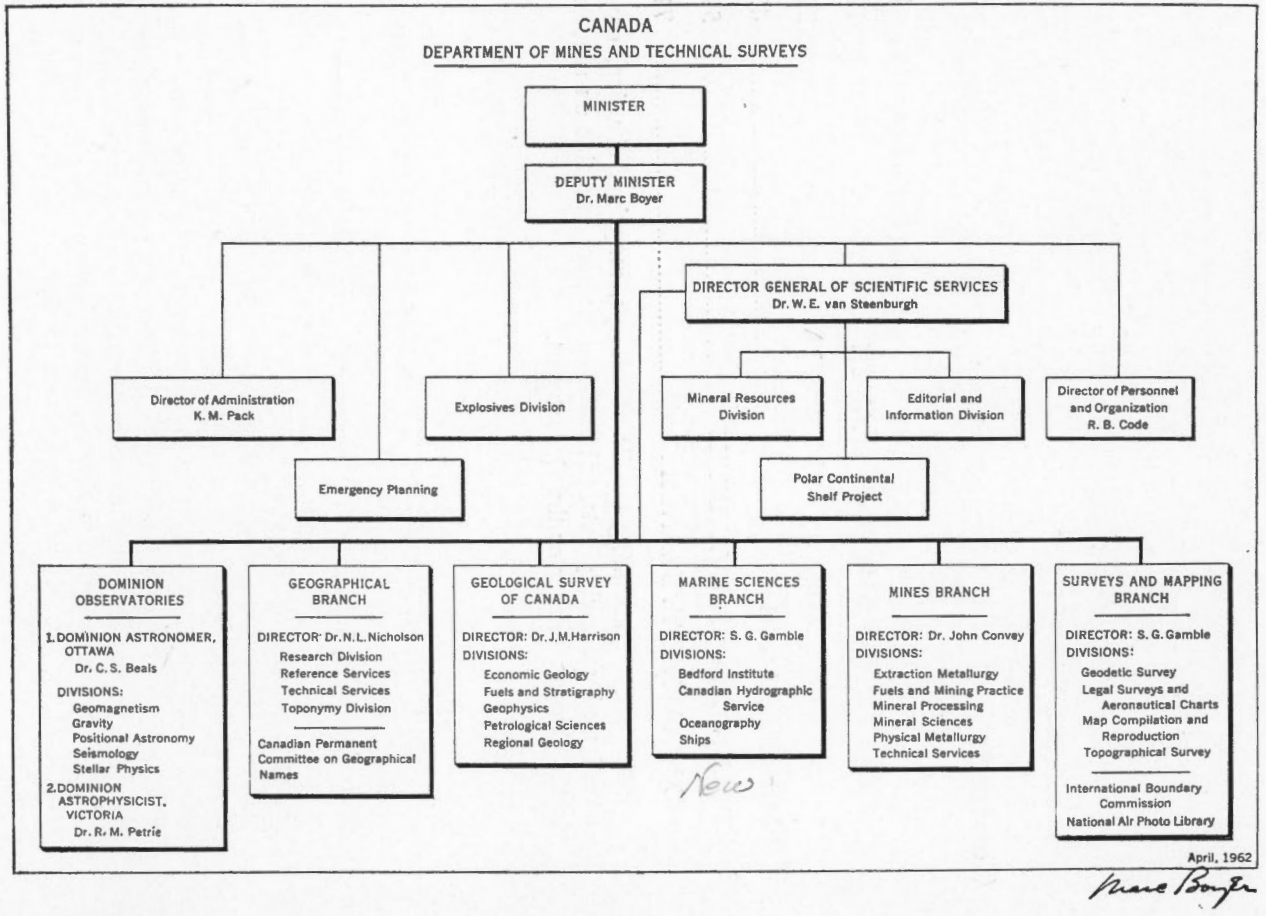
Revenues and Expenditures

A summary of revenue and expenditures for 1961 follows:

	Revenue	*Ordinary Expenditures*
Minister of Mines and Technical Surveys	$	$ 12,978.51
Departmental Administration	.....	1,290,899.37
Explosives	9,333.86	102,445.70
Mineral Resources Division	200.00	376,039.47
Assessment for membership in the Pan-American Institute of Geography and History	.....	9,149.99
Surveys and Mapping Branch	205,796.94	15,550,449.23
Geological Survey of Canada	26,153.59	5,346,159.50
Mines Branch	10,735.33	4,836,584.05
Geographical Branch	1,095.07	461,851.50
Dominion Observatories	8,965.65	2,210,639.11
General—		
To provide for payments under the Emergency Gold Mining Assistance Act (Chap. 95, R.S., as amended)	.....	12,620,130.51
To provide for purchase of Air Photography and the expenses of the Interdepartmental Committee on Air Surveys	.....	1,536,626.81
Provincial and Territorial Boundary Surveys	.....	20,358.75
Polar Continental Shelf	.....	1,411,792.45
Awards	.....	3,000.00
	$262,280.44	$ 45,789,104.95

Contents

APPENDICES tabulating details of surveys, mapping, charting, ores investigated, research grants, publications, etc., are available on request to the Queen's Printer or the Department.


CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINISTER
DEPUTY MINISTER
Dr. Marc Boyer
DIRECTOR GENERAL OF SCIENTIFIC SERVICES
Dr. W. E. van Steenburgh
Director of Administration
K. M. Pack
Explosives Division
Mineral Resources Division
Editorial and Information Division
Director of Personnel and Organization
R. B. Code
Emergency Planning
Polar Continental Shelf Project
DOMINION OBSERVATORIES
1. DOMINION ASTRONOMER, OTTAWA
Dr. C. S. Beals
DIVISIONS:
Geomagnetism
Gravity
Positional Astronomy
Seismology
Stellar Physics
2. DOMINION ASTROPHYSICIST, VICTORIA
Dr. R. M. Petrie
GEOGRAPHICAL BRANCH
DIRECTOR: Dr. N. L. Nicholson
Research Division
Reference Services
Technical Services
Toponymy Division
Canadian Permanent Committee on Geographical Names
GEOLOGICAL SURVEY OF CANADA
DIRECTOR: Dr. J. M. Harrison
DIVISIONS:
Economic Geology
Fuels and Stratigraphy
Geophysics
Petrological Sciences
Regional Geology
MARINE SCIENCES BRANCH
DIRECTOR: S. G. Gamble
DIVISIONS:
Bedford Institute
Canadian Hydrographic Service
Oceanography
Ships
MINES BRANCH
DIRECTOR: Dr. John Convey
DIVISIONS:
Extraction Metallurgy
Fuels and Mining Practice
Mineral Processing
Mineral Sciences
Physical Metallurgy
Technical Services
SURVEYS AND MAPPING BRANCH
DIRECTOR: S. G. Gamble
DIVISIONS:
Geodetic Survey
Legal Surveys and Aeronautical Charts
Map Compilation and Reproduction
Topographical Survey
International Boundary Commission
National Air Photo Library
April, 1962

introduction

IN 1961 the Department of Mines and Technical Surveys pressed forward with a broad field and research program of benefit to many aspects of Canadian endeavor and adding substantially to Canada's stature in the world of science. Survey crews—the largest number to date*—worked in every province and the territories and over large areas of polar continental shelf. Their efforts would provide maps, charts and technical data vital to navigation, mineral exploration and to the over-all development of the country. Meanwhile, those in the laboratories were developing improved techniques for economical processing of Canadian ores, industrial minerals and fuels, and new uses for Canadian mined metals.

Some projects were fundamental in nature, enlarging the pool of scientific knowledge to be drawn upon by either science or industry. Some projects contributed to man's knowledge of the universe, of outer space, of the interior of the globe on which he lives. Whatever the case, the entire program was destined to put Canada in a stronger position to meet the difficulties and challenges of the years ahead.

Generally speaking, the Department's work was concentrated in five broad categories under branches named accordingly: Surveys and Mapping Branch, Geological Survey of Canada, Mines Branch, Dominion Observatories and the Geographical Branch. In 1961 plans were well advanced for the formation of the new Marine Sciences Branch, adding another dimension to the Department's sphere of activity, namely, in the field of oceanography. Scheduled for an official opening late in 1962 was the Bedford Institute which, when fully staffed, would house some 300 oceanographers and supporting personnel.

*e.g., the Geological Survey of Canada sent 102 parties to the field, compared with 87 in 1960.

The Polar Continental Shelf Project in its third season drew scientific talent from a number of branches, as did the Upper Mantle Project, a joint undertaking with the national Research Council and various Canadian universities. Both projects called for work in a number of disciplines (e.g., geology, geomagnetism, seismology, gravity, etc.). Both would produce much useful scientific data. They also led to the development of new instruments and techniques that would have application in other fields both scientific and commercial.

The year was especially noteworthy in the realm of new facilities and equipment. The Department officially opened its new Surveys and Mapping building on Ottawa's Booth Street. The CHS *Maxwell* was launched at Halifax during the summer and the oceanographic vessel *Hudson,* was well under way. The Dominion Observatories completed its mirror transit telescope in Ottawa and erected a 48-inch telescope near Victoria. On blueprints were new Mines Branch laboratories to be built over the next few years.

Detailed accounts of these and other activities are given in the chapters that follow.

Division of Oceanographic Research

The new Division of Oceanographic Research was occupied a great deal with organizational and personnel matters, but several important scientific projects were also carried out. The Division concentrates on the physical and chemical phenomena in the oceanic waters that are of concern to Canada. It worked closely with other agencies which have been, or are, doing research in the fields connected with oceanography, such as the Hydrographic Service, the Geological Survey, the Dominion Observatories, the Atlantic and Pacific Oceanographic Groups of the Fisheries Research Board, and several Canadian universities.

By the end of the year, the staff of the Division consisted of 19 scientists, two technical officers, 16 technicians, and an administrative staff of five. Until the completion of the Bedford Institute of Oceanography, expected in mid-1962, the staff is housed in several locations. Field research was carried out with the chartered vessel *Theta,* and from the ships *Labrador, John A. Macdonald,* and *Baffin.*

Salinity measurements were taken over by the Division during the year, after intensive work on the refinement of equipment for this purpose. Other oceanographic research apparatus was also developed.

In the departmental data centre based in Ottawa Canadian data from the east coast were coded, punched, and verified. A punch card compatible with expected international systems was being developed, along with programs for the integration of the U.S. National Data Centre's material of Canadian interest.

The Sea and Swell Hindcasting project undertaken at the request of the Department of Transport is intended to better describe and make understandable the variability of sea and swell conditions in the lower Gulf of St. Lawrence. Five years of meteorological records will be analyzed to estimate the probability of occurrence in the gulf of sea conditions more rigorous than those of Lake Superior. The techniques of this study have been derived from similar sea and swell studies developed elsewhere, but are being revised and enlarged to exploit machine computation.

The importance of understanding of oceanographic conditions in the Gulf of St. Lawrence for ice forecasting involved the Division in the joint Gulf of St. Lawrence project in which the Canadian Hydrographic Service, the Fisheries Research Board and the Meteorological Service take part. Division scientists undertook a theoretical study of the tidal pattern in the gulf under the auspices of the Canadian Hydrographic Service and a preliminary study of photogrammetric techniques in the delineation of sea surface drifts.

The design and construction of surface wave recorders to be moored in the gulf in mid-1962 was begun.

A comprehensive oceanographic survey of Hudson Bay was carried out during the late summer and early fall in the charter vessel *Theta,* to obtain preliminary data which would allow assessment of the general characteristics of the region. Secondary purposes included training of personnel and testing of geophysical equipment now under development or in prototype stage.

The area was surveyed twice (two synoptics) and additional ship-time was used for equipment-testing, with specialists in the various fields joining in the necessary appraisals. Some changes in detail were required to suit the ice and weather conditions, and the coverage in the south-western part of the bay was not so extensive as planned.

Opportunities were taken to investigate gravity, geomagnetism and sub-bottom stratification with equipment and personnel provided by the Geological Survey and the Dominion Observatories. Biological sampling was undertaken on behalf of the Fisheries Research Board.

As part of the Arctic Archipelago project, CMS *Labrador* undertook an extensive oceanographic survey of Davis Strait, Baffin Bay, Lancaster Sound and Smith Sound, and isolated observations in McLure Strait were obtained.

The proposed program was 95 per cent completed, occupying 125 stations for physical oceanographic observations and collecting plankton samples for the Fisheries Research Board. In addition, CMS *John A. Macdonald* occupied stations in the Gulf of Boothia and Fury and Hecla Strait.

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Polar Continental Shelf Project

The Polar Continental Shelf project was set up pursuant to a decision of the federal cabinet in 1958 to "conduct surveys and scientific research in the continental shelf area of Arctic Canada". This decision had itself been prompted mainly by one of the resolutions adopted by the International Conference on the Laws of the Sea held in Geneva that year, to the effect that mineral and other resources underlying continental shelves should be considered the property of the country claiming the coastline adjacent to the shelf.

The Polar Continental Shelf project has been set up as a small, semi-independent unit of the Department. It is responsible to the Director-General of Scientific Services, but works in cooperation and collaboration with the main field survey branches of the Department—Dominion Observatories, Geological Survey, Geographical Branch, and the Surveys and Mapping Branch.

The terms of reference given to the project at the time of its establishment were very wide. The area to be investigated runs from the Alaskan to the Greenland borders—a distance of some 1,600 miles.

The first field party left for the Arctic in early March 1959. The 1961 field season is thus the third for the project. Whereas the work of the 1959 field season was devoted mainly to reconnaissance, and to measuring the conditions under which the equipment of the field parties would operate best, the following season was devoted to full-scale, systematic surveying and research. Fifteen different surveys and investigations were carried out during the summer of 1960.

Continued development of equipment and techniques during the winter of 1960-61 led to further improvements in the 1961 program. Chief among these was the successful development of techniques for hydrographic sounding from the surface of the pack ice with equipment light enough to be carried in helicopters. This eliminated the laborious business of having to drill at each station through ice that is a minimum of nine feet and sometimes more than 18 feet thick. By this single advance the pace of hydrographic surveying was increased threefold and the cost reduced in even greater proportion.

Another important development was the adaptation of a specially damped remote-reading gravity meter to take readings on the heaving pack ice.

In 1961 field transport was provided by three S-55 helicopters and one G2A helicopter, in addition to the two Otters and Beechcraft that had been used the previous year.

An addition to the program in 1961 was the inclusion of an aeromagnetic survey in which a twin-engined aircraft flew back and forth in a systematic pattern of flight lines.

Generally poor flying weather over the Queen Elizabeth Islands—the area of most of the project work—makes for a very short field season between late March and mid-May. Even then flying and especially take-off and landing are often hazardous, and in April an Otter aircraft was lost after landing on thin ice. Fortunately, the men aboard escaped unharmed and were picked up soon after by a search and rescue team.

Important conclusions have already emerged from the project, which is beginning to outline a continental shelf 80 to 100 miles wide with a deeply buried, gently undulating surface. The preliminary oceanographic program is completed. It shows that the water of the Arctic Ocean over the shelf is uniformly cold, with a temperature hovering about the freezing point, and a slightly warmer layer sandwiched between two cold layers. The submarine geological team progressed well into a long-term study of the conditions of sedimentation in the Arctic environment, both on the islands and the underwater continental shelf itself. One of the studies pursued by the project that is being followed most closely by the oil industry is the series of seismic traverses to investigate the sedimentary Sverdrup Basin.

An interesting by-product of these investigations is information that suggests the layer of permanently frozen ground under the islands to be 150 to 400 feet thick.

The systematic gravity survey has provided information on the crustal and tectonic features of the area, and for geodetic analyses. Local, detailed gravity traverses were run to follow and interpret geological contacts, to survey the floor of an ice-cap, to establish the floating condition of debris-covered ice floes, and to follow the shape of the ocean floor.

Geomagnetic studies have shown that magnetic fluctuations are erratic and sometimes violent in the area, which lies north of the north magnetic pole.

Geographical studies have concentrated on the physiography of the major islands of the Queen Elizabeth group. The problem of the extent of regional glaciation in the western islands is very difficult, and is still not fully solved. Much has been learned about formation and changes of glaciers from careful measurements and observation of the small Meighen Island ice-cap.

A botanical survey of the islands has shown that vascular plants cannot persist in areas in which the July mean temperature is less than 36°F.

A trend is developing whereby those activities of the Polar Continental Shelf project that have passed the experimental stage, and which are established as long-term investigations, are handed over to other units of the Department.

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Mineral Resources Division

The value of Canada's mineral production in 1961 amounted to $2,573,782,838, setting a new record over that of $2,492,509,981 set in 1960. The increase resulted from greater values of shipments of nickel, crude petroleum, iron ore, asbestos, cement, partially offset by a reduction of uranium shipments from $270 million in 1960 to $204 million.

With the growth and diversification of the Canadian mineral industry, demand for the services of the Mineral Resources Division is increasing. The main function of the Division is to collect data and prepare reports concerning the mineral industry, and to make such information available to other branches of the Department, government and private agencies, foreign governments, and the public.

International Services

The division continued research on the supply and demand of lead and zinc in the Free World and the effect of the United States import quotas on Canadian producers. Officers of the division continued to meet with industry and government representatives to review and revise statistical reporting in Canada in connection with the country's participation in the International Lead and Zinc Study Group. Members of the Division attended two meetings of the study group, in Mexico City and in Geneva, and took part in the International Tin Council meeting in London, England.

An officer of the division, together with officers of the Mines Branch, travelled through eight European countries, assessing sales possibilities for a product made from Quebec-Labrador iron ore. The delegation has released a report on its findings, and its recommendation that a mineral economist be posted to the Canadian high commission at London has been carried out.

The Division also helped to prepare a brief on lead and zinc which was submitted to the United States Tariff Commission by the Canadian Metal Mining Association early in 1962.

Roads

The Interdepartmental Roads Committee in which the Division played an active part was dissolved in 1961 after its work was completed with the signing of all pending agreements. The committee was composed of officers from the Departments of Northern Affairs and National Resources, Public Works, and Mines and Technical Surveys, and had been formed to advise the Minister of Northern Affairs and National Resources on road construction, in cooperation with provincial and territorial governments, to encourage exploration for and development of natural resources.

Energy

Division officers continued close association with the National Energy Board on matters concerning Canada's petroleum and natural gas industries.

A study of present energy supply and demand in the Atlantic Provinces, forecast to 1980, was prepared in the Division. Markets, pipeline transportation of oil and gas, petroleum refining and gas processing and related matters continued to receive attention. The Division is represented on the Interdepartmental Advisory Committee on Energy Statistics formed during 1961.

Officers of the Division and the Mines Branch jointly continued, through the Maritime Region Study Group, to compile information on the mineral and mineral-based industries of the Maritime Provinces, particularly Nova Scotia. The group was formed pursuant to recommendation 14 of the Royal Commission Report on Coal, issued in September 1960. Upon request of the Western Region Study Group, which consists essentially of companies in Western Canada engaged in the production, transportation and use of metallurgical coal and coke from Alberta and British Columbia, field investigations of sales opportunities were undertaken in Western Canada and western United States. A report on the findings, covering present markets with a forecast to 1970 was prepared in association with the Mines Branch.

Income Tax Act and Regulations

An important part of the Division's work in 1961 was the advice given to the Department of National Revenue concerning the application of income tax legislation to the Canadian mineral industry. The Division reviewed applications from 27 companies for a tax exemption under section 83 of the Income Tax Act, three applications for certification as operators of a non-bedded deposit, and one application claiming pipeline depreciation.

Transportation, Public Buildings and Housing

The services of the Division are used by other Government departments studying subjects such as production economics, transportation, public buildings and housing, related to mineral developments and mining communities. Government departments and agencies that were provided with information and advice on such matters in 1961 included Transport, Public Works, Labour, Central Mortgage and Housing Corporation, Bank of Canada and Industrial Development Bank.

Foreign Mineral Industry Studies

The Division continued the long-range appraisal, begun in 1960, of the Western European market (including Britain), whose potential absorption of minerals and their products equals that of the United States. Officers of the Division conducted field investigations in most of the countries in that market area with particular emphasis on iron ore, iron and steel, and the main non-ferrous metals. In addition, officers visited Middle East countries (petroleum), the Soviet Union (non-ferrous metals), and those Latin American

countries which are among Canada's main competitors in marketing copper, lead, and zinc. A senior officer represented the Division at the Seventh Commonwealth Mining and Metallurgical Congress in southern Africa in 1961.

Wartime Oils Limited

The Division administers the agreements made by Wartime Oils Limited, a former Crown company, with oil well operators in Turner Valley, Alberta, during World War II. The total recovery on the project, including repayment of advances, payment of interest and royalties, was $4,111,749 at December 31, 1960. This was $54,196 more than the advances made by the Government during World War II.

Training

Working with the External Aid Office of the Department of External Affairs, the Division arranged instruction for 17 foreign trainees, sponsored chiefly under the Colombo Plan. Eight of these were trained in the Department of Mines and Technical Surveys, and the other nine on the job in plants of Canadian mining and metallurgical companies. From time to time tours are arranged by the Division for senior administrative or technical personnel of foreign governments or companies to acquaint them with Canadian research and installations. In 1961, a group from the Technische Universitaet Berlin was conducted on a tour of mining areas in northwestern Quebec and northern Ontario.

Information Services

The Division issued 58 mineral reviews that described Canadian developments, in 1960, of the metals, industrial minerals and fuels produced or consumed in significant amounts in Canada. Map 900A—*Canada, Principal Mineral Areas,* 11th Edition—which is widely distributed was revised, as were seven Operators' Lists. Issued for general distribution were eight reports of the Mineral Information Bulletin series, three of the Mineral Report series, and a report on the administration of the Emergency Gold Mining Assistance Act. The Division continued work on a color filmstrip on copper, and additions were made to the photographic file library.

Divisional publications distributed during the year totalled 148,844, and 11,724 publications were distributed on behalf of the Mines Branch. The Division received 1,375 inquiries concerning the mineral industry. It continued to compile a detailed and comprehensive inventory of mineral deposits and occurrences in Canada.

Field Work

To ensure that the advice and services provided by the Division are current and competent, visits were made to mines, smelters, refineries, fabricating plants, oil and gas fields and associated processing and transportation

facilities throughout Canada. In 1961, field investigations covered all provinces, except Prince Edward Island, and the territories, with particular emphasis on new mining areas; metallurgical coal producers in Western Canada; iron ore producers in Labrador and Quebec; non-ferrous smelters, refineries, and consumers, and the rapidly expanding natural gas-producing and processing industry in Western Canada. Foreign countries visited in 1961 included the United States, Mexico, Chile, Peru, Britain, France, West Germany, Italy, Belgium, Luxembourg, the Netherlands, Soviet Union and certain countries of southern Africa and the Middle East. The usual annual inspections were made of all gold mines in Canada receiving assistance under the Emergency Gold Mining Assistance Act.

The Emergency Gold Mining Assistance Act

A key function of the Division is to administer the Emergency Gold Mining Assistance Act—a task carried out by a senior officer under the direction of the Deputy Minister. In addition, the Division's inspection engineers visit each mine or project receiving assistance, review its operations for the year, discuss pertinent problems, and determine the exploration and development capital expenditures to be regarded as "allowable costs", as defined by the Act. The Audit Services Division, Office of the Comptroller of the Treasury, conducts an annual audit of the books of account of each mine to verify the applications.

The Emergency Gold Mining Assistance Act was amended on July 7, 1960, extending the application of the Act for three years to the end of 1963 without change in the method of determining the amount of assistance.

Since the inception of the Act in 1948 the amount payable to the operators of a gold mine has been calculated by a formula consisting of two factors: the "rate of assistance", based on the cost per ounce of gold produced from the mine, and "assistance ounces" which are a specified proportion of the total gold produced. Under the formula prescribed for the years 1955, 1956, and 1957, the rate-of-assistance factor was determined by taking two-thirds of the amount by which production cost per ounce exceeded $26.50. The maximum rate was $12.33 per ounce. The number of assistance ounces was two-thirds of the total produced.

The amount of assistance payable for the years 1955 to 1957 was obtained by multiplying the rate of assistance by the number of assistance ounces. By an amendment to the act in 1958, however, the amount of assistance payable to an operator for 1958 and subsequent years has been computed by adding 25 per cent to this figure.

The Emergency Gold Mining Assistance Regulations established by Order in Council P. C. 863 on June 10, 1954, as amended, have been revoked and replaced by The Emergency Gold Mining Assistance Regulations made by Order in Council P. C. 1960-1162 on August 24, 1960.

Since January, 1959, the sale on the open market of a part of the gold produced by an operator does not in itself render him ineligible for assistance payments on the balance of the gold produced and sold to the Royal Canadian Mint during a quarterly period or the full calendar year. Prior notification of the intention of the operator to sell a part or all of the mine production of gold on the open market is not required. However, he must disclose full details of production, sale, and transfer of gold in an application for assistance.

In 1961 the average price per ounce of gold paid by the Royal Canadian Mint was $35.44 compared with $33.95 in 1960 and $33.57 in 1959.

In all, 67 lode and placer mines submitted 200 applications for quarterly or annual assistance payments. These were processed by the Audit Services Division, reviewed and approved by the Department of Mines and Technical Surveys, and payment was made by the Chief Treasury Officer of the Department. Thirty-eight final audits concerning the calendar year 1960 were not completed at the end of 1961.

One lode gold mine began production and three ceased operation in 1961. Twelve were operating at costs less than $26.50 per ounce of gold produced and, therefore, were not eligible for assistance.

The amount of assistance paid per calendar year since the Act became operative is as follows:

1948—	$10,546,315.84	or 3.33	per ounce produced
1949—	12,571,456.90	or 3.48	" " "
1950—	8,993,490.51	or 2.55	" " "
1951—	10,728,503.71	or 3.30	" " "
1952—	10,845,978.62	or 3.76	" " "
1953—	14,680,110.42	or 4.62	" " "
1954—	16,259,179.23	or 4.29	" " "
1955—	8,885,478.73	or 2.97	" " "
1956—	8,667,235.38	or 3.46	" " "
1957—	9,679,753.32	or 3.53	" " "
1958—	11,420,463.70	or 4.29	" " "
1959—	11,952,272.38	or 4.89	" " "
1960*	11,555,401.34	or 4.96	" " "
1961**	8,179,457.92	not available	

*Final audits are not completed.
**Advance payments made during 1961.

Explosives Division

The Explosives Division administers the Explosives Act which controls the manufacture, authorization, sale, storage, and importation of explosives, as well as the transportation of explosives by road.

During the year, the Division issued 19 factory licences, 1,438 magazine licences, 100 registered premises certificates, 275 transportation permits, and 1,417 importation permits. Two new factories were licensed, one in Alberta for the manufacture of shotgun cartridges and the other in Quebec for the manufacture of a blasting explosive based on ammonium nitrate. Two other factories which had temporarily suspended operations in 1960 were re-licensed.

The number of inspections carried out during the year, including those by deputy inspectors of the Royal Canadian Mounted Police, was 2,271. The laboratory tested and analyzed 219 samples of explosives, and 46 samples of Chinese firecrackers were tested in Vancouver by the R.C.M.P.

There were 13 prosecutions for infractions of the Act and Regulations. Eleven of these involved illegal storage, and the other two failure to put warning signs on vehicles transporting explosives.

The manufacture and use of explosives based on ammonium nitrate continued to expand at the expense of nitroglycerine. Trials of the former in underground mines have had a good deal of success, and several million pounds of ammonium nitrate explosives were used in underground production during the year.

Accidents

There were no serious accidents in the manufacture or in the storage of explosives. Of the 34 accidents due to misuse of explosives, 21 were caused by playing or tampering with detonators. Thirty children suffered hand or eye injury from these small but dangerous devices. Homemade bombs continue to attract youths, and three were killed in such experiments. Circulation of the pamphlet "Explosives—a Continuing Danger" has now reached 58,000, and 4,000 copies of the warning poster "You Wouldn't Hurt a Child" have been distributed to magazine licencees.

Eight fireworks accidents caused injury to as many boys, and it is significant that all were caused by firecrackers. After submissions by a fireworks manufacturer and by the Canadian Association of Fire Chiefs, it was decided to change the definition of authorized Chinese firecrackers. Importation of the large cannon type is now prohibited.

(Readers desiring more detail are referred to the Annual Report of the Explosives Division, published separately.)

60462-9—4

surveys and mapping branch

FOR the Surveys and Mapping Branch, the year was marked both by record demands for services and by the acquisition of important new facilities. An outstanding milestone in the history of the Branch was reached with the move to new quarters in February. At Halifax, a new hydrographic survey ship was launched, and several others were either being built or contracted for.

The workload was especially heavy in the field of topographic mapping, owing, in part, to the preparation of maps for civil defence purposes. The Branch put 82 parties into the field during the 1961 season, consisting of 1,500 surveyors, hydrographers, and ancillary personnel. As in past years, much of the charting took place in the north, ranging from geodetic triangulation to the laying-out of new subdivisions in arctic settlements.

New links were established in the field of international collaboration, both through participation in conferences and practical instruction, such as the advice provided to the External Aid Office on mapping in Nigeria and on the Mekong Project in southeast Asia, and the training of students under the auspices of the Colombo Plan.

Geodetic Survey

Seventeen field parties were extending horizontal and vertical control which provides a national framework for mapping, charting and major engineering projects. During the operations, data for investigations concerning the size and shape of the earth were obtained.

The extension of the network of first-order triangulation was carried on in the Northwest Territories, Saskatchewan, Manitoba, Ontario, Quebec,

New Brunswick and Labrador. In the Territories a chain of tellurometer-controlled triangles was completed from Cambridge Bay to Beechey Lake, some 120 miles south of Bathurst Inlet. The large Great Slave Lake arc extending from McLennan, Alberta, to Prince Albert, Saskatchewan, was completed, and the easterly extension of the arc was completed to Dubawnt Lake, approximately 100 miles east of the junction point of the two arms of the arc. In Manitoba and Saskatchewan the Brandon-Beatty arc was extended 150 miles to the vicinity of Kamsack, Sask. In northern Ontario the reconnaissance of the narrow, tellurometer-controlled arc along the Trans Canada Highway was completed from Hearst to connect with existing control near Lake Nipigon. In southern Ontario the 22-station control net for Metropolitan Toronto was completed. The Kaniapiskau Lake-Hudson Bay net in northern Quebec was extended from Lac Bienville to Clearwater Lake. The reconnaissance was completed for two new arcs in New Brunswick, Fredericton to Newcastle and Newcastle to Grand Falls. In Labrador, the Nain-Strait of Belle Isle arc was completed from Nain to North West River and a short spur connected the main net to shoran and hydrographic stations at Hopedale.

During the past season two double and two single parties extended the precise level net. In addition, a small party inspected bench marks in Saskatchewan. The double party in British Columbia completed five lines of levels and one short tie in the Okanagan and Kootenay areas. The double party in Alberta and Saskatchewan completed three lines in the area between Edmonton and North Battleford and three lines in the vicinity of Prince Albert. A single party in Ontario and Quebec, working along railways, completed a line from Fraserdale to Moosonee and then did a section of the Senneterre-Chibougamau railway. A second single party in Ontario and Quebec, following highways, completed the line along the Severn Canal, completed a section of the Senneterre-Chibougamau line, and ran a line between Hawkesbury and Plantagenet. The inspection party in Saskatchewan inspected 1,039 first- and second-order bench marks.

The annual check on the piers of the Quebec Bridge was carried out in October.

One base line, which serves as control for triangulation, was measured with the Model 2 Geodimeter. This base was located on the Thelon River, 150 miles east of Fort Reliance, N.W.T.

Three Laplace stations were established to control triangulation nets in the vicinities of Dauphin, Man., Cambridge Bay and Bathurst Inlet, N.W.T. A fourth Laplace point was established at Cavers in northern Ontario for investigation purposes, and in connection with the same investigation a precise azimuth was taken at Schreiber, Ont. The precise longitude and latitude observations for a Laplace station were taken at Acorn, north of Kamsack, Sask.; the station will be completed next season.

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Latitudes and longitudes were determined for investigational purposes at 19 triangulation stations.

The Geodetic Survey continued to make full use of specialized electronic equipment and to develop new techniques in its use. During the field season four officers worked with triangulation parties, one in Toronto and three in the Northwest Territories. The development of frequency calibration equipment has continued. Portable equipment was used in the field for the calibration of all master tellurometer unit crystals. A precise system has been developed for use in the laboratory but is not yet in use. A temperature differential sensing device has been developed for experimental use on precise level operations. The laboratory is handling the repair and maintenance of a steadily increasing amount of radio and electronic survey equipment from the Division and from other Divisions of the Branch.

In addition to the adjustment of various triangulation nets, most data obtained during the past field season have been adjusted and computed to obtain preliminary results. The so-called GROOM program which produces adjusted positions, lengths and azimuths from basic field data has been tested on several nets and proven satisfactory. The conversion of all IBM 650 programs for use on the Department's IBM 1620 computer is under way.

During the year the Survey continued its interest in international geodetic organizations. One staff member is in Europe, working at the Institute of Geodesy, Royal Technological Institute, Stockholm, Sweden. He is studying the methods of applying gravity and potential data to the problem of determining the shape of the earth.

Topographical Survey

The Topographical Survey, as the federal agency responsible for the provision of development mapping, in 1961 was faced with an unprecedented demand for mapping concerned with roads to resources, economic development of the far north, ground-water studies in the prairies, revision and more detailed mapping of highly developed areas compounded with various urgent defence requirements. The Topographical Survey had to use considerable discretion to keep the workload within the capacity of the organization and many reasonable demands could not fully be satisfied. In the past two years, requests for mapping originating in the Department of National Defence have enlisted the best efforts of both organizations to meet urgent needs and only mapping of the highest priority is now being undertaken for economic development.

The Topographical Survey and the Army Survey Establishment continued the 1:250,000 mapping coverage of Canada at an accelerated pace, so as to complete it within six or seven years.

Before this adjustment was satisfactorily arranged, an urgent demand for 'survival' mapping of key urban centres at a scale of 1:25,000 required immediate action on the part of both organizations in a two-year crash program. This undertaking cut drastically into the normal 1:50,000 mapping program and to a lesser extent into the accelerated plans for 1:250,000 mapping. This mapping required field surveys and compilation procedures of greater accuracy than those to which this organization had been accustomed and all operations had to be closely supervised to ensure specified accuracy.

Superimposed on this effort in 1961, was the need for reliable aeronautical charts for low level navigation in large areas around National Defence training centres in eastern and western Canada. A concentrated effort was immediately launched to complete the mapping already in hand, together with any other sheets that could readily be undertaken in the time allotted. Some areas are being compiled by commercial agencies and in the remainder, for expediency, interim maps are being prepared.

A further complication is the rapidly increasing demand for large-scale plots of special nature for development or assistance to other survey agencies. Usually of an urgent and often complex nature, they require a great deal of planning effort and the use of precision equipment.

The move to modern quarters in the new Surveys and Mapping Building was made in March and has simplified many procedures and eliminated time-consuming correspondence. Unfortunately, a faulty design in the air circulation system prevented the re-location of a large part of our multiplex and balplex plotting equipment.

The Topographical Survey had 42 field officers engaged in field work during the year.

A second successful season was experienced in extending traverse control in the eastern Arctic Islands. Despite poor weather, efficient operation of the tellurometer traverse technique enabled extension of surveys sufficiently to hope the task would be completed in the 1962 season. Geographically, this party covered the northwest quarter of Baffin Island, Devon Island and a large part of the southern end and western side of Ellesmere Island, with about 3,000 miles of traversing.

Vertical control for 1:250,000 mapping was completed in a large area in Quebec embracing the watersheds of the Eastmain, Rupert, Broadback and Nottaway Rivers. Some supplementary horizontal control was established in the area as well. Later the same field party covered an extensive area in Ontario south and west of James Bay, with heighting control for 1:250,000 mapping.

The sudden call for reconnaissance mapping in northern Alberta required the addition of a third helicopter-supported party to obtain vertical control

in a 23,000 sq. mi. block west of Lake Athabasca. The same party was able to establish control for eleven 1:50,000 map sheets requested by the B.C. Government northeast of Squamish.

Eight field parties were engaged in establishing mapping control for Phase 2 of the 1:25,000 mapping program and field inspection of Phase 1 map sheets (controlled the year previously) in St. John's, Newfoundland; Halifax, Nova Scotia; Saint John and Fredericton, New Brunswick; Ottawa, Ontario; Winnipeg, Manitoba; Regina, Saskatchewan; and Edmonton and Calgary, Alberta. One of these parties also established control for 1:25,000 mapping of an area around Port Hawkesbury, Nova Scotia. The Army Survey Establishment was assisted in the Montreal area by establishing spirit level control in 13 map sheets.

Two field parties continued to correlate Dominion Land and Geodetic Survey systems in Manitoba, Saskatchewan, and Alberta by careful tellurometer traversing, in preparation for revision mapping.

Three winter parties operated in northern Ontario and completed the basic control, both traverse and levelling, for the medium-scale mapping of the interior of the province.

One party extended spirit levelling 315 miles along the Stewart River in the Yukon. This work was requested by the Department of Northern Affairs and National Resources in its investigation of power possibilities in the Yukon River basin.

As a special project for the Department of Transport, two parties conducted intensive surveys along the St. Lawrence River between Montreal and Sorel to assist studies related to maintaining water levels in this important stretch of the St. Lawrence Seaway. Another party conducted precise surveys along the Ottawa River to control plots of areas to be flooded above the new Carillon Dam.

Two field officers assisted the Polar Continental Shelf Project by conducting tellurometer traverses in the arctic islands and another assisted a Dominion Observatories party by surveys around the New Quebec Crater in Ungava. At the request of other departments, the Topographical Survey undertook local surveys for large scale plots of experimental farms at Kentville and Sheffield Mills, Nova Scotia and at Regina, Sask.; and of northern settlements at Pelly Bay, Spence Bay, Gjoa Haven, Cambridge Bay, Bathurst Inlet, Read Island, Coppermine, Paulatuk, Stanton, Tuktoyaktuk, Reindeer Station, Inuvik, Arctic Red River, Fort McPherson, Fort Good Hope, Norman Wells, Fort Norman, Fort Franklin, Wrigley, Fort Simpson, Jean Marie River, Fort Providence, Enterprise, Resolution, Rocher River, Snowdrift, Fort Reliance, Rae, Lac la Martre and Old Crow (Y.T.). Electronic computers have greatly facilitated provision of adjusted computation control, and the best possible use was made of the 40 hours time

available on the computer at Ottawa University. The volume of survey records and computations being handled led the Topographical Survey to institute an improved filing system of records.

In the main, compilation facilities have adjusted to mapping requirements. The most serious bottleneck now occurs after compilation, in the checking, inspecting and editing sections, where a shortage of experienced personnel delays processing of completed manuscripts.

Special projects undertaken in 1961 for other divisions or departments numbered 48. The Topographical Survey has undertaken the final inspection for acceptance of mapping being done by Canadian surveyors in the Lower Mekong Basin, southeast Asia under the Colombo Plan. There are about 750 map sheets covering 36,175 square kilometers, and the job of inspecting was not yet completed at the end of 1961.

The Survey again supplied over 23,000 advance information prints of recent mapping to many agencies and filled numerous requests for control information, maps and mosaics. About 20,000 aerial photographs were added to the field photo library. The assembly of photo-mosaics was completed for the eastern Arctic Islands which marks the virtual conclusion of an extensive photo-mosaic program. Future work of this nature will consist in satisfying special requests and will be much reduced. Demand for prints of existing mosaics continues high indicating their popularity.

On-the-job training continued for recruits and personnel of several mapping agencies, and universities took advantage of the training facilities in modern mapping methods. Two survey officials from Indonesia received intensive photogrammetric training under the auspices of the Colombo Plan.

Several members of the staff during the year took courses to keep the Topographical Survey abreast of technological developments.

Canadian Hydrographic Service

The Canadian Hydrographic Service is responsible for the charting of coastal and inland navigable waters of Canada, the analysis of tides and currents, and the investigation of water levels in the St. Lawrence and Great Lakes region. The resultant data are published in standard Canadian navigation charts, charts for special purposes, sailing directions, water level bulletins, tide tables, and reports on currents.

A record demand for Canadian nautical charts in 1961 resulted in the distribution of 147,500 copies. During the year, 26 new charts were published, bringing the total number now maintained to 821. To provide the latest information available, 162 charts were revised and published as new editions.

The demand for small-boat charts of the Rainy Lake, Muskoka Lakes, Harricanaw River, Lake Timiskaming, Columbia River and Kootenay Lakes has persisted, and a prototype small-boat chart was published of the Ottawa River from Britannia Bay to Chats Falls.

Sailing directions for all the coasts of Canada have now been completed with the publication in 1961 of Volume III of the *Pilot of Arctic Canada.* This volume contains information on the western Arctic. A total of fourteen volumes of sailing directions are now published, and supplements are issued from time to time as additional information becomes available.

The Pictou Depot, destroyed by fire a few years ago, has been reactivated and is now in full use; two hydrographic ships are wintering there.

The regional office at Halifax has direct control of ships based at Halifax and Pictou, and the staff, exclusive of ship's officers and crews, numbers 41. This office has now assumed functions similar to those of the Victoria office.

A major accident occurred on August 14 in James Bay, when the chartered ship *North Star IV* struck an uncharted reef three miles north of Grey Goose Island and became a total loss. The depths encountered in this part of James Bay are extremely irregular with many sharp changes in the bottom pattern. All attempts to free the vessel failed, but fortunately most of the survey equipment and all the records were saved. After spending an uncomfortable night ashore on the uninhabited Grey Goose Island, all hands were picked up by a Hudson's Bay Company vessel. The stricken *North Star IV* remained fast to the reef with only the superstructure above water. Summer storms eventually broke up the ship completely and nothing remains to mark the scene of the wreck.

The C.H.S. *Acadia* took part in the evacuation of residents from fire-threatened villages on the Newfoundland coast, and removed some 500 persons to safety.

The launching of the survey ship C.H.S. *Maxwell* took place during the year, and work began on the C.H.S. *Hudson.* Specifications for vessels to replace the *Acadia* and *Cartier* are now complete and contract negotiations are in hand. On the west coast, a replacement for the *Perry* is being considered, and contracts have been let for a 65-foot launch, to be named *Richardson.* New launches, nine on the east coast and one for Lake Winnipeg, were completed and delivered in 1961.

Twenty regular field parties were engaged in hydrographic work aboard six surveying vessels, two chartered ships and twelve shore parties during 1961. Hydrographers also served aboard four D.O.T. ships in the eastern Arctic, a D.O.T. ship and a R.C.M.P. launch in the western Arctic. A third chartered ship was carrying out tidal and current surveys in the Gulf of St. Lawrence area. A hydrographic launch was used for six weeks revising sailing directions in the Great Lakes and St. Lawrence River.

Operating on the east coast were the *Acadia, Maxwell, North Star IV, Baffin, Arctic Sealer, Kapuskasing,* and *Cartier,* and several launches. Surveying in Newfoundland was carried out at Cape Freels, Catalina Harbour, Long Pond, Fortune Bay, Pistolet Bay, Niger Sound. In Nova Scotia, sounding was continued between Yarmouth and Grand Manan Island; the hydrography of

the Cape Sable area was completed and the survey of Lunenburg Harbour continued. Other parts surveyed include the waters between Canso and Liscomb, the vicinity of Sable Island, the East River near Trenton, Halifax Harbour, Liverpool Harbour, and the Bay of Fundy. Along the Prince Edward Island coast, surveying proceeded in the northwestern part of the province, at East Point, and at Summerside. A survey was made of LeTete Passage in New Brunswick. In Quebec, the area west of Natashquan and the newly developed harbour at Port Cartier were charted, as well as the approach to Grand Entry Harbour in the Magdalen Islands. A reconnaissance survey was made of Fort George on the east coast of James Bay.

In the Arctic, the *Baffin* did extensive surveying in Barrow Strait, and between the nearby islands, in Erebus Bay, Gascoyne Inlet, in the Lady Franklin and Monument Island groups. Other ships operating in the northern waters were the *North Star IV* and the *Arctic Sealer,* both chartered. Hydrographers also operated on board vessels belonging to other services.

In inland waters, charting was completed of the Ottawa River between Britannia and Chats Falls, and control established between Ottawa and Carillon. Charting in the St. Lawrence Seaway, in Georgian Bay and the North Channel of Lake Huron was continued. The approaches to Moosonee were investigated thoroughly to study the feasibility of establishing a commercial port. In Manitoba, the charting of Lake Winnipeg continued, and in Alberta a reconnaissance survey was made of the Athabasca River, Lake Athabasca, and Slave River between Waterways and Fort Fitzgerald. The same type of survey was made of that part of Slave River between Fort Smith and Great Slave Lake in the Northwest Territories.

On the Pacific coast, the *Stewart* and the *Marabell* were surveying Hecate Strait, the Strait of Georgia, and other areas. The Gulf Island area was charted by launch, and wharf plans were made of Cowichan Bay and Osborne Bay.

At the end of 1961 there were 93 permanent gauging stations throughout the navigable waters of Canada, chiefly in the St. Lawrence system, and in the Great Lakes. The Division continued to develop better technical means of recording and processing water level information, which will speed operations and save labor. During the year, the Hydrographic Service adopted the International Great Lakes Datum (1955).

An extensive investigation of water circulation and properties of the Gulf of St. Lawrence was launched under the supervision of the Canadian Committee on Oceanography, a study which will help winter navigation in that area. During the summer, the chartered ship *Theta* was used on a reconnaissance survey of the currents in Gaspé Passage and Jacques Cartier Passage.

Other projects undertaken or participated in by the Hydrographic service included a NATO survey of currents in the Faroes-Shetland area,

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observation of tides in the Bay of Fundy, and research on measuring tidal streams. On the Pacific coast, the *Parry* did tidal and current work throughout the season, at Dodd Narrows, Yuculta Rapids, Meyers Passage, and Samuel Passage.

Legal Surveys and Aeronautical Charts

The need of other federal departments for legal surveys in Indian reserves, national parks and territorial lands continued in 1961, although there was an indication of slackening interest in Indian lands on the part of private and provincial agencies. The demand for more highly specialized and improved charts and handbooks increased sharply during the year.

The general demarcation of provincial and territorial boundaries continued in 1961 under the direction of the respective boundary commissions.

Work continued on the series of 36 map-sheets that will form the official record of the northern British Columbia boundary position and dimensions. This task was nearing completion at the end of the year.

The Manitoba-Saskatchewan boundary was surveyed northward from Township 83 for a distance of 118 miles to the northerly side of Reindeer Lake. At the end of the year, technical examination of the returns of this survey was in progress and the field party was on the point of beginning the survey of the northerly 132 miles of the boundary, extending to the corner common to Manitoba, Saskatchewan, and the Northwest Territories. When this corner has been determined on the ground, it is proposed to submit all three boundaries for legislation ratification.

Although the Manitoba-Northwest Territories boundary survey had been extended eastward to Hudson Bay in 1960, the technical examination of the returns indicated the desirability of minor supplementary field work. This was carried out in September 1961. The returns are now being brought into final form.

At the request of the Indian Affairs Branch of the Department of Citizenship and Immigration, legal surveys were carried out in 60 Indian reserves in the provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia. These consisted of section, village and lot subdivisions, road and parcel surveys, and boundary retracements. They engaged eight survey parties for the full season and six other parties for most of it. In addition, Indian residential school lands at Prince Albert and Portage la Prairie, and lots and parcels at Fort Fitzgerald, Fort Resolution, Fort McPherson, and Fort Good Hope were surveyed for that Branch.

Surveyors in private practice were engaged for work in two Indian reserves in Quebec.

Two parties operated for the full season and one for part of the season in the Territories on surveys requested by the Resources Division of the Department of Northern Affairs and National Resources.

In the Yukon and Northwest Territories subdivision surveys, for the expansion of towns and settlements, were carried out at Whitehorse, Watson Lake, Marsh Lake, Tagish, on the Whitehorse-Mayo Road, at Hay River, Fort Smith, Frank Channel, Fort McPherson, and Inuvik. Other surveys in the north were connected with public and transportation services.

Surveys in national parks and historic sites were carried out at Banff, Prince Edward Island, Cape Breton, old Fort Amherst, the birthplace of W. L. M. King at Kitchener, Fort Beauséjour, Battleford, and Louisbourg and, by contract, at Jasper and Yoho.

Technical instructions were issued to private surveyors for 102 legal surveys in federal lands for private interests.

In the course of aeronautical mapping, a new series of charts was designed to meet both civil and military requirements for low altitude enroute radio air navigation. This series of 12 charts is revised and re-issued every 35 days.

Survey documents recorded in the Canada Lands Surveys Records numbered 559 plans and 46 field books, and several thousand document extracts, publications, star and sun cards were sent out, along with other information.

The Board of Examiners for Dominion Land Surveyors held four meetings. Of the 59 candidates examined, 15 were successful in the combined categories.

The revised *Canada Lands Surveys Examination Regulations,* to be effective 1 April, 1962, were approved by Order-in-Council P.C. 1961-903. Revised *Rules and Instructions* and *Descriptions of Subjects of the Various Examinations before the Board of Examiners were drafted.*

Map Compilation and Reproduction

Production in 1961 was greater than in 1960, even though the move into the new building and the delay in the installation of photo-mechanical equipment tended greatly to decrease output.

Here are the highlights of the year's work:

—Two new two-color presses, installed in the new building before the move, helped a good deal.

—All map stocks, 9,116,683 copies, originally stored in various locations, have been consolidated at the Map Depot, 615 Booth Street.

—A group of employees was selected and set apart to do shaded relief work for the RCAF.

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—The *Ice Atlas of Arctic Canada* prepared at the Scott Polar Research Institute, Cambridge, England, under the Defence Research Board, was completed early in the year. The maps for the 67-page atlas were drawn and reproduced by the Division.

—The number of maps received from the Topographical Survey decreased 59% during the year. Because of this, it was not necessary to release maps for engraving by contract.

—Conversion of the 221 eight-mile maps to 1:500,000 scale was completed 37%.

—The distribution of individual maps amounted to 897,227 copies, as compared with 818,720 for 1960, while the total distribution, including bulk sales, was 3,097,333 as compared with 3,401,421 for 1960.

—The map compilation staff was concerned mainly with maps on the scales 1:125,000, 1:250,000, 1:500,000, and 1:1,000,000. Considerable effort was also expended on the preparation of the Low Level Pilotage Charts, in an attempt to produce these charts by January 1962.

—The map-drafting and the editing sections again worked on standard series maps from 1:50,000 to 1:1,000,000.

—The overall effort of the photo-mechanical section was divided approximately as follows: photography 36%, preparation of color negatives 18%, preparation of blue-line and color proofs 11%, negative correction 24%, and plating 11%.

—Considerable time and effort were expended in experimenting with, and assessing the value of, shaded relief photography. This was required for Low Level Pilotage Charts.

—During the year, two two-color presses were put into production in lithographic printing.

—The map distribution section received 36,457 requests for maps, compared with 35,326 in 1960. Revenue from sales amounted to $123,667.30.

—Several operational research projects were completed and the results put to use.

International Boundary Commission

The Canadian and United States Commissioners made a joint inspection of various points of the international boundary from Lubec, Maine to Fort Francis, Ontario. They inspected the work of a United States party rebuilding range marks and repairing monuments along the New Brunswick-Maine boundary; the location of a new international bridge from Campobello Island to Lubec, Maine, which could affect boundary range marks; the results of chemical spraying on growth at the boundary crossing between Armstrong, Quebec and Jackman, Maine; the work of two Canadian field parties on the

Quebec-Maine and Quebec-Vermont boundaries; the work of a United States field party on the Quebec-New Hampshire boundary; the location of reference monuments along the St. Lawrence Seaway and boundary tablets on the international bridge at Cornwall; and the work of a United States field party on the Ontario-Minnesota boundary.

A Canadian party working on the Quebec-Maine boundary in the St. Pamphile area inspected and repaired monuments, recleared 37 miles of boundary vista to a skyline width of 20 feet and applied chemicals to retard growth throughout this section.

A Canadian party working on the Quebec-Vermont boundary inspected and repaired monuments, recleared to a width of 20 feet and chemically treated some 25 miles of boundary vista. In addition, measurements were made along the boundary line to verify the position of the monuments. Applications were made of various chemicals both in the liquid and dry state to test their usefulness in boundary maintenance.

Minor surveys were made in the Windsor, Point Pelee and Niagara areas to relocate monuments and to establish further boundary control.

In all, 80 miles of boundary and 120 monuments were inspected, 62 miles of boundary vista were recleared, eleven monuments were repaired, the positions of 51 monuments were checked and one new control point established.

National Air Photo Library

The Library has on file one print of each aerial negative exposed by, or for, the Federal Government. In the past year 36,480 photos were added, bringing the total number to 2,890,771.

During this past year, 4,713 requisitions, involving the purchase of 358,993 reprints, were prepared and forwarded to the Photographic Establishment of the Royal Canadian Air Force at Rockcliffe, Ontario. These prints were for various Federal and Provincial Government departments, mining and industrial concerns, as well as private persons.

geological survey of Canada

IN 1961, the Geological Survey placed 102 parties in the field, an increase of 15 parties over the previous year. Of these, 36 parties conducted bedrock mapping, chiefly the reconnaissance mapping of remote or little known areas, and 20 parties made groundwater surveys or mapped surficial deposits. Some 15 parties undertook stratigraphic and palaeontological investigations, 26 parties made detailed or special geochemical, geophysical, mineralogical, or economic investigations, and 3 parties began submarine geological studies off the Arctic and Atlantic coasts. The distribution of the parties is shown on the accompanying map of Canada and in the Appendix.

Field work was completed (or nearly so) on 49 of the seasons 102 projects, covering just over 200,000 square miles. In addition, several thousand square miles were investigated in mapping projects not yet completed, and many square miles in geophysical and geochemical surveys and special projects.

Use of helicopters and/or fixed-wing aircraft for reconnaissance mapping continued in 1961, successfully speeding up and, for the most part, lowering the cost of the preliminary geological mapping of Canada.

One party used three Piper Super Cub aircraft in mapping about 30,000 square miles of the Canadian Arctic Islands—including Axel Heiberg Island and the western part of Ellesmere Island.

Geological mapping connected with the federal-provincial "Roads to Resources" program in northwestern Ontario was completed in 1961. This program, begun in 1959, included studies of magnetic anomalies, geochemical studies, the mapping of surface and bedrock geology, and an

aeromagnetic survey of eight map-areas measuring 1 x 2 degrees. Three of the eight map-areas were examined in 1961, covering approximately 18,000 square miles, suitable for publication on a scale of 1 inch to 4 miles. Preliminary geological maps for the three areas will be published early in 1962; similar maps for the other five map-areas have already been published.

At the end of 1961 the Survey had completed the preliminary field mapping of about 65 per cent of Canada, and had published geological maps on about 57 per cent. This is an increase of nearly 10 per cent over 1960, and it now appears that preliminary mapping of most of the country will be finished by 1970 or shortly thereafter.

Little divisional reorganization took place within the Geological Survey during 1961. A Marine Geology unit was formed to tackle problems arising from the increased interest being given oceanographic problems off Canada's coast.

Grants-in-aid totalling $75,000 were made to 16 universities in support of 28 new and 15 continuing research projects. These grants are awarded on the advice of the National Advisory Committee on Research in the Geological Sciences from funds provided by parliament, and are a valuable extension of the research undertaken by Survey officers in the field and laboratory.

Work on the Tectonic Map of Canada continued satisfactorily, and by the end of 1961 most basic information had been compiled. It is expected that this information will be assembled and correlated during 1962.

Some 197 potassium-argon age determinations from many parts of Canada were completed by the Survey during the year. Equipment was also installed late in the year for rubidium-strontium age determinations and the first three were completed. In addition, radiocarbon dating became a reality at the Survey in January 1961 and 62 carbon-14 age determinations were completed.

Late in the year the Government of Canada announced its part in the Upper Mantle Project, a three-year international scientific study of the earth's interior, designed to supplement information secured during the recent International Geophysical Year. The Geological Survey will play a prominent role in Canada's part of this project. Plans prepared during 1961 call for (1) detailed petrological, chemical, mineralogical, and isotopic investigations of certain basic and ultrabasic rocks, (2) drilling of two 10,000-foot holes (about 3,000 feet deeper than any hole yet drilled in hard rock in Canada) into ultrabasic rocks in the Muskox Intrusion in the Northwest Territories and in Mount Albert in Gaspé, Quebec, and (3) detailed geological and paleomagnetic investigations.

One of the outstanding features of 1961 was the inauguration of an $18,000,000 cooperative program with various provinces—an aeromagnetic survey of most of the Canadian Shield and adjacent areas to be completed within about twelve years. The surveys are being made by contracts with various established commercial survey companies, and their cost is being shared equally by the province concerned and the Geological Survey. Surveys in Yukon and Northwest Territories will be financed by the Geological Survey. The Geological Survey spent close to $500,000 on this work in 1961 and the program calls for a Survey expenditure of $1,000,000 annually thereafter. Aeromagnetic surveys in 1961 were made in Yukon, District of Mackenzie, British Columbia, Saskatchewan, and Ontario.

Field Work

Northwest Territories

Five field parties operated in the District of Franklin. One party completed reconnaissance mapping of Andrew Gordon Bay and Cory Bay map-areas on the southwest coast of Baffin Island. Several small magnetite showings in Grenville-type Precambrian rocks were mapped.

A second party completed reconnaissance mapping of an area north of Alexandra Fiord on southeast Ellesmere Island. The gneissic and granitic rocks in this region are the northernmost exposures of the Canadian Shield in Canada.

Four staff geologists, with the aid of two Piper Super Cub aircraft, began a two-year program of reconnaissance studies of the bedrock geology of Axel Heiberg and Ellesmere Islands. Some 30,000 square miles were examined in 1961. Except for the Mississipian, all Palæozoic and Mesozoic systems are represented in the area. Devonian rocks for the first time were found to outcrop throughout much of the miogeosynclinal belt that trends northeasterly across Ellesmere Island, and have been folded along with the Silurian and older rocks with which they occur. Pennsylvanian and Permian gypsum and anhydrite beds are widespread on northern Axel Heiberg and Ellesmere Islands, and thick biohermal reefs of early Permian age are extensively developed between Hare Fiord and Greely Fiord in northern Ellesmere. Evidence for at least two periods of tectonic activity following the deposition of Early Cretaceous rocks, one of which resulted in the folding of Tertiary beds, has been found in eastern Axel Heiberg Island.

A fourth party, with the aid of a Piper Super Cub airplane, studied the surficial geology of the fiord-land of western Ellesmere Island and eastern Axel Heiberg Island. Raised marine features were found up to 500 feet above present sea level around the northern part of Eureka Sound, and features suggesting multiple Pleistocene glaciation were observed.

Several Survey geologists, in connection with the Polar Continental Shelf Project, conducted geophysical and submarine geological studies in

the Queen Elizabeth Islands. Preliminary spectographic results indicate that there is very little chemical activity in arctic sediments, and that certain elements may be used as sedimentary tracers.

In the District of Keewatin a party conducted submarine geological investigations in Hudson Bay. By means of echo-sounding equipment it was found that the depth of unconsolidated sediment is less than 10 feet over most of the Bay, particularly its central and western parts, but was up to 30 feet in troughs of steeply folded Precambrian rocks. Areas of flat-lying Palæozoic rocks under the Bay were delineated from areas of highly folded Precambrian rocks.

Two parties operated in the District of Mackenzie. One continued from 1960 the study of pegmatites in relation to surrounding rocks in the Yellowknife-Beaulieu area. The second party continued a regional study of Precambrian rocks northwest of Yellowknife.

An aeromagnetic survey was made, by contract, of an area between Uranium City and Fort Reliance, thus filling the remaining gap in aeromagnetic surveys of the Canadian Shield of southern District of Mackenzie.

The *Yellowknife Office* continued to supply geological information to the public through its sale of departmental publications, its library and laboratory facilities, and its consulting services.

Yukon

Five parties operated in the Yukon. Two staff geologists completed Operation Ogilvie, a helicopter-supported reconnaissance. The Tintina Trench, a major fault zone, passes through this region in a northwesterly direction, and the rocks on either side are believed to differ in age, facies, and metamorphic rank.

A second party spent part of the summer establishing gas caches and appraising stratigraphic sections vital for the geological mapping of Operation Porcupine, a helicopter-supported project planned for 1962 to map 80,000 square miles of northern Yukon.

A party of several staff geologists continued Operation Klondike, the study and mapping of the surficial geology and distribution of heavy minerals in the Klondike placer district, a project aimed at prolonging the life of placer gold mining in the region. Much gold production has come from terrace gravels on tributaries of Yukon River; recognition of terrace gravels on other tributaries has been an important result of this study. Studies of heavy mineral concentrates from some of the gravels are being made in hopes of establishing some correlation between the presence of one or more of the heavy minerals and the occurrence of gold.

Studies in engineering geology concerned potential dam sites in the Yukon. Five sites were examined on the Yukon River drainage basin, and five within the Mackenzie River drainage basin. Since 1959, 32 possible dam sites have been examined.

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A field study of the geology of the copper deposits in the Yukon was completed, and the results will eventually be part of a Survey report on copper deposits of the Yukon and northern British Columbia. During the summer the Whitehorse copper belt and the Atlin area were examined. A geological map of the former has been prepared for publication at a scale of 1 inch to 1 mile.

In 1961, the Geological Survey made, by contract, its first aeromagnetic survey in Yukon. The preliminary results suggest that similar surveys can be made in other parts of southern Yukon where the relief is not prohibitive.

The *Whitehorse Office,* staffed by a resident geologist and a clerk, continued to provide geological and geographical information and advice to prospectors, exploration companies, government departments, and the general public.

British Columbia

Twenty-two parties conducted geological mapping in British Columbia in 1961. Of these, ten did bedrock mapping, five others mineralogical and petrological investigations.

Five parties with two helicopters continued reconnaissance mapping in northern and central British Columbia.

One party continued from 1960 the detailed mapping of MacDonald Creek map-area on the Alaska Highway. Silurian and Middle Devonian carbonate rocks were found to be much thinner in this area than in adjoining areas. Barite and fluorite are common in Middle Devonian breccias.

Another party continued from 1959 stratigraphic studies of Triassic formations in the foothills and Rocky Mountains of northeastern British Columbia. Work in 1961 was in Halfway River map-area, and revealed that Triassic clastic sediments were derived from a source to the northeast and were transported southwesterly across a shallow-water platform into a deeper marine basin. A new discovery of fossil fish was made near the base of the Triassic succession in this map-area.

A party completed the stratigraphic study of some Lower and Upper Cretaceous rocks in the foothills of Alberta and British Columbia between Smoky River and Peace River. A change from nearshore sands to shale found within the Commotion Formation indicates favorable stratigraphic traps in the region of Peace and Pine Rivers.

A geophysical party conducted, in cooperation with the British Columbia Department of Mines and Petroleum Resources, an aeromagnetic survey of an area in central British Columbia between 121°30′ and 125° W longitudes and 52°15′ and 56° N latitudes. Although there are no high-intensity anomalies, the area contains plenty of magnetic character, and the aeromagnetic data should be of considerable help in future geological investigations.

Five parties shared a helicopter in southeastern British Columbia, three of which made detailed studies of granitic rocks as part of the general study of granites in Canada. Work on the Adamant batholith was completed. Work on the Valhalla Complex was also completed.

A small party spent several weeks in the Kamloops-Quesnel area supplementing collections of Tertiary plant remains in order to determine ultimately the floral succession and possible stratigraphic application of the fossil plants.

A party started the petrographical, mineralogical, and geochemical study of contact metasomatic magnetite deposits in southwestern British Columbia. This is a part of a general study on iron in Canada now being conducted by the Survey. Seven magnetite deposits on Vancouver and Texada Islands were examined and mapped in great detail.

A party began surficial geology and groundwater studies on Vancouver Island and adjoining islands. A till sheet covers most of the area mapped. Evidence of two and possibly three major ice advances was obtained, and an area of permeable deposits that yield large volumes of groundwater was outlined, together with possible recharge areas.

Study of the sand and gravel deposits of the Strait of Georgia area was begun, with work being carried out on Vancouver Island from Victoria to Comox.

A party completed the detailed mapping and sampling of the Tulameen ultramafic complex, Yale district, as a contribution to the general study of ultramafic rocks in Canada. The Tulameen body is a single intrusion that has undergone mechanical and chemical differentiation during emplacement to form a series of ultramafic and basic rocks ranging from dunite to gabbro.

Another party continued the study and mapping of the surficial deposits of Nicola map-area, and has recognized two major glaciations separated by an interglacial interval.

Very detailed mapping was completed on a small area of very well exposed rocks of the Monashee Group near Revelstoke, as part of the general study of granites.

One-mile mapping of Rossland-Trail map-area was started in order to determine the relationships between copper-ore deposition and structural geology.

The *British Columbia Office* at Vancouver had its busiest year in 1961, with 9,560 visitors registered and 23,028 publications distributed. In addition 1,264 collections of rocks and minerals were sold.

Alberta

Nine field parties were active in Alberta, or in Alberta and British Columbia, of which five were stratigraphic and/or palaeontological.

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One party spent several weeks in the southern foothills and Rocky Mountains of Alberta and British Columbia studying sections of late Palæozoic and Mesozoic rocks. The study is expected to aid in the interpretation of drill cores and cuttings from wells penetrating these rocks in the structurally complex southern foothills.

A second party completed the geological mapping of the southeast quarter of Mount Robson map-area. Thrust sheets of the Main Ranges were found to be geometrically similar to those of the Front Ranges.

Other parties started special studies of Ordovician and Silurian rocks in Alberta and British Columbia and of selected folds in the foothills and front ranges of the southern Rocky Mountains.

Another commenced stratigraphic studies of late Palæozoic rocks in the foothills and southern Rocky Mountains. Field work in 1961 was chiefly within the Fernie map-area. Significant changes in thickness in the late Palæozoic rocks were found along the Rocky Mountains, but the presence of distinct and persistent faunal zones permits satisfactory correlation despite these changes. Thinning of the succession occurs from the Rocky Mountains eastward to the foothills and is accompanied by significant changes in lithofacies.

A party started stratigraphic studies of the pre-Devonian rocks. The pre-Devonian stratigraphy east of the Continental Divide, contrary to some published works, is of a 'layer cake' nature, that is, it is constant over wide areas.

One party collected column samples of various coal seams of the Edmonton Formation for seam correlation and detailed petrographic purposes.

A party continued from 1960 chemical correlation work in the Lower Cretaceous of western Canada. Some 500 samples were collected in 1961, and the area sampled now extends 500 miles north to south and 300 miles east to west. Laboratory investigations on the samples are under way.

Another party spent several weeks in the southern Alberta Foothills to obtain additional information on major thrust faults in the area as an aid in interpreting structural data available from the drilling of recent wells.

One party commenced a detailed study of Upper Devonian reefs in the eastern Rocky Mountains. This work is expected to provide lithic, biogenic, and petrographic information on the reefs, which, it is hoped, will aid in the understanding of their mode of origin and serve as a standard for comparison of oil- and gas-bearing reefs elsewhere in the subsurface of Alberta.

Palaeontological and stratigraphical investigations of Devonian outliers and inliers in northeastern Alberta and adjoining parts of Saskatchewan were made, to study these relatively isolated and rather inaccessible exposures of Devonian rocks, and to augment the Survey's fossil collections.

A party completed mapping the surficial geology of the east half of Lethbridge map-area. Several hundred miles of buried preglacial and interglacial valleys were traced and an unglaciated area delineated.

The *Western Plains Office* in Calgary had a very busy year marked by the addition of two to the geological staff, receipt of more than 226,000 samples, largely from wildcat or exploratory wells, and visits from 1,735 persons.

Saskatchewan

Four parties conducted field investigations in Saskatchewan. Two of these were geophysical parties testing the ability of geophysical equipment to delineate buried river channels in the Estevan and Watrous areas as an aid to groundwater studies. One party, using both refraction and high resolution reflection seismic equipment, delineated a rather shallow broad channel suspected of being the buried Missouri River Valley in the Estevan area. Reflection techniques in the Watrous area succeeded in discovering a previously unknown channel near Nokomis. The other geophysical party conducted experimental resistivity surveys in the same region, and found the method useful in detecting small shallow aquifers.

A party completed a groundwater survey of the south half of Saskatoon map-area and supplied technical assistance on request to the R.C.M.P. and Indian Affairs Branch on water supply problems at several localities in the province.

The comprehensive cooperative study of the Coronation Mine of Hudson Bay Mining and Smelting Company, a project started in 1960, continued.

During the year, the Geological Survey, jointly with the Saskatchewan Department of Mineral Resources, contracted for an aeromagnetic survey of nearly 20,000 square miles in northernmost Saskatchewan (latitudes 59° to 60°, longitude 102° to 110°), and subsequent compilation of aeromagnetic maps on a scale of 1 inch to 1 mile. This project was inaugurated under the federal-provincial aeromagnetic program.

Manitoba

Five field parties operated in Manitoba during 1961, three of which were conducting regional geological mapping.

One party began and completed reconnaissance mapping of Tadoule Lake map-area. The area lies entirely within the Canadian Shield and is underlain by granite and granite-gneiss, separated by sedimentary rocks. The granite intruded the sedimentary rocks.

A second party commenced and completed reconnaissance mapping of Kasmere Lake map-area. This area is underlain mainly by granite and granite-gneiss, but contains northeast-trending synclinal belts of sediments and metasediments.

A third party began and completed reconnaissance mapping of Gods River map-area. Bedrock is almost entirely restricted to a narrow band across the southern part of the map-area. Rocks in this band include basic volcanic rocks, clastic sediments, and widespread granite and granite-gneiss. A deposit containing a rubidium mica, the first known rubidium mineral, was discovered on Red Cross Lake.

Another party continued the groundwater survey of the Red River Basin, a region that is extremely dry. Several aquifers were recognized, details of which are included in a report and maps being prepared for publication by the Survey.

The fifth party launched a study of the surficial deposits of the Manitoba part of Riding Mountain map-area. Several buried valleys may lie within this area.

Ontario

Nine geological field parties were active in Ontario, of which five did bedrock mapping.

The 'Roads to Resources' project, which consisted in the geological mapping of eight 1 x 2-degree map-areas in northwestern Ontario, was completed. Preliminary bedrock maps of the eight map-areas will be published by the spring of 1962. Several sedimentary and volcanic belts lie within the three areas mapped in 1961, as well as some granitic and ultrabasic rocks.

A party continued the study of the Anstruther batholith—part of the general granite study. It is hoped from detailed geological mapping and gravity data to establish the subsurface shape and depth of the batholith, and the reasons for its pronounced doming. The origin of some associated uranium deposits is also being investigated.

Two parties mapped three map-areas in the Huronian belt, completing programs begun in 1956 and 1959 to revise and extend former surveys.

A party completed the field study and mapping of the surficial geology of Ottawa map-area.

Investigations of the Palæozoic rocks of southeastern Ontario continued from 1959. Field work in 1961 was conducted in Bath and Sydenham map-areas near Kingston.

The study and mapping of the surficial geology of the southwest quarter of Kingston map-area was completed. Recognition of numerous beaches younger and lower than those developed by glacial Lake Iroquois indicates that temporary lake stages existed in the Ontario basin prior to the formation of modern Lake Ontario.

A party commenced a study of mineral deposits in the Huronian belt and adjacent part of the Superior geological province. This region was selected for study because of the abundance and variety of known deposits, the existence within a relatively small region of strikingly different geological

terrains of at least three different ages, and the existence of fairly complete geological coverage. The aims of this project are to evaluate the significance of differences between various types of mineral deposits, and to extend such an evaluation to many deposits described by others. Most of the 1961 field work was between Sudbury and Matachewan. Sudbury deposits were not studied.

Another party continued subsurface studies on the Palæozoic rocks in southwestern Ontario. Field work included some examination of subsurface data from deep wells in adjacent parts of the United States to provide better control for extrapolation of Ontario data, particularly beneath the Great Lakes, where offshore drifting is taking place.

During the year, the Geological Survey, jointly with the Ontario Department of Mines, contracted for an aeromagnetic survey of that part of Ontario that extends from latitude 50°30′ south to the United States border, and from longitude 90°00′ west to the Manitoba border. This was the second of the inaugural cooperative aeromagnetic surveys of the federal-provincial plan.

Quebec

Five parties were active in Quebec during 1961.

A party continued from 1960 the seismic investigations of the Quebec part of Vaudreuil map-area in order to determine the course of a buried river valley discovered in 1960. The buried valley was traced almost to Rigaud Mountain, and a tributary channel was found that joins the buried valley with St. Lawrence River through St. Dominique.

Another party continued a groundwater study of the same map-area in Quebec and Ontario. Well tests conducted in sands of the buried valley near Rigaud Mountain indicate that a large water supply would be more satisfactorily developed by driving numerous sand points than by drilling one large well. The surficial deposits in this area were also mapped.

A third party completed the remapping of Sutton map-area, which contains an important section of Cambro-Ordovician rocks.

A party carried out a stratigraphic and geomorphic study of the unconsolidated sediments in the Rivière du Loup-Trois Pistoles-Cabana region. Three clays with marine shells were found, two of which are older than the Champlain Sea (Leda) clay. Two esker systems were traced from near the south shore of St. Lawrence River south across the watershed elevation 850 feet, into New Brunswick, marking the first definite indication that deglaciation extended across the Appalachian mountains.

A helicopter-supported reconnaissance project, known as Operation Leaf River, started mapping of a large relatively unknown region in northwestern Quebec. In 1961, 59,000 square miles were mapped for publication on a scale of 1 inch to 8 miles. A slightly smaller area remains

to be mapped, probably in 1963. Most of the area lies within the Superior geologic province and is underlain by granitic paragneiss, with minor bodies of basic and ultrabasic rocks, greenstones, and iron formation.

New Brunswick

Four parties operated in New Brunswick.

One party completed the field study of the geochemistry and other aspects of sedimentation in Chaleur Bay and its tributary rivers. Many samples of waters and measurements were taken, including measurements of water colour, depth of water, turbidity, current velocity and direction, bottom and surface temperatures, Eh and pH of the sediments at the water-sediment interface, chlorinity-salinity by the conductivity method, and colorimetric determination of the total heavy metal content.

A second party continued the geochemical study of the mineral deposits and associated rocks of the Bathurst-Newcastle base metal district. Both selective detailed mapping and detailed investigations of specific problems were undertaken.

Another party continued groundwater investigations in the Moncton area, and a piezometric map of the region with marginal notes describing groundwater occurrences, flow, quantity, and quality has been prepared for publication.

A party completed the geochemical sampling of stream sediments and rocks in southern New Brunswick. The region contains several large areas of anomalously high concentrations of lead, zinc, and copper in its stream sediments, and some stream samples contained sufficiently high concentrations to merit further studies.

Nova Scotia

Regional geology, geophysical, and submarine geology were studied in Nova Scotia in 1961.

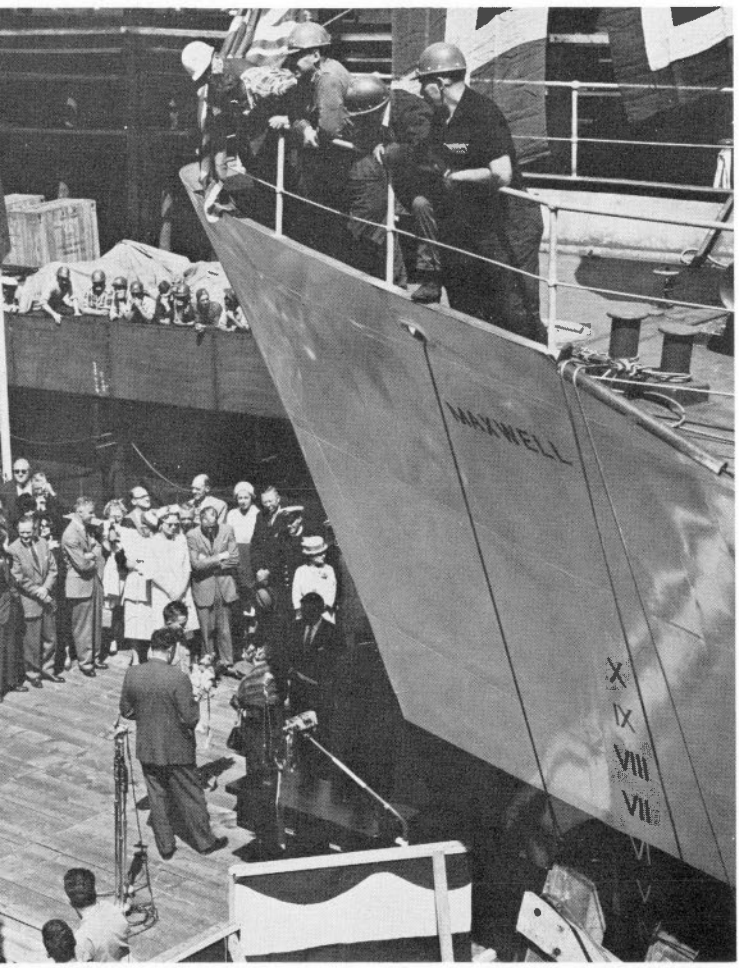
One-mile mapping was completed in Hopewell map-area, providing information on the stratigraphy and structure of the Mississippian rocks of central Nova Scotia, and also on Cape Breton Island, where revisions of the stratigraphic relationships of some Carboniferous rocks were made.

A party collected bottom sediments and fauna from the continental shelf off southeastern Nova Scotia in an attempt to establish the relationship of fauna to bottom sediments and to bathymetry.

Another party completed the mapping of the Walton area on a scale of 1 inch to 1,000 feet. Recent underground work at the Walton barite-silver mine was investigated, and several indications of barite-silver mineralization were found along the Windsor-Horton contact.

A party completed the reconnaissance mapping of Annapolis map-area, a continuation of 4-mile mapping of southwestern Nova Scotia commenced

The new $8-million Surveys and Mapping Building, occupied in 1961.



The launching of *CHS Maxwell* at Halifax, August 17, 1961. This new hydrographic ship, built at a cost of $450,000, will chart Canada's eastern coastal waters.

(Courtesy John S. Holmes studios, Halifax, N.S.)

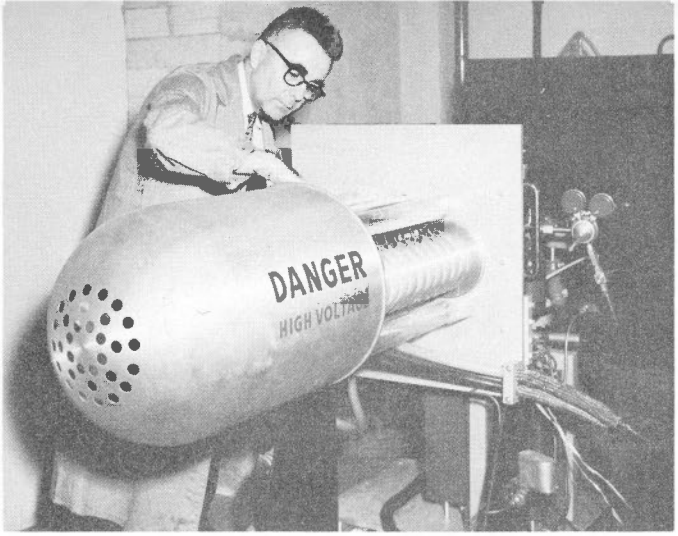
Current meter being placed in the Gulf of St. Lawrence. Meter and position-marking buoy float alongside ship. Concrete anchor, which will hold the meter at a certain depth below the surface, is about to be lowered.

Hydrographer operating a tellurometer in the Arctic.

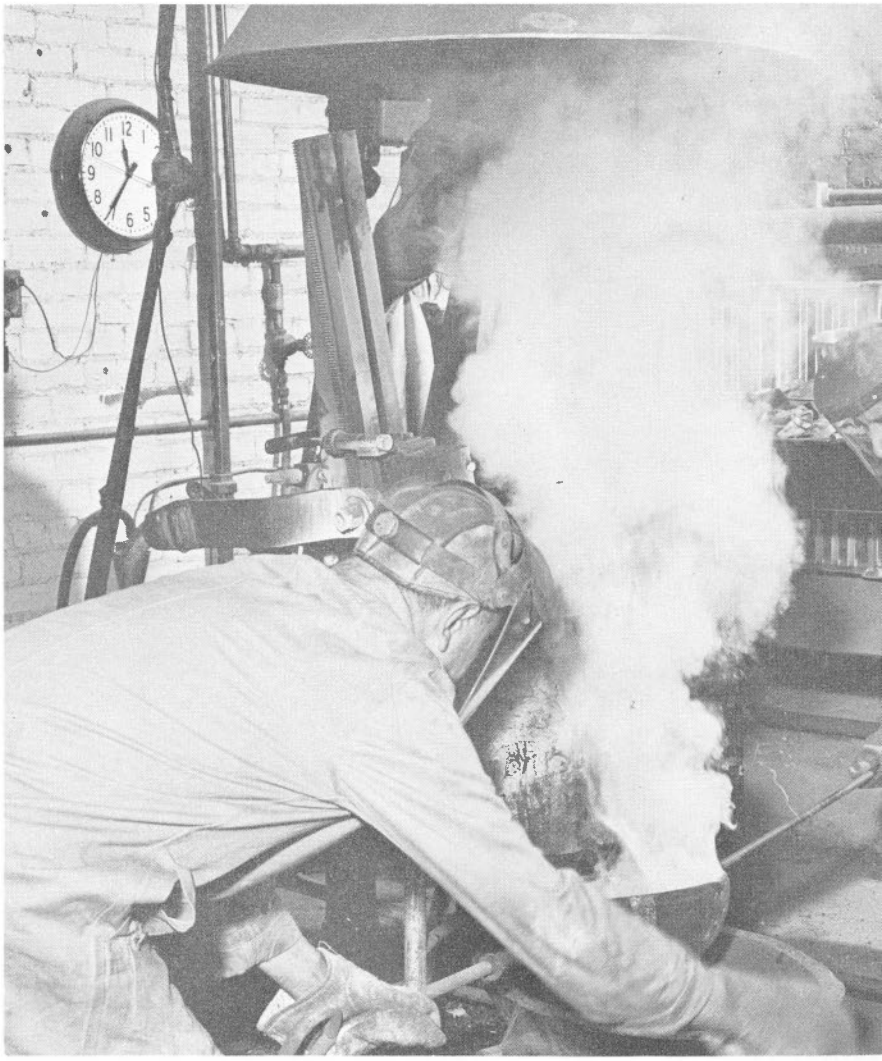
Low-flying helicopter equipped with echo sounder tows 'fish' that sends out sonar signals to record water depth. In the past, all sounding was done from surface craft.

(Courtesy Ken. Gosling, Cornwall, Ont.)

Dr. W. E. van Steenburgh, Director General of Scientific Services, inspects a new Hi-Fix Decca navigation system installed on helicopter. The instrument records the helicopter's position as soundings of water depth are made by the echo sounder.

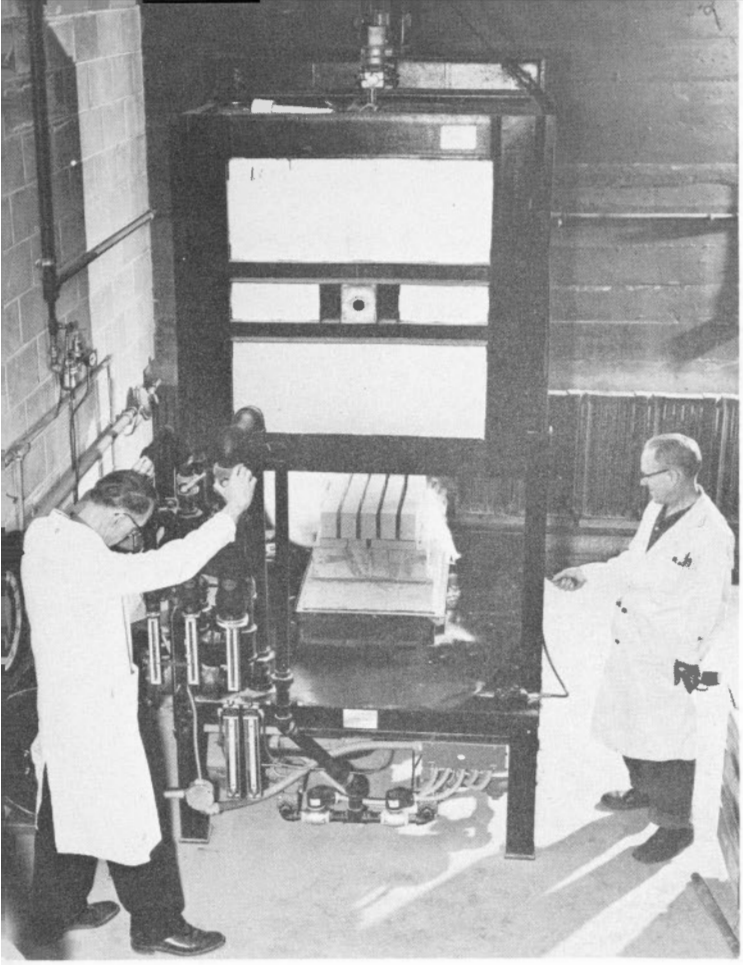


This neutron generator is housed in a specially constructed concrete bloc cell in the basement of the Mines Branch Building. The unit is used in conjunction with a gamma-ray spectrometer that records intensity of radiation, enabling scientists to determine elements in a sample, and their quantity.

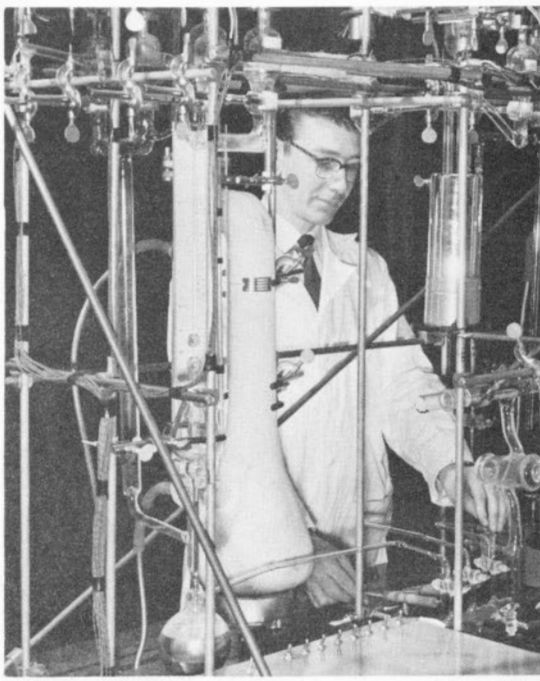


In this high-pressure pilot plant, new techniques are being developed for refining the low-grade oils and bitumens of western Canada.

Extraction metallurgy—Laboratory investigation of a lead-silver ore.

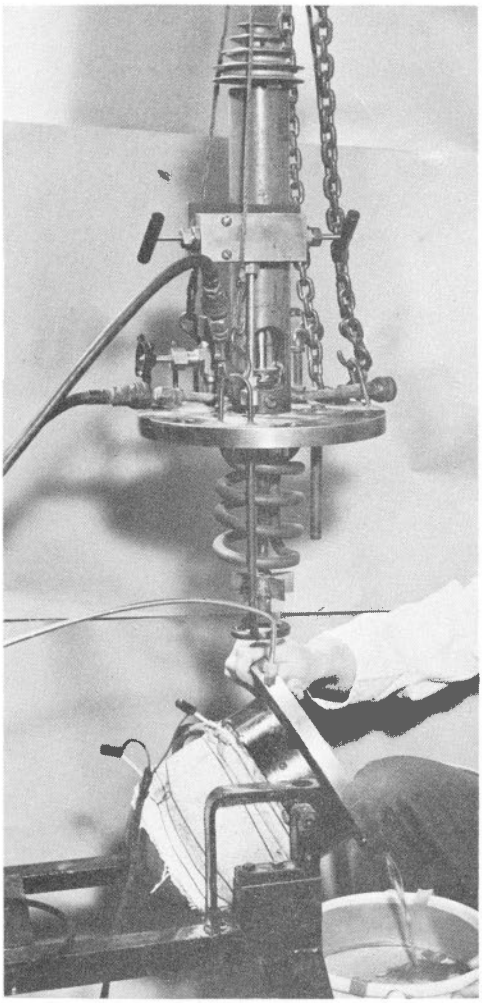


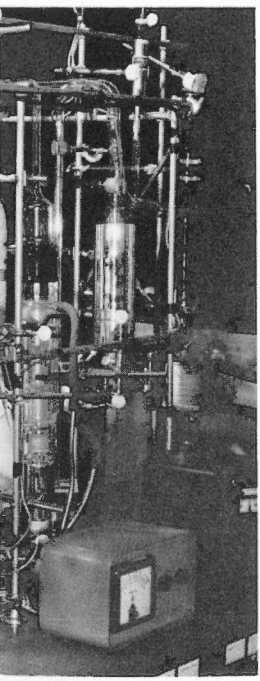
New methods are being developed for processing Canadian kyanite and alumina for use in refractory grogs working at temperatures of up to 3500°F.

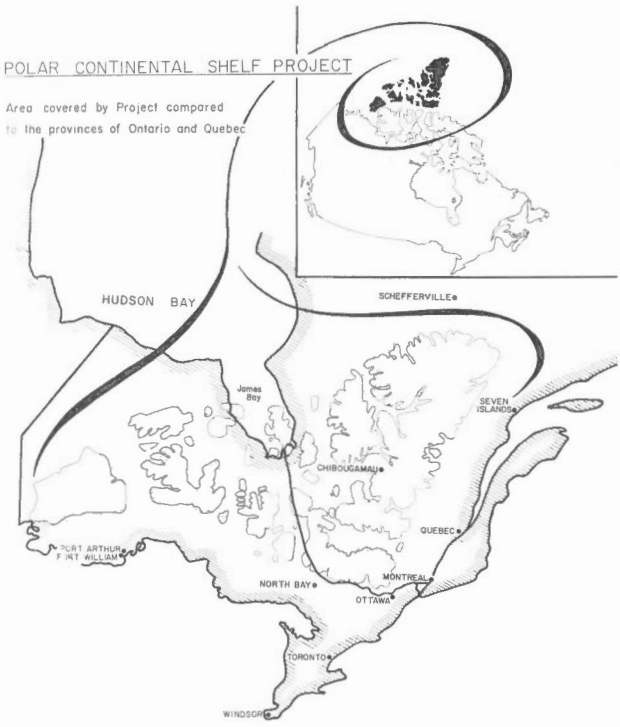


Trapped gas, under stress, affects the behavior of all metals. Here, a gas-analysis expert determines the hydrogen content of a steel.

Autoclaves play an important part in studies to determine optimum leaching conditions for ores, concentrates and metallurgical products.

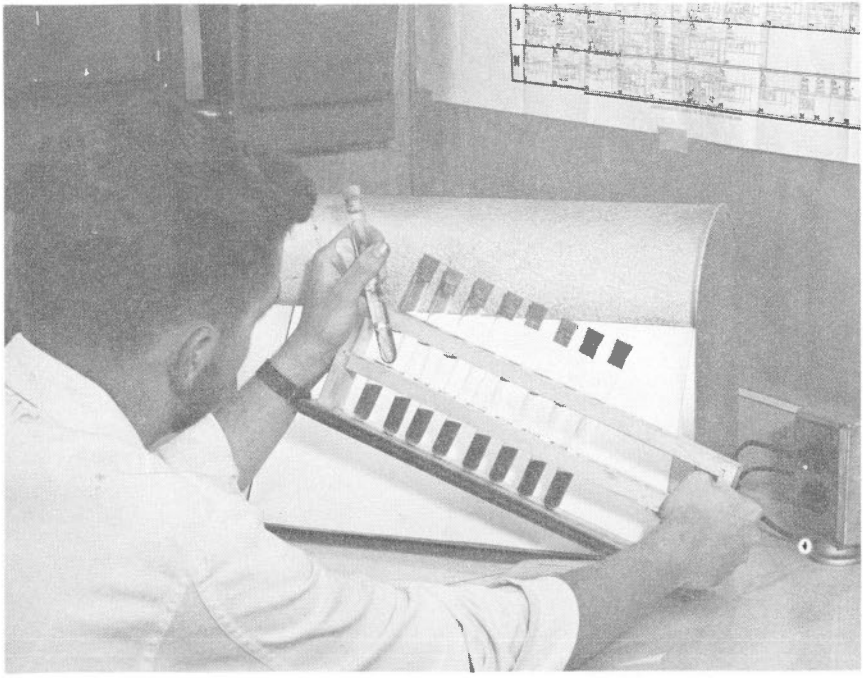


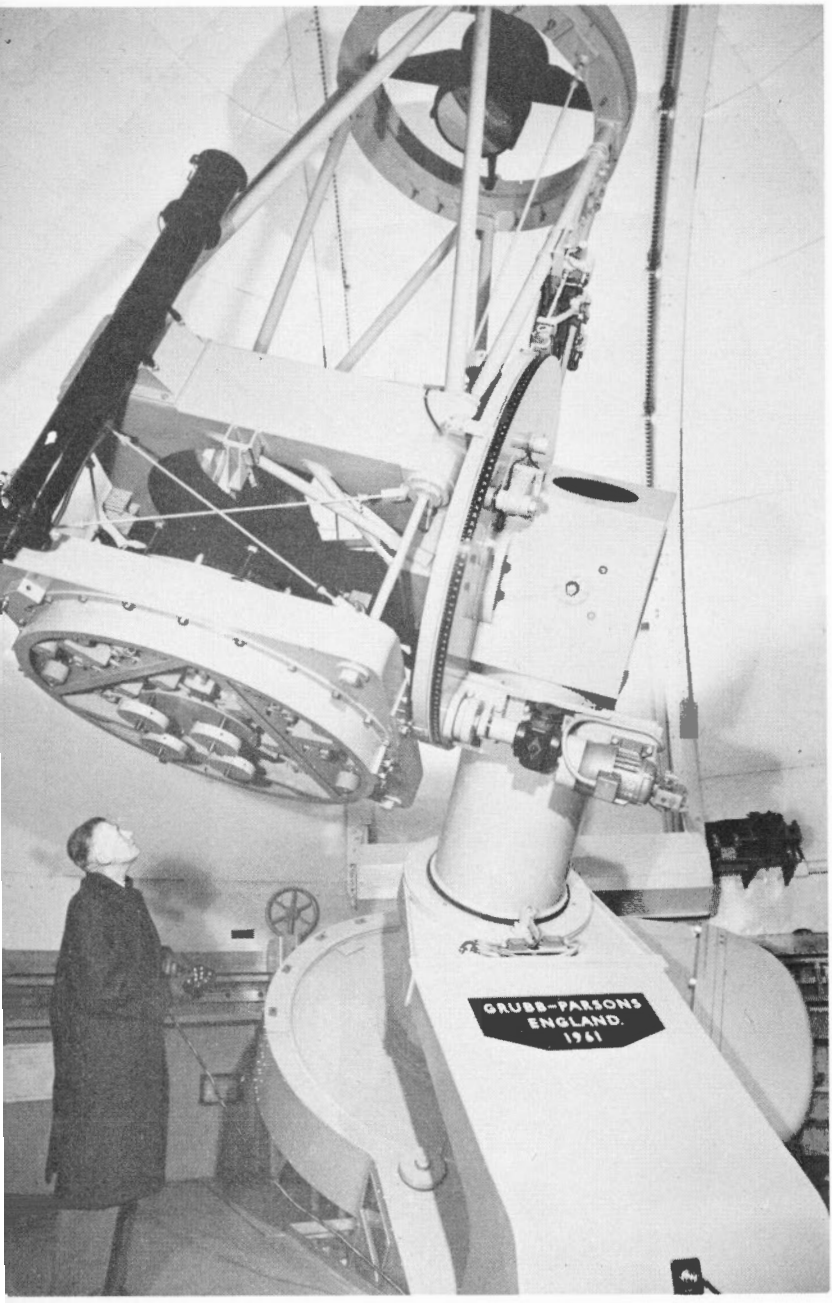



POLAR CONTINENTAL SHELF PROJECT
Area covered by Project compared to the provinces of Ontario and Quebec
HUDSON BAY
SCHEFFERVILLE
James Bay
SEVEN ISLANDS
CHIBOUGAMAU
QUEBEC
PORT ARTHUR
FORT WILLIAM
NORTH BAY
MONTREAL
OTTAWA
TORONTO
WINDSOR

Two geochemists at work in a creek near Bathurst, New Brunswick. The man at right is doing a water analysis while the other tests its acidity.

A geochemist studies soil samples, comparing them with standard solution.





Canada's newest and most advanced telescope, with a 48-inch mirror, was installed in the Victoria Astrophysical Observatory late in 1961. The instrument was designed by scientists of the Dominion Observatories.

A gravimeter being used to measure terrestrial gravity in northern Canada by a member of the Dominion Observatories.

An office worker prepares for mailing copies of a new booklet about the geology and scenery of Prince Edward Island National Park. This is one of a series on Canada's national parks, issued by the Geological Survey of Canada.

An information officer works on a relief map of Canada, reproducing the curvature of the earth.

in 1959. The area is underlain chiefly by Ordovician and Silurian clastic sediments and granite, but a small outlier of previously unknown Mississippian rocks was found in the valley of Southwest Arm River.

A geophysical party participated in a continuing sea-magnetometer survey near Sable Island and southwest of the Bay of Fundy, and the results are being interpreted in the Survey's laboratories for comparison with seismic data of the Lamont Geological Observatory in the United States.

Prince Edward Island

One party began the geological study and mapping of the bedrock and surficial deposits of the west half of Rustico map-area. The area is underlain by gently folded, plunging, and block-faulted beds of late Palæozoic age.

A second party conducted hammer seismic surveys in the Montague-Souris area from which calculations of the depths to bedrock are being prepared.

Newfoundland and Labrador

Five parties were active in Newfoundland in 1961, three of which were conducting bedrock mapping. One party undertook reconnaissance mapping in Labrador.

A party continued the reconnaissance mapping of Belleoram map-area, commenced in 1960. Small bodies of Cambrian strata are faulted against a Precambrian (?) volcanic and intrusive complex that forms the core of Burin Peninsula. Several new Cambrian localities were found.

A geophysical party collected oriented samples of intrusive, volcanic, and sedimentary rocks from parts of eastern and central Newfoundland for palaeomagnetic studies. These samples represent eleven geological units ranging in age from Proterozoic to Devonian, and should help refine the polar wandering curve for rocks in eastern North America. The studies may also provide evidence of rotation of thrust fault sheets in Newfoundland.

Another party completed the study of elevated marine shoreline and associated shore deposits along the coast from White Bay to Burin Peninsula. Shorelines in the eastern parts of the area studied are older than those to the west.

A party completed the 4-mile reconnaissance mapping of the east half of Sandy Lake map-area, part of a study of mineralized Ordovician and Silurian rocks of the Notre Dame Bay region.

The fifth party began reconnaissance mapping of the west half of Botwood map-area, seeking to unravel many of the geological problems that have existed since separate parts of the map-area were examined and mapped in greater detail nearly twenty-five years ago. Fossils discovered in the Botwood Group indicate it is of Silurian rather than Devonian age,

as formerly believed, and lithological comparisons suggest that several rock groups are probably the same units in their widely separated occurrences throughout the area mapped.

In Labrador a party commenced and completed reconnaissance mapping in the Battle Harbour-Cartwright area. Most of the rocks are Archæan, but there are a few small areas of previously known Proterozoic and Cambrian rocks. An intrusive anorthosite suite forms a large mass that includes the Mealy Mountains, and several smaller bodies elsewhere in the map-area. Granites, granite-gneisses, and paragneisses are widespread.

General

The study of Canada's mineral deposits is a continuing task of the Geological Survey. Results of such studies appear from time to time as Bulletins or Economic Geology Series publications.

Field studies of titaniferous iron deposits in Eastern Canada, including the Stratmat Magpie titaniferous magnetite deposit in Saguenay district, Quebec, were completed. The latter deposit appears to be of a type transitional in position and composition between the high-titanium magnetite deposits characteristically found within gabbroic anorthosites and gabbros, and the low-titanium magnetite deposits found in rocks beyond the parent mafic bodies.

Field study of fluorine, barium, and strontium deposits in Canada was concluded with the examination of 42 major occurrences and deposits in Eastern Canada in 1961. Considerable attention was given the extensive occurrences at or near the contact of the Windsor and Horton Groups in Nova Scotia.

A party began the investigation of the geology of tin deposits and occurences in Canada. Numerous occurrences in the Maritimes, western Ontario, and Manitoba, and in the Yellowknife-Beaulieu region of the Northwest Territories were examined during the field season.

Field work on a project to prepare a series of popular accounts of the geology of each of Canada's national parks continued from 1960, with the examination of Terra Nova, Cape Breton, Kootenay, and the three small Ontario national parks. The first publications in this series are expected to be released early in 1962.

A party continued a general survey of groundwater conditions and problems in the Yukon and District of Mackenzie.

A party carried out a study of the distribution of uranium in natural waters in an area of about 1,000 square miles around Bancroft, Ontario. High values obtained in waters sampled near uranium orebodies decrease rapidly to background levels away from the orebodies and offer narrow targets for prospecting.

A palaeontological party spent several weeks collecting samples for microfossil analyses from specified Middle Palæozoic sections in the Maritimes and Ontario.

Another palaeontological party continued studies of the Jurassic system in Canada with the examination of strata in southern Alberta. Parts of Montana were also studied for correlation purposes across the international boundary.

A party spent several weeks examining the Middle Devonian-Upper Devonian boundary and collecting fossils near Norman Wells and two other localities in the Northwest Territories.

Another palaeontological party collected plant fossils from Cretaceous rocks near Schefferville, Quebec, where mining is gradually eliminating the collecting locality, and from Devonian rocks at Sextant Rapids, Abitibi River, Quebec.

A post-doctorate research fellow at the Geological Survey studied geochemical prospecting methods for petroleum and natural gas, with the collection of samples over oil and gas pools in southern Ontario and Alberta. Preliminary laboratory analyses of some of the samples by gas chromatography indicate anomalous amounts of hydrocarbons in the soil above a gas pool in southwestern Ontario, and provide hope for the success of the method as a prospecting tool.

A staff geologist commenced preliminary studies of diabase dykes in the Canadian Shield. Samples from a large dyke swarm in the northern part of the Superior geological province were collected for laboratory studies, including oriented samples for palaeomagnetic work.

Approximately 12 tons of minerals, rocks, and ores from 35 localities in Ontario and Quebec were collected during 1961 to prepare suites for sale to the public. In addition several collections were made of rarer minerals for inclusion in the National Reference Collection at the Geological Survey.

A party made a study of iron formations in a broad belt from Lake of the Woods to Lake Nipigon. Iron formations within this belt are recrystallized, and coarser-grained than in most other parts of the Superior geological province, and may therefore be particularly interesting from an economic viewpoint.

With the aid of two helicopters a party spent several weeks in the Baie Comeau area of Quebec continuing the study and development of reconnaissance mapping methods in heavily-wooded areas of Grenville-type rocks.

Preliminary groundwater studies were begun in the Annapolis Valley of Nova Scotia, and a favorable area was found for a large industrial water supply. The area is now being tested to determine whether sufficient water is available.

Engineering geology studies were made in connection with the proposed causeway to Prince Edward Island and the Chignecto Canal.

A party completed a detailed study of peridotite bodies and associated copper-nickel deposits in the Gordon Lake area in Ontario, as part of the study of ultrabasic rocks in Canada. Nickeliferous copper and iron sulphides occur in the peridotite bodies and in the surrounding gneisses.

Study of the stratigraphic Pleistocene palynology of Canada involved field activities in the Yukon in connection with the surficial geology studies in Operation Klondike. Preliminary regional palynological studies on and collections from surficial sediments in Ontario were completed.

Laboratory and Office Work

Services provided in 1961 by some laboratories increased by as much as 50 per cent over 1960, and several new services, including strontium-rubidium and radiocarbon age dating, were introduced. Much basic research was carried out both on developing new apparatus for research studies and on developing new laboratory techniques.

The analytical chemistry laboratories completed 1,577 chemical analyses and 2,433 spectographic analyses in 1961. A polarographic method for the rapid determination of aluminum in rock and mineral samples was developed early in the year, and investigations were commenced into the development of a fusion-pyrolysis method of separating fluorine and chlorine from rocks and minerals. A method was developed to permit the fluorimetric determination of traces of uranium in various rock types, and 334 determinations were made. A new apparatus for the determination of total water in rocks and minerals was designed, constructed, and put into operation during the year. Development continued satisfactorily on quantitative methods for spectrographic analysis of most types of samples submitted to the laboratories, including silicates, carbonates, iron ores, and mixtures of these.

Major activity in the isotope and nuclear research laboratories has centred on potassium-argon age determinations, of which 197 were reported in 1961. Late in the year equipment was set up for rubidium-strontium age determinations and chemical extractions of these two elements from micaceous minerals were carried out. Three rubidium-strontium age determinations were completed. Other new equipment will permit the expansion of the uranium-lead and thorium-lead dating techniques to include age determinations based on the uranium, lead, and thorium content of zircons and other minerals wherein these elements occur in minute quantities. The C-14 dating laboratory became operative in January 1961 and completed 62 age measurements by the year's end.

Output of service work from the mineralogy laboratories reached an all-time high in 1961 in spite of demands for more detailed mineralogical

studies than formerly, such as cell-edge and mineral-composition determinations. Addition of a second X-ray diffraction unit in November permitted some increase in output by the end of the year. During the year an X-ray powder diffraction method was devised and tested for determining the composition of olivines, especially the small amounts of olivine normally found in thin sections of altered ultramafic rocks. Accuracy of composition with this method is within about ± 2 per cent for sterite. Several new minerals were identified during the year, one a hydrous zinc sulphate from Keno Hill, Yukon, another a muscovite-type mica with about 15 per cent rubidium from Gods Lake map-area, Manitoba, the first rubidium mineral ever discovered. Some 1,808 mineral identifications, 394 cell-edge determinations, and 549 diffractometer analyses were completed in the X-ray laboratories. The X-ray spectrography laboratory developed a method for the determination of the proportion of potassium in micas for age determinations, a method for the determination of individual rare earths in a chemically separated rare earth fraction, and investigated a method for the determination of Mg, Al, and Si in igneous rocks. The laboratory received 755 samples and made 2,370 quantitative and 1,143 semi-quantitative determinations.

The year 1961 saw the formal establishment of a National Mineral Collection, which will consist of a Systematic Reference Series, to be maintained and administered by the Geological Survey, and a Display Series, to be maintained by the National Museum. The approximately 6,000 specimens in the Survey's mineral collection were inventoried, and an alphabetical list prepared for ready reference.

The sample-preparation and mineral-separating laboratories processed approximately 57 per cent more samples in 1961 than in 1960, for a total of 1,948 mineral concentrates.

Almost 7,000 mineral and rock sets (242,467 specimens) were sold in 1961, an increase of more than 25 per cent over 1960. Plans were completed for revision of the larger sets of 120 minerals representing Canada's mineral industry, and a booklet to accompany each set will be submitted for publication early in 1962.

Research mineralogical studies of micas were continued, and it was found that all fresh biotites show a variable deficiency of the (OH,F) group, which appears to be related to oxidation of ferrous iron at the expense of the hydroxyl.

Substantial additions to the Canadian meteorite collection were received, and the Survey's rock collection continued to grow.

In addition to its standard geophysical surveys, the G.S.C. conducted experimental surveys of various types, instrument development, and several research projects during 1961.

The Survey continued its geologic-aeromagnetic interpretation of data obtained from both aeromagnetic surveys and sea magnetometer surveys. Methods have been improved of reporting on the interpretation of aeromagnetic data for Canadian Shield areas in the form of composite aeromagnetic maps having several tones of one color together with an explanation of the observed anomalies in geological terms.

The Survey also evaluated and acquired a new type of hammer seismic instrument, and tested it in several parts of Canada. It appears to be adaptable to refraction surveys to depths of approximately 300 feet and reflection surveys to about 500 feet, and because of its versatility and portability is expected to be used extensively in the future. A D.C. resistivity apparatus was also purchased by the Survey and tested in Saskatchewan, and was found useful in delineating near-surface aquifers and the planimetric position of certain buried valleys, but gave unreliable information relative to depth-to-bedrock determinations.

Meanwhile, construction was under way of more accurate and efficient equipment for palaeomagnetic measurements, as well as compilation of new data on 272 oriented specimens from Prince Edward Island, 225 specimens from the Sudbury basin, 38 specimens from anorthosite bodies in Quebec, and other specimens from various parts of Canada. These data in certain cases are proving of value in stratigraphic correlation where palaeontological methods are not applicable.

In the realm of instrument development and research, improvements were made to the two direct reading nuclear magnetometers constructed at the Survey in 1960. These were subsequently installed and tested on Canadian Hydrographic ships operating off the east coast, and in Hudson Bay. Work continued on the design and construction of a direct reading nuclear precession magnetometer for helicopter and fixed-wing aircraft installation, and the magnetometer was undergoing tests at the year's end. Construction of electronic components of a spinner-type remanent magnetometer for use in palaeomagnetic studies neared completion, and work was completed on the construction of a microwave electron spin resonance spectrometer for use in detecting trace elements of the transition group of the periodic table in solution form. Theoretical work in the testing of several electromagnetic systems, for possible use in geophysical prospecting for minerals and groundwater, was continued during the year.

Activities of the realm of economic geology included: systematic gathering of basic data both on reconnaissance and detail scales in map and manuscript form; investigation into geological processes and evolution; applied research and development in methodology, techniques, and tools; analytical and experimental laboratory research; applied and theoretical studies on quantitative measurements with increasing use of various fields of mathematics, computers, and data-processing instruments.

A mineralographic laboratory was established in November, with a sample preparation room, a room for mineral separation and chemical tests, and a microscopy room.

The geochemical work was greatly furthered by the establishment of a gas analysis laboratory, which undertook gas analyses of soil samples from oil and natural gas fields in southwestern Ontario and Alberta. In November a mobile spectrographic laboratory designed by a Survey officer was built and put into operation. Studies were continued on the effects of pH and temperature on the adsorption of trace elements from solution on finely ground quartz, feldspar, and other minerals. A laboratory study of soils, waters, rocks, and ores of the Walton barite-lead-zinc-silver deposit in Nova Scotia was completed, and results are being compiled. Laboratory work in the geochemical correlation of Lower Cretaceous strata of Alberta and Saskatchewan was also completed and the results are being compiled for publication. Sampling of the 'Roads to Resources' project in Northwestern Ontario (some 12,000 samples collected during two field seasons by several field parties) was completed and the analytical results have been plotted on 4-mile map-sheets. During 1961 the trace elements laboratory dealt with 6,191 samples of varied types and carried out 15,643 analyses for five elements.

Most pleistocene projects concerned field activities, but the commencement of radiocarbon dating within the Survey provided personnel of the section with valuable assistance to their field studies. Investigations by the palynology laboratory including description and cataloguing of modern pollen and spores were continued. The sedimentology laboratory showed a marked increase in production over 1960, as a result of the growing need for precision of nomenclature of clastic sediments, and studies into the behavior of sediments.

Most groundwater studies were related to field projects, but investigation was started aiming at combining stream flow and meteorological and evapotranspiration data to determine the groundwater potential of drainage basins, which in turn may provide a practical means of groundwater reconnaissance. Studies of the feasibility of constructing a submarine drill and the development of a rapid sediment analyser were continued. Information was given to other government officers and private citizens on local groundwater and engineering conditions in various parts of Canada.

To gain more information on petroleum geology, the Branch studied the petrographic features of some Upper Devonian sedimentary rocks of southern District of Mackenzie. Some 126,000 feet of drill samples from 15 wells in the southern Foothills and Rocky Mountains of Alberta and British Columbia were examined.

Specialists in stratigraphic palaeontology prepared 143 reports on 1,764 separate lots of fossils, 1,398 of which were submitted by Survey officers.

Some 79 lots of fossils were submitted by other government departments, 261 by industry, and 26 by miscellaneous sources. Loans totalling 746 lots of fossils were made to 39 individuals or institutes throughout the world, and 116 lots of fossils and 81 plaster replicas were sent out as gifts or exchanges to 17 individuals and institutions. A total of 765 fossil types described in publications during 1961 were added to the Survey's type collection, and numerous type specimens in this collection were redescribed and/or refigured. During the year some 5,000 lots of plant fossils were cleaned, recorded, and cross indexed.

The Survey initiated two new coking coal projects during 1961, one an examination of the Carboniferous coking blends and the other a petrographic study of Cretaceous coking coals. Petrographic studies were initiated on subbituminous coals of the Edmonton Formation of Alberta, and spore investigations of samples from coal seams of Pictou and Springhill coal fields, and of other Carboniferous material from the Maritimes were undertaken during the year. In addition, Survey personnel provided technical assistance to the Nova Scotia Department of Mines on the locating of boreholes in a drilling-for-coal program.

Compilation of the *Lexicon of Stratigraphic Names Used in Canada* continued during the year, by the end of which about 800 names had been written up, and over 4,000 prepared.

Geological Survey publications are made available to the public through the publication distribution office. During 1961 this office received 13,516 requests for publications and information, and sent out 203,565 publications, consisting of 107,648 maps, 76,300 reports, and 19,617 miscellaneous items.

mines branch

THE Mines Branch in 1961 continued to develop ways and means of aiding Canadian industry through research in the fields of extractive and physical metallurgy, fuels and mining practices and in a variety of mineral sciences. The work called for investigations of immediate practical benefit to mining, metal fabrication and other industries; and included projects of a fundamental nature that would lay the foundation for further research. Some of the work was important to national defence.*

However, most of the investigations under way in 1961 had a direct bearing on the processing and application of Canadian ores, minerals, and metals; and all resulted in the further strengthening of Canada's scientific and technological position.

Physical Metallurgy

The work in physical metallurgy, devoted to problems of direct interest to Canada's mining and metallurgical industries, increased both in fundamental studies and applied research during 1961.

In the international field, senior staff members contributed to the work of many organizations including those concerned with defence, such as NATO, and those dealing with international standards and specifications.

Distinguished scientists from various countries visited the physical metallurgy laboratories.

Official certification of industrial radiographers by the Mines Branch for the Canadian Government Specifications Boards was inaugurated in

* For example, the development of ceramics, ferrites, and magneto strictive materials for hydrophones and transducers.

1961. Examinations were held in Toronto, Ottawa and Montreal for junior-grade candidates, and written and practical tests for seniors were conducted in the Nondestructive Testing Section.

Staff members were called on to investigate many problems concerned with the production and use of metal manufactures. Metallurgical examination is often the only way by which the cause of dissatisfaction can be determined and appropriate remedies suggested. Apart from industrial producers and fabricators, the armed services and other government departments submitted a significant number of cases. Typical examples of investigational work are given below.

At the request of the Department of Transport an examination was made on cast steel propeller blades which had broken in service on the ice-breaker C. M. S. *Camsell.* A specification was written which should help to ensure the production of satisfactory propeller blades in the future.

The Department of National Defence requested several investigations in connection with apparently defective items of army equipment. In one case the problem was due to inadequate heat treatment of the part, and recommendations were made by which the parts could be corrected. In another case, breakage of spring attachments was attributed not to metallurgical fault but to the method of installation, which could be simply modified.

At the request of several foundries as well as potential Canadian suppliers of foundry sand, numerous tests were made on sand samples for suitability in the production of ferrous or non-ferrous castings.

Help was given to the Department of Public Printing and Stationery with the composition of type metal and the adjustment of alloy content to bring metal on hand to correct composition.

Examination of high tensile brass propellers for the Department of Transport showed that these could be repaired by heating and straightening almost indefinitely, provided fatigue damage was not present. Previously this material had been believed to be limited to only three repairs.

The R.C.M.P. obtained technical aid in the study of the behavior of .22-calibre lead bullets.

Four billets of a special zirconium-tin alloy containing a range of nickel were prepared by consumable-electrode vacuum arc-melting for Atomic Energy of Canada Ltd.

Semi-production quantities of zinc and uranium were extruded; of zinc as part of an investigation sponsored by a private concern, into the general characteristics of zinc extrusion techniques and the properties of extruded zinc; and of uranium as a service to Atomic Energy of Canada Ltd., for prototype reactor fuel element development.

At the request of the National Energy Board, the cause of failure of welded gas pipelines at North Bay and Gravenhurst, Ontario, was investigated.

In connection with a NATO-sponsored project on gas analysis of refractory metals, the staff undertook the determination of gas content in samples of niobium, tantalum, molybdenum and tungsten from suppliers in four countries. The results will be compared with those obtained in other laboratories to determine the best methods.

In research work, non-nuclear uses for uranium received much attention during 1961, mainly in the ferrous field following the interesting and encouraging discoveries and developments of earlier work. The Branch has demonstrated the beneficial effects of small amounts of uranium on corrosion and some mechanical properties such as fatigue strength of low-carbon steels, and work on austenitic, ferritic and martensitic stainless steels has also revealed new potentiality for expanded uses of uranium.

The study of the effects of uranium additions to iron and steel included an investigation of the uranium distribution, or partition, between oxide, carbide and intermetallic compound phases present.

Other aspects of uranium addition studied during the year concerned alloy techniques, scrap melting, resistance to corrosion, steel hardenability and high temperature characteristics.

Research into improved material for farm ploughshare points, requested by the Canadian Federation of Agriculture, has produced useful information.

Development of improved chromium-molybdenum-vanadium steels for naval steam turbine rotors was continued, and work is progressing favorably on the development of niobium-bearing plain carbon structural and low-alloy steels for use at low temperatures.

The Branch also made progress in the study of ageing in aluminum-magnesium alloys, the effects of heat treatment on tensile properties of magnesium-silver-zinc-zirconium alloys, segregation of zinc in various alloys of the magnesium-zinc system, the development of heat-treatable titanium-aluminum-molybdenum alloys, and the effects of heat treatment on structure, corrosion behavior and mechanical properties of zirconium-copper-molybdenum, particularly with respect to ageing.

Metal-melting and -refining research saw activity in studies on the uses of directly reduced iron, a product of considerable potential importance to Canada.

A study has been started to determine the effects of alloying elements on the activity coefficient of oxygen in molten iron. The elements the Branch is mainly interested in are carbon, silicon, aluminum, manganese and uranium, and this work should lead to a better understanding of steelmaking reactions.

Research on the foundry characteristics of copper alloys was continued, and the investigation of the effects of composition on mechanical properties of complex aluminum-bronzes has been completed. These alloys are widely used in modern marine propellers. An extensive study is being made of the influence of thermal gradient on cast structures, particularly soundness, of the more commonly used copper alloys. In cooperation with laboratories in other countries, a study has been made of the design and preparation of sand-cast test bars used for the evaluation of mechanical properties of aluminum casting alloys.

Work in the field of powder metallurgy was continued with attention to the preparation of dispersion-hardened aluminum alloys containing zirconium or cerium, and to the slip-casting of nickel powders.

The importance of the damaging effects of fatigue on metals is widely realized. Grain boundary behavior in pure aluminum bi-crystals was examined and the electron microscope was used to determine dislocation reactions occurring in the boundary regions during fatigue. As part of this work, measurements of fatigue crack velocity, using a special replica technique, were made on alpha brass of various zinc contents.

The Branch participated in a cooperative program sponsored by the Organization for Economic Cooperation and Development (OECD) concerning the effects of stress history and spectrum-loading on fatigue damage and endurance of an aluminum alloy and chromium-molybdenum steel.

Research on many welding problems was conducted during the year. The fundamentals of the inert-gas metal-arc welding process were studied through high-speed photography and refined instrumentation. Extensive studies were made of ways to obtain sound welds in structural steel in cold weather, particularly important in Canada's vast cold areas. The laboratory has a cold room where welding tests can be conducted at an air temperature of -50°C (-60°F). Weldability studies were continued on high-strength ship steels, on uranium-bearing plain carbon steels, and on the repair of leaded bronze and gun metal castings by the use of a modified filler wire developed and produced experimentally.

Galvanizing by the hot-dip process was studied extensively with several commercially-produced steel sheet materials. The effects of alloying additions to the galvanizing bath on the properties of the resultant zinc coating were studied. Methods of applying satisfactory zinc coatings to niobium were investigated and their efficacy assessed. The problem of hot water corrosion of domestic copper plumbing in the Vancouver area was studied.

Other corrosion studies concerned the supporting members of mine shaft conveyances, the problem of quantitative evaluation of fretting corrosion, and zirconium alloys containing copper and molybdenum which may be useful in nuclear reactor design. In one alloy examined, corrosion could be reduced by a factor of 10 through selected heat-treatment procedures.

Some other projects:

—The use of gold as a barrier to hydrogen when applied to steel pressure vessels was assessed.

—In the field of pure and applied metal physics, a considerable effort has been directed towards a better understanding of the physics of liquid metals and melting and solidification.

—X-ray diffraction data obtained from metals and alloys to give more accurate and significant results were processed by newly refined mathematical treatments made practical by the use of electronic computers.

—The study of precipitation processes and deformation was continued by means of transmission electron microscopy of thin foils. Such information may be useful in the design of working and heat-treating procedures for steels and other alloys.

Fuels and Mining Practice

In the fields of fuel and mining practice the Branch continued research to help the coal industry, beset by market problems, research on distillation and hydrogenation of low-grade crude oils, and on ground mechanics, with emphasis on problems of 'hard rock' mines.

The Branch took part in a study on the possible specialized metallurgical markets for coking and high-carbon coals in Western Canada and the western United States. Further studies were also conducted by the Departmental Maritime Region Study Group.

The Interdepartmental Committee set up to consider the Recommendations of the Royal Commission on Coal (1955) requested a report on Recommendation 14 of the Rand Report dealing with research, and both oral and written reports were submitted.

A senior metallurgical advisor visited most countries in western Europe at the head of a departmental group to evaluate the market possibilities for metallic iron products and iron ore, and he also studied various aspects of uses for fuels in pyrometallurgical application.

The analytical laboratories analyzed 1,738 samples of solid, liquid and gaseous fuels, necessitating 25,872 determinations. To provide information for vendors and purchasers of Canadian coal, 145 tipple samples were collected at 20 mines in Nova Scotia, 13 in New Brunswick, three in Saskatchewan, three in Alberta, and two in British Columbia. A new supplement of the *Analysis Directory of Canadian Coals* was published during the year.

The electric equipment certification laboratory completed 60 investigations of equipment in hazardous locations. These investigations included flame-proof and intrinsic safety tests on industrial electrical apparatus, as well as on fire-resistant belting and electric cables. In addition to these

investigations, the laboratory conducted research in the field of explosive atmospheres. The explosive laboratory completed 224 investigations relating to hazardous or explosive substances which included some research work.

The redesigning of fire grate bars in stoker-fired furnaces to improve the combustion of Atlantic region coals in cooperation with private industry was almost completed during the year. It was demonstrated that, given certain standards in design of bars and in combustion control procedures, the coals of the Atlantic region can be burned at various loads without undue grate wear and noisome smoke. This work has also resulted in the invention of a stoker for burning low-ash fusion and highly caking coals, and this stoker is now being developed. A laboratory combustion apparatus was designed and constructed with industry help in which pulverized coal is burned in special 'opposed' burners in a slagging furnace of a small water tube steam boiler. In addition to a steam cycle, the rig is provided with air heaters which could furnish power for a steam and gas turbine combination.

Further progress was made in cleaning fine coal particles. To obtain a better separation over a wide range of fine sizes, a water cyclone of triconical section was designed. Trials of cones with compound cyclones in the pilot plant at the Research Council of Alberta are now being conducted, not only on coal but also on iron ore.

Several studies, including steam evaluation, plant performance tests and sampling procedures at defence plants, were conducted in eastern Canada.

Blends of various coals from Canada and the United States were evaluated for use as metallurgical-grade cokes by laboratory and pilot plant methods. The 500-pound movable-wall electrically heated oven at Booth Street was completed and ready for use at the end of the year.

Field studies in coal mining techniques, both in Cape Breton and in the west, were continued by resident engineers, but special attention was given to "hard rock" mines, in compliance with requests.

Two new types of stressmeters were built and tests of them were started.

Because of the difficulty in conducting long-term research in mines without interference to mining operations, a new laboratory technique was developed with models.

To encourage the preservation of Canada's petroleum reserves, the emphasis in petroleum research was on the development of new and better refining techniques of the low-grade high-sulphur-content crude oils.

Petroleum deposits are irreplaceable, and it appears that in time new discoveries here and abroad will not be able to supply growing world demands. Certain farsighted companies are therefore studying the possibilities of securing oil from the Alberta bituminous sands; and their experiments have led to an increase in the branch's consultation load.

One of the fundamental problems in the processing of heavy oils is the lack of scientific knowledge of the structure of the so-called asphaltenes which

constitute the highest molecular weight fraction of the heavy oils. During the year, a scheme of hydrocarbon structural group analysis was developed and applied to this problem; also, a new low-temperature reduction technique was explored which promised to reveal a great deal of structural information. Detailed knowledge of the structure of the asphaltenes will greatly assist in the classification of petroleum and will clarify many relations between the different types of petroleum and the geochemical environment.

Applied petroleum research in the Branch deals with three main areas of hydrocarbon refining technology: distillation, catalytic cracking, and hydrogenation.

Certain crude oils are most conveniently refined by making an initial vacuum distillation to separate the asphalt from the lighter oils that are destined for further refining, and it is believed that certain economies may be made in this process by using inert gas stripping. Research in this field was continued during the past year to test the integrated system of safety and temperature controls, and progress has been encouraging.

Catalytic cracking is one of the most common refining techniques. Branch scientists are attempting to develop a catalytic cracking unit capable of operating at pressures of 1,000 psi. Such a unit would have the desirable flexibility to treat the wide variety of intermediate petroleum products that will be produced in the processes used in the hydrogenation program. The design of this unit has taken several years to complete, and the assembly, now in progress, will require approximately another year.

The hydrogenation program consists of fundamental research on hydrogenating pure compounds to understand the mechanism of the reactions taking place, and applied research in vapor- and liquid-phase hydrogenation. During the year, vapor-phase research has been concentrated on the influence of the hydrogen pressure on the rate of coke deposition on the catalysts. This is a rather critical aspect of oil refining as the carbon deposition rate determines the time for which the plant is shut down to burn the carbon off the catalyst.

The liquid-phase investigations have been conducted, firstly, to secure essential data for the design of the gas scrubbing section of the combined liquid- and vapor-phase pilot plant which is now being designed; and secondly to develop a suitable Canadian substitute for the Winkler generator dust or "Grude" which is used as a catalyst support in the German liquid-phase operations. This has implications in the refining of coal tar products as well as the heavy oils.

An estimate was prepared of the cost of refining Weyburn heavy crude oil, based on the latest German hydrogenation technique for treating heavy Middle East crude oils. During the year experiments have been conducted to verify the yields and qualities of the products that can actually be obtained from Weyburn crude oil.

Considerable stress has been placed on the development of catalyst and catalyst carriers. During the year the emphasis was on the control of the pore size and pore size distribution in catalytic supports.

The progress made in the construction of facilities for catalytic cracking required the construction of similar facilities for the production of catalyst design for fluid-bed operation. A spray drier was built and operated during the year, and catalysts of quality superior to that sold commercially were produced.

The rapid progress in the study and preparation of catalysts has been in large measure due to the construction of a 60,000-pounds-per-square-inch mercury porosimeter. This project has afforded excellent training for the summer students in techniques that are apt to stimulate chemical secondary industry in Canada.

Mineral Sciences

The Branch's work in mineral sciences consists in basic and applied research and technical assistance in support of the mineral and metal industries. It falls into four groups: mineralogy, physical chemistry, physics and radiotracer, and analytical chemistry.

The Branch completed a general mineralogical investigation of the cesium deposit at Bernic Lake, Manitoba, but further detailed work involving X-ray crystallography is continuing on a tantalum-tin mineral found in the deposit. A critical assessment was made of compositional variations of the niobium-(columbium)-bearing minerals (pyrochlore and niobian perovskite) found in one of the Oka, Que. deposits now being developed. Samples from a unique deposit at Seal Lake, Labrador, which contains complex beryllium-niobium-barium mineralization were investigated. Other special investigations were made of iron ore from Swift Creek, Alberta, and manganese ore from the Queen Charlotte Islands, B.C. The characteristic gamma-ray spectra from natural ores and rocks have been studied jointly with the Geological Survey of Canada during the past few years. The data are useful in airbone geophysical prospecting. Field and laboratory studies were completed, and a report was issued on the laboratory work.

As part of the program on niobium, the system lime-niobia-silica was intensively studied. To elucidate certain reactions in complex basic refractory materials, further work was done in the dicalcium silicate-alumina-ferric oxide system. Molten chloride-fluoride flux compositions used in the melting and refining of magnesium were extensively studied, and work was begun on the constitution of sintered compositions in the lead-zirconite-lead-titanate series.

Diffusion phenomena between solid-liquid and solid-solid systems, and the adsorption of molecules on the solid surfaces were investigated through the use of radioisotopes. The sulphite minerals, pyrite, galena, and sphalerite

were studied with respect to diffusion rates of radio-sulphur and radio-phosphorus. By using carbon-14-tagged oleic acid, the extent of surface coverage of hematite and quartz particles was found and some of the controlling factors have been defined. This information is of interest in connection with froth-flotation processes. Diffusion and exchange reactions, using silver-110, were conducted on oriented single crystals of silver to gain basic information from a relatively simple, ideal system. The solid diffusion of silver-110 in bismuth telluride single crystals was investigated as part of the program on semi-conductor materials.

Analytical and spectrochemical work was done for the determination of trace impurities in refractory metals, of interest to the aircraft industries, at the request of the Advisory Group on Aeronautical Research and Development of NATO. Similar collaborative work on the determination of copper in aluminum is carried on through the Canadian Standards Association and the International Standards Organization. Based on the selection of the best determinations submitted by laboratories from the nations participating in these programs (U.S., Britain, Germany, France, Italy), reference standards are being established for metals and alloys.

A substantial portion of the research and development program of the Mineral Sciences Division is devoted to finding new and improved determinative methods applicable to problems in analytical chemistry, spectrochemistry, radiometric assaying, and mineralogy.

The precious metals program on improved analytical methods which has been carried on for several years was continued. A new fire assay method for the determination of gold was disclosed, and further improvements were made in the extraction and separation of the platinum group metals. Because of the sensitive and precise methods developed it has been possible to determine trace amounts in rock samples in collaboration with officers of the Geological Survey, engaged in a geochemical investigation of certain basic igneous rock complexes in Northern Canada. Other analytical chemical problems encountered and overcome by improved methods included the interference of nickel in the volumetric determination of tin and the determination of trace amounts of chloride in zinc oxide. During the year certain commitments were made with the American Society for Testing Materials for the sampling and analysis of metal-bearing ores and related materials, and preliminary work was undertaken on the analysis of manganese ore, chrome ore, and fluorspar.

Radiometric assay methods are widely used in the Branch to measure the amount of radioactive elements present in ores, concentrates, and metals, or the concentration of radiotracer elements in experimental materials. A method and apparatus for the radiometric determination of uranium in steel were devised, so that a precise assay can be made in one minute from the time of placing the sample in the machine.

The determination of the amounts of minerals present in pulverized samples by quantitative X-ray diffractometry was studied.

The staff again helped to design and build new equipment. Almost completed was the construction of an electron probe microanalyser, an important aid for the study of fine-textured materials.

An automatic reflectivity apparatus for scanning and counting ore minerals in polished section is being designed in prototype form.

A conductivity probe for the continuous control of acid or alkaline leach solutions as used in industrial processes, developed two years ago, was adapted to industrial use. One instrument manufacturer is now producing a probe based on the prototype developed in the Branch and another is interested in producing it.

A neutron generator for activation analysis and for producing certain radioisotopes for research was installed during the year. The shielding of the machine, which proved difficult at first, has been greatly improved and further minor modifications are expected to create ideal conditions.

In addition to research and development, the Branch provides scientific services to other government agencies and to industry. In the twelve-month period ending September 30, 1961, substantial increases occurred in the volume of chemical and spectrographic work, in comparison with the year before; a 3½-fold increase in radiometric assays resulted in part from heavy demands from the uranium steel program and from increasing requirements in other fields; a 40 per cent increase in X-ray diffraction work was due mostly to requirements in mineralogy and to a significant gain in support of the physical chemical work.

Several applications of radioactive tracers were made during the year on behalf of industrial operators and in support of research projects in the Branch itself.

Extraction Metallurgy

The activities of the Branch in the field of extraction metallurgy are divided broadly into hydrometallurgy and pyrometallurgy. The Branch also conducts corrosion investigations.

The Branch continued its liaison with uranium producers, principally through the Canadian Uranium Producers' Metallurgical Committee. Interest in this aspect of metallurgical research inevitably fell off, however, as some mines closed owing to lack of markets, and others saw only modest prospects.

Since sulphuric acid is the principal cost item in the acid leaching of uranium ores, much work has centred on reducing the amount consumed. Special techniques for floating acid-soluble minerals selectively from uranium have been developed, and the work was completed during

the year. It was shown that the acid consumption could be reduced by 40% at an estimated reagent cost of about 8 cents per ton of ore, although about 8% of the total uranium in the ore was lost in the rejected concentrate.

When this technique was applied to ores from the Bancroft area, the saving of acid turned out to be a good deal less. However, modifications in flotation showed that these ores, too, could be produced much more efficiently.

The pressurized leaching method, in which compressed air is blown into a pulp which is held at temperatures above the boiling point of water, enables uranium ores to be leached effectively without consumption of any sulphuric acid, since the sulphides present in the ore oxidize under these conditions to form the necessary acid. The general effectiveness of this technique had been established earlier, but during 1961 its applicability to the ore of one of the principal Canadian uranium mines was demonstrated.

With the present market for uranium, it is unlikely that any technique requiring capital expenditure will be adopted by the producers. But as markets develop and competition grows, any suggestion which promises operating economies will be carefully scrutinized.

The program of work with the gold mines which was started in the previous year was expanded. The control of cyanide circuits was studied, along with the device for measuring the oxygen content of solutions and pulps which was developed the year before, and tested in the field by arrangement with the managers of eight gold mines.

These investigations demonstrated that improvements in the controls applied to cyanidation circuits can lead to operating economies. In one outstanding example, by improvements in control coupled with modifications, the mill operator was able to reduce cyanide consumption by half, while making a small but noticeable improvement in gold extraction. Small improvements were made in four other gold mills.

Interest in Canadian niobium (columbium) ores continued during the year, with one company going into the production of niobium concentrates, and a second company planning production in the near future, both in the Oka district near Montreal. The Branch undertook to investigate the possibilities of chemically upgrading a low-grade concentrate from the Oka district, to increase sales potential. Experiments showed that chemical treatment could result in a product containing over 90% niobium oxide, at a reagent cost of about 25 cents per pound. It is believed that such a concentrate would be readily marketable.

In recent years much interest has developed in low-niobium steels, containing from 0.05 to 0.1% niobium, because of their strength. Experiments established that it was practical to permit the reduction of niobium to take place in the furnace, and that recovery of niobum in the steel was reasonably good.

Following the discovery of a substantial deposit of pollucite, the principal ore of cesium, in eastern Manitoba, the Branch undertook to develop a process for cesium recovery, by the construction and operation of a pilot plant to produce about four pounds of cesium chloride per day. This plant was operated for six weeks, during which the treatment process was proved in principle, recoveries and product purity were established, and operating procedures defined. The product obtained was at least equal in purity to that of other cesium chloride obtainable, and the recovery of cesium from the ore was 95% or better. Much of the cesium chloride produced will be used for experiments in metal production.

While markets for cesium salts and cesium metal are very small, there is much research under way to expand them, perhaps the most interesting approach being an investigation into the direct conversion of heat into electricity.

The Canadian iron ore companies continued to follow the trend set some years ago of preferring the production of high-grade iron concentrates to direct-shipping or lower-grade ores. With more concentrates available, the lower-grade materials tended to fall out of favor with operators of blast furnaces. This has led to attempts to upgrade the lower-grade ores.

A substantial amount of work in this direction was done on Canadian siderite ores, of which there are very large reserves north of Lake Superior. These ores contain about 35% iron and by simple sintering can be raised in grade to about 50% iron. An attempt was made to convert the iron content of the ore to magnetite by subjecting the ore to an oxidizing roast in a kiln, so as to concentrate the magnetite by magnetic separation later on. This experiment met with only moderate success, owing apparently to the presence of various non-iron carbonates. It is worth noting, however, that, although the concentrates obtained contained manganese and calcium, they also contained only about 2% silica, and this is desirable from the point of view of slag formation.

The Branch dealt with many problems of corrosion. The most important project carried over from the previous year concerned zinc-plated cartridge cases which had been found to corrode in storage. A modified plating procedure was developed, and when good platings were obtained from pilot plant trials, the full-scale plant was modified according to the new recommendations. Several thousand shell cases have now been plated with excellent results. A report on this work has been transmitted to the proper authorities in NATO.

Along with these investigations, basic research continued. One interesting discovery was that the oxidation by air of iron dissolved as the sulphate in sulphuric acid solution can be catalyzed by activated charcoal.

The effect of the charcoal is quite dramatic, at a rate of 1,000. This discovery has an obvious application in uranium leaching, since air might be used as an oxidant instead of sodium chlorate.

Also investigated were several gas-solid reactions of metallurgical interest. Reactions of this type occur in roasting, calcining, sintering, and drying, operations that are very common to metallurgical processes. Studies of systems such as the decomposition of calcium carbonate or of calcium hydroxide have made it possible to predict, by a mathematical equation, the course of the decomposition of either of the materials of any regular geometrical shape. Many practical difficulties in this research are still to be mastered, but the industrial importance of such reactions appears to warrant the effort.

Another investigation of general interest has been the study of the operating variables of the hydrocyclone. Hydrocyclones are used extensively in the mineral industry and in the pulp and paper industry for operations such as classification, thickening, and dewatering.

Mineral Processing

Owing to greater demand by the mining industry, both personnel and laboratory facilities for mineral processing, as in previous years, were engaged to capacity. The increase in work arose from more complex problems in the mining industry and greater demands on the laboratories, especially in respect of recoveries and grades of concentrates.

The metallic minerals laboratories received several requests for investigations from mines seeking to improve the efficiency of their operations, but most ores were received from companies building or about to build concentrating plants and requiring help with planning.

In the pilot plant and in the laboratory, 52 samples of ore were investigated, varying in weight from a few pounds to several carloads. Iron ore continued to predominate with 21 samples. Five were mill products or ores of gold, and twelve were ores of copper or copper associated with iron, zinc, or gold. There were three investigations on silver, silver-zinc and silver-lead ores, two on manganese, and the remainder were on special products or ores of less common metals.

Typical of such studies were the successful processing of 150 tons of ore from an Ontario property by magnetic separation in the pilot plant; the processing of 50 tons of copper ores from a copper-gold-zinc property in Quebec about to start producing a reported 1,000 tons per day; the analysis of 180 tons of ore in the flotation pilot plant from a large property, also, in Quebec, where a 3,000-ton concentrator is to be built; a field study at a silver mine in Ontario, which resulted in improved recoveries by a rearrangement of the grades and reporting areas of the silver in the milling procedure; and others.

Ten metallurgists of various mining companies collaborated with scientific officers, mostly on pilot plant work. Four mining companies took advantage of Mines Branch facilities to carry out seven investigations using the pilot plant and small-scale investigations at a steady rate.

The Branch decided to establish a research laboratory for investigation of iron ores and with special reference to hematite ores and general investigations of this type of ore. It is expected that this research laboratory will be kept fully occupied with samples for investigation.

A record number of major laboratory investigations on industrial minerals were carried out during the year. In addition to 650 samples received in the industrial minerals laboratories of the Mines Branch for examination and testing, this group was frequently consulted by industry on technical problems.

Six major investigations were completed on structural clay products; three were studies of mineral composition, properties and raw materials for the industry. Plasticity, firing properties and thermal expansion of local shale-plastic clay mixtures were correlated with material preparation, kiln design and firing schedule for a new face brick plant in eastern Ontario. A manufacturer in the Montreal area was assisted in selecting a suitable clay to be incorporated with a local shale. In another study, the cause and prevention of efflorescence on an Ontario face brick has been investigated. A relationship was established between ceramic properties and mineralogical composition for several Saskatchewan clays. Plasticity and workability of a bentonitic clay from Alberta were studied to develop a better control of the material in structural clay products manufacture. In the laboratory a method was developed to incorporate feldspathic tailings from a deposit in Quebec in the manufacture of a premium quality buff face brick. In addition, the properties of 121 clays, shales, refractory raw materials and ceramic products were determined for industry, private individuals and government departments.

Extensive field and laboratory studies of Canadian clays and shales were completed as part of a continuing project. During the year particular attention was directed towards clays from the Maritime provinces and from the Whitemud formation in Western Canada.

At the request of Atomic Energy of Canada, the problem of making dense compacts of lithium fluoride was investigated.

Continuing the development of piezoelectric compounds in cooperation with the Naval Research Establishment, the sintering of lead-zirconate-titanate compounds was improved by control of particle size and purity of the primary materials.

Research was continued to develop fired compounds of metallic oxides with desirable electrical properties.

In the Branch's work in construction materials, several projects deserve notice. Noteworthy was the participation in the restoration of the fortress of Louisbourg.

Exploration for new sources of pozzolans continued to be active in Western Canada. These materials are particularly effective in mass concrete in large structures for controlling heat released during hydration of cement.

Lightweight aggregates have become important as construction materials. Lightweight structural concrete made from expanded clay or shale is being used cast-in-place in precast panels or slabs, and—to a lesser degree—in prestressed building components. Seventy-four samples of clay and shale from five provinces were investigated to determine their properties as an expanded aggregate. The more promising were selected for further processing in a pilot plant kiln and were incorporated in experimental concrete mixes.

Architects have found that, by exposing aggregates, color, texture, and varied design can be incorporated in structures in contrast to the traditional drab gray appearance of conventional concrete. The Mines Branch is collecting colored rocks suitable for use as exposed aggregate.

Research is in progress to discover the effect of prolonged low-humidity exposure on concrete containing the various types of aggregate commonly used in Canada. The Branch is co-ordinating a cement-testing program sponsored by the Canadian Standards Association. Twenty-eight laboratories across Canada are participating in an attempt to develop more uniform procedures for the testing of cement.

During 1961, beneficiation of several industrial minerals was studied. A process was developed for the concentration of a potential commercial-quality graphite from a deposit in eastern Ontario.

A muscovite schist in eastern British Columbia, near Jasper, is being developed to provide a source of material for grinding into products for Western Canada industry.

A process was established for the separation of silicon carbide from furnace residues for the manufacture of abrasives.

The problem of beneficiating impure Canadian kaolin was approached through chemical treatment and flotation. Removal of fatty acid coatings from mineral particles introduced through flotation has been possible with several minerals.

In the long-term research on the flotation of pure non-metallic minerals, 450 tests were completed.

During 1961, the industrial waters laboratories moved into new quarters, and analyzed 2,300 samples.

Surveys of the chemical quality of surface waters in the remote and thinly populated regions of Canada, particularly in the Yukon Territory, continued.

To provide information on water quality in the major rivers of Western Canada, the five-year survey started in 1960 has been extended to 72 sampling stations in the four western provinces. At the request of the International Joint Commission, 15 of these have been located on international rivers.

Technical assistance on problems of water quality, treatment and corrosion was made available to provincial government agencies, municipalities, consultants and industry.

Thirty heating plants at military establishments across the country are now included in the boiler water treatment program. In addition, the survey of water quality at a number of defence establishments continued.

In cooperation with the National Association of Corrosion Engineers, the Branch participated in a two-year study to correlate water quality with the corrosion of water distribution systems at selected locations in Canada and the United States.

During the year, 222 non-metallic mineral samples were received for examination. Of these, approximately one third required further investigation in the laboratory.

Research on a process for converting apatite to phosphate fertilizer by fusion continued. In another study, 71 samples of bentonitic clays from Manitoba were investigated to determine their properties, possible methods of processing and usefulness to industry. The Branch continued the development and improvement in processing silica raw materials to provide a product that meets the stringent specifications of the domestic glass industry.

The Branch cooperated with other government departments by providing technical assistance on frequent occasions and assisted the Canadian Standards Association and Canadian Government Specifications Board in the preparation of specifications in industrial minerals and their products.

dominion observatories

THE work of the Dominion Observatories during 1961 concerned the physical nature and other characteristics of the stars, the members of the solar system, the deep interior of the earth, the earth's crust and the earth's atmosphere.

The Observatories continued to study solar flares and solar magnetism, which have a strong influence on the earth's atmosphere. The stations at Meanook and Newbrook, Alberta, observed meteors, and field parties investigated meteorite craters at several sites. The maintenance of accurate time was refined; the accurate time signal broadcast by the Observatories on three short-wave frequencies has become widely known and appreciated.

The work of providing accurate star positions for navigation and surveying was continued and a new mirror transit telescope, designed to improve the accuracy of observations and to reach fainter stars, was finally completed and subjected to the first of a series of tests which will extend over many months.

In accordance with the policy of extending geophysical observations to the Canadian north, a regional gravity survey covering 120,000 square miles was carried out in Southern Baffin Island. Still further north on the Polar Continental Shelf gravity was measured on the arctic ice on the channels between Borden and Meighen Islands and for 130 miles out to sea on the Arctic Ocean.

New seismic and magnetic observatories were set up at Alert and Mould Bay, N.W.T., and one of the first observations at the Alert station was a seismic record of what was believed to be a hydrogen bomb blast

in northern Europe. Many small earthquakes have already been recorded by these two stations, indicating that the Canadian Arctic Archipelago is a seismically more disturbed region than was formerly supposed.

Geomagnetic records from the Alert station indicated a level of magnetic field variations much greater than would be expected in this area and the suggestion has been made that this may be due to the presence at great depths under the station of a volume of rock of high electrical conductivity. In connection with the preparation of magnetic maps the Observatories' three-component airborne magnetometer was used to map a large area of Southern Canada extending from the Pacific coast to eastern Ontario and western Quebec, and from the United States border to 65° north latitude.

At the Dominion Astrophysical Observatory in Victoria a new 48-inch reflecting telescope of highly specialized Canadian design has been installed, and this fine instrument will in effect double the observing capacity of the Observatory. The Radio Astrophysical Observatory at Penticton, B.C., has made interesting discoveries concerning the invisible clouds of hydrogen in the milky way with the aid of its short-wave 84-foot reflector and has begun the construction of a new antenna array for the study of long-wavelength galactic radiation.

The Branch prepared intensively for the so-called Upper Mantle Project, a world-wide study of the relationship between the earth's crust and the layer of ultra-basic rock immediately below the crust. This project, which was initiated by the International Union of Geodesy and Geophysics, aims at directing the attention of geophysicists to the influence of the earth's mantle on the flow of heat, the production of earthquakes, the outbursts of volcanism and the formation of orebodies on or near the surface of the earth.

Positional Astronomy

An accurate knowledge of star positions and movements is indispensable in all forms of endeavor involving position-finding on earth, and positional astronomy occupied an important share of the Observatories' work.

Observations with the Meridian Circle transit telescope were continued within the current program which began in 1956 and which will be completed in 1963. About one-third of the nights at Ottawa are suitable for meridian astronomy, which compares favorably with other locations.

For almost ten years, Ottawa astronomers have been developing a new design of transit telescope called a Mirror Transit consisting of two telescopes facing each other in a north-south line, with a mirror between them. The Mirror Transit is now mechanically complete and is being tested

and adjusted. Observations made thus far indicate that the new instrument will function satisfactorily, and astronomers hope that it will provide much-needed improvement in meridian observation.

Maintenance of accurate time by means of steller observations was the main task of the Photographic Zenith Telescope (PZT). During 1961, the Observatory at Ottawa contributed 172 nights of observations to the Bureau international de l'Heure and to the International Latitude Service. The PZT was built in Canada following the design of a similar instrument developed at the United States Naval Observatory. From night to night the PZT observations measure earth rotation with an accuracy of a few thousandths of a second.

Measurements of the earth's annual journey around the sun, deduced from photographs of the moon against the background of stars, were being made with a Markowitz Moon Camera adapted to the 15-inch equatorial. During 1961 the best plates were measured and the results computed. The plates are being sent to Washington for comparison with those of other observatories.

The uniformity of pulses emitted by the Observatory's short-wave transmitter CHU is better than one-thousandth of a second per day. For many years seconds' pulses via CHU have been broadcast with a precision that was adequate for most purposes. The present status of the transmitter raises it to the level of a national working standard for the monitoring of broadcast frequencies in Canada. The transmitter is operated in cooperation with the National Research Council, which maintains an atomic clock. While the time signal is received regularly in much of Canada and in other parts of the world, it is not received well in the far north and west of the country, and means are being considered to rectify the situation, probably by the establishment of satellite transmitters.

The advance in Canadian timekeeping permitted the Observatory to adjust on January 1 to the new uniform system of synchronized transmissions adopted by the United States and Britain on that date. During the year, other national observatories have adjusted their emissions and regulated them with the atomic clock monitoring.

A few observations were made at Ottawa of artificial earth satellites using a wide-angle equatorially mounted camera and an accurately timed shutter to provide a segmented or dashed trail. Measurements made on observations of Echo I and Sputnik IV were forwarded to Russia, England, and the U.S.A.

The future location of the Ottawa Observatory is not at all certain. For the present, it is decreed that a new site will have to be selected so that the present location may be restored to the Department of Agriculture for the development of its growing requirements. The search for a new site concerns mainly the two astronomical divisions. Good seeing conditions with freedom from encroachment by both urban and industrial developments is a

prime factor. The Gatineau Park seems to present the required isolation and higher terrain, and a spot about 25 miles by road and trail from the Observatory has been selected for tests. To begin with, meteorological instruments will be installed, and early in 1962 observing will begin.

Preliminary steps are being taken to observe the total solar eclipse of 20 July 1963 in cooperation with the R.C.A.F. from an altitude of 30,000 feet.

Stellar Physics

The Dominion Radio Astrophysical Observatory, near Penticton, B.C., used its 84-foot radio telescope in a study of the distribution of hydrogen surrounding an interesting association or cluster of stars in the constellation Auriga. Such investigations should clarify details of the process of stellar formation, and the 84-foot telescope has proven capable of producing excellent records.

Further instrumental developments have continued at the Radio Astrophysical Observatory. Much energy has been devoted to adapting a low-noise amplifier device for use with the telescope. This shows promise of improving the sensitivity of the instrument so that the rate at which observations are taken may be increased by a factor of ten or more. Techniques for the analysis of the data by digital computers have been developed to speed up the reduction and analysis of observation.

During 1961 the design of a low-frequency telescope array was completed and part of the installation was accomplished. This instrument will supplement the data obtained from the 84-foot reflector. The new array will be in the shape of a "T" with a long crossbar about $\frac{3}{4}$ of a mile in length. This instrument will take advantage of the exceptionally quiet nature of the site to work at a frequency near 22 megacycles where man-made interference has prevented some other observatories from operating. By observing the same sources at a high frequency with the 84-foot dish and at a low frequency with the T-array, information on the type of emission will be secured which is unavailable from studies with only one instrument.

The program of solar research is conducted in Ottawa where a solar telescope equipped with a powerful spectrograph is the main instrument. Auxiliary equipment is nearing completion which will convert this instrument to a solar magnetograph, capable of measuring the strengths of the powerful magnetic fields which occur in localized regions on the sun. The importance of magnetic fields and their control over many aspects of solar physics has been emphasized by scientific developments in recent years. The magnetograph employs the fact that a magnetic field will slightly alter the spectrum given off by a hot source, such as the sun, and by careful study of the spectrum the magnitude of the magnetic field may be measured.

The magnetograph of the Dominion Observatory will scan selected areas of the solar disc at fairly rapid intervals. It has been found necessary to incorporate an automatic guiding device to compensate for motions of the image produced by atmospheric turbulence near the telescope. This guider was assembled and initial tests were carried out during 1961.

A patrol camera designed for the detection of solar flares was operated for some time during the year.

The meteor observatories at Meanook and Newbrook in northern Alberta continued the photographic recording of meteor trails and meteor spectra. Because of favorable weather the year produced a volume of photographic data well above average. The data are analyzed in Ottawa and may be used to study the physical properties of both meteors and the upper atmosphere near heights of 50 miles. A better knowledge of the atmosphere and the distribution of meteoric material within the solar system is especially valuable in dealing with problems in space research.

While meteors may collide with the earth at any time there are certain intervals during the year when the earth passes through a stream of meteoric material and a meteor "shower" results. Many of these showers are quite constant from year to year while others may vary dramatically. An unexpectedly strong Leonid shower was observed at the Alberta stations on November 16, 1961, emphasizing the importance of observing on all suitable nights. This shower is the remnant of a stream which produced the most spectacular meteor display of the nineteenth century in November 1833, and the opportunity of observing it with modern equipment has produced several first-class spectrum observations.

The stellar physics staff was well represented at the meetings of the International Astronomical Union held in August, 1961, in Berkeley, California. The formal meetings and opportunities for informal discussion with astronomers from other countries provided a stimulus to the research activities.

Geomagnetism

The routine and research work in geomagnetism again increased, stimulated by post-I.G.Y. activities in geomagnetism, aeronomy and space-science, technological advances in data-processing and instrument design; and by greater emphasis on the use of geomagnetic phenomena to investigate physical parameters of rocks at depth within the crust and upper mantle.

Magnetic charts of Canada are widely used for air and sea navigation, surveying and civil engineering purposes and for geophysical prospecting. They must be revised periodically because of continuous changes in the direction and intensity of the magnetic field. Data for such revisions were obtained by field parties operating in western Quebec, Ontario, Manitoba

and along the west coast. During June and July, a survey of the central part of Canada was made with the Dominion Observatory's three-component airborne magnetometer in a chartered DC-4 aircraft. The variations of the compass, and the horizontal and vertical intensities of the magnetic field were measured along east-west lines, spaced 60 miles apart and totalling 45,000 line-miles. The area covered extends from the southern border of Canada to latitude 64°N, and from longitude 66°W to 122°W.

More than 1,250 items of magnetic data were supplied to government mapping agencies and geophysical prospecting companies, including information on magnetic declination (variation of the compass) for 63 map sheets. The development of automatic computing techniques for map compilation has continued. More than 15,000 ground and airborne observations (those up to 1960) have been entered on punch cards, and machine programs devised and run to correct the observations for secular change. A program to smooth the data ready for mapping is under way, and the revision of programs for use with the new 1620 computer started. The airborne magnetometer results have been distributed to interested agencies in a book format.

The completion during the year of permanent buildings at Alert and Mould Bay, Northwest Territories, brought the number of continuously operating magnetic observatories in Canada to seven. The others are Agincourt, Ontario; Meanook, Alberta; Victoria, British Columbia; and Baker Lake and Resolute Bay, Northwest Territories. Instruments and facilities at all these locations were improved during the year. Observatory publications for the International Geophysical Year were published for Resolute Bay and Baker Lake, and further progress made with others. Considerable magnetic disturbance index information for the International Geophysical Year has now been compiled ready for publication. It is expected that Agincourt magnetic observatory will have to be replaced by a new observatory within the next few years, because of increasing industrial development in the Agincourt area. Detailed surveys have been made of four possible sites for a new observatory in eastern Ontario.

A proton-precession magnetometer was developed which indicates the intensity of the magnetic field directly.

Planning of a new gyro-stabilized platform for the three-component airborne magnetometer has started. Work is also well advanced on the construction of a semi-automatic magnetogram analyser.

A study of the effect of time variations in the earth's magnetic field on aeromagnetic surveying was completed and published. As a result of this research, the staff has embarked on a regional experimental program using pairs of recording proton precession magnetometers separated by considerable distances and capable of continuous automatic operation. With increasing station separations along north-south and east-west lines, scientists found that magnetic fluctuations of different period change magnitude and

phase differently. Preliminary experiments between Ottawa and Old Chelsea, and Ottawa and Farrelton have been completed and an analysis of the results will be used to direct further larger-scale experimental programs.

Research has continued on irregular fluctuations in the earth's field during different types of magnetic storms recorded during the I.G.Y.; the first results will shortly be published together with a discussion of the daily variation of the magnetic field in Canada. Many interesting differences occur between the Canadian results and those reported from similar latitudes in Russia.

The unusual behavior of the earth's magnetic field at Alert, N.W.T., revealed in the I.G.Y. observations, was investigated with an intensive field program during April-August 1961. The effect seems to be largely local, and there is some evidence that a highly conducting region of the earth's mantle could account for the results. Further work on this phenomenon is planned.

Currents induced within the earth by the rapidly varying magnetic fields which characterize magnetic storms were studied in detail at Meanook, Alberta, and progress was made in the interpretation of the observations in terms of the conductivity of the earth at depths of about 30 to 100 miles. The Branch intends to continue these studies as a contribution to the International Upper Mantle Project beginning in 1962.

Gravity

The measurement of gravity over the oceans of the earth has been a challenge to earth scientists since 1849 when Stokes propounded his famous theorem which would relate the sea level surface to the spheroidal, i.e., mathematical surface, if gravity observations were available from all over the world.

Measurements of gravity on land were accumulated slowly until the past two decades, when there was a tremendous increase in gravity measurements following the break-through in the 1930's with the development of the spring gravimeter. Progress in measurements at sea has been much slower, and all scientifically advanced countries are making enormous efforts in this field both to make use of existing instrumentation and to push research in the hope of a spectacular advance similar to that which occurred in land measurements twenty-five years ago. During the year the Branch extended the scope of its measurements on sea ice, initiated a program of measuring gravity on the sea floor and accelerated research on a vibration gravimeter for use on surface vessels and submarines. A LaCoste and Romberg underwater meter modified specially for use on sea ice proved very satisfactory for measurements on the Arctic Ocean, and some 350 stations were observed over the continental shelf (see map). Water depth soundings were made simultaneously by an observer of the Canadian Hydrographic Service,

and both observers and instruments were transported by an S55 helicopter. These are the first measurements of gravity to be made over an oceanic area by a Canadian team. The quality of the observations was equal to that usually obtained over land, but progress was slow owing to the short period of good flying weather and the restricted facilities for navigation and station fixing.

The same basic instrument was re-adapted to its original function as an underwater meter. Thirty measurements were made on the floor of Hudson Bay between Churchill and the Belcher Islands. These were the first underwater measurements made by the Branch and as such they provided not only a rigorous test of the instrument but showed that this technique is eminently suitable for surveys of inland waters including Hudson and James Bay, coastal waters, and the continental shelves out to depths of about 1,000 feet.

In spite of extensive and persistent research by scientists throughout the world, no reliable, accurate method of measuring gravity on a surface vessel has yet been developed.

At the observatory, research on a principle differing completely from the usual spring or pendulum has been under way on a modest scale for several years. Essentially, the principle consists in measuring the effect of changes in gravity on the frequency of a vibrating wire. Initially a beryllium copper wire was used, but during the past year technicians began the construction of a second unit made entirely of quartz. Also, in cooperation with the National Research Council a gyrostabilized platform originally designed for airborne use was modified for use with gravity apparatus at sea. In addition, theoretical studies have been made to assess the range and limit of accelerations that may be encountered by a gravimeter on a ship.

Each of these approaches to the problem of gravity measurements at sea has its limitations. The ice-meter is limited by ice and weather conditions as well as by the area of Decca coverage; the underwater-meter is limited to relatively shallow (less than 1,000 feet) water and to the availability of a suitable ship; surface measurement is still in the development stage, but with even the most promising developments the accuracy attainable will be lower than that obtained on land by a factor of ten or more. By pursuing each of these techniques to take optimum advantage of all opportunities and developments the Observatory expects to keep pace with other disciplines working towards solutions of the many mysteries concealed by the oceans of this planet.

In conjunction with the departmental Polar Continental Shelf Project some 700 stations were observed (see map) over the islands and channels of the Queen Elyizabeth Islands apart from the work on the sea ice mentioned above. An anomaly map and report on the work of the last two years in this area is being prepared. In the report interpretation of the anomaly pattern gives an estimate of the depth to basement rock formations along several

profiles and of the amount of basic rock that has been intruded over the sedimentary layers. In another report the depth and configuration of the intrusions beneath the Isachsen and Dumbbells gypsum domes is being estimated from the anomaly pattern.

The measurement of gravity on the land area of Canada is still far from complete even at reconnaissance scale. Here, as in many other types of surveys, the field technique is well established so that the major research effort can be devoted to interpretation of the anomalies that are observed. In 1961 the Observatory strengthened its map compilation section which was formed during the previous year and made refinements in the electronic data-processing procedures. Benefits from these efforts will accrue gradually in the form of a steady output of anomaly maps.

Two major aircraft-supported parties were in the field during the summer. In central Quebec (see map) some 1,700 stations were observed at a density of one station every eight to ten miles; two Beaver aircraft were used for transportation on this project. In the southern half of Baffin Island (see map) some 2,200 stations were observed at intervals of approximately eight miles; for this survey two Bell 47J helicopters were used, supported by a DC3 aircraft on skis in May and early in June and by a Norseman aircraft on floats after the ice went out of the lakes in mid-July until freezing started again early in September. The results of these surveys are being processed as rapidly as possible and will take the form of Bouguer anomaly maps at a scale of 1:500,000. The field officers in charge of these projects will then correlate these anomalies with available geology and density information and will prepare reports for distribution to the public along with the maps.

Several more detailed gravity surveys were undertaken at the request of other agencies. In the Mount Albert region of Gaspé one hundred stations were observed to provide more information needed to evaluate the basic intrusive rock formation as a possible drilling site for the Upper Mantle Project. In Ontario 175 stations were established near the Anstruther Batholith in the Bancroft area to assist geologists of the Geological Survey of Canada in their study of this feature.

During the year the Observatory's program of study of ancient meteorite craters was continued. Detailed mapping of the surface geology of the Brent crater and vicinity, and a careful examination and petrographic study of drill core specimens from the underlying rock formations are being carried out. As a preliminary to a comprehensive study of the New Quebec Crater in the remote Ungava region of northern Quebec, gravity measurements and depth soundings were obtained in March from the ice surface of the lake which occupies the crater. Further gravity and depth determinations were made later in the summer. At the same time sufficient horizontal and vertical control measurements were carried out to prepare a large scale topographic map of the crater area.

Seismology

In 1958 the Department began a program to expand the seismological network of Canada. This was done partly as a contribution to the study of the earth's interior by international seismology, partly to assist in the study of nuclear explosions and partly to give information on seismic risks within Canada. During 1961 the final planning for this network was completed. All sites have now been visited and site plans for the last of the vaults are being drawn. During 1961 stations at Alert (the most northerly seismograph station in the world) and Mould Bay were brought into operation, and new instruments were installed at Victoria. The vault at Seven Falls was prepared for the new instruments, the vault was completed at Schefferville, Que., and construction of a new vault at Ottawa and a training vault at Scarborough were well advanced. During 1961 also, as part of the Upper Mantle Project, the decision was reached to speed up the rate of installation of new stations to five per year. With this program the new network will be completed in 1965. Canada's effort in improving this seismological network is being parallelled in other countries, and a good deal of thought is being given internationally to standardizing these networks and to setting up central agencies to avoid duplication in routine work. The Chief of the Seismological Division is a member of an international committee set up for this purpose and he was also a member of a UNESCO Mission sent to South America to investigate the state of seismological observatories in that continent.

There were no major earthquakes in Canada during 1961, but some 314 minor shocks were recorded, 11 in Eastern Canada, 60 on the Arctic Islands and 243 on the west coast. These locations have been published in the Canadian bulletins and will be listed in a paper under the title "Canadian Earthquakes 1961". Catalogues have been sent to press listing all the known earthquakes in the Canadian Arctic and all earthquakes in Eastern Canada to the end of 1927.

One of the interesting possibilities of seismological instrumentation at present lies in tape recording. Equipment is being developed to use tape recorders to record blasts in the field and to record earthquakes in the central observatory. In the latter program the instruments have been perfected, but the central station has been shut down for the construction of new vaults so that the new instruments have not been placed in routine operation. Tape-recording field equipment has been tested under field conditions and final difficulties are being ironed out.

Field work has been carried out in the vicinity of Ottawa, in British Columbia and on the Polar Shelf. In Eastern Canada and British Columbia this field work aims at studying the thickness and physical properties of the earth's crust. On the Polar Shelf primary interest concentrates on the sedimentary layers, but the work is being extended to greater depths.

Seismological studies were also made during the year of the depth of the large meteorite crater 7½ miles in diameter at Deep Bay, Saskatchewan. The depth found, 2,000 feet, was closely in agreement with the depth of lunar craters of similar diameter.

The Observatory's program for studying the mechanism of all large earthquakes has been continued.

Dominion Astrophysical Observatory

The Dominion Astrophysical Observatory pursued its aims along two general lines:

(1) by the observation of the motions and distribution of the stars and the material between the stars so that the organization and natural laws of our galaxy may be investigated; and

(2) by detailed studies of the physical and chemical nature of stars and interstellar matter, the abundance of the elements in extra-terrestrial bodies, and something of the amount and mode of generation of solar and stellar energies.

During 1961 a major addition to equipment has been made in the acquisition of a new telescope and powerful spectrograph. This latter instrument, the most powerful of its kind to be used in Canadian astronomy, receives starlight collected by the telescope and arranges it in an orderly pattern for measurement and study. Photographs of the dispersed radiation of stars obtained with a spectrograph form the original observations and are the starting point of astrophysical researches. Much of the spectroscopic equipment used at the telescope and the specialized instruments employed in the study of the photographs are designed at the Observatory and built in its workshop. During the year much of the new spectrograph has been constructed and a new instrument for the measurement of intensities of stellar radiations has been put into service. Other instruments are being designed.

The Observatory during the year continued the observation and study of the motions and distribution of distant stars, the detailed study of a few selected stars, and the observation of a number of double stars. The telescope was used on 185 nights to obtain 1,350 photographs of stellar spectra. A catalogue of spectral details of selected stars was prepared as part of an international cooperative project, and a catalogue of the measured speeds of 550 distant stars was prepared for printing. Computational programs designed to extend our knowledge of the composition of stars by theoretical methods were carried on with the aid of powerful modern computers. Special attention was given to detailed observations of some 20 double stars whose orbital motions will yield information about stellar masses, dimensions and internal structure.

Staff members attended six Canadian and international scientific conferences presenting a total of eleven papers. One staff member spent four months in the U.S.S.R. under an agreement for the exchange of scientific personnel. A British astonomer and a Czech astronomer each spent four months at the Observatory as guest investigators. The Observatory was represented on the Executive Committee of the International Astronomical Union, on the Astronomical Society of the Pacific, the Royal Astronomical Society of Canada, and the Canadian National Committee of the International Astronomical Union.

Some 15,000 members of the public visited the Observatory during the year and 23 public observation periods were attended by 3,500 persons. Astronomical information was supplied to airport and meteorological authorities, and a large number of inquiries from the press, the public, and from business concerns was received and answered.

geographical branch

THE Geographical Branch, in 1961, accelerated its land-use mapping and published the first four land-use sheets on topographical scales. Field work was carried out in every province, except Quebec, Manitoba, and Alberta. The Branch also intensified its work in glaciology and started a long-range investigation of the Barnes icecap and vicinity on Baffin Island.

Elsewhere in Canada, the Branch undertook several studies in terrain analysis with emphasis on the far north, and conducted a study of 30 settlements in the District of Mackenzie.

During the year research and investigations concerning geographical names were transferred to the Branch. Decisions on the official use of such names are made by the Permanent Committee on Geographical Names which was established by Order in Council on July 13, 1961.

In all, 31 geographers were in the field: 14 in the far north, three on the arctic mainland, one in Newfoundland, two in New Brunswick, two on Prince Edward Island, one in Nova Scotia, one in Ontario, four in Saskatchewan, and three in British Columbia.

Terrain

During 1961, terrain analysis studies were continued in various parts of arctic Canada. These studies will contribute to an understanding of physical processes at work in the north and will permit a more precise assessment of resources.

The field work for a reconnaissance study of the physical geography of Ellef Ringnes Island, N.W.T., was completed, particular attention being paid

to the geomorphic processes now modifying the landscape in that area. In addition, field workers made quantitative studies, measuring ground temperature and examining stream flow and sedimentation. A preliminary study of the physical geography of Borden Island was also completed, with emphasis on the influence of snow melt-water in landscape development and on the physiographic significance of the drainage pattern.

Five geographers carried out a reconnaissance study of a wide area in central Baffin Island. The results of this reconnaissance will be used in planning a comprehensive terrain study of Baffin Island to be made during the next several field seasons. Three geographers of this group, operating from a base near the northern end of the Barnes icecap, carried out detailed studies of the glacial geomorphology of the area. Examination of landforms helped to understand the sequence of events during glaciation and deglaciation. Specific studies included analysis of till fabric characteristics in the peculiar morainic ridges of the area, and precise levelling of glacial lake shorelines. A brief examination was made of emerged marine features in the vicinity of Steensby Inlet.

Two geographers examined selected areas across the waist of Baffin Island south of the Barnes icecap and completed a reconnaissance study of terrain between Home Bay on the east coast and Foxe Basin in the west. This party began a detailed study of post-glacial land emergence on the Foxe Basin coast in the vicinity of Piling and Ikpik bays.

A geographer continued studies begun last year of the boulder barriers in the tidal zone of arctic waters. Field work was concentrated this year in the vicinity of Churchill, Manitoba, and Frobisher Bay, N.W.T.

Two geographers, working with a topographical engineer, completed field studies of the physical geography of 30 settlements in the Mackenzie River region, from Hay River to Tuktoyaktuk and along the mainland coast from Northern Yukon to Pelly Bay. The data collected will form the basis of reports useful in planning the development and construction of settlements in the north.

Glaciology and Ice

The Geographical Branch was given a larger share of glaciological studies in Canada, and it carried out two particularly important projects in 1961. A glaciological party camped on the small Meighen Island icecap for three months during the summer, taking standard meteorological and ice regime observations, and measuring temperatures within the ice with thermocouples. The icecap was resurveyed to permit precise determination of movements of the ice margin, and an examination was made of the physiography of the ice-marginal area.

To further the inventory of Canadian glaciers, in which the Branch collaborates with the Sub-Committee on Glaciology of the Associate Committee on Geodesy and Geophysics of the National Research Council of Canada, a geographer travelled on the eastern Arctic patrol vessel *C. D. Howe*. He photographed valley glaciers and icecaps in southern Ellesmere Island, Devon Island, and eastern Baffin Island. By comparing his own photographs with those taken by early explorers the geographer determined whether there had been any recent changes in the position of the ice margin.

On Baffin Island, the northern and southern margins of the Barnes icecap and the glacial tongues and icecaps in the vicinity of Ekalugad Fiord were examined briefly.

The Branch intensified and expanded its investigation of sea ice, both to aid navigation and to provide scientific reference reports on the changes of ice distribution and its character. Early in the year the Branch completed its annual aerial survey of ice in the Gulf of St. Lawrence and St. Lawrence River, in 11 flights and 175 flying hours. The project was carried out in cooperation with the Royal Canadian Air Force and the Defence Research Board of Canada. The first aerial survey of ice north of Parry Channel, begun during summer in cooperation with the Polar Continental Shelf Project, took up 116 flying hours.

Land Use

Land-use mapping is essential in developing a solid basis for forestry, agricultural, community and industrial development. The Branch's work in this field, carried out in cooperation with some of the provinces, consisted of the following:

In Newfoundland, five map sheets at 1:250,000 were mapped in the field.

Of the eight 1:250,000 sheets of Nova Scotia, three were published and two were sent for printing.

The mapping of New Brunswick at a scale of 1:250,000 continued, and five of the sheets were field-mapped.

A new base at the scale of 1:126,720 was produced for the Prince Edward Island land-use map and the field data for Prince County were reduced from 1:50,000 to this scale.

One 1:50,000 sheet of the Niagara Peninsula Land Use (Dunville 30 L/13 E) was published and five other sheets were sent for printing. A portion of Essex County was mapped and the material prepared for publication. A composite sheet at 1:50,000 covering Point Pelee and Pelee Island was prepared for publication. A study of the relationship between land use and manufacturing in the Toronto area, in cooperation with the University of Toronto, was continued.

In Saskatchewan, the air photo interpretation of the Hanna-Kindersley 1:500,000 sheet was checked in the field, and a study of the physical basis of land use in the prairies continued in the Moose Jaw-Watrous area.

In British Columbia, in close cooperation with the Lower Mainland Regional Planning Board of B.C., the mapping of the Lower Fraser Valley was continued, and one sheet completed for the printers. The field mapping of the four 1:50,000 sheets covering southern Vancouver Island was completed and the material prepared for publication.

Toponymy

Research on geographical names and terminology is necessary for decisions concerning their official use, particularly on maps and charts. During the year, data on the origins, correct spelling and application of 16,391 names were investigated and provided to members of the Canadian Permanent Committee on Geographical Names. In addition, 1,256 general inquiries for information were dealt with, which included assistance to the publishers of the Canadian official Railway Guide. The preparation of a gazetteer of Ontario was almost completed.

Other Activities

The Branch continued to measure special geographical features of Canada to update sections of the *Canada Year Book* and provide accurate information for various other reference works. Areas and elevations of several of the larger Canadian lakes were re-measured, from maps, during the year.

One geographer worked with the Emergency Measures Organization in an investigation of designated zones and regions of Canada.

The Branch added approximately 12,066 map sheets to its map collection, bringing the total to 168,466 sheets, and acquired 1,588 books, pamphlets and atlases. It made further exchanges of publications (including maps) with foreign governments and geographical institutions.

Among the many special projects in which the Branch participated was photogrammetric research on a test area in Ontario which was carried by the *Institut fuer Photogrammetrie, Topographie und allgemeine Kartographie* of Munich, and the preparation of a report on urban geography and urban land use for the Royal Commission on Government Organization. The Branch also contributed information on Canadian geography to the *Bibliotheca Cartographica, Bibliographie Cartographique Internationale,* and *Geo-Science.* It participated in several national conferences and served as a consultative member of the Canadian National Commission for UNESCO, and maintained the Secretariat of the Canadian Committee of the International Geographical Union.

The Branch director was vice-chairman of the Canadian delegation to the VII General Assembly of the Pan-American Institute of Geography and History, held in Buenos Aires, Argentina. He also attended the meetings of the International Commission on the Methods of Economic Regionalization in The Hague.