CANADA

ANNUAL REPORT

CALENDAR YEAR

1960

Department of

MINES AND TECHNICAL SURVEYS

annual report

Calendar Year 1960

Department of Mines and Technical Surveys

98195-1—1

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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 1960.

Respectfully submitted,

PAUL COMTOIS
Minister of Mines and Technical Surveys

The Honorable Paul Comtois,
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 1960.

MARC BOYER
Deputy Minister

Senior Personnel of the Department
as at December 31, 1960

MINISTER

THE HONORABLE PAUL COMTOIS

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 1960 follows:

	Revenue	Ordinary Expenditures
Minister of Mines and Technical Surveys	$	$ 17,000.00
Departmental Administration	....	971,128.94
Explosives	8,068.82	94,580.73
Mineral Resources Division	....	327,904.36
Assessment for membership in the Pan-American Institute of Geography and History	....	8,871.86
Surveys and Mapping Branch	203,958.13	11,300,453.53
Geological Survey of Canada	23,962.59	4,133,186.44
Mines Branch	13,155.68	4,258,199.58
Geographical Branch	5,383.62	416,149.93
Dominion Observatories	6,089.14	1,793,321.51
General—		
To provide for payments under the Emergency Gold Mining Assistance Act (Chap. 95, R.S., as amended)	....	12,504,088.48
To provide for purchase of Air Photography and the expenses of the Interdepartmental Committee on Air Surveys	....	1,524,875.88
Provincial and Territorial Boundary Surveys	....	40,692.25
Polar Continental Shelf	1.00	1,507,018.58
Awards	....	7,352.50
	$260,618.98	$38,904,824.57

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.

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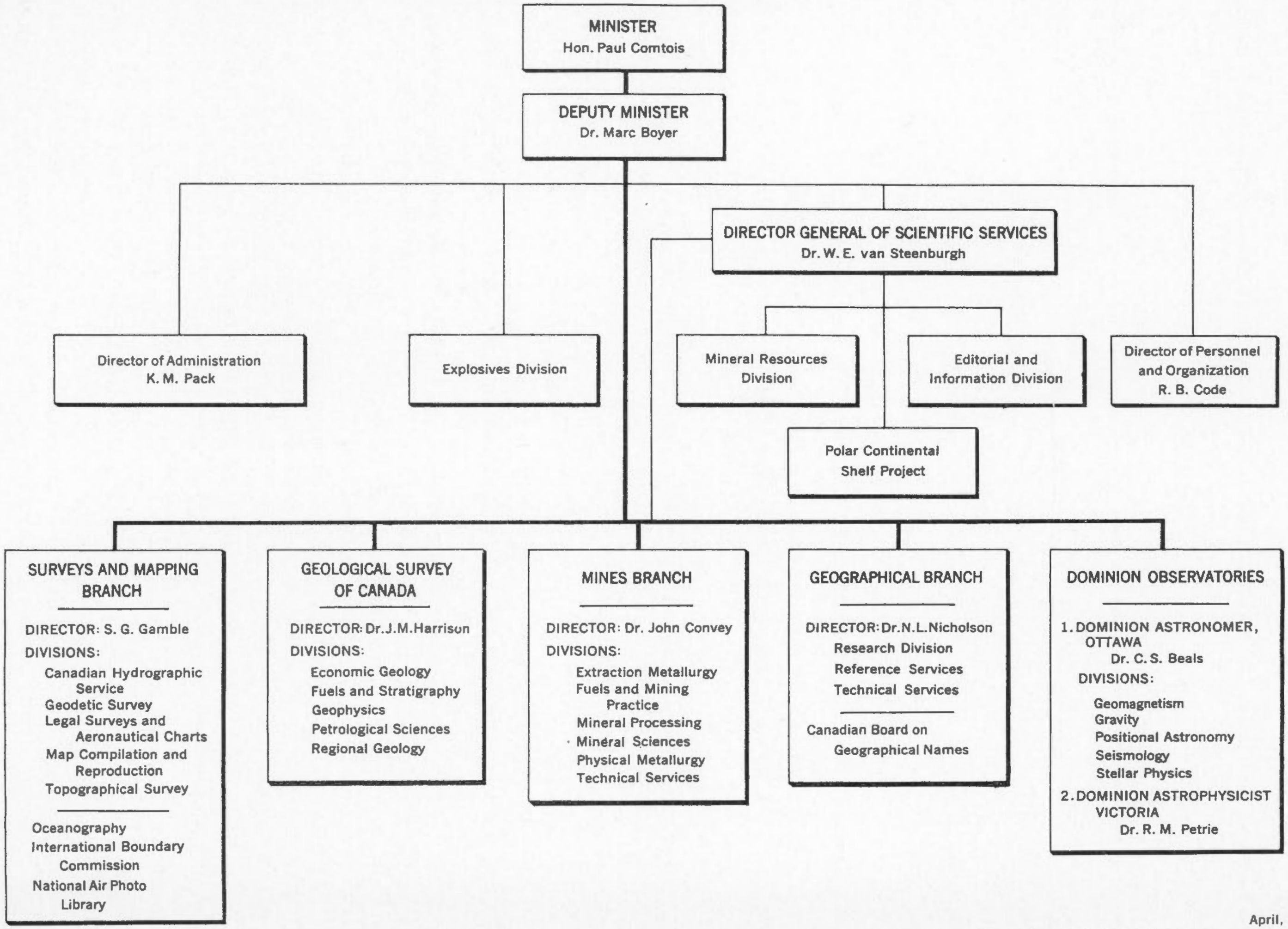
CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS



April, 1961

introduction

The Department of Mines and Technical Surveys moved into the 1960's with a field and laboratory program of importance to Canada's economic growth, her scientific progress and to some extent her national sovereignty. Under way during the year was a wide variety of research projects, both fundamental and applied; and technical surveys undertaken in every province and the territories and over areas of the continental shelf.

Some projects were of immediate benefit to industry (particularly mineral exploration, mining and metallurgy). Other, more basic investigations were designed to further a particular science—and indeed the work of the Department touched, directly or indirectly, just about every discipline. Still others sought to provide the maps and charts vital to navigation by water or air or to the development of our national resources. The Department also made substantial progress in its program to survey and investigate the undersea continental shelf regions on both coasts and in the Arctic.

For the Department itself 1960 was a historic year. In Ottawa, the Geological Survey of Canada officially opened its nine-storey Booth Street headquarters while that of the Surveys and Mapping Branch, an even larger building, was almost ready. In Penticton, B.C., the Dominion Observatories dedicated a new 84-foot radio telescope. And on the east coast near Halifax a laboratory to provide oceanographic research facilities for 300 scientists and other staff was under construction. Its fully-equipped floating counterpart, the C.G.S. *Hudson,* was scheduled for commissioning in 1962.

The Department's field program was the largest to date. The Surveys and Mapping Branch launched a field force of 190 engineers and technical officers, and 290 student assistants; and it assigned nearly 1,000 officers and crews to the charting of Canada's coastal and inland waters. The Geological

Survey of Canada sent a record 87 parties to the field and covered, geologically speaking, over 274,000 square miles and additional large areas in geophysical and geochemical surveys, and special research projects. The Dominion Observatories, using helicopters for the first time, made major advances in gravity measurements and expected to complete the reconnaissance gravity mapping of Canada's land areas within the next decade. The network of seismograph stations was extended in both Northern and Southern Canada. The Observatories' airborne magnetometer was flown a distance of 45,000 line miles. And the Geographical Branch intensified and expanded its land-use mapping. Meanwhile the Department sent its second expedition, a team of 70 scientists, engineers and others, to the polar continental shelf.

The large field programs of recent years have, of necessity, imposed a mushrooming work load on the laboratories where results are compiled and interpreted and materials are processed and analyzed. In 1960 the Department had many types of supporting research under way and its scientists worked to develop new instruments and techniques to further both the work in the field and the laboratory.

At the same time the Department's Mines Branch worked towards commercially feasible methods by which Canada's mineral deposits, particularly those of low grade, might be processed. It explored means of reducing current processing costs, a matter of importance if Canadians are to compete in the world mineral market. And it sought to discover and develop new uses for those minerals of which Canada has an overabundance.

Particularly urgent was the work on uranium. The Department worked to improve extraction processes in use at uranium camps and to find new applications of the metal. In 1960 it experimented with notable success on the use of uranium as an alloying element in steel.

The Department stepped up its work on iron ores and sought to help the coal industry through research on combustion equipment, coal cleaning, coking coals, etc. It also experimented with niobium and manganese ores of which Canada has large, low-grade deposits. In fact, in one way or another the Department in 1960 was dealing with just about every known mineral commodity—metallic, non-metallic and otherwise.

Oceanography and the Arctic

In 1960 the Department made major advances in its oceanographic-polar continental shelf programs—projects of far-reaching significance to Canada's economic and scientific progress. The aim: to survey and investigate scientifically Canada's continental shelves. These vast undersea areas off the Atlantic and Pacific coasts and in the Arctic total more than 1,450,000 square miles, considerably more than one third the size of Canada's exposed land mass. Yet relatively little is known of the characteristics of the shelves or their economic potential.

From practical considerations alone (for example, transport and navigation, weather and ice forecasting, commercial fishing, national defence, mineral development, disposal of radioactive waste), the need for oceanographic data is urgent. No less important is the fact that, if Canada is to hold sovereignty over these areas (particularly in the Arctic), she must show more than a passing interest in acquiring knowledge about them and in the development of their resources. And finally by studying the oceanography of its continental shelves Canada can make a considerable contribution to world science.

The Department's oceanographic work is integrated with that of other organizations by the Canadian Committee on Oceanography set up by the government in 1959. Represented are the Department of Mines and Technical Surveys, whose Director General is chairman, the Fisheries Research Board, the Department of National Defence, the Defence Research Board, the Department of Transport, the National Research Council and the Universities of British Columbia, Dalhousie and Toronto. Further liaison and joint action is provided by working groups set up on the east and west coasts and on the Great Lakes, and by the Working Group on Ice and Navigable Waters which handles ice research and ice-forecasting problems in eastern and Arctic waters. The Department of Mines and Technical Surveys is primarily concerned with the physical aspects of the science including defence oceanography, Arctic oceanography, deep-ocean studies and submarine geology. In 1959 and 1960 it took several key steps to further its program.

Construction began on a $4,000,000 oceanographic and hydrographic research station expected to be completed by mid-summer 1962. To be known as the Bedford Institute of Oceanography it will house a staff of 300 oceanographers, hydrographers, submarine geologists and other personnel and will provide facilities for research in most aspects of these sciences. Also under way was a multi-million-dollar ship building program to provide a fleet of survey-research vessels. The C.G.S. *Hudson,* to be commissioned in 1961, will be in essence a floating laboratory for hydrographic and oceanographic studies.

Every effort was made to recruit and train personnel. The Department appointed Dr. W. M. Cameron, a leading authority in the field, to direct its oceanographic research program. It sought to stimulate public interest in oceanography and urged new graduates in physics, chemistry, mathematics and other disciplines to study, train and work in one of its working groups or aforementioned universities. Important in this regard was the establishment in 1960 of the Institute of Oceanography at Dalhousie University and the Great Lakes Institute at the University of Toronto. The Department hoped to have a staff of 23 scientists and 31 supporting technicians by the end of 1961 and at least 50 scientists by 1964.

Meanwhile the Department went ahead with its oceanographic work. It carried out observations on both coasts and in the Arctic from tidal-survey vessels of the Canadian Hydrographic Service and the C.H.S. *Labrador* of the Department of Transport. In 1959 it sent a reconnaissance party to the polar continental shelf, followed the next year by a full-scale expedition.

In 1960 the Department carried out tide and current studies in the Bay of Fundy and on the west coast and took part in a wide-ranging survey of Lancaster Sound, Barrow Strait, Prince Regent Inlet, Fury and Hecla Strait and the eastern portion of Davis Strait. In the realm of submarine geology it studied cores from the Nova Scotia shelf and compiled and interpreted data from a magnetic survey over the east coast. A large volume of oceanographic information gleaned over the years was transcribed on data-processing cards where it would be readily available.

The Department also undertook aerial surveys of ice conditions in the St. Lawrence River, Gulf of St. Lawrence and the Strait of Belle Isle and worked on long-term problems of ice-forecasting.

In 1960 the Department sent its second expedition—a team of 70 scientists, engineers and supporting staff—to the continental shelf at the rim of the polar basin. The combined survey-research project involved an area extending 250 to 300 miles onto the shelf from a base line (established by an advance party the previous year) which extends from Meighen Island to Borden Island. Often working from holes blasted through the ice, the scientists began a detailed investigation of the physical characteristics of shelf waters and of the topography and composition of the shelf floor and the adjacent islands and strait. Accurate positioning (determining longitude and latitude) was provided by a Decca navigating chain and by various tellurometer surveys and special traverses.

It should be noted that oceanographic work in the Arctic Ocean poses several unique problems in operating techniques and logistics. In the area of the polar continental shelf, the ocean is for all practical purposes completely covered with sea-ice throughout the year. Oceanographic work must be carried out from camps on the ice in temperatures which range to —45°F. Holes must be cut through the ice, which has a minimum thickness of about 8 feet in early summer, and kept clear so that instruments can be lowered and samples retrieved. Machinery, instruments, and water samples must be protected from freezing when withdrawn from the relatively warm water into sub-zero air temperatures. The problem of measuring water currents, when the instruments are suspended from floating ice, which may be moved by both wind and current, is a difficult one. Elaborate means must be set up to determine the positions of the stations that drift at an irregular rate, in an area where there is nearly continuous summer overcast and fog, a lack of navigation facilities, and irregular ionospheric conditions that interfere with electronic communications. All equipment must be transportable by hand and by light aircraft and be capable of operating under severe climatic conditions.

The polar shelf project called for research in a variety of fields. Oceanographers, seeking data on the character and movement of water masses overlying the shelf, ran a traverse—the first of a series—from the northwest point of Ellef Ringnes Island about 155 miles out to sea. They found conditions (water temperature, etc.) surprisingly stable. Hydrographers outlined the shelf in the assigned area and found that it extends for some 85 miles out from the northern fringe of the islands to a clean-cut edge and slopes gradually and smoothly into the abyss. Geologists examined sediments inshore and sampled and studied material from the ocean bottom across the shelf. Seismologists launched a program designed to provide data on the ocean bottom and the crustal structure down to a depth of nine miles or so. Their reflection and refraction traverses established that the bottom limit of the permafrost can be mapped by seismic methods.

The work on gravity comprised (1) research into the problems of measuring gravity at sea, (2) a regional gravity survey with the aim of completing a map of the area covered by the Decca chain by 1962, and (3) detailed gravity studies to supplement other scientific data. In 1960 approximately 400 regional-station observations were made at 8-mile intervals on land and sea-ice in the vicinity of Ellef Ringnes, Amund Ringnes, Lougheed and Borden islands, and 300 additional observations at shorter intervals in an investigation of the Meighen Island ice cap, ring dykes, gypsum domes and other phenomena. In addition, scientists tested a land gravimeter, modified for use on sea-ice, and worked towards developing an instrument for gravity measurements on the ocean floor.

A start was made also in establishing magnetic stations throughout the area. A magnetic observatory was established at Isachsen and operated during the entire season. It provided significant information on the pattern of magnetic fluctuations, magnetic storms, etc.

Geographers made a thorough study of Arctic land forms, glacial deposits, etc., made measurements of ground temperature and its variation at depth, and observed phenomena such as mud flow, decay of ground ice and patterned ground. Studies of sedimentation and stream flow were begun on a river near Isachsen.

The glaciological research station, established in 1959, on the summit of the Meighen Island ice cap, was manned for four and one half months of the year.

Mineral Resources Division

Because of the importance of the Canadian mineral industry to the domestic economy and external trade, the services of the Mineral Resources Division were in greater demand in 1960. Its field investigations and mineral reports provided vital data on the state of the industry; and its advisory services which embrace an ever-growing portion of its work were in constant demand by government departments, crown corporations, foreign governments and agencies, industry and the general public.

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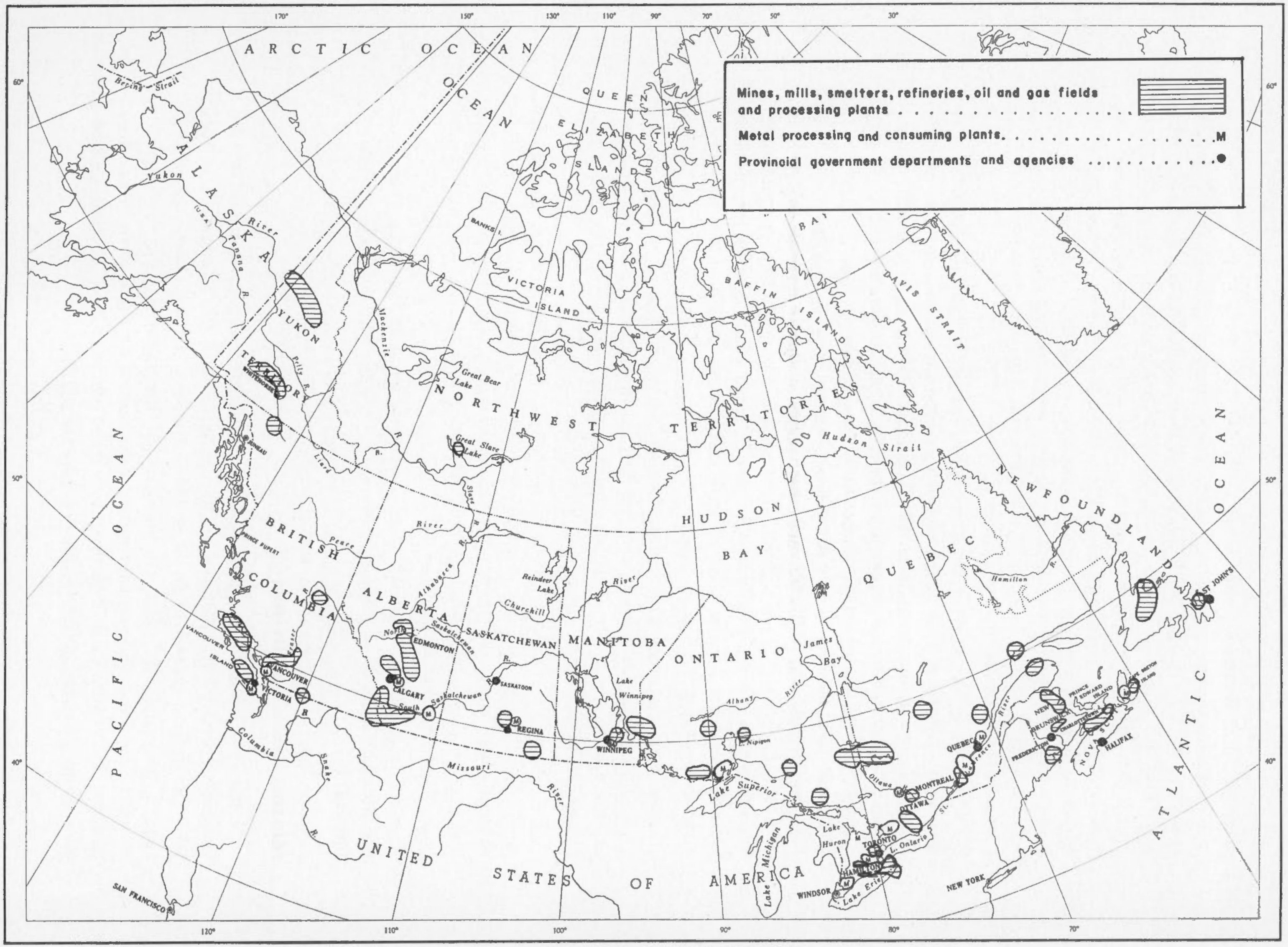

Mineral Resources Division— Field Work, 1960

International

In 1960 the United States Tariff Commission held hearings in Washington to determine if iron ore imports had caused or threatened "serious injury" to the United States mines in that field. The Mineral Resources Division sent an observer and provided considerable material to the Canadian Metal Mining Association for use in the preparation of the brief it presented to the Commission.

The Division also continued its analysis of the effects on Canadian producers of the United States import quotas on lead and zinc. It constantly scrutinized production and export trends and held discussions with industry and other government departments. And the Division represented the Department on the Joint Industry-Government Committee on Lead and Zinc, and conducted special studies on its behalf.

A senior officer of the Division continued to serve as a member of the Canadian delegation to the International Lead and Zinc Study Group. For this purpose two meetings, at Geneva, Switzerland, were attended during the year and detailed Canadian statistical data were prepared.

Other metals of concern were tin and nickel. In 1960 an officer of the Division served as a member of the Canadian delegation to the United States Tin Conference in New York. And at the request of NATO, the Division prepared a comprehensive and analytical report, with a forecast to 1965, on the free world's nickel productive capacity.

Roads

The Interdepartmental Roads Appraisal Committee in which the Division plays an active role* held eleven meetings in 1960 to consider various proposals in respect to the Government's 'Roads to Resources' and 'Northern Development Roads' programs. The province of Quebec entered the 'Roads to Resources' program in 1960 and the construction of three roads in this province was approved by the Committee. In New Brunswick a careful review and field examination was made of the roads program for the Bathurst area in which major deposits of base metals occur. And study and analysis were carried out on a large number of other road proposals in the various provinces and territories.

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*The Committee, composed of officers from the Departments of Northern Affairs and National Resources, Public Works, and Mines and Technical Surveys, advises the Minister of Northern Affairs and National Resources on roads programs to encourage the exploration and development of natural resources. Three officers of the Mineral Resources Division, one of whom acts as Secretary of the Committee, represent the Department of Mines and Technical Surveys.

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Income Tax

An important aspect of the Division's work in 1960 was the advice provided to the Department of National Revenue in the administration of the sections of the Income Tax Act and Income Tax Regulations pertaining to the Canadian mineral industry. The Division reviewed applications of 19 companies for a tax exemption under Section 83 of the Income Tax Act, four applications for certification as operators of a non-bedded deposit and one application claiming pipeline depreciation.

Coal, the Maritimes, etc.

In December 1959, the Chief of the Division was seconded as secretary to the Royal Commission on Coal for which the Division prepared four analytical studies of specific aspects of the Canadian coal industry and related matters. Subsequently, a senior officer of the Division was appointed Secretary of the Interdepartmental Committee on Coal established by the Cabinet to study the Report of the Commission and prepare recommendations for government action. The Division also took part in the Department's Maritime Study Group formed late in the year to study means by which the Department could best help industry in the Maritime Provinces.

Energy

Officers of the Division also continued to work closely with the National Energy Board on matters of concern to Canada's petroleum and natural gas industries. They prepared a study of the present and future use of natural gas in industry and scrutinized a report submitted to Cabinet dealing with the supply of Canadian crude oil to the Montreal refining area. A study of energy supply and demand in the Atlantic Provinces was under way at the year's end. A paper on the importance of the pipeline industry in the Canadian fuels economy was prepared by a senior officer of the Division for presentation at the World Power Conference in Madrid, Spain.

Transportation

The services of the Division are used wherever studies on transportation problems are considered by other government departments. Requests for advice and recommendation involve railways, pipelines, airfields, docks, harbor development and breakwaters, in cases where they affect the movement of minerals. In 1960 studies of this type concerned harbor dredging and development at Moosonee, Ontario; the Pine Point Railway; a breakwater at Port Renfrew on Vancouver Island, British Columbia; and a dock at Baie St. Paul, Quebec and other projects.

Wartime Oils Limited

The Division is responsible for the administration of the World War II agreements which Wartime Oils Limited, a former Crown company, made with oil well operators in Turner Valley, Alberta. By the end of December 1960, seventeen of the twenty-one successful wells drilled there had repaid the advances made by the Government of Canada. As of March 31, 1960, the total recovery on the project including repayment of advances, payment of interest and royalties amounted to $4,104,952. This was $47,399.00 in excess of the total advances made by the federal government during World War II.

Foreign Mineral Industry Studies

Because Western Europe and the United Kingdom is second only to the United States as a free world consumer of minerals and mineral products, it is important to assess and follow developments that affect mineral markets in those areas. In 1960, therefore, the Division launched a long-range appraisal of mineral industries of foreign countries with initial emphasis on European "trading blocs". It undertook investigations in the United Kingdom, Europe, Mexico and United States giving particular emphasis to iron ore steel manufacture, uranium, lead and zinc, petroleum and natural gas.

Training Program

Working with the Economic and Technical Assistance Branch, Department of Trade and Commerce, and the External Aid Office of the Department of External Affairs, the Division arranged programs for foreign trainees sponsored by the United Nations and other organizations. Ten nominees began scientific or technical study programs in the Department. Five study programs for trainees were arranged with the Canadian mining and metallurgical industry. And a group of three mining delegates sponsored by the Office of the High Commissioner for India, was conducted by officers of the Division on a study tour of provincial mines departments and research organizations in Ottawa, Toronto, Niagara Falls, Regina and Saskatoon.

Consulting Services

The Division served both industry and government in a variety of ways. It provided mineral economic reports on all phases of the industry for interdepartmental and Cabinet committees; advised the Industrial Development Bank in connection with outstanding or proposed loans; supplied mining companies, individuals, and mining associations with information ranging from answers to simple queries to detailed economic reports; advised the Department of National Revenue in the administration of sections of the

Income Tax Act and Income Tax Regulations and the Department of Finance on mineral tariff questions; and helped in assessing transportation facilities and other installations for the Departments of Transport and Public Works.

Information Services

The Division issued 57 mineral reviews describing Canadian developments in each of the metals, industrial minerals and fuels. Its popular map, *Canada—Principal Mineral Areas* was revised as were seven operators lists. Issued for general distribution were eight reports of the Mineral Information Bulletin series, and two of the Mineral Report series. The Division also completed a color filmstrip on uranium and began work on a color filmstrip on copper, both of which will form part of the Department's filmstrip series on the mining and metallurgical industries of Canada. A Mineral Report on platinum metals was completed and sent for printing at year's end.

Each month the Division prepared a summary of about fifteen pages on important developments in or affecting the Canadian mineral industry. This was made available to senior officers of interested federal government departments and agencies, to Deputy Ministers of provincial departments of mines, and to senior Canadian trade representatives in about thirty-five foreign countries.

The Division continued to maintain an extensive and growing volume of records, both historical and current, on the Canadian mineral industry. And it distributed 152,523 of its own publications and 28,763 for the Department's Mines Branch. The Division also received a large number of enquiries —over 1,800—concerning the mineral industry.

Field Investigations

Officers of the Mineral Resources Division conducted field investigations on all aspects of the Canadian mineral industry. They visited mines, oil and gas fields, mills, smelters, refineries, fabricating plants and the industries using Canadian metals and fuels. In 1960, these investigations were made in all provinces except Prince Edward Island with particular emphasis on processing; metal fabrication; end-use of metals; and on the development, transportation, processing and marketing of petroleum and natural gas. The Division inspected all gold mines 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 shouldered 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 Cost and Audit 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 by Chapter 28 of the Statutes of 1960. The amending act, which received Royal Assent on July 7, 1960, extended the application of the Act for three years to the end of 1963 without change in the method of determining the amount of assistance. Subsection 1 of Section 3 of the Act was amended to ensure the maintenance of the policy of the government to pay assistance on gold bullion only when it is sold to the Royal Canadian Mint, and not on gold bullion that is exported and sold elsewhere. Assistance will continue to be paid on gold exported as contained in ore or concentrates which cannot be economically treated in Canada.

Since the inception of The Emergency Gold Mining Assistance 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. 2664 on June 11, 1948, 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.

The regulations have been revised mainly for the purpose of consolidating and codifying certain administrative rules, particularly with respect to depreciation, pre-production expenses, and capital expenditures on exploration and development as costs of production. The 1960 Regulations permit advance payments of ninety per cent of the total assistance payable. In other words, the amount held back until inspection and audit procedures are completed has been reduced from 20 per cent to 10 per cent of the assistance payable.

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 1960 the average price per ounce of gold paid by the Royal Canadian Mint was $33.95 compared with $33.57 in 1959 and $33.98 in 1958.

In all, 64 lode and placer mines submitted 201 applications for quarterly or annual assistance payments. These were processed by the Cost Inspection and Audit Division, reviewed and approved by the Department of Mines and Technical Surveys, and payment was made by the Chief Treasury Officer of the Department. Twenty-seven final audits were not completed at the end of 1960 with respect to the calendar year 1959.

Two lode gold mines commenced production and three ceased operation in 1960. 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 with respect to each of the calendar years 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—	11,386,232.60	or	4.38 " " "
1959[1]	11,309,469.17	or	5.08 " " "
1960[2]	7,930,605.50	not available	

Explosives Act

The Department's Explosives Division issued 2,054 licences and permits in 1960 covering the manufacture, storage and transportation of explosives. These comprised 19 licences covering factories, one licence for a magazine depot, 445 licences for permanent magazines, 1,174 licences for temporary magazines, 99 permits for registered premises and 296 permits for transportation of explosives.

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[1]Final audits are not completed.
[2]Advance payments made during 1960.

The number of inspections carried out during the year was as follows:

Explosives factories	45
Explosives magazines and registered premises	2,601
Unlicensed premises containing explosives	148
Vehicles transporting explosives	139

The Division issued 1,374 general import permits and 59 annual import permits, covering importation of explosives such as fireworks and ammunition, distress signals, nitrocellulose for paint and lacquer manufacture, and seismic explosives for oil exploration.

In the laboratory, explosives were tested and analyzed as required by the Act. In all, 239 samples were received and examined.

There were no fatal accidents in the manufacture of explosives, and only three accidents were reported in which persons were injured, the injuries being of a minor nature. In the *misuse* of explosives, however, there were several distressing accidents causing loss of life.

* * *

By contrast, the year saw the Department involved in still another field of endeavour: human welfare. In 1960 many of the staff worked under the inspired leadership of the Deputy Minister, Dr. Marc Boyer, to put the current community chest campaign over the top.

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surveys and mapping branch

IN 1960 the Surveys and Mapping Branch moved into the field with a force of about 190 engineers and technical officers backed by approximately 290 student assistants, laborers etc. At the same time the Canadian Hydrographic Service assigned about 1,000 officers and ships crews to the charting of Canada's coastal and inland waterways. And, at home a large corps of technicians, draftsmen, printers and other specialists shouldered the monumental task of converting field data into finished maps.

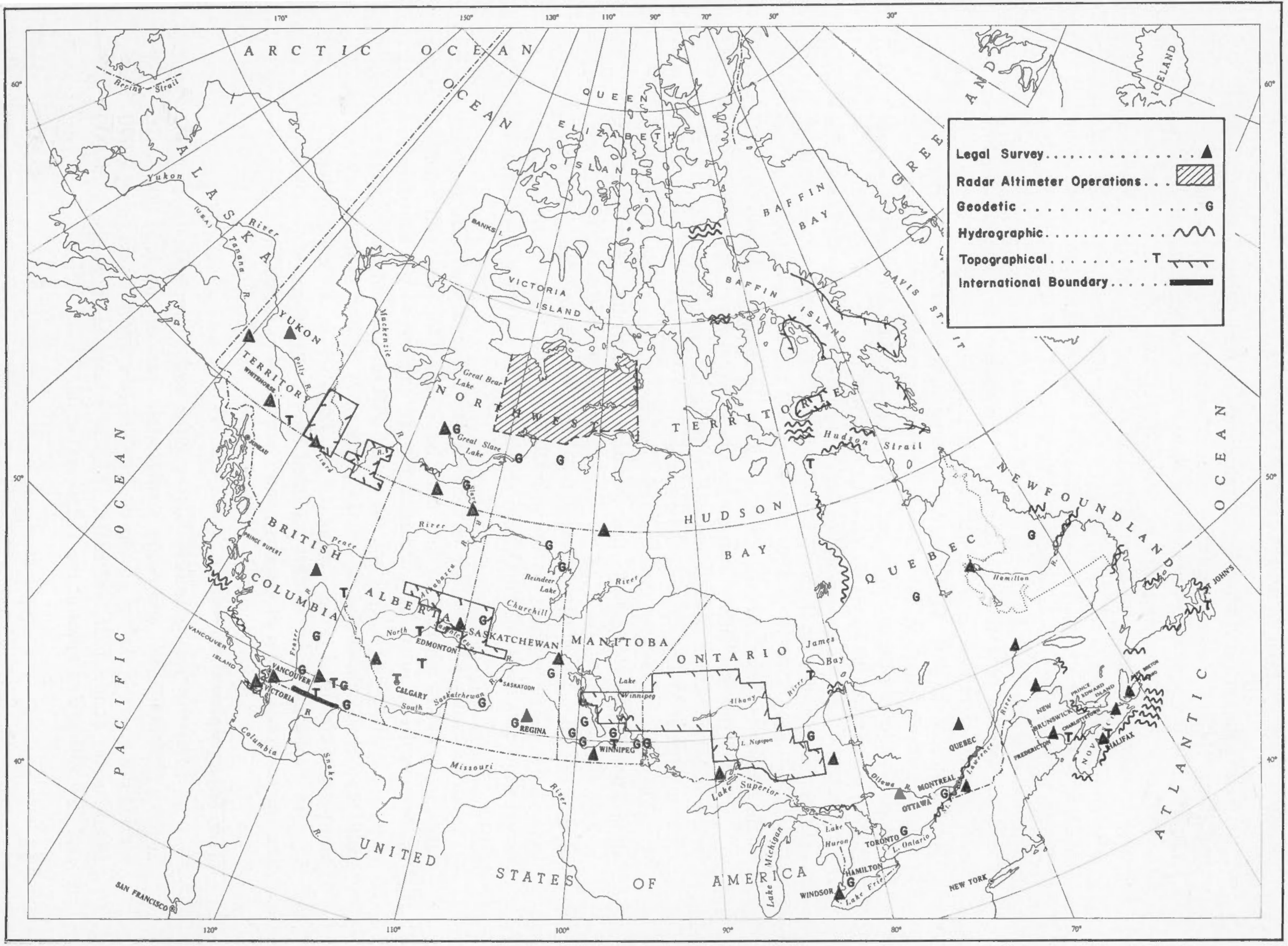
Again the Branch gave considerable emphasis to the development and use of new techniques and specialized equipment; and to the training of personnel.

Plans went forward rapidly for the move to a new 10-storey building, the construction of new ships and the acquisition of new instruments, printing presses and other equipment. In this way the Branch sought to meet the ever-growing demand for its services, for the maps and charts urgently needed in Canada's continued development.

The Geodetic Survey of Canada

The Geodetic Survey continued its work in extending horizontal and vertical control which provides a national framework for mapping, charting and major engineering projects. It also obtained data for investigations concerning the size and shape of the earth. In 1960, eighteen parties were in the field.

In 1960 the Geodetic Survey carried on the extension of the network of first-order triangulation in Northwest Territories, Saskatchewan, Manitoba, Ontario, Quebec and Labrador.



Surveys and Mapping Branch—Field Work, 1960

Triangulation provides a basic framework of well defined points whose positions (latitude and longitude) are determined to a high degree of accuracy. It offers a means of relating local survey projects to one another.

Precise levelling operations to establish elevations above sea level were carried on by parties working in British Columbia, Alberta, Saskatchewan, Manitoba and Ontario. The Geodetic Survey also measured six base lines, to serve as control for triangulation in the following areas: Telford, Manitoba; Brandon, Manitoba; Wollaston Lake, Saskatchewan; Fort Resolution, Fort Reliance and Wholdaia Lake, Northwest Territories.

Astronomic observations for the determination of latitude, longitude and azimuth were also carried out. These are usually made by recording the precise time of the passage of a star, and serve three functions: to control the direction of triangulation, to determine the position of points in areas where triangulation control is not available, and to provide data for scientific investigations concerning the size and shape of the earth.

In 1960 four Laplace stations were established to control triangulation nets in the vicinities of Fort Reliance, N.W.T., Fort Resolution, N.W.T., Wholdaia Lake, N.W.T., and Wollaston Lake, Saskatchewan. Another was established near Ottawa mainly for training and investigational purposes.

Twenty-two deflection stations were observed: eighteen in the Winnipeg-Brandon, Manitoba, area; three in the Fort Reliance-Fort Resolution, N.W.T., area and one at Molanosa, Saskatchewan.

The Geodetic Survey continued to develop its use of the tellurometer, an instrument of high accuracy that measures a line by determining the time a radio wave takes to travel along it. During the field season three officers of this section worked with triangulation parties in Manitoba and Ontario to carry out distance measurements with tellurometers. Tellurometer measurements were also made in the Ottawa area for further investigations of index error.

An increasingly large share of the Geodetic Survey's work load is undertaken in its offices where field data must be adjusted for error and countless mathematical computations are carried out. In addition to the adjustment of triangulation nets and a level net, the major part of data obtained during the field season was processed to obtain preliminary results. The Survey also computed a system of plane coordinates for the province of Newfoundland.

In 1960 two senior officers attended the Twelfth General Assembly of the International Union of Geodesy and Geophysics in Helsinki.

The Topographical Survey

In 1960 the Topographical Survey gave added emphasis to mapping at the 1:250,000 scale, and made a substantial start on the 1:25,000 scale. During the season a staff of 45 officers established control for mapping 2,690 square miles at the 1:25,000 scale, 117,850 square miles at the 1:50,000 and 126,330 square miles at the 1:250,000 scale.

Favorable field conditions, particularly in areas where three helicopter-supported parties were assigned, permitted several extensions to the original field program. At home, a stable, well-trained staff and the effective use of plotting equipment contributed to the year's high level of map compilation: 258 map sheets involving 188,800 square miles. This output was achieved despite the changing priorities and an increased demand for a variety of unusually large-scale projects. Map sheets forwarded for reproduction involved a record 171,800 square miles.

In 1960 the Survey met a growing demand for advance information prints of new mapping and for photo-mosaics which were becoming more popular in many planning projects.

To complete the medium scale (1:250,000) map coverage of Canada at the earliest possible date—a project undertaken in a joint effort with the Army Survey Establishment, D.N.D.—the Topographical Survey diverted a good proportion of its capacity to this scale of mapping. The aim: to produce 40 to 50 map sheets per year. The Survey agreed also to participate in a two-year program of 1:25,000 mapping of key urban centres in Canada, and undertook the field work for and completion of these maps for St. John's, Newfoundland; Halifax, N.S.; Saint John, N.B.; Ottawa, Ontario; Winnipeg, Manitoba; and Calgary and Edmonton, Alberta. To secure the required mapping control several key staff members, previously allocated to compilation and inspection of medium-scale mapping, were sent to the field.

Field operations in 1960 reflected the trend to these more diversified mapping requirements. Three major field parties equipped with helicopters and tellurometers established control for nearly all the new or original mapping at the medium and detailed scales. A few ground parties worked toward the completion of 1:50,000 mapping in the settled parts of Canada, but the majority conducted surveys to establish control for the 1:25,000 mapping reported above, other special projects, and for revision of out-dated maps.

Other field highlights:

——A helicopter-supported party conducted tellurometer traverses in the Arctic Islands and made surveys for detailed plots of settlements at Cape Dorset, Lake Harbour, Pangnirtung, Clyde River and Pond Inlet.

——A second party, also using a helicopter, established control over a large part of northern Ontario and eastern Manitoba required for the 'Roads to Resources' program.

——A third major party established control for blocks of detailed mapping on the Liard River and southeast corner of Yukon Territory and obtained vertical control over the vicinity of Nelson Forks and various blocks in central Saskatchewan and Alberta.

——Two parties completed field work for detailed mapping of settled agricultural areas in Saskatchewan and southern Alberta.

——Two parties completed field work for 29 map sheets in the Penticton area and established control for the Monkman Pass area of British Columbia.

——Tellurometer surveys were carried out in the prairie provinces and spirit levelling undertaken along the Teslin River and the Canol Road in Yukon.

At the request of other departments, the Topographical Survey undertook local surveys for large-scale plots of Experimental Farms at St. John's, Newfoundland, and Fredericton, N.B., and of Northern Settlements at Belcher Island, Port Harrison, Povungnituk, Ivugivik, Sugluk, Koartak, Wakeham Bay, Payne Bay, Hopes Advance Bay, Fort Chimo, George River, Coral Harbour, Repulse Bay, Baker Lake, Chesterfield Inlet, Rankin Inlet, Whale Cove, Padlei, Wilson River, Eskimo Point, Churchill (Camp 20) in the Hudson Bay region, and at Teslin and Ross River in the Yukon.

The Topographical Survey undertook 28 large-scale plotting projects for various government agencies and supplied numerous advance-information maps. It added about 100,000 prints to its library of 2,500,000 airphotos.

The Canadian Hydrographic Service

The year brought a further increase in the demand for information on Canada's coastal and inland waterways. As a result the Canadian Hydrographic Service assigned to the task more parties than ever before—a force comprising a total of seven hydrographic ships, three chartered ships and thirteen launch parties were employed. Hydrographers were also aboard Department of Transport ships operating in both the Eastern and Western Arctic.

On her longest trip into the Eastern Arctic the C.H.S. *Baffin* circumnavigated Baffin Island, a feat that a few years ago would have been considered historic but is now almost commonplace. And for the first time a hydrographic team proceeded to Alert, Canada's northernmost settlement, to install the most northerly tide gauge in the world.

During the year a major ship-building program was under way: Construction of the C.G.S. *Hudson,* a research ship equipped to undertake oceanographic or hydrographic surveys in any part of the world began at Saint John, N.B. A new inshore survey vessel, the *Maxwell,* designed for work on the coasts of Newfoundland and Labrador, was taking shape in a Halifax shipyard and nine new sounding launches were being built at Lunenburg, N.S. Plans were also being drawn for three new ships to replace those nearing the end of their usefulness.

The increasing use of electronic devices in hydrographic work has underlined the need for facilities to test and evaluate equipment under development. In 1960 the Service formed a unit to conduct these trials on the Ottawa River, and to train new staff.

During the year the Service issued fifty-one navigational charts and one hundred and fifty revised charts.

By the end of the year the number of charts listed in the catalogue has risen to 796. The number distributed (144,000) showed a slight increase over that of 1959.

Conducting hydrographic surveys on the Atlantic Coast were the ships *Acadia, Theron, Arctic Sealer, Cartier, Kapuskasing* and, in addition to her other projects, the *Baffin*. These were supported by the launches *Eider, Anderson* and *Merganser*.

The *Theron* and *Arctic Sealer* also operated in Hudson Bay and Strait. In James Bay a new launch, the *Lemoyne,* was commissioned and put to work.

In the Arctic the *Baffin* carried out three major surveys: in Lancaster Sound, Fury and Hecla Strait and Radstock Bay. Hydrographers were also abroad the *C. D. Howe*—to carry out surveys at ports-of-call on the eastern arctic patrol—and the *Labrador*—to carry out a reconnaissance of the west end of Barrow Strait. In the Western Arctic hydrographers travelling by air and water, established control for future surveys and gathered data at various points.

Charting was carried out in the St. Lawrence Seaway, Georgian Bay (by the *Bayfield* and the *Boulton*), in Lake Winnipeg and on the Mackenzie River (by the launches *Sandpiper* and *Rae* respectively). In the Pacific the *Wm. J. Stewart* continued Decca sounding of Queen Charlotte Sound and Hecate Strait; and the *Marabell* worked on the west coast of Vancouver Island, on Carpenter Bay (in the Queen Charlotte Islands) and in Spiller Channel. Surveys of Swanson Channel and Fulford Harbour, in the Gulf Islands, were completed and work was started in the Satellite Channel and Cowichan Bay areas.

In 1960 the Service carried out current surveys in the Bay of Fundy, Lancaster Sound (north of Baffin Island) and the Fraser River, and on the Pacific coast. And it expanded its already extensive network of tide gauging stations in the Great Lakes, St. Lawrence River, on the east coast and in the Arctic. A total of thirty-four gauges were operated on the west coast.

Legal Surveys and Aeronautical Charts

In 1960 the Surveys and Mapping Branch faced a heavy demand for legal surveys in Indian reserves, national parks and the Territories. The need for aeronautical charts also increased sharply as a result of continued expansion of aviation and the aids required for its safe, efficient air travel.

The Branch continued to work with the provinces in directing the demarcation of certain boundaries and related tasks. Other projects carried forward during the year included the preparation of 36 final map sheets of the British Columbia-Yukon boundary, and 16 final map sheets, index and key maps of the Saskatchewan-Northwest Territories boundary. Work on the final reports for these surveys continued. Also undertaken, early in the year, was the survey and monumenting of 147 miles along the Manitoba-Northwest Territories boundary.

Thirteen parties undertook legal surveys on 49 Indian reserves in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia. The Branch engaged private surveyors to work on Indian lands at Schefferville and subdivisions in the Seven Islands and Maria Indian reserves, Que., a school site at Cold Lake, Alberta, and a subdivision in Twawwassen Indian reserve, B.C. It assigned two parties to Northwest Territories and Yukon for surveys requested by the Department of Northern Affairs and National Resources and another party to Banff townsite for lot and block surveys for the Department of Northern Affairs and National Resources. The Branch also undertook surveys of an historic site at Amherstburg, Ontario, a hydrographic station at Riverside, Ontario and seismological stations at Schefferville, Quebec and Fort St. James, B.C. It issued technical instructions to private surveyors for 91 legal surveys in federal lands for private interests.

There was a marked increase, in 1960, in the production of new and revised charts for radio air navigation and for instrument approach procedures; and of those containing aeronautical information for visual air navigation. To plot land heights on aeronautical charts the Branch had over 4,200 line miles of ground profile recordings made under private contract for the Bathurst Inlet-Aberdeen Lake area, Northwest Territories.

The flow of information from the survey records to government departments and outside agencies continued at a steady pace. During the year 217 plans were recorded and approximately 14,000 prints of plans and field notes despatched.

The Board of Examiners for Dominion Land Surveyors examined 89 candidates at various centres across Canada, of whom 21 were successful.

Map Compilation and Reproduction

The year's output in the compilation and reproduction of maps was higher than that of 1959 despite a number of time-consuming alterations in procedure:

—1) the changing of the National Topographic System, which affected records as well as all maps in production concerning areas lying north of latitude 60° (1:50,000 and 1:250,000 scales);

—2) the introduction of a bilingual surround;

—3) the production of provisional maps in east and west halves rather than a single sheet.

Duirng the year 396 provisional maps were released for engraving by contract. And good progress was made on the conversion of the 8-mile series to 1:500,000 scale, about 25 per cent of which has been processed.

By year's end, however, the backlog of standard 1:50,000 scale maps not yet in production stood at 132, though advance prints of these were available from the map distribution office. The backlog of provisional 1:50,000's stood at 121.

The number of maps and charts printed during the year came to 2,561 which was greatly in excess of the 1959 figure. Similarly, the distribution of individual maps showed an increase of 7,000 copies, though the total distribution, including bulk sales was slightly lower.

Most of the work in compilation concerned maps of the 1:250,000, 1:500,000, 1:1,000,000 and miscellaneous scales. In terms of man-hours about half the total effort was given to the 1:250,000 scale. On the other hand about 35 per cent of the work in drafting was on maps of the 1:50,000 scale and 15 per cent for the 1:250,000 scale. The remainder was divided among miscellaneous, air overprints, and 1:500,000 and 1:1,000,000 scale maps.

In 1960 a total of seven employees were engaged in checking all maps and charts produced by the Branch at various stages and nine were concerned with nomenclature. Forty-five employees undertook the photomechanical operations: photography, retouching, preparation of color negatives, blue lines and color proofs, negative corrections and plating; forty-six were occupied in lithographic printing. Two new two-color presses were purchased and at year's end, were being installed in the Branch's new Booth Street building.

Canadian Board on Geographical Names

In 1960 the Canadian Board on Geographical Names, a federal-provincial body responsible to the Minister of Mines and Technical Surveys, reviewed or rendered decisions on 18,995 names for 139 new maps, 21 new charts, 4 map or chart revisions, and 325 miscellaneous submissions.

The name Massey Sound, in honor of the Right Honorable Vincent Massey, was adopted in January for the feature between Amund Ringnes Island and Axel Heiberg Island, Northwest Territories.

Work on the *Gazetteer of Canada* series continued: The *Prince Edward Island* edition was released during the year and the *Nova Scotia* report sent to the printers, supplementing those for *Southwestern Ontario, British Columbia, Manitoba, New Brunswick, Saskatchewan, Alberta,* and *Northwest Territories* and *Yukon* (*Provisional*) published to date.

The Board initiated an information campaign with lumber, mining, and oil companies across the country in an effort to acquaint these agencies with the work of the Board and obtain their cooperation in maintaining a high standard in Canadian nomenclature.

International Boundary Commission

The Commissioners made a joint inspection of various points on the International Boundary from Lubec, Maine, to Point Roberts, British Columbia. Inspections were made of the work of field parties on the Quebec-Maine, Quebec-New Hampshire, Ontario-Wisconsin, and British

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Columbia-Washington boundaries; and of monuments and range towers at Blaine, Washington, and Point Roberts, B.C. Inspections were also made of chemically treated brush on the Yukon-Alaska boundary, with further inspections being made at the Alaska Highway crossing, at Little Gold Creek west of Dawson City, and at Fortymile River.

On the Quebec-Maine boundary a Canadian party inspected and repaired monuments, recleared the boundary vista to a skyline width of 20 feet through 25½ miles of forested country and applied chemicals to retard re-growth throughout this section. On the British Columbia-Washington boundary a Canadian party recleared three miles of vista east of Nelway, B.C. At the coast, the same party completed the reclearing of a 9½-mile section between Huntingdon and Point Roberts, B.C.

In all, 86 miles of boundary were covered in the course of inspection and maintenance work; nine range marks and 111 monuments were inspected; a 20-foot vista was recleared through 38 miles of forest and 51 miles of line were treated with chemicals during 1960.

National Air Photo Library

In 1960 the National Air Photo Library had on file one print of each aerial negative exposed by or for the federal government. During the year, 81,517 photos were added, bringing the total number to 2,854,291. The library also prepared 4,835 requisitions, involving the purchase of 435,793 reprints. These were for various federal and provincial government departments, mining and industrial concerns, as well as private individuals engaged in the development of Canada's resources.

geological survey of Canada

IN 1960 the Geological Survey of Canada conducted a program of research, both in the field and the laboratory, of considerable significance to the science of geology and to the continued development of Canada's mineral wealth. To these ends most of the resources of the Survey were used in mapping and studying the geology of the country. In 1960 the Survey placed 87 parties in the field, an increase of 11 parties (approximately 15 per cent) over the previous two years. Of these, 42 parties were involved in bedrock mapping, chiefly the reconnaissance mapping of remote or little known areas, and an additional 19 conducted ground-water surveys and mapping of surficial deposits. The remaining 26 parties made detailed or special investigations in geochemistry, geophysics, mineralogy and economic geology. The distribution of the parties is shown on the accompanying map of Canada.

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

Helicopters were again the means of speeding preliminary geological mapping and were used in several projects. Operation Pelly, in the Yukon Territory, was completed after three years (it covered 21,000 square miles, mapping to 4-mile standards). Operation Back River, involving two helicopters and three fixed-wing aircraft, resulted in the mapping of approximately 55,000 square miles of the Arctic. In British Columbia five parties, sharing one helicopter, were able to reduce normal field mapping time by 50 per cent or more, and mapping costs by 20 to 50 per cent.

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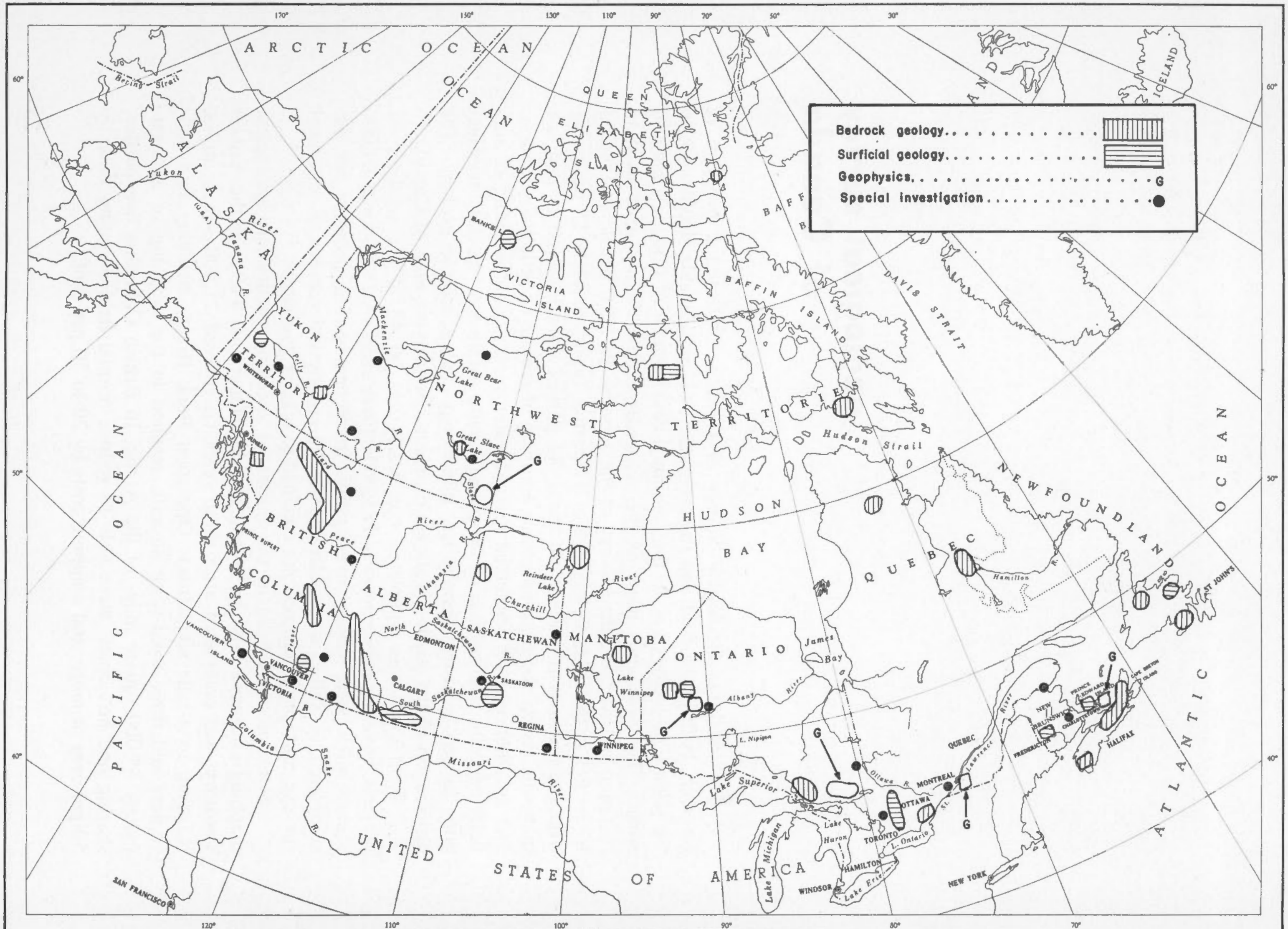


Geological Survey of Canada — Field Work, 1960

As part of the federal-provincial 'Roads to Resources' program, the Survey conducted geomagnetic and geochemical studies, and mapped the surficial and bedrock geology over four map-areas in northern Ontario. The project involved eight Survey geologists and 40 other field personnel, including student assistants, supported by aircraft. They mapped approximately 25,000 square miles of terrain on a scale of 1 inch to 4 miles. Their investigations will be an important contribution to the development of this segment of Ontario.

By the end of 1960, the Survey had completed the preliminary field mapping of about three-fifths of Canada, and published geological maps for approximately half. The aim: to complete the preliminary mapping of the entire country by 1970.

While the Survey's primary research was in the field, much of the actual import of the work would be determined in the laboratories and offices where data are analyzed, interpreted and explained. In 1960 a great variety of laboratory procedures were under way: microscopic examination of animal fossils and plant spores and pollen; analyses of minerals, sediments and rocks; X-ray and other identifications; radioactive age determinations, etc. Under development were new techniques and instruments to further the work both in the field and the laboratory and special research projects to enlarge man's knowledge of the earth, how and when its rocks and mineral deposits were formed.

Some projects in geological research were allotted to the universities. In 1960 grants totalling $50,000 were made to 13 universities in support of 29 projects. These were awarded on the advice of the National Committee on Research in Geological Sciences of which the Survey's Director is chairman.

Field Work

Highlights of the Survey's 1960 field program are given below. A more detailed account of the field work may be found in Information Circular No. 4, March, 1961.

Northwest Territories

Three field parties operated in the District of Franklin. One completed the reconnaissance mapping of Mingo Lake and Macdonald Island map-areas in southern Baffin Island, one of the major unmapped areas in Canada. A second finished the 1-inch-to-8-mile coverage of southeastern Ellesmere Island and the third party completed reconnaissance of surficial deposits on Banks, Victoria, and Stefansson islands. The last was an investigation begun in 1959 as part of a project involving nearly 110,000 square miles of Arctic terrain. Banks Island, in particular, promises to afford an unusually complete record of the Pleistocene history of the Arctic for it bears evidence of three and perhaps four ice sheets.

In the District of Keewatin, a party of four staff geologists mapped, at 1 inch to 8 miles, about 55,000 square miles. The project, known as Operation Back River, was supported by two Bell helicopters and two planes during the 2½-month field season. A fifth staff geologist accompanied the party to study the surficial geology of the area.

Six parties operated in the District of Mackenzie. One made groundwater surveys of most of the settlements of the District and showed that permafrost along the Mackenzie River north of the Arctic Circle is generally too thick for locating ground water. South of the Arctic Circle, however, permafrost was found to be sporadic or of limited thickness, so that ground water may be sought by standard methods. These studies should be valuable in the planning of any northern development program.

A second party began a geochemical study in the Beaulieu and Prosperous Lake map-areas, and a third launched a regional study of Precambrian rocks within mapped areas of the District of Mackenzie. Its aim: to refine, confirm or revise the current correlation of the various map units and test new concepts of the geological history of the Great Slave Lake-Great Bear Lake region.

Another party completed the detailed field mapping of the Muskox complex in the Big Bend of the Coppermine River and results have been compiled on a scale of 1 inch to 1,000 feet. The complex, which has been traced for 75 miles, contains a series of gently inclined layers of (from bottom to top) dunite, peridotite, pyroxenite, hypersthene gabbro, granophyric gabbro, and granophyre. This remarkable intrusion contains one of the most complete sections of igneous rock types to be found in any stratiform body in Canada. It is expected that the study of it will produce valuable basic geological information on the origin, emplacement, and alteration of the ultrabasic rocks.

An officer of the Survey, on a party of the Water Resources Branch of the Department of Northern Affairs and National Resources, investigated the engineering geology at ten proposed damsites on the South Nahanni River.

The sixth party, composed of seven staff officers, made aeromagnetic surveys in parts of the District of Mackenzie and in northern Saskatchewan. Altogether some 43,240 line miles were flown.

To the north, Survey personnel on the polar continental shelf project in 1960 established that the bottom limit of permafrost can be mapped by seismic methods.

The Survey's *Yellowknife Office* continued to act as a source of geological information for the public through its sale of Departmental publications, its library and laboratory facilities, and its consulting services.

Yukon

In southeast Yukon, the Survey completed Operation Pelly using two geologists supported by a helicopter and a Beaver aircraft. The project, begun in 1959, included geological mapping for the Wolf Lake (north half), Quiet Lake, Finlayson Lake, Sheldon Lake, Toy River, Nahanni and part of the Francis Lake map-areas. Approximately 14,000 square miles were mapped in 1960. Mineralization was found southwest of South Nahanni River where carbonate rocks of Cambrian age were intruded by granitic stocks.

Another party began studying and mapping the surficial geology and geomorphology of the Klondike placer mining district. Findings may provide basic data of value to the Yukon placer mining industry.

A third party examined about 40 copper-bearing properties as part of a study of the copper deposits of Yukon and British Columbia. Small percentages of gallium were found by spectroscopic analyses of iron-rich ores of the Whitehorse copper belt.

Others carried out studies in engineering geology in the neighborhood of proposed damsites in the Yukon River drainage basin—a project begun in 1959 at the request of the Water Resources Branch of the Department of Northern Affairs and National Resources.

The *Whitehorse Office* provided assistance and information to those working in the mineral industry in Yukon and northern British Columbia. It also reported to the Survey and other departments on the area's mining and prospecting developments.

British Columbia

In northern British Columbia two parties, sharing a helicopter and a Piper Super Cub, nearly completed the geological mapping (on a scale of 1 inch to 4 miles) of Sumdum, Tulsequah, Kechika, and Rabbit River map-areas. The project was launched in 1958, and, by conventional methods, would have taken a great deal longer (possibly four to five years per party per map-area). The speed-up made possible through the imaginative use of aircraft more than offset the costs. Moreover, the field officers were able to spend considerably more time in examining outcrops.

On the Alaska Highway a party began a detailed study of MacDonald Creek map-area. Minor copper mineralization is evident along the borders of some of the many basic dykes that cut Proterozoic strata in the south-central part. Barite and fluorite are common in what is probably Lower Devonian strata.

Two Survey officers and their parties joined forces to investigate the stratigraphy and palaeontology of the Triassic rocks in the Foothills of the Rocky Mountains in Tuchodi Lakes and Toad River map-areas. They studied some twenty localities involving about 22,000 feet of Triassic strata and found previously unknown Upper Triassic beds. Others worked in the Halfway River map-area, continuing studies of the previous year.

In northeastern British Columbia the Survey made further progress in the study of Cretaceous stratigraphy and fauna. Field work on the Upper

Cretaceous Smoky group was completed, and almost so on the Lower Cretaceous Fort St. John and Bullhead groups. The study of comparable rocks in Dawson Creek map-area was also completed during the 1960 season.

The Survey put a helicopter to work in the central and southern part of the province, sharing the aircraft with five parties. The purpose was to test this mode of mapping in so-called Rocky Mountain terrain. Results: three of five parties completed field mapping, in the Prince George, Quesnel Lake West Half, and Fernie West Half map-areas, and that of the Pine Pass and Rogers Pass map-areas was nearly completed—an achievement that more than justified the costs. It was decided that this mapping method would be continued.

The project also resulted in mineral discovery. A geologist noted serpentinized ultrabasic bodies, locally containing asbestos, in Quesnel Lake West Half and Prince George map-areas, and Devonian gypsum beneath the east flank of Bull River valley from Sulphur Creek to the north boundary of Fernie West Half.

Ground-water investigations were completed on the east coast of Vancouver Island from Courtenay to Campbell River, a project started in 1959. An aquifer below till underlies the Comox area and yields approximately 1 million gallons daily to meet all local demands.

Another party began a detailed study of the Tulameen ultrabasic complex in southwestern British Columbia. It mapped the northern part of the complex on the scale of 1 inch to 1,000 feet during the 1960 field season. A laboratory study of the distribution of platinum-group metals found within the complex was planned.

Also begun was the mapping (for publication on a scale of 1 inch to 2 miles) of surficial deposits of the Nicola map-area. Evidence was found for two major glaciations separated by an interglacial interval of sufficient duration for the establishment of vegetation and the deposition of at least 75 feet of sand, silt, and gravel.

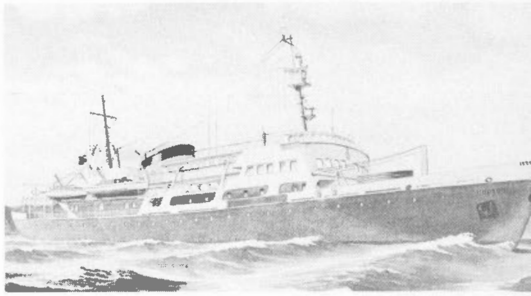
Two parties investigated the granitic rocks of southern British Columbia. One mapped approximately 80 square miles of Monashee group rocks on a scale of 1 inch to ½ mile in the northeast corner of Vernon map-area. The other continued detailed mapping in Passmore and Burton map-areas, outlining a gneiss dome within the Valhalla Mountains. These studies were part of a broad investigation of Canada's granitic rocks and will provide valuable basic geological information on the origin, emplacement, and alteration of rocks of this type.

In addition to the work in British Columbia, the Survey carried out stratigraphic, structural, and surficial geological studies in provincial border areas of both British Columbia and Alberta. The study and mapping of Fernie East Half map-area, begun in 1958, and those of the surficial deposits east of the Continental Divide in Fernie East Half, were completed.

Tellurometer set up at survey station on pressure ridge on sea ice, Prince Gustaf Adolf Sea

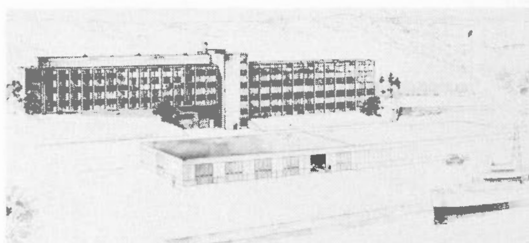
A view of the airstrip at Isachsen on northern Ellef Ringnes Island in mid-May 1960. The project is equipped with two Bell helicopters and two deHavilland Otters to assist in transporting field parties and equipment to various locations on the ice of Canada's Arctic continental shelf.

Members of the crew of a hydrographic ship retrieve a paddle-wheel current meter in Northumberland Strait. This type of current meter automatically records velocities and directions of currents while anchored beneath the surface for periods of up to a month.

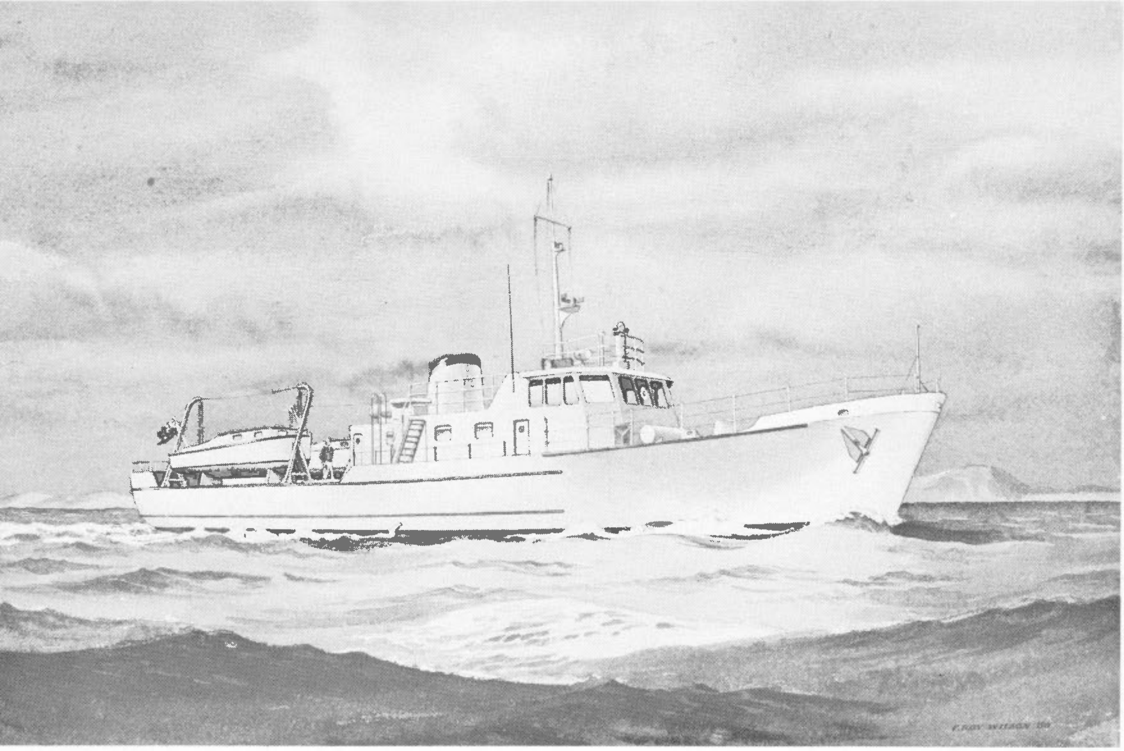


The C.G.S. Hudson, soon to be commissioned, will be in essence a floating laboratory for hydrographic-oceanographic work.

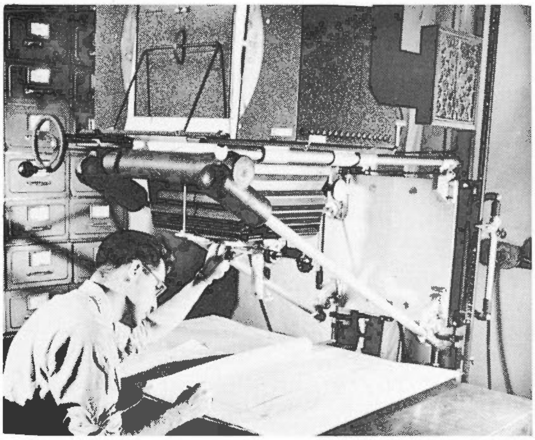
Artist's sketch of Bedford Institute of Oceanography.



Under construction: The Bedford Institute of Oceanography will provide research facilities for 300 oceanographers, hydrographers, submarine geologists and other personnel. It is located in Nova Scotia's Bedford basin, near Halifax.

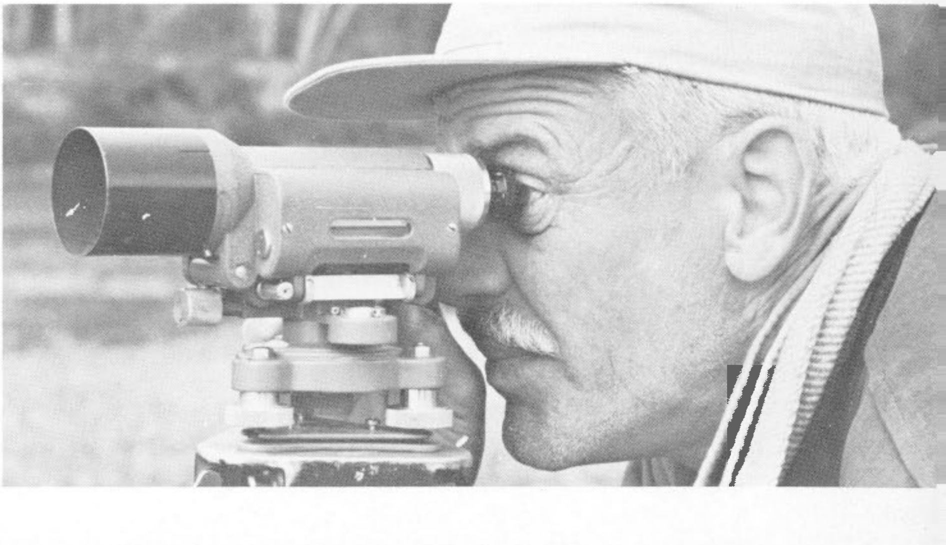


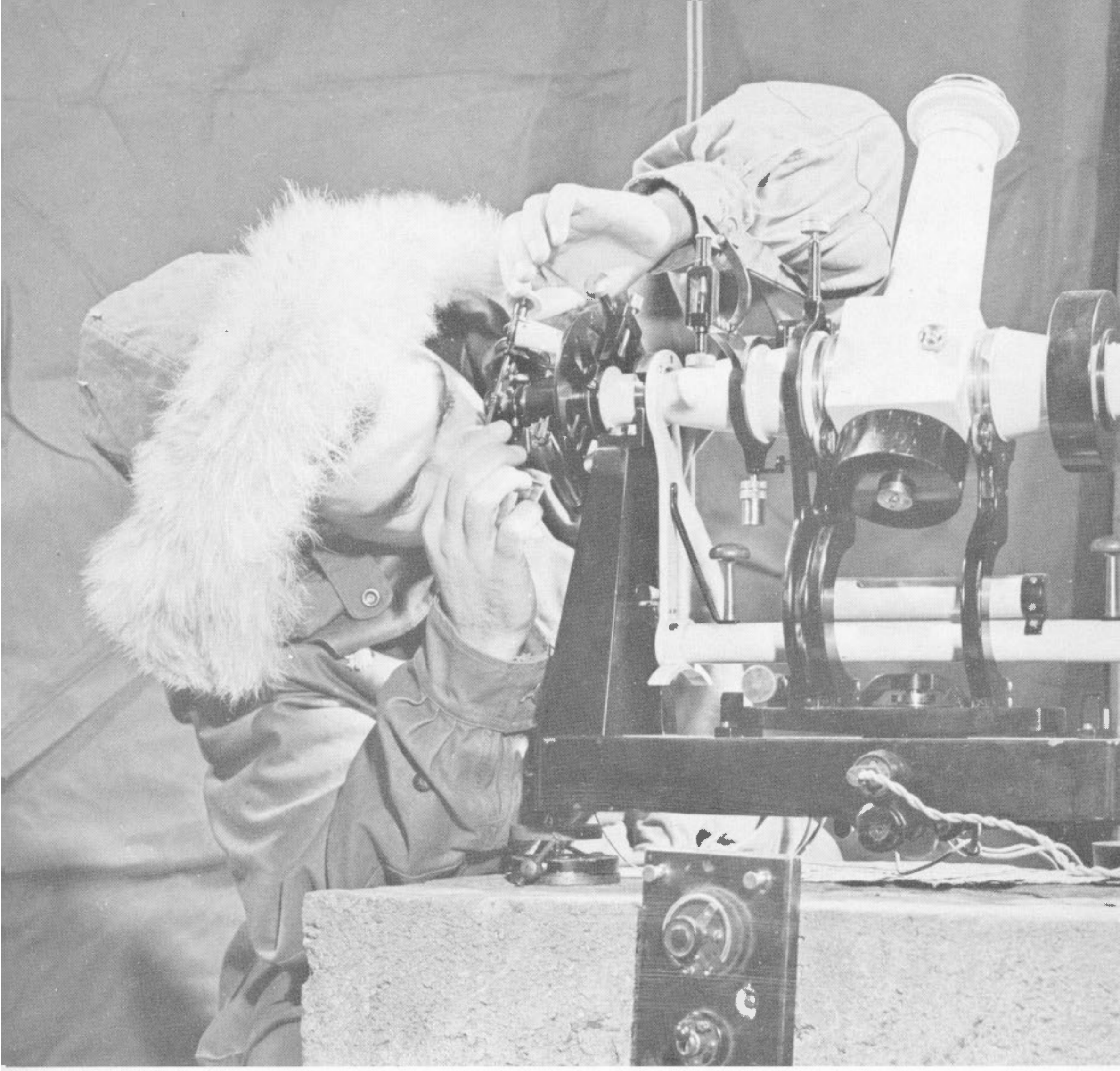
The C.H.S. Maxwell destined to be launched in 1961 is part of Canada's new multi-million dollar oceanographic-hydrographic fleet. She carries a crew of 20, has a range of more than 2,000 miles and a top speed of over 12 knots. The ship is 115 feet long with a 26-foot beam. Its approximate cost: $450,000.



Producing a finished map involves many operations and a great many man-hours. One phase of the process calls for the use of a giant enlarger, shown here.

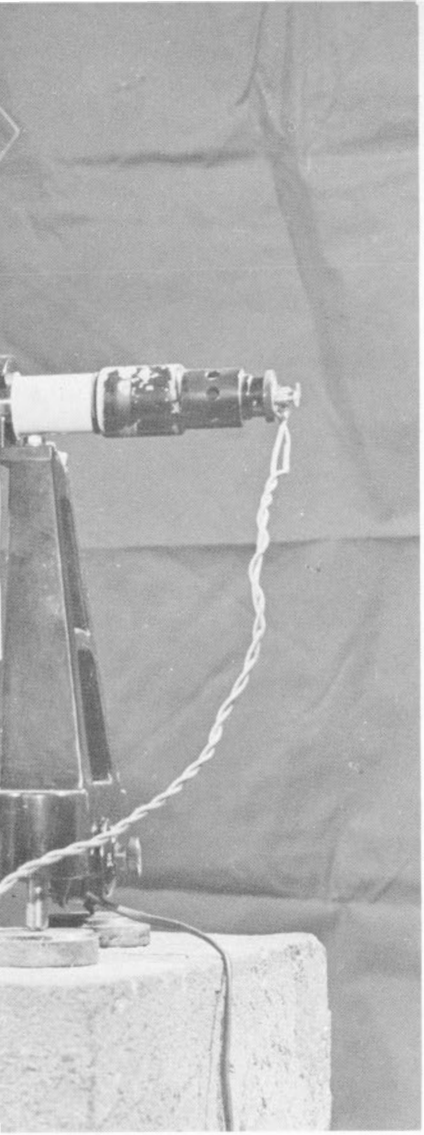
The first-order precision work of the Geodetic Survey is supplemented by surveyors from the Department's other divisions. Here a topographical surveyor takes observations while levelling along the Pelly River inYukon.

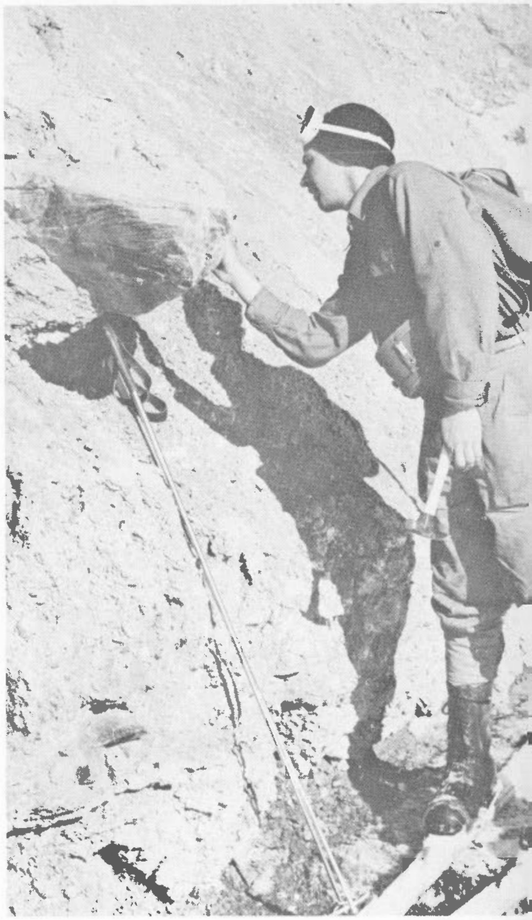




One function of the Geodetic Survey is the establishment of latitude. This engineer is using a meridian transit telescope to observe 20 pairs of stars which will provide a value to within 10 feet.

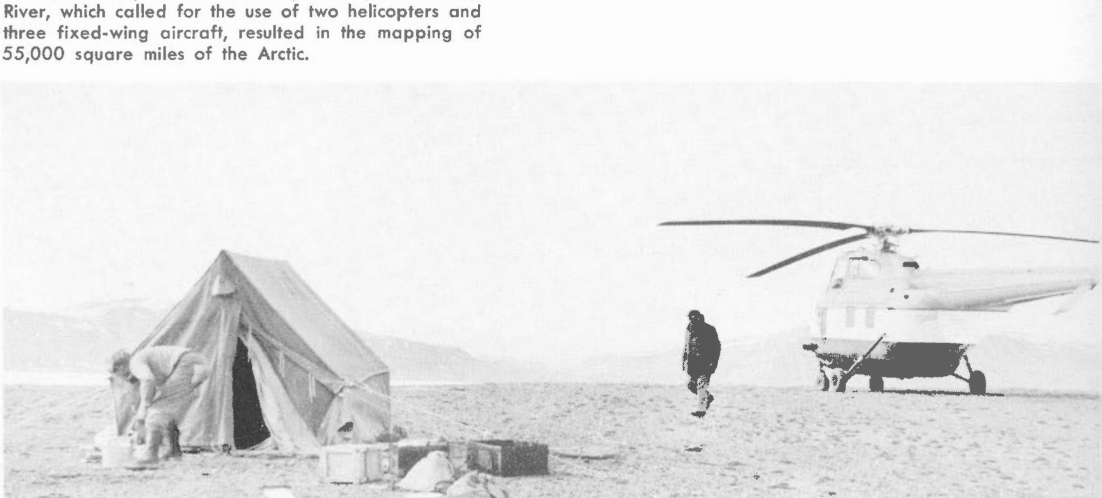
New headquarters of the Geological Survey of Canada were officially opened in 1960 by the Hon. Paul Comtois, Minister of Mines and Technical Surveys.



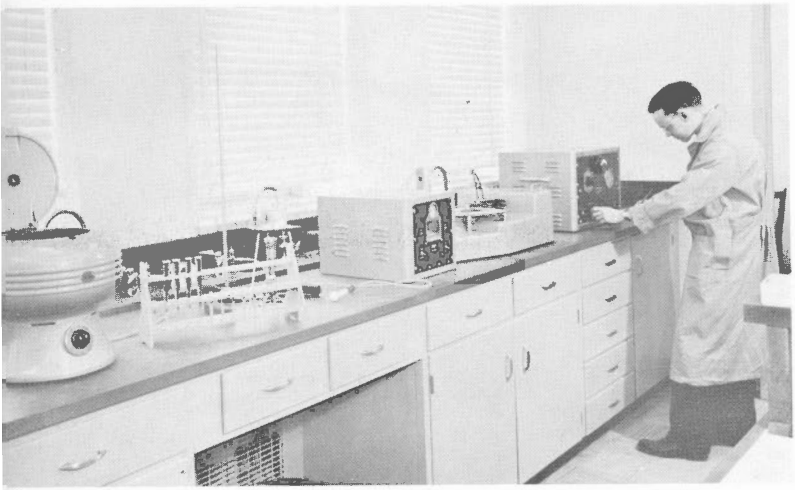


A geologist on skis examines a gypsum deposit on northern Ellesmere Island.

Again in 1960 good use was made of helicopters as a means of speeding preliminary geological mapping, Operation Pelly, involving 21,000 square miles of the Yukon, was completed after three years. Operation Back River, which called for the use of two helicopters and three fixed-wing aircraft, resulted in the mapping of 55,000 square miles of the Arctic.

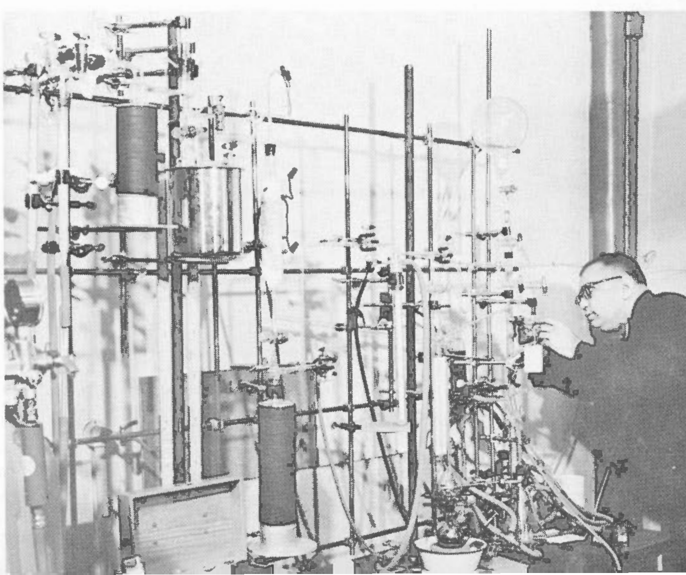


A section of the Geological Survey's sedimentology laboratory where soils, sands and silts are analysed according to particle size and heavy-mineral content; and individual grains and pebbles are measured for roundness. This information reveals much about the invironment under which sediments were laid down.

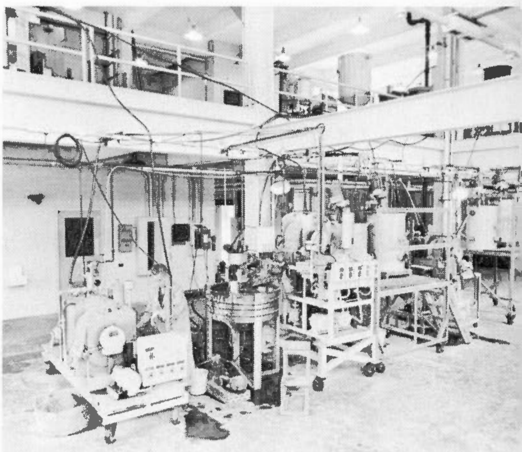


The Geological Survey's radiochemical laboratory where isotopes are used to trace the diffusion of metal bearing and other solutions in rock and the absorption of various elements by plants. At right a scientist checks the radioactive counting equipment.

The Mines Branch is making a careful study of the fundamental chemistry of the desulphurization of petroleum. A scientist studies the kinetics of the desulphurization of thiophene.

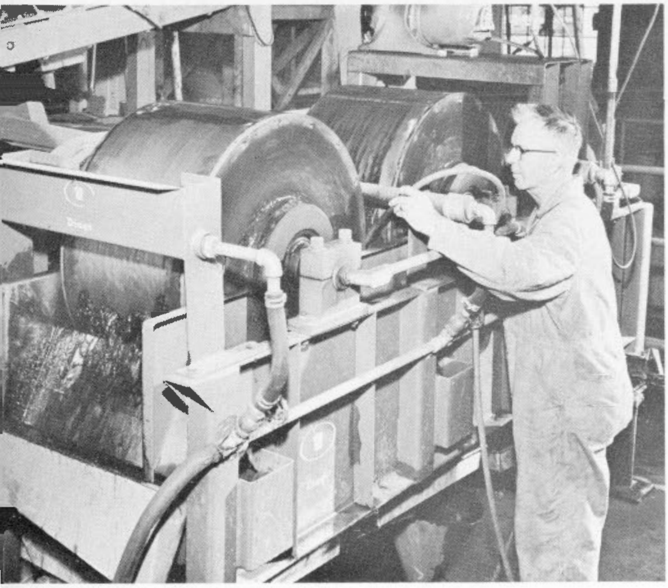


The Mines Branch's 'dry box' permits work on highly reactive materials in controlled atmospheres, such as nitrogen, argon or completely dry air.



A pilot plant, one-half ton per day capacity, is arranged for treating uranium ore.

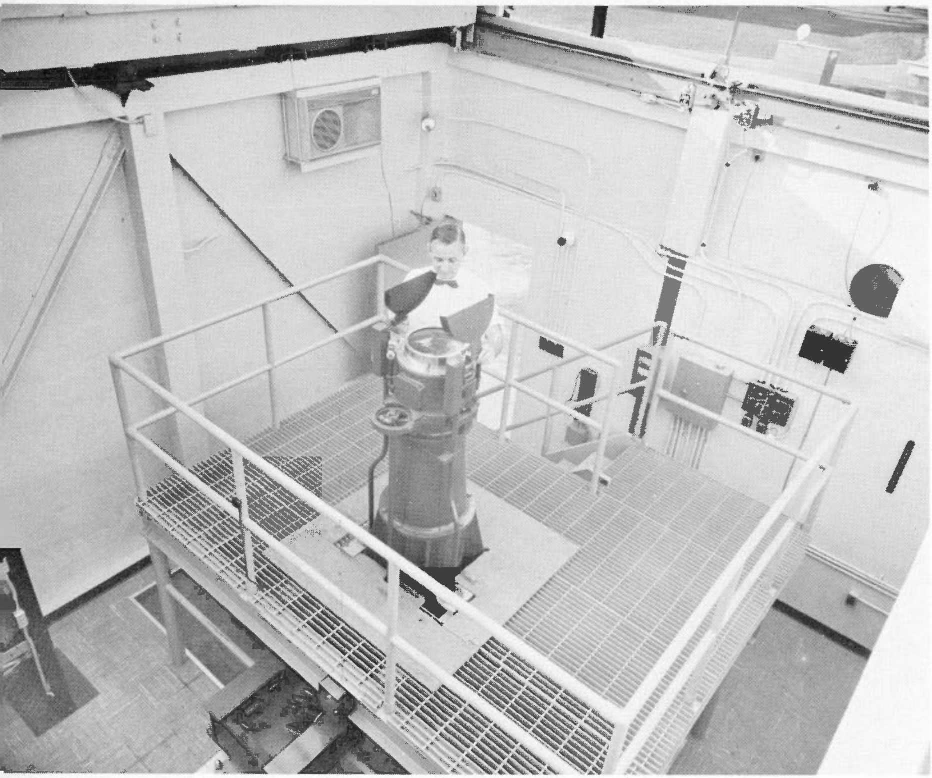
An inert arc vacuum melting unit used in the Mines Branch to produce new alloys for nuclear energy applications.



A large percentage of the wide variety of ores received for investigation are iron ores with a resultant high demand for magnetic concentration tests.

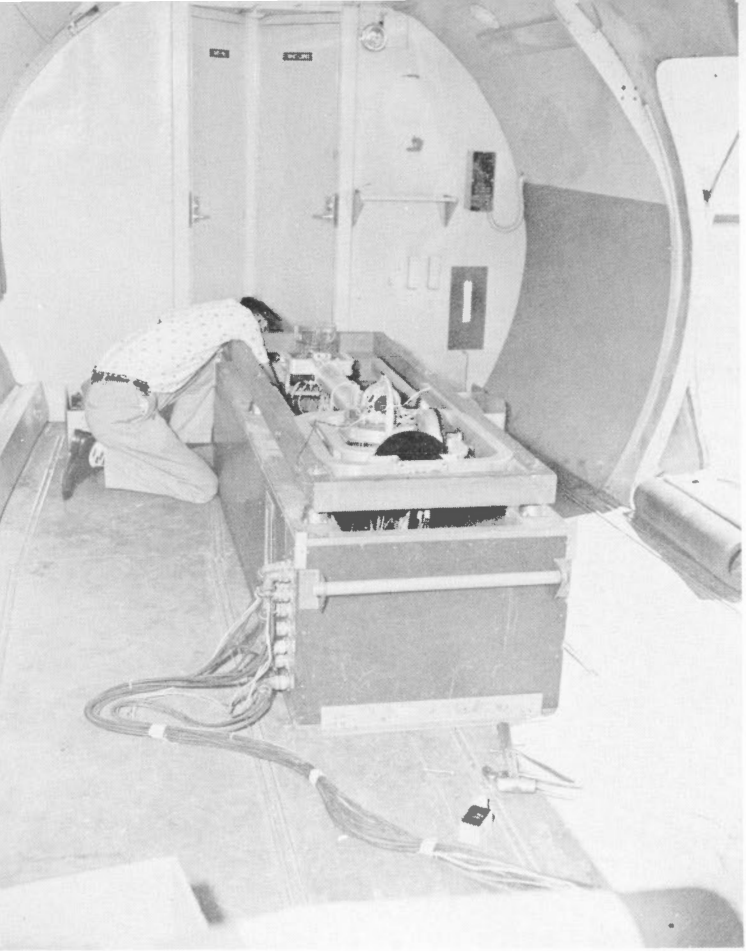
Vibration gravity meter being developed by the Dominion Observatory. This instrument allows gravity to be measured on unstable platforms, such as ice, or ships at sea.

The Dominion Observatory tracks earth satellites with this equatorially-mounted wide angle camera. Time and position of several points of each passage are computed and data forwarded to international centres in England, U.S.A. and Russia. Of particular interest in 1960 were the observations made of the U.S. satellite Echo I.



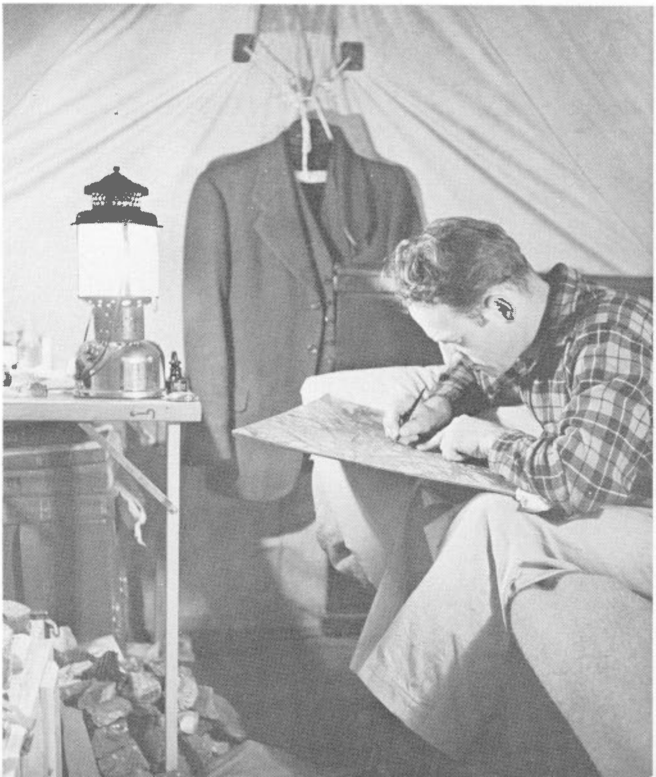
The photographic zenith telescope, shown here, enables astronomers to measure a single rotation of the earth within a few thousandths of a second. This precision instrument which operates automatically is the mainstay of the Dominion Observatory's well known time service.

The last day in the field. Camp 10 of Operation Keewatin is dismantled.



In 1960 the Dominion Observatory's airborne magnetometer, which measures and records magnetic declination (variation of the compass) as well as the horizontal and vertical intensities of the magnetic field, was flown a distance of 45,000 line miles. The instrument was carried inside a chartered DC–4.

The Geographical Branch in 1960 had the most active year in its history. Two geographers rig the aerial for their portable radio.



Inking in the results of a day's field work on a aerial photo.

A Survey geologist undertook structural and stratigraphic work in Blairmore West Half, Beehive Mountain East Half, Carbondale River West Half, and Livingstone River West Half map-areas. His investigations suggested that the mechanical behaviour of rocks between the top of the Fernie group and the lower part of the Blairmore group may have been a controlling factor in thrusting and folding of the southern Cordillera.

The staff of *Vancouver Office* gave information and assistance to persons interested in metallic and industrial minerals, engineering geology, ground-water supplies and construction materials and undertook a number of short-term field projects, mainly at the request of other government departments.

Alberta

In Alberta the Survey continued the work it began in 1959 which was confined to the Mount Robson Southeast Quarter map-area. The area covered in 1960 lay entirely within Jasper National Park. Most of the strata is of Cambrian, Devonian, or Carboniferous age. Gypsum occurs locally in the Triassic Whitehorse formation between Mount Stornoway and the Snake Indian River.

One party began and completed the geological study and mapping of the Precambrian rocks within parts of Bitumont, Clearwater West Half, and Frobisher Lake map-areas in Alberta and Saskatchewan.

The *Western Plains Office* in Calgary received about 200,000 samples, mostly from wildcat wells. Its personnel were engaged in numerous field investigations.

Saskatchewan

In Saskatchewan the Survey completed its reconnaissance ground-water survey, begun in 1958, of the 11,500-square-mile area lying within the Souris River watershed. Purpose of the project: to update and supplement the Survey's 1935 ground-water inventory of that region. It was found that well levels in unconsolidated deposits were generally higher in 1960 than in 1958 and 1959. The Survey also completed the 1-inch-to-4-mile mapping of surficial deposits of the Elbow map-area and began contouring the bedrock surface to aid in the evaluation of ground-water potential. It found evidence for only one major ice advance.

The ground-water survey of Saskatoon South Half continued and several buried glacial and pre-glacial channels were identified. These are potential large-scale sources of ground water.

An officer of the Survey, acting on behalf of the National Advisory Committee on Geological Research in Canada, coordinated and directed a comprehensive study of the Hudson Bay Mining and Smelting Company's

Coronation mine. This project, originally envisaged in 1957, is a co-operative study—or series of studies—by geologists, geochemists, geophysicists, and mineralogists of a particular Canadian ore deposit.

During the summer an aeromagnetic survey was made of the mine area and initial field work undertaken. This involved the preparation of a 1-inch-to-400-foot surface geological map of an area extending from the Palaeozoic escarpment just south of the mine, north to Birch Lake mine. Areas close to the Coronation mine and underground were mapped on scales of 1 inch to 100 feet and 1 inch to 20 feet.

The project is a joint one involving the Hudson Bay Mining and Smelting Company (owners of the mine); the Saskatchewan Research Council; National Research Council; Universities of Saskatchewan, Manitoba, and Western Ontario, Queen's University; Canadian Aero Service Limited; and the Geological Survey of Canada and the Surveys and Mapping Branch of the Department of Mines and Technical Surveys. The field phase of the project is expected to be completed by 1963.

Manitoba

In Manitoba the Survey completed its map revision of the Cross Lake map-area and began the ground-water survey of townships 7 to 12, ranges 1 to 5 west of principal meridian, between Winnipeg and Portage la Prairie. In the latter case, indications are that potable water can be expected at three subsurface levels ranging from less than 25 feet to 175 feet.

Mapping of Whiskey Jack Lake map-area was begun and completed during the season.

Ontario

As a result of an agreement reached in 1959 between the Ontario Department of Mines and the Department of Mines and Technical Surveys, the Survey began the geological mapping of 48,000 square miles of northwestern Ontario—a phase of the government's 'Roads to Resources' program. Acting coordinator of the project in 1960 was a senior Survey officer assisted by eight staff geologists and about forty seasonal employees. They used a Beaver and a Piper Super Cub plane and a Bell helicopter to undertake a variety of investigations (bedrock, surficial, geochemical, and magnetic*) over four 1° by 2° map-areas: North Spirit Lake, North Caribou Lake, Lake St. Joseph, and Miminiska. A fifth, Trout Lake, had been mapped as a pilot project in 1959. Three adjoining map-areas remain to be covered in 1961 to complete the project. Bedrock mapping was for publication on a scale of 1 inch to 4 miles.

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*Seventy-five per cent of the cost of an aeromagnetic survey of the eight map-areas, including map compilation, was borne by the province of Ontario with the federal government bearing the rest.

The Survey completed several other projects in Ontario: the study of stratigraphic palynology between Lake Erie and James Bay (expected to result in the correlation of late and post-glacial events of the Great Lakes, James Bay Lowlands, and Ottawa and St. Lawrence Valley regions); bedrock mapping in Wakwekobi, Dean Lake and Sault Ste. Marie map-areas; and the mapping and field study of the surficial deposits in a triangular area on the Ontario side of the Ottawa River, including the Chalk River research establishment of Atomic Energy of Canada Limited.

Also completed was the field work for a palaeomagnetic study of the Sudbury irruptive. This and other similar investigations may well produce a useful method of determining the ages of rock formations where other methods are unsuitable and may shed light on the controversial theories of continental drift.

Another party began a detailed and comprehensive study of the Anstruther batholith. This project, a phase of the investigation of Canada's granitic rocks, is expected to provide a detailed description of the intrusion and its geological environment, and explain how, when, and why these features developed. Meanwhile the Survey's study of surficial deposits in the Kingston area, begun in 1960, resulted in some refinement in the boundaries of glacial Lake Iroquois as outlined by Coleman in 1936.

The study of the Palaeozoic strata of southeastern Ontario continued and mapping was completed within Wellington and Belleville and the western third of Tweed map-areas. And a party of staff officers carried out aeromagnetic surveys of the remaining segments of areas 31 and 41 lying between latitudes 45°30′ and 48°00′ and longitudes 78°45′ and 80°15′.

Quebec

Survey parties investigated ground-water conditions of Vaudreuil East Half map-area, and undertook further field work in New Quebec and Labrador. One party completed field work necessary for compilation of a final report and map of the structure and stratigraphy of a strip extending northeasterly from the western boundary of the Labrador Trough through what is now Schefferville to Attikamagen Lake. Results should be of considerable interest to those concerned with the origin of the Labrador iron ores. Another conducted advanced reconnaissance for a helicopter-supported project, Operation Leaf River, to be launched in 1961. It calls for geological mapping of a large area of Ungava north of the 56th parallel and west of the Labrador Trough. Preparing for the project the Survey established gasoline caches and selected several campsites.

In the southeastern end of the trough the Survey completed the geological study and mapping of Ossokmanuan map-area.

New Brunswick

In New Brunswick survey parties carried out a series of geochemical studies to acquire further knowledge of the distribution of various metals and their origins. Investigations of Chaleur Bay sediments and those of its tributary rivers, in New Brunswick and Quebec is expected to determine the factors governing the distribution of trace elements such as copper, lead, and zinc within sediments deposited in fresh, brackish, and marine waters.

A party continued geochemical studies of the mineral deposits and associated sediments of the Bathurst-Newcastle base-metal district and completed the field work for one phase of this project. A third party undertook similar work in the Bay of Fundy-Petitcodiac River-St. John district and completed field work within Alma, Hillsborough, and Moncton map-areas.

The Survey completed its ground-water investigations in the Moncton West Half and Hillsborough West Half map-areas, where it found that bedrock was the chief ground-water source. The Boss Point formation was found to be an excellent aquifer.

A Survey party completed the 1-mile mapping of the surficial deposits along the Saint John River valley between Edmundston and Fredericton; it studied and mapped parts of Andover, Florenceville, Woodstock, and Canterbury map-areas.

Also completed was the work in the Hayesville and Doaktown West Half map-areas. Geologists found that the Ordovician sedimentary and volcanic rocks there trend northeasterly and appear to be extensions of those associated with the mineral deposits of the Bathurst-Newcastle area. Minor occurrences of molybdenite, fluorite, beryl, and wolframite were observed in a few small granitic bodies.

Nova Scotia

In Nova Scotia the Survey had four parties engaged in bedrock geological mapping. One began the geological study and mapping (at 1 inch to 1 mile) of the Hopewell West Half map-area and completed the project during the season. A second party worked in the Lake Ainslie map-area of Cape Breton Island as part of a project to revise the previous geological maps of this and neighboring areas. Here geologists found a little galena and sphalerite in the Mississippian rocks.

The geological study of Guysborough map-area was completed and the resulting map will be issued on a scale of 1 inch to 1 mile.

Another project finished during the year was the field work in Shelburne map-area, begun in 1959, and that of the western third of Eastport East Half-Annapolis West Half map-areas. This was for publication on a scale of 1 inch to 4 miles. The party working in these areas observed minor spodumene and beryl in a pegmatite dyke near Brazil Lake.

Prince Edward Island

Two parties worked in Prince Edward Island. One began and finished the study and mapping of bedrock and surficial deposits of Rustico East Half map-area. The other gathered a complete field collection of red Carboniferous sandstones and olivine diabase for palaeomagnetic* studies.

Newfoundland

In Newfoundland the Survey investigated and mapped surficial deposits and shoreline features. One party began the reconnaissance mapping of Paradise map-area. A second surveyed parts of Sandy Lake East Half map-area for a map to be published on a scale of 1 inch to 4 miles. Rocks in this area include several ultrabasic asbestos-bearing bodies among which is the Baie Verte deposit of Advocate Mines Limited.

The third party began the geological mapping of the marine shoreline and shore deposits of the Newfoundland coast from Trinity Bay to White Bay, and on the Burin Peninsula. This is the westward extension of similar work completed in 1959 on the Avalon Peninsula. Here are extensive stratified sand and gravel deposits that provide much of the sparse agricultural land adjacent to many Newfoundland communities, large reserves of road material and good sources of potable water.

General

In 1960 the Survey made further progress in its studies of Canada's mineral deposits, acquiring data finally published in the *Economic Geology* series. Investigations in 1960 centred on deposits of iron, beryllium, titanium, and fluorine, barium and strontium.

The Survey's field investigations of Canadian iron deposits, under way since 1957, involved the examination during the season of the Labrador Trough and its southwesterly sector extending as far as the recently discovered iron ranges of the Siegneley River area. The Survey's study of beryllium occurrences centred on those of British Columbia, Manitoba, and Quebec. Preliminary examination suggested that, within the Cordilleran region, beryllium minerals are most plentiful in rocks bordering the Cassiar batholith and those along the eastern flank of the Nelson batholith.

The work on titanium deposits called for the examination of ilmenite and titaniferous magnetite deposits in Ontario and Quebec. Other field investigations concerned occurrences of barium, fluorine and strontium. In 1960 about 28 deposits, mainly in the Cordilleran region, were examined.

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*The science of palaeomagnetism, or fossil magnetism, is founded on the fact that certain minerals, when formed, acquired and retained a magnetic polarization aligned with that of the earth. Since the earth's magnetic pole has changed position over the years, these studies offer clues to the age of the earth and to the position in which these minerals were originally laid down.

The year brought the beginning of a new project: publication of a series of popular accounts, in booklet form, of the geology of each of Canada's national parks. With this in mind, Survey geologists carried out field work in Fundy, Prince Edward Island, Yoho and Jasper National Parks.

Also launched was a project to investigate the geochemistry of sandstones in Western Canada; studies in 1960 were confined mainly to the Cretaceous Blairmore group. And the Survey continued to maintain an up-to-date estimate of the coal reserves of Canada; one of its officers visited operating coal mines and provincial government agencies in Saskatchewan, Alberta, and British Columbia.

Palaeontological (fossil) collections were made by four parties in various parts of Canada, from Newfoundland to British Columbia. One completed field collections of Devonian flora of the Gaspé-Maritimes region, and made additional collections near Ghost River, Alberta. A second collected Silurian and Devonian material from Ontario and New Brunswick, respectively, for a detailed study of the microfossils (mainly ostracods) of the enclosing strata. Another party collected pre-Carboniferous fossils from a number of localities in Gaspé, northern New Brunswick, and the island of Newfoundland; and the fourth examined the stratigraphy of Jurassic rocks in the Rocky Mountains and Foothills of Alberta between the 49th parallel and Edson, and in the Nelson and Salmo map-areas.

Two parties spent part of the field season testing a new, relatively fast method, calling for helicopter traverses, of mapping Grenville rocks. These are found in the southeastern part of the Canadian Shield and, in Quebec and Ontario, are essentially unmapped. One party, aided by a helicopter, covered most of the Pembroke West Half map-area in eastern Ontario and western Quebec. The other made a series of road traverses between Ottawa River and the Shelter Bay-Gagnonville railway line of Quebec Cartier Mining Company. The results of the experiment suggest that helicopter traverses, used in conjunction with other techniques, should be applied as one of the fundamental methods of reconnaissance in the Grenville subprovince.

An officer of the Survey, continuing his study of radioactive deposits of Canada, worked at Port Radium and Rayrock mines, District of Mackenzie, at various mines in the Beaverlodge area of Saskatchewan, and at the Faraday mine in the Bancroft district of Ontario. The resulting data are expected to further the study of the geochemistry of the mineralized bodies and their enclosing wall rocks.

Another Survey officer collected about 90 samples for age determinations by the potassium-argon method. These came from the region between Chibougamau, Quebec, and Hearst, Ontario, filling a major gap in the sampling program. Knowing the ages of these rocks is vital to understanding the historical geology of the Precambrian, and for compilation of the Survey's *Tectonic Map of Canada.*

To provide suites of rocks and minerals for sale to prospectors, students, and the public, the Survey collected more than 17 tons of material from numerous localities in Ontario, Quebec, and southeastern Manitoba.

Laboratory and Office Research

The Survey's laboratory work was mainly directed towards supplementing, expanding and explaining the results of recent field projects. And with the large-scale field programs of the last few years the facilities for these services in 1960 were operating to the full; the volume of work processed showed a large increase. And thanks to new quarters and new and better techniques, the laboratories operated at a new level of efficiency. In addition to mineral analyses, X-ray identifications, age determinations, fossil, spore and pollen studies and other scientific procedures, the staff intensified its efforts in developing scientific tools and methods to further the work both in the field and at home.

In 1960 the analytical chemistry laboratories completed 2,013 chemical and 2,252 spectrographic analyses, compared with 391 and 509 respectively in 1959. Much credit for the increased production is due to improvements in techniques and greater use of certain analytical methods, e.g. rapid chemical analyses, flame photometry, X-ray, and spectrograph methods. Developed were new, more rapid chemical means for determining aluminum and magnesium in rocks and minerals; and new chemical methods for determining potassium in mica which will enable potassium-argon determinations to be made in considerably less time.

The isotope and nuclear research laboratories completed the construction and testing of a new solid source mass spectrometer, the precision and sensitivity of which exceeded all expectations. Construction began also on a second gas source mass spectrometer of importance in the potassium-argon dating program and to research projects involving lead and sulphur isotopes. A radiocarbon dating laboratory was established for the dating of carbonaceous materials of relatively recent geological age (0-35,000 years), and by year's end calibration tests on the apparatus were almost completed.

In 1960 the Survey conducted 157 potassium-argon age determinations on samples from British Columbia, Yukon, Northwest Territories, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Newfoundland. In connection with this program, excellent progress was made in the mineralogical study of micas.

The Survey also undertook preliminary studies on the application of X-ray diffraction methods to the study of variations in composition in ultrabasic rocks; made improvements in the quantitative method of analyses for barium and strontium, and developed a qualitative method for the analyses of volatile elements.

The X-ray laboratory completed 1,483 mineral identifications, 155 determinations of unit cell constants, 597 X-ray diffractometer patterns, and prepared 54 reference X-ray powder diffraction patterns. Production in the mineral preparation laboratories increased by 600 per cent over that of 1959 thanks to improved facilities and better mineral separating techniques. Some 5,336 mineral and rock sets prepared by Survey personnel were sold to the general public during the year.

The Survey continued to undertake and interpret geophysical surveys as an aid to geological mapping and made further progress in research towards new methods and instruments for geophysical surveying and prospecting.

Completed in 1960 was the compilation of 115 maps from the Maritime Provinces-Gulf of St. Lawrence area. The aeromagnetic surveys for this project had been flown in 1958. Readied for publication were an additional 160 aeromagnetic maps prepared by a private firm at the joint request of the Ontario and Federal Departments of Mines as part of the 'Roads to Resources' program. Similar federal-provincial cost-sharing aeromagnetic surveys in the Canadian Shield were planned for the future.

Substantial progress was made in the compilation and interpretation of data from previous magnetic surveys. Those made by the C.H.S. *Baffin* south of Yarmouth, Nova Scotia, indicated that certain rock formations in the southern part of the province extended southward for considerable distances under the sea. Data from the magnetic survey made by the C.H.S. *Kapuskasing* southeast of Cape Breton revealed the presence of one large intense anomaly. The Arctic Island reconnaissance, completed in 1960, revealed anomalies associated with the Boothia Arch, and with basic dykes and piercement domes in the Sverdrup Basin. On the other hand interpretation of two aeromagnetic profiles across Hudson Bay indicated that there was no deep sedimentary basin in the Bay near these profiles.

The Survey sought to develop and test new instruments for its geophysical work. Being readied for use was a spinner-type, air-driven magnetometer, which will greatly speed up palaeomagnetic measurements of rock samples. Two proton free-precession magnetometers, designed and constructed by the Survey, were installed in the *Kapuskasing* and the *Baffin*. Developed also was a long-needed, lightweight airborne magnetometer, which can be easily moved from one aircraft to another. Two spectrometers were constructed and used for the study of magnetic resonance absorption in rock samples. And the Survey built a magnetically-shielded hut for magnetic resonance experiments, electromagnetic studies, and for testing magnetometers.

As part of its geochemical work the Survey prepared nearly 12,000 samples for trace element analyses in 1960; 9,000 of these were for the 'Roads to Resources' program in northwestern Ontario. Its trace elements laboratory carried out almost 24,000 analyses on 7,646 samples of rocks, soils, sediments, minerals, natural spring precipitates, and water. At the same time the Survey developed new methods of trace analyses and a rapid analytical method for the determination of carbonates in sediments, and launched investigations into the major and trace elements of coexisting minerals in metamorphic rocks and pegmatites. A mobile geochemical laboratory suitable for colorimetric and other analyses was designed, built, and put into service in New Brunswick.

During the year the Survey laid the ground work for experiments using radioactive tracers that will provide valuable data concerning the diffusion of metal-bearing and other solutions in rock.

The Survey continued its investigations of pollen and spore to further the basis for interpretation of fossil assemblages, and undertook palynological studies of Pleistocene deposits in Ontario. These have aided in preliminary correlations of the Great Lakes geological history with the events in the St. Lawrence Lowlands. Meanwhile, the sedimentology laboratory completed 237 mechanical analyses of sediments for Survey personnel comprising 90 sieve analyses and 147 complete sieve and pipette analyses. Many heavy mineral separations and microscope mounts of sediments were also prepared. During the year the laboratory devised and tested a field method for mechanical analyses of sediments.

A substantial share of the laboratory work was aimed at determining the succession, age, lithological character, structure, and correlation of the sedimentary bedrock formations in Canada—data and information necessary in the exploration for the fossil fuels (oil, gas, and coal); the preparation of palaeontological reports (143 were made on 1,237 lots), the study of Canadian coking coals, and spore studies on various maritime coal seams.

Geological Survey publications were made available to the public through the publication distribution office. During 1960 this office sent out 160,167 separate publications, consisting of 91,038 maps and 69,129 publications, in answer to 15,524 written and personal requests.

mines branch

IN 1960 the Mines Branch made further advances—many of them notable—in its broad program of applied and basic research. Some of its projects were of immediate economic importance to industry, principally mining and metallurgy. Others were aimed at furthering a particular science, providing knowledge that would pave the way for technological progress. In either case the ultimate goal was to develop new and improved means of processing Canadian ores, non-metallic minerals and fuels and to enlarge their practical application.

This brought under investigation directly or indirectly virtually every mineral commodity, though some, depending on the needs of industry, received more attention than others. Generally speaking, the problems tackled by the Mines Branch in 1960 were more diversified and more complex; and its facilities were functioning at peak capacity and often overloaded.

Mineral Processing

In 1960 Branch facilities for mineral processing research were taxed to the full—both in terms of personnel and equipment. The number of investigations carried out on metallic and industrial minerals, ceramic and construction materials and on industrial waters continued at a high level. Reflecting the technical problems faced by industry, they were, moreover, increasingly complex and, in some ways, more diversified.

Metallic Minerals

This was particularly true of metallic minerals. In 1960 the Branch investigated 68 samples of ore ranging from a few pounds to several carloads. Iron ores continued to dominate the scene: 28 samples were ores of this metal. Eight were mill products or ores of gold; nine were ores of copper or copper associated with iron, zinc or gold, and three were silver, silver-zinc or silver-lead ores. The remaining investigations concerned special products or ores of the less common metals. Ores of niobium were also under study and were subject to pilot-plant runs involving about 150 tons.

Thirteen metallurgists of various companies collaborated with scientific officers of the Division, either on small-scale investigations or on pilot-plant work. While mining companies continued to send in diversified smaller samples at a steady rate, pilot-plant runs were accelerated; twelve companies took advantage of the facilities offered by the Mines Branch for this phase of investigation.

Industrial Minerals

The year's activities also reflected a high level of interest in industrial minerals. Forty-six investigations were in progress and nearly six hundred samples examined and tested in the Branch's Industrial Minerals laboratories.

In ceramics the Branch undertook five major investigations for the clay products industry; three of which concerned the properties and processing of raw materials. It determined (at the request of various companies and government departments) the properties of 190 clays, shales, refractory raw materials, and ceramic products and conducted innumerable investigations in this field, both in and out of the laboratory. Research also continued toward the development of cermet units (fired compounds of metallic oxides with special electronic properties) and in many other promising projects.

The Branch's work on construction materials was directed mainly towards improving the quality of concrete aggregate. In 1960 its scientists developed and tested many types of concrete, some of which were designed to withstand severe climatic conditions. They continued to investigate the use of pozzolans and lightweight aggregate, and the application of lightweight concrete.

The Branch undertook six major milling investigations on samples of barite, brucite, beryl, graphite and pollucite. In addition, fifty-four samples of non-metallic minerals were examined and investigated on a smaller scale.

In applied research, progress was made on the beneficiation of Canadian kaolins, and long-range work on the floatability of pure minerals of the non-metallic group was continued, with 300 industrial tests completed. A number of practical concentrating techniques were under development.

In 1960 the Branch received 175 samples of non-metallic minerals for laboratory study, 20 per cent of which were sufficiently interesting to warrant further investigation to determine processing techniques. As part of the Branch's project to develop domestic sources of silica of glass-grade quality, it investigated samples of sand, sandstone and quartzite from Nova Scotia, Quebec, Ontario, Alberta, and British Columbia.

The Branch continued its surveys of the chemical quality of surface water in the more inaccessible and unpopulated areas of Canada, particularly in the drainage basins of the Arctic Ocean, Hudson Bay and Labrador coast. To provide longer term knowledge of variations in water quality, Branch scientists began a five-year survey of major rivers in Western Canada and for this purpose established 57 sampling stations, 14 of which were located on international streams in the Prairie Provinces. They assisted the Polar Continental Shelf Project by carrying out water quality and sediment load studies, and the Geological Survey of Canada by analyzing 250 samples of ground and surface waters. The Branch also helped other government departments, federal and provincial, in solving corrosion and water treatment problems.

Extraction Metallurgy

The work of the Mines Branch in the field of extraction metallurgy concerned a wide diversity of metals: uranium, gold, niobium, tungsten, cesium etc. Problems related to the production of uranium concentrates continued to demand a major share of the effort, though considerable attention was given to the treatment of gold ores and the cyanide process. In addition, the Branch continued to investigate problems in corrosion and protective coatings.

Most of the projects under way in 1960 came as a result of specific requests from a Canadian industry, in which case Branch metallurgists worked with those of the companies concerned; but a significant number of long-term investigations were initiated within the Branch.

The work on uranium gave particular emphasis to plant operating economy and product purity. Branch metallurgists sought means of reducing a major item of expense in the acid leaching of uranium ores: the amount of sulphuric acid consumed. They found that considerable savings could be achieved by (1) raising the leaching temperature and (2) floating off unwanted acid-consuming minerals. They experimented with pressurized leaching, which requires no sulphuric acid whatever—a process that does not call for the addition of sulphuric acid—and gave intense study to methods that would enable uranium mines to produce refined concentrates. Also sought were more effective ways of making uranium dioxide nuclear fuel. In 1960 the Branch constructed a simple electrolytic cell that efficiently reduces uranium to the tetravalent form, normally one of the most expensive steps in the process.

Although the cyanidation process for extracting gold is well established, problems still arise in applying it to specific ores, particularly those containing pyrrhotite. During the year Branch metallurgists were able to show that detrimental effects of this mineral can be greatly reduced by strict control of the alkalinity of cyanide solutions. They devised a technique which, applied at one mill, brought about a dramatic improvement in the gold precipitation step and resulted in a substantial reduction in costs. They also developed an instrument for measuring conveniently and accurately the oxygen content of the cyanide solution—a matter of considerable importance since the extraction of gold depends on the presence of oxygen. The device is expected to have application in other aspects of metallurgy and possibly in other fields.

A number of the projects in extraction metallurgy concerned iron ores, particularly siderite which responds indifferently to standard beneficiation techniques. The Branch applied magnetizing roasting methods to these ores with promising results. The work reached the pilot-plant stage and, at year's end, was continuing.

The less common metals also received attention and substantial progress was made in the development of processing methods for several. The Branch continued to seek methods for treating niobium concentrates and, in 1960, experimented with the use of chlorine gas in a reducing atmosphere at high temperatures. Material from a tungsten deposit in Northwest Territories and a cesium deposit (pollucite) in eastern Manitoba was also investigated.

The Branch work in corrosion and protective coating involved such matters as zinc plating procedures, ammunition shells, the treatment of zinc-coated hoist ropes used in many Canadian mines and many other problems from government and industry.

Mineral Sciences

In 1960 the program in mineral sciences moved forward on four fronts: The Branch continued to maintain laboratories for chemical analyses required in metal and mineral research. It sought to apply the principles of physics, (radiometry, electronics, radioactivity etc.) to further the work of the Branch and to solve process problems in industry. Its central mineralogical laboratory conducted research on the mineral textures of ores, particularly as they affected the distribution of metals, and undertook many special investigations vital to the development of ore dressing techniques. The work in physical chemistry concerned the constitution of inorganic materials (refractories, ceramics, fluxes, slags, metals etc.) encountered in mineral research, the effects of high temperatures and the chemical reactions involved. In 1960 the work grew both in volume and complexity with increasing emphasis given to basic research.

Highlights of the year's program:

The Branch's analytical chemists had under development new methods for determining trace impurities in metals and alloys, using the techniques of wet chemistry and spectrography, and for platinum-group metals in rocks, ores and concentrates. Early in the year a 100-kv spectrometer was installed, the first instrument of its kind in Canada, paving the way for improved accuracy in analytical work and making possible the determination of traces of niobium in steel in the ranges .006% to .001%.

Almost 8,000 samples were subjected to chemical analysis and fire assay—a program calling for approximately 26,000 determinations. And over 9,500 spectrographic analyses were made on approximately 1,000 samples. In 1960 Branch scientists were active on a number of international committees, to evaluate and establish standard analytical methods, and undertook a large number of analyses for this purpose. Work continued toward the development of new instruments that would enhance process control in various industries—particularly in the field of uranium. Branch scientists designed and built a new induction type continuous monitor probe for the measurement and control of acid leach pulps and were experimenting with a solution monitor for detecting the breakthrough of uranium solutions from ion-exchange columns. They were also working on carbon-14 dating apparatus for the Geological Survey of Canada and on other equipment. Their X-ray spectrometer was in constant operation in the analysis of special samples, routine assays and identifications, the monitoring of airborne dusts etc.

Meanwhile the radiotracer laboratories continued to develop tracer techniques to further milling and metallurgical research. For example, tracers were applied to study froth flotation processes, surface exchange reactions and other problems in surface chemistry, to determine the service life of steel grinding balls for milling, to test the performance of rotary kilns and in many other projects.

Over 480 radiometric assays were made during the year.

Branch mineralogists were concerned with the iron content of sphalerites and used a number of methods for determining it. This is a matter of some importance to zinc producers, for the iron content of the mineral provides clues to the efficiency of the concentrator during the milling operation.

Also investigated were the oolitic iron ores from the Peace River district of Alberta, the cesium deposits of Bernic Lake, Manitoba, the beryllium deposits of Seal Lake, Labrador and other materials of interest. The year brought a considerable increase in the number of regional or field investigations, as opposed to those involving head samples and mill products originating within the Branch.

The Branch continued to study the physical chemistry of metal and mineral substances, with emphasis on high-temperature phase-equilibrium relationships. It undertook an investigation of molten salt fluxes, important to the melting of magnesium metal and its alloys, examined slags from numerous operations and many other materials of importance to industry.

The study of one phase of the iron-titanium oxygen system was completed and further progress made on systems of lime-niobia-silica and those related to refractory clinkers used in metallurgical furnaces and kiln linings.

Fuels and Mining Practice Division

The work in Fuels and Mining Practice Division in 1960 was aimed at assisting the coal industry—particularly in the Maritimes—in its immediate problem of maintaining a market. At the same time, the Branch carried forward its long-term research program in various aspects of refining low-grade crude oils and bitumen, and in ground and rock mechanics.

Its laboratories analyzed 1,604 samples of solid, liquid and gaseous fuels, a matter involving some 27,808 determinations. A total of 126 samples of coal were collected by Divisional Officers at 10 mines in Nova Scotia, 17 in Alberta and one in British Columbia. The Branch also made considerable progress in its coal survey-and-analysis project designed to provide information for vendors and purchasers of Canadian coal.

The electric certification laboratory completed 56 investigations of electric equipment designed for use in hazardous locations. These included flameproof and intrinsic safety tests as well as examination of fire resistant belting, electric cables, a diesel engine and a cap lamp.

The explosives laboratory, in addition to the work on the design and construction of special research facilities, dealt with 239 investigations relating to hazardous or explosive substances.

The Branch played an important role for the Royal Commission on Coal: presenting technical information from first-hand studies in five specific fields. One of its key scientists in the field of mining research served as a member of an industry mission to Europe. And the Branch had a part in forming a regional study group to investigate the contribution that fuels, in particular, can make to developing new industries.

A senior scientist attended an International Surface Chemistry conference in Paris and visited fuel research laboratories and universities in several European countries. Others were consulted on the cause of explosions and safety in the use of fuels.

Some of the achievements of 1960:

—Further advances were made in the field of combustion engineering. In 1960 emphasis was given to the redesign of fire grate bars in both overfeed and underfeed stokers; improving the combustion efficiency of low ash fusion, high caking coals of Nova Scotia and New Brunswick and the conditioning of coal through the use of additives.

—The water cone pilot plant at the Research Council of Alberta was completed and used to test four western Canadian coals. Washability studies were conducted at a number of commercial plants.

—Laboratory and pilot-plant methods were applied to the Branch's studies on the coking properties of new seams and coal blends. Two officers visited Japan on a mission to study the application of Canadian coal in Japanese blast furnaces.

—Research on ground and rock mechanics was continued both in the laboratory and in the field. The Branch developed several stress and strain measuring devices to further the work and formed a 'fundamental physics group' to provide basic knowledge on the constitution and deformation of rock. The work on jet piercing of rocks, a project undertaken with industry, resulted in the design of a burner to produce flames of varying characteristics.

—The Branch conducted an intense research program on the beneficiation of Canada's heavy oils. It has developed—and tested with success on Athabasca bitumen—an inert gas stripping tower using the combustion gases from natural gas. This is of considerable interest to small refiners treating heavy crudes for the manufacture of hard pitch.

—Considerable time and effort were brought to bear on the design of a high-pressure catalytic fluid cracking unit for operation at pressures up to 1,000 lb/sq in. It will be used in research that may open the door to improved methods of controlling the temperature of high-pressure catalytic reactions—a matter of importance to both the chemical and petroleum industries.

—The Branch continued its work on hydrogenation, one of the most promising methods of refining heavy oils and bitumens. The year's program in this field included investigations to clarify the so-called chemical mechanism of desulphurization, the study of various catalysts to find the optimum conditions for the production of gasoline and diesel oil, and research to determine the best sequence to follow in the many process operations required to refine a specific crude.

—Considerable progress was made in the study of catalysts and catalyst carriers, particularly the preparation and control of pore size distribution in alumina and silica carriers. These are the principal types used in industry for such operations as isomerization cracking, polymerization and hydrogenation. Results of the work will make possible improved yields in many commercial processes.

—The Branch made further advances in its new techniques for classifying pure hydrocarbons. It offers a systematic and speedy method of characterizing naturally occurring hydrocarbons and a valuable aid in following the complicated transformations taking place during the refining process. It has been applied with considerable success to fractions isolated from Athabasca bitumen.

Physical Metallurgy

The Branch's work in physical metallurgy was marked by extensive research in many fields bearing directly on the advance of mining and metallurgy in Canada. Intensive study was given to the development of industrial, non-nuclear uses for uranium metal and a similar program on gold was carried forward. The Branch also sought new and improved alloy steels and worked on a wide range of fundamental studies in metal physics, fatigue of metals, and the properties of liquid metals. Some of the main projects of 1960 are listed below:

The Branch examined a great many metal parts and products that had failed or been damaged. This involved a metallurgical study coupled with a review of their production and service histories. Whenever possible recommendations were made to correct the difficulty.

Other investigations concerned the joining of metals by welding, non-metallic inclusions in steel, failure of metal due to fatigue, corrosion in aluminum and copper, and practical applications for a newly-developed high-strength aluminum bronze.

At the request of the Canadian Government Specifications Board Committee on Industrial Radiography, the Mines Branch has undertaken to supervise the examination and certification of industrial radiographers. It continued to train RCAF personnel in the theoretical and practical aspects of radiography as applied to inspection of aircraft castings and components.

Again in 1960 the Branch's sand testing laboratory investigated a number of potentially useful foundry sand materials including crushed sandstone and natural sand from Ontario deposits.

The Branch's metallurgical research in 1960 covered a broad spectrum of studies ranging from theoretical work on the atomic structures, properties, and alloying behaviour of metals, to practical development and evaluation of new alloy compositions with emphasis on their engineering potential.

An extensive program of research was launched to develop non-nuclear uses for uranium—applications that would call for quantities large enough to benefit the uranium mining industry. Initial results were encouraging: additions of uranium were made to steel and it was found that relatively small amounts (0.05 to 0.40%) improved the steel's corrosion, fatigue and high temperature properties.

Similar research into industrial uses for gold resulted in the development of a method to render ultra-high strength steel immune to the embrittling effect of hydrogen in fabrication or service. Patent applications have been filed in principal countries covering this new use of gold.

The Branch made considerable progress in its fundamental studies of the titanium-aluminum, zirconium base and aluminum-magnesium alloys and worked toward the design of ultra-high-strength steel. Other projects concerned the direct reduction of iron ore, the desulphurization of steel and the vacuum degassing and casting of steels.

Welding research in 1960 covered a wide range of subjects: The effects of storage conditions and moisture content of coatings on the diffusible hydrogen content of weld metal deposited from a variety of commercially available electrodes; the problem of welding defects in leaded bronzes; and the tensile properties of mild steel weld metal.

Further research was carried out (using specially designed equipment) into the damaging effects of arc strikes on the strength of steel samples. Line arc strikes were found to be less detrimental than spot arc strikes; but it was also found that the damage of either type could be repaired by superimposing weld metal, or mitigated by tempering at 650°C (1200°F) for one hour. Research was also conducted on the fundamentals of the inert-gas metal-arc welding process with a view to resolving the problem of spatter of weld metal with increasing welding current.

In the field of corrosion research, Branch scientists have attacked a number of important problems: the mechanism of fretting, the question of corrosion-fatigue, the development of corrosion resistant zirconium-base alloys for nuclear reactor application, and the prevention of corrosion by protective coatings, particularly those of zinc. They continued their fundamental work on the mechanism of fatigue, observing the structural changes in polycrystalline copper under torsional stress, and, using bicrystals of aluminum, studied the effect of grain boundaries on the fatigue process. The effect of stress history and spectrum loading on fatigue damage and endurance was also examined in specimens of mild steel.

In studying the problem of segregations in metals, the Branch used radioactive tracers to follow the movement of impurities during solidification of zinc and tin. This will provide badly needed knowledge of the solidification process and the distribution of desirable and undesirable foreign atoms in ingots.

The Branch's electron microscope was used to study the precipitation of carbide particles in iron, lattice imperfections and dislocation behaviour in graphite and MoS_2. The instrument was also put to good use in a number of other projects in basic research.

Special Services

The Technical Services Division assisted in innumerable Branch projects, providing engineering services and special equipment and components. It undertook the construction of specialized electrical furnaces, X-ray cameras, spectrographic equipment, and produced standard and special test pieces for metallurgical and other research. It maintained and improved much of the Branch's equipment and was consulted on a great variety of engineering problems.

The Branch also maintained a special naval section for work on underwater acoustic devices and piezoelectric ceramics, ferrites and magnetostrictive materials for hydrophones and transducers. Also investigated were new methods and materials for lapping, boring and fabrication of non-metallic materials.

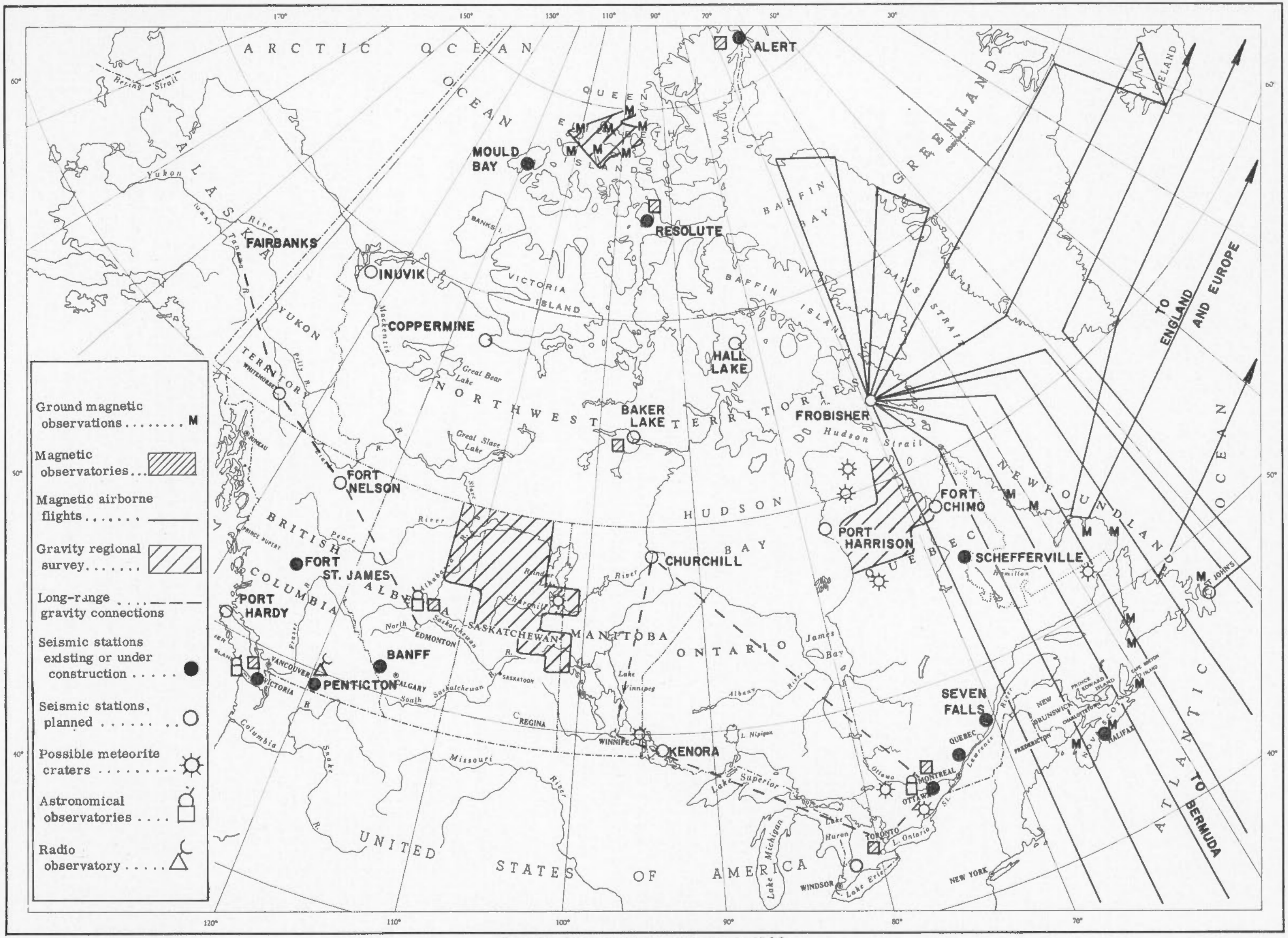
dominion observatories

IN 1960 the Dominion Observatories made major advances in its program of astronomical, astrophysical and geophysical research, and toward the improved instrumentation of its facilities. Observatory services in transmitting the time and providing data on the earth's gravity, magnetism and movement, and on star positions were in increasing demand for a host of enterprises, both commercial and scientific. Its studies of individual stars, interstellar clouds and the milky way were contributing to man's understanding of the nature and size of the universe and the laws prevailing at great distances from our solar system.

In 1960 the Observatories used helicopters for the first time for gravity measurements over the northern parts of the Prairie Provinces and fixed-wing aircraft for similar work in Quebec and Labrador. It is probable that the reconnaissance gravity mapping of Canada's land areas will be completed in the next decade.

Five magnetic observatories were operated during the year and airborne magnetometer flights made over Eastern Canada and the Atlantic Ocean. The network of seismograph stations was extended in both Northern and Southern Canada.

In Ottawa, the mirror transit telescope was being readied for operation —an instrument that will make possible a new degree of precision in positional astronomy—and a solar magnetograph for studies of the sun's atmosphere was under construction. In Penticton, B.C. the new 84-foot radio telescope was officially opened and, in Victoria, special equipment was being designed and built to serve a new 48-inch reflecting telescope. In the Arctic, the Observatories were testing instruments for measuring gravity at sea. It also sought to improve equipment at seismograph stations and magnetic observatories.



Dominion Observatories — Field Work, 1960

Positional Astronomy

The demands of research astronomers, surveyors and aerial and marine navigators for accurate star positions, were at a record level in 1960 and the Observatory devoted a substantial part of its program to meeting these needs. Observations were made every clear night with a large transit instrument fitted with highly accurate equipment for measuring the stars' time of passage and angle relative to the equator. In order to insure the necessary accuracy, observations were pooled internationally with many observatories.*

Two international programs which have occupied Ottawa observers for the past six years were brought within a year of completion. One will result in the extension of the fundamental catalogue of 3,000 brighter stars used for practical astronomy, geodesy, surveying and navigation. The second, involving 20,000 stars, will provide a background of reference stars to be used in a comprehensive photographic survey of the sky, part of a study of the motions and distributions of stars in our galaxy or milky way. It is necessary to carry out such surveys every few decades because each star has a motion differing from that of its neighbors, motions that must be taken into account in compiling catalogues of stellar positions.

In order to improve the accuracy of Ottawa observations and to make possible their extension to fainter stars, a new mirror transit telescope has been developed and, in 1960, was being readied for operation. The instrument's only moving optical part is a large mirror accurately mounted to reflect the starlight into a horizontal telescope of large size which is solidly mounted in a north-south direction on concrete piers. Precision techniques in star tracking, photographic registration, and remote control will contribute to the accuracy of this instrument and extend its range to include fainter stars. In addition, its automatic features will minimize observer fatigue. The new telescope will prove useful in many investigations: for example, research into the motions of stars in our galaxy, the wobble of the earth on its axis, the variation in speed of the earth's rotation and the relation between solar time and the more accurate system of time called "ephemeris time" now used by astronomers.

Canada's time service is based on astronomical observations obtained photographically with a fixed vertical telescope. Not only the rotation of the earth but the variation of latitude is determined from these observations. In May 1960 the telescope, a photographic zenith type, was moved from the large stone observatory where it was temporarily mounted to a properly designed hut on Observatory grounds—a change that brought about a marked improvement in night-to-night observations. A single rotation of the earth can now be measured with a precision of a few thousandths of a second, an improvement in accuracy of approximately 2.5 times.

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*Approximately 20 observatories are engaged in meridian work.

In its new location the telescope is designed to operate automatically. After dark the roof of the building opens by itself and closes before dawn. During the night the transits of approximately 50 time stars are recorded photographically without the presence of a human observer. On the average, observations made in this way attain a higher accuracy than those made by the human eye.

In 1960 the Observatory continued to track Russian sputniks and American earth satellites with an equatorially-mounted, wide-angle camera. The time and position of several points of each passage were computed and the data forwarded to international centres in England, the U.S.A. and Russia. There the information was coordinated with other observations to study the shape of the earth and the physics of the earth's atmosphere. Of special interest was the American satellite, Echo I, observations of which continued into 1961.

The Observatory transmitters (radio station CHU on frequencies of 330 k.c., 7335 k.c. and 14,670 k.c.) underwent improvements that increased their usefulness not only in Canada but also in other countries. Installed were a new speaking clock that gives the time every minute throughout the day, and a new precision quartz clock at the transmitter site.

At the end of 1960, the seconds pips from CHU were synchronized with those from other national institutions in England, Switzerland and the U.S.A. which have similar controls. Time maintained in world-wide synchronism will have undoubted value in satellite tracking and be useful in many scientific observations and experiments where exact timing is of importance.

The quartz oscillator associated with the quartz clock at the transmitter site was operated in conjunction with the cesium standard (atomic clock) of the National Research Council and with the monitor service of the Department of Transport, ensuring that the frequencies of the transmitters is kept accurate to one part in 10,000,000,000. With this important change station CHU became a standard of frequency as well as of time and now offers a service to scientists and those engaged in communication for frequency calibration in laboratory equipment, radio and television transmitters and other technical applications.

The Observatory again used its special Markowitz camera to take accurately timed pictures of the moon. The resulting exposures, when properly identified, were forwarded to a data centre in Washington, D.C., where with similar contributions from about 20 other observatories, ephemeris time was computed. In 1960, 80 moon plates were secured for time determination, the plates being taken between first and last quarters of each lunation.

Stellar Physics

For the Dominion Observatories the highlight of the year in the realm of stellar physics was the official opening of the Dominion Radio Astrophysical Observatory, on June 20, 1960, by the Honorable Paul Comtois, Minister of Mines and Technical Surveys. The ceremonies were attended by Canadian scientists and government officials and guests from other countries. The opening was followed by a meeting of the Canadian committees of the International Astronomical Union of Radio Science and a two-day symposium during which many problems associated with radio astronomy were discussed.

The new radio observatory is located about 15 miles south of Penticton, B.C., and is equipped with a radio telescope 84 feet in diameter. It is well suited for the study of the distribution of hydrogen* both within and beyond the milky way star system.

After a series of instrument performance tests the telescope was launched on a full scale astronomical research program, and one of its first projects centres on the space surrounding certain "associations" of stars known to have formed in quite recent astronomical eras. Preliminary observations are bringing to light aspects of galactic structure not recorded in any previous work of this nature.

In the field of solar research, at Ottawa, emphasis was given to the construction of a new instrument known as a solar magnetograph. It will be used with the Observatory's solar telescope and high-dispersion spectrograph in fundamental studies of the physics of the sun's atmosphere. In this project, astronomers will capitalize on the fact that the spectrum given off by a hot gas, like that found in the solar atmosphere, is slightly changed if the gas is in a magnetic field. With the high-dispersion spectrograph it is possible to detect this effect and determine the strength of the magnetic field in the sun's atmosphere.

The magnetograph is capable of measuring magnetic forces controlling sun-spot activity and is designed to record results automatically. It can also scan an active region on the sun in a shorter time than other instruments and should follow changes in the magnetic fields when solar flares occur. The radiation emitted during a solar outburst can have appreciable effects on the earth's atmosphere and on interplanetary space.

Observations of meteors were carried out at two stations in Alberta—Meanook and Newbrook. Photographic methods were used to record the paths of these particles as they move through the upper atmosphere, and to record the spectrum of the light given off as the particles disintegrate. From these observations information is obtained on the composition of the meteors and the physical state of the upper atmosphere near heights of 40 to 70 miles.

The Observatory also continued its study of ancient meteorite craters with special emphasis on the Brent crater in Algonquin Park. This ancient topographical feature is two miles in diameter and filled with Palaeozoic sediments. Diamond drilling showed that the form of the crater underneath

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*The most significant astronomical discoveries of the past decade are a direct result of the fact that hydrogen, the most abundant material in the universe, emits energy at a particular radio frequency.

the sediments resembled that of known meteorite craters. The zone of shattered rock, 2,400 feet thick in the centre, could have been caused by a stone meteorite 300 feet in diameter striking the earth at a speed of 20 miles per second.

Geomagnetism

Continuous changes in the direction and intensity of the earth's magnetic field call for constant revising of the magnetic charts vital to air and sea navigation, surveying and geophysical prospecting. In 1960 Observatory field parties gathered data for this purpose along the Labrador coast, in Newfoundland, Nova Scotia, Ontario, and in the environs of Ellef Ringnes and northern Ellesmere islands. In July and August the Observatory's three-component airborne magnetometer, which measures and records the magnetic declination (variation of the compass) as well as the horizontal and vertical intensities of the magnetic field, was flown a distance of 45,000 line miles in a chartered DC-4. Six north-south lines spaced about 100 miles apart were flown between Frobisher and Bermuda, covering eastern Quebec, the Maritime Provinces and Davis Strait. Additional flight-lines covered Baffin Bay and southern Greenland. And four trans-Atlantic lines were flown about 200 miles apart covering the north Atlantic ocean between latitudes 50 and 64 degrees north. During the meetings of the International Union of Geodesy and Geophysics, the aircraft and its equipment were stationed at Helsinki airport and examined by about 200 scientists.

The results of the airborne survey were made available to foreign countries over which flights were made and to international magnetic-charting agencies. In addition, some 2,000 items of magnetic data were supplied to governmental mapping agencies and geophysical prospecting companies.

The study of changes in the earth's magnetic field that occur from hour to hour, day to day and month to month are based on continuous records mainly from the Observatory's five magnetic observatories. These are situated at Agincourt, Ontario; Meanook, Alberta; Victoria, British Columbia; and Baker Lake, and Resolute, Northwest Territories. In 1960 the Branch directed the design and construction of precision instruments and by year's end had installed magnetometers employing proton precession techniques at all permanent magnetic observatories in Canada.

At Meanook magnetic observatory further progress was made in the study of magnetic activity to aid in forecasting conditions of the earth's magnetic field—a matter of considerable importance to prospecting agencies using airborne magnetometer equipment.

And attention was given to the state of the upper atmosphere during intense magnetic storms in the regions surrounding the north magnetic pole. Records from magnetic observatories located both inside and outside the polar region were used to investigate the physical nature of these phenomena and the radio blackouts associated with them.

Gravity

The Observatory's gravity work again centred on observations of the earth's gravity and the development and improvement of gravity-measuring instruments and techniques. In line with increasing demand for gravity maps and data—particularly from the exploration and mining industry and from the Department of National Defence—observations were made from a record 5,000 regional gravity stations. Field work was conducted in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Newfoundland and in the Northwest Territories. In all, the regional gravity surveys comprised an area of about 300,000 square miles to provide data for the publication of ten gravity maps on a scale of 1:500,000. At this rate, it is probable that the reconnaissance gravity mapping of Canada's land areas will be completed in the next decade.

One survey party, using two fixed-wing aircraft for transportation and support, continued the gravity mapping of northern Quebec. It established 900 stations to form a large network extending from latitude 56°N to Hudson Strait and lying between longitude 72°W and the east coast of Hudson Bay, and made observations from about 100 stations near the Quebec-Labrador boundary.

A 10-man party, supported by two helicopters and one fixed-wing aircraft, mapped about 110,000 square miles of northern Saskatchewan and northeastern Alberta. It is expected that the results will be of considerable value in tracing major structural features of Precambrian rocks obscured either by glacial drift or overlying sedimentary formations.

In the Prairie Provinces the Observatory continued its program of regional gravity mapping. Initiated in 1957, the work is, in part, being carried out with oil exploration companies who have provided gravity data for about 6,500 stations. At year's end the task of incorporating this information into the national gravity network was nearing completion.

The Observatory also made measurements of gravity in the far north as part of the Department's polar continental shelf project. Approximately 400 regional stations were observed at 8-mile intervals on both land and sea-ice in the vicinity of Ellef Ringnes, Amund Ringnes, Lougheed and Borden islands. About 300 additional observations were made at much shorter intervals to supplement geological studies of ring dykes, gypsum piercement domes and to provide detailed information concerning the ice thickness of the Meighen Island glacier.

As this was the first year of the Arctic Islands program, Observatory scientists gave special attention to the problem of measuring gravity on sea-ice which, because of wind and tide, is usually in a state of constant motion. They found that conventional land gravimeters, although modified for operation under unstable conditions, were unsuitable for measurements on open-sea ice; it was necessary to restrict the 1960 sea measurements to the channels and inlets. An attempt to overcome this difficulty was planned for 1961 using an instrument designed for measurements on the more stable ocean floor.

The Observatory also worked to develop a vibration gravimeter designed for oceanographic work and cooperated with the University of Toronto in tests to measure gravity on Lake Erie, and with the United States Hydrographic Service to make measurements in Hudson Bay and the Foxe Basin.

In addition to the usual control stations, the Observatory established a network on Vancouver Island and the mainland coast of British Columbia along with other control points in northern Quebec and Labrador, and northern Manitoba. This control data is expected to provide a basic trans-Canada framework of high precision to which local gravity surveys, undertaken by private industry or other agencies, may be accurately related.

The Observatory's pendulum apparatus is used for basic control, where large differences in gravity are involved, and coordination ("tying in") with the world gravity network. In 1960 Observatory scientists undertook a comprehensive study to reveal the magnitude and sources of error in pendulum measurements, improved the instrument's temperature control unit and incorporated a new timing mechanism.

In the past two years geophysicists in industry and elsewhere have sought means of measuring gravity from an aircraft. So far, the most promising advances have been made by those engaged in mineral exploration, one company having announced the successful development of an airborne gravity-measuring instrument and another their intention of constructing one. To provide suitable means of testing such a device the Observatory completed theoretical studies to enable the gravitational field at various heights above the earth to be calculated from a knowledge of gravity at its surface.

Gravity surveys have an interesting application in the Observatory's program of study of fossil meteorite craters; anomalies associated with these features not only serve as evidence of their origin, but provide a measure of the total amount of rock ruptured by the exploding meteorites during the craters' formation. In 1960 preliminary gravity investigations were carried out at the New Quebec crater, and in the vicinity of circular topographic features, west of Labrieville in Quebec and near Trout Lake in northern Saskatchewan.

Seismology

In 1960 the Observatory continued its program launched two years before to expand Canada's seismological network. When completed no point in the country will be more than 500 miles from a seismograph station all of which will be equipped with identical instruments of the most modern design. In 1960 potential sites were surveyed in the Arctic and sub-Arctic and material was sent for new stations at Mould Bay and Alert; a new station was brought into operation at Penticton, B.C., and preliminary arrangements were completed for constructing stations at Schefferville, Quebec and Fort St. James, B.C. Stations at Halifax and Ottawa were brought up to standard with the installation of modern instruments.

Data from this enlarging network are reported to the world in quarterly seismological bulletins and information from key stations is supplied by radio to a central agency in Washington, D.C. and by air mail to international organizations in Strasbourg and Cambridge.

The Observatory also made progress in its annual listing of Canadian earthquakes (at year's end the report covering 1960 was well under way) and in preparation of the seismic history of various parts of Canada. Papers were prepared listing earthquakes in the Arctic, in Western Canada from 1955 to 1959, and in Eastern Canada to the end of 1927.

The Observatory continued to work toward the development of tape recorders both for field work and for earthquake recording, and "play-back" equipment of high fidelity. By the end of the year the equipment was in the final design stage. It will allow scientists to analyse earthquakes in much greater detail.

Limited field work was done in the vicinity of Ottawa in testing the magnetic tape instruments currently being developed within the Division. Observatory seismologists also investigated the crustal structure of the British Columbia coastal area*.

Dominion Astrophysical Observatory

The Dominion Astrophysical Observatory continued its investigations into the physical nature and properties of the stars, and the organization and motions of stars and interstellar clouds of the galaxy, or milky way, system. Studies of individual stars reveal their chemical composition, their physical conditions and something of the enormous energy they radiate. Studies of our galaxy reveal the laws prevailing at great distances from the solar system and provide clues to dimensions of the universe and the origin of stars and solar systems. The Observatory obtained original data using its 73-inch reflecting telescope and spectroscopes. The results of its observations are tabulated as speeds, distances, luminosities, temperatures, masses, densities, and chemical compositions of stars.

Special attention was again given to high-temperature stars which are intrinsically very bright and may be observed, therefore, at great distances from the earth. These are not only useful space probes but are of special interest because of their great masses and the large amount of energy they radiate. In 1960 the Observatory completed a 15-year program of observations and compiled a catalogue of 550 distant-star speeds—a major contribution to this aspect of astronomical research.

*A project undertaken with the University of British Columbia and the Pacific Naval Laboratory.

The Observatory also gave emphasis to further study and observation of certain double stars measuring their masses, dimensions and mean densities; and studied stars with unstable atmospheres and cooler stars, rather resembling our sun.

In 1960 the telescope was used on 170 clear nights to obtain some 950 photographs of stellar spectra. Line-of-sight speeds were measured from several hundred of these photographs. Other studies yielded information on the chemical composition and temperature of stellar material.

Special equipment required by the scientific programs was designed and constructed in the Observatory shop. A new instrument for the rapid analysis of stellar spectrograms was completed and progress was made in the design and construction of a new spectrograph of great power to be put into service late in 1961 when the new 48-inch reflecting telescope becomes available.

The staff of the Observatory attended 12 international scientific meetings and conferences, presenting a total of six papers. Over 15,000 people visited the Astrophysical Observatory during the year.

geographical branch

THE Geographical Branch, in 1960, published its first map of the land-use series—symbolic of its efforts to intensify and accelerate this type of survey work. Field work for the program was carried out in New Brunswick, Prince Edward Island, Saskatchewan and British Columbia.

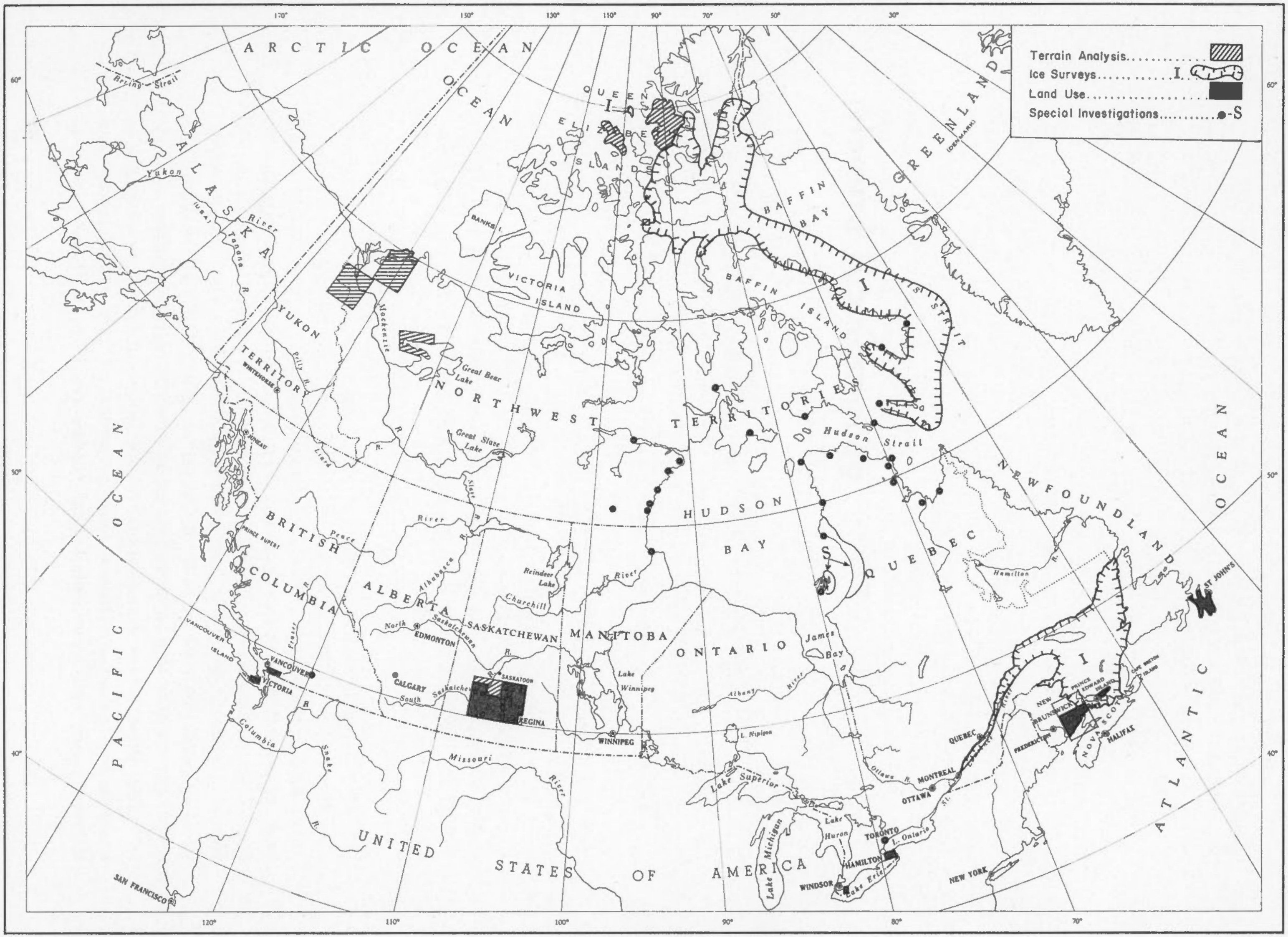
Elsewhere in Canada the Branch undertook a number of studies in terrain analysis with emphasis on the far north, and conducted a survey of the economic geography of the Great Whale River area.

In all, twenty-eight geographers were in the field: nine in the far north, eight on the Arctic mainland, two in New Brunswick and Prince Edward Island, two (on ice distribution surveys) in the Gulf of St. Lawrence and the St. Lawrence River, two in Ontario, three in Saskatchewan and two in British Columbia.

Terrain

In the realm of terrain analysis the Branch conducted further reconnaissance in the Mackenzie River delta area and to the east as far as Eskimo Lakes and Liverpool Bay. Field observations comprised examination of the finger-like peninsulas in the Eskimo Lakes; an investigation of the glaciation of Tuk Peninsula and of post-glacial submergence; studies of permafrost and patterned ground; and other geomorphological features. The aim: to understand physical processes at work in this unique portion of the Canadian landscape, and contribute to a more precise assessment of its resources.

The Branch also carried out physiographic studies along Arctic Red River with attention to terraces, erosional processes, post-glacial history and sedimentation; and geomorphological studies on Ellef Ringnes Island, to



Geographical Branch— Field Work, 1960

examine the effect of glaciation on the island, and observe run-off of a small high Arctic stream. An airphoto interpretation key, which may be applied to similar landscapes, was completed for the Isachsen area of the island.

Detailed geomorphological observations were made on Axel Heiberg Island in the vicinity of South Fiord, and reconnaissance observations at various other locations on the island. This project was undertaken in association with the McGill University-Jacobsen expedition.

A general report on the topography of the Canadian Arctic archipelago was completed.

The Branch made further progress in its studies of periglacial geomorphology. Two geographers spent the summer at Resolute, Cornwallis Island, working on soil temperatures, permafrost, patterned ground and erosional processes. One conducted a study of boulder barriers in Hudson Bay, Hudson Strait and the east coast of Baffin Island. The distribution of these barriers is not well understood and they are a phenomenon of importance to navigation in northern waters.

Northern Economics

The Branch continued to analyze data from a survey of the economic geography of the Mackenzie River delta. This work will enable an assessment to be made of the area's present resources, the uses made of them and will determine the direction of change necessary to increase local productivity. Also under way was a similar area economic study of the east coast of Hudson Bay between Cape Jones and Port Harrison and, for this purpose, the Branch collected information on the area's resources and their utilization by the local population.

A geographer, working in company with a topographical engineer, made studies of the physical environment of 20 settlements along the south coast of Ungava Bay, Hudson Strait and the coasts of Hudson Bay. Being sought was basic information for those planning the development and construction of settlements in the north.

Ice Distribution

In 1960 the Branch intensified its work on ice—its distribution, character, extent and movement and its effect upon the terrain. Much of this work is of importance to navigation. Glaciological studies were continued on the Meighen Island ice cap, and observations of the sea-ice of the Arctic Ocean begun. Early in the year the Branch completed its annual aerial survey of ice conditions in the St. Lawrence River, Gulf of St. Lawrence and the Strait of Belle Isle—the most extensive program yet attempted. (It consisted of eleven flights and 165 flying hours, and was carried out in cooperation with the Royal Canadian Air Force and the Defence Research Board of Canada.) And the Branch's network of shore-based observing stations (established in 1957) continued to report ice conditions and factors such as temperature, wind, currents and tides. Begun during the year was an inventory of Canadian glaciers, in collaboration with the Sub-Committee on Glaciology of the Associate Committee on Geodesy and Geophysics of the National Research Council of Canada.

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 collaboration with the provinces, is summarized below:

——The land-use mapping of Newfoundland's Avalon Peninsula for publication at the scale of 1:250,000 was begun.

——All land-use information on the province of Nova Scotia was transferred to the 1:250,000 scale. Of eight sheets to be published, five were sent for printing.

——Field mapping of Prince Edward Island was completed and all data transferred from air photographs to 1:50,000 scale maps.

——A start was made on the land-use mapping of New Brunswick for publication at the scale of 1:250,000. Some of the material collected in 1960 has been transferred from air photographs to 1:50,000 map sheets.

——The 1:1,000,000 map of the southern part of Ontario was published. In the Niagara Peninsula the area covered by ten 1:50,000 sheets was mapped in the field. (At year's end six of these were being processed and two being printed.) Also carried out was field mapping of Pelee Island and Point Pelee. And further progress was made on the Branch's analysis of the relationship between land use and manufacturing in the Toronto area, a study undertaken with the cooperation of the Department of Geography, University of Toronto.

——In Saskatchewan preliminary mapping was carried out in the area of the South Saskatchewan Dam to supplement that of 1959. The airphoto interpretation of the 1:50,000 sheet 72 NE, based on the 1959 field work, was checked in the field where necessary and by the end of the year the sheet was being prepared for publication. Paralleling this work were the Branch's investigations of the physical basis of land use in the area.

——The Branch continued its land-use mapping of central British Columbia and the Lower Fraser valley. The latter project was carried out with the close cooperation of the Lower Mainland Regional Planning Board of British Columbia. Two sheets were being prepared for publication. The mapping of southeastern Vancouver Island was started and the Victoria sheet was being prepared for publication.

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. Re-measured during the year were areas and elevations of several larger Canadian lakes.

One geographer worked with the Department's Mineral Resources Division in various gold mining areas; another was attached to the Emergency Measures Organization in an investigation of designated zones and regions of Canada.

A project was set up to study the application of mechanical data processing to geography. In this considerable progress was made: plans were completed for processing data for four projects on a digital computer.

The Branch added approximately 16,400 map sheets to its map collection, bringing the total to 156,400 sheets, and acquired 1,740 books, pamphlets and atlases. It made further exchanges of publications (including maps) with foreign governments and geographical institutions; its library now maintains a file of 225 geographical periodicals in which all the main articles are indexed. The book collection of the Royal Canadian Geographical Society was added to the library on a temporary basis.

In 1960 the Geographical Branch cooperated with and was active in many allied organizations. It contributed data on Canadian geography to the *Biblioteca Cartographie, Bibliographie Cartographique Internationale,* and *Geo-Science.* It participated in the 19th International Geographical Congress and the Branch Director was elected Head of the Canadian Delegation to the 10th General Assembly of the International Geographical Union held in Stockholm.

The Branch also 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 represented Canada on the Directing Council of the Pan-American Institute of Geography and History at its meeting in Mexico City.