ANNUAL REPORT

CALENDAR YEAR 1962

MINES AND TECHNICAL SURVEYS

Annual Report

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

Calendar Year
1962

70686-1—1

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1963

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 1962.

Respectfully submitted,

WILLIAM M. BENIDICKSON
Minister of Mines and Technical Surveys

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The Honorable William M. Benidickson,
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 1962.

W. E. VAN STEENBURGH
Deputy Minister

MINISTER

THE HONORABLE WILLIAM M. BENIDICKSON

DEPUTY MINISTER

DR. W. E. VAN STEENBURGH

Assistant Deputy Minister (Research) ..... J.-P. DROLET

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

Director, Marine Sciences Branch ..... DR. W. M. CAMERON

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

Revenues and Expenditures

A summary of revenue and expenditures for 1962 follows:

	Revenue	*Ordinary Expenditures*
Minister of Mines and Technical Surveys	$	$ 15,948.81
Departmental Administration	500.00	1,685,040.50
Explosives	6,621.47	104,500.46
Mineral Resources Division	3,737.37	416,663.12
Assessment for membership in the Pan-American Institute of Geography and History	.....	283.78
Surveys and Mapping Branch	168,637.07	6,012.066.70
Marine Sciences Branch	70,773.99	11,514,350.33
Geological Survey of Canada	27,347.81	6,025,668.93
Mines Branch	10,592.42	5,001,824.47
Geographical Branch	881.84	509,321.78
Dominion Observatories	12,667.37	2,406,812.08
General—		
Payments under the Emergency Gold Mining Assistance Act	.....	13,991,010.00
Purchases of air photography and expenses of the Interdepartmental Committee on Air Surveys	.....	724,201.02
Provincial and territorial boundary surveys	.....	13,543.20
Polar Continental Shelf Project	.44	1,726,485.14
Awards	.....	1,925.86
	$301,759.78	$ 50,149,646.18

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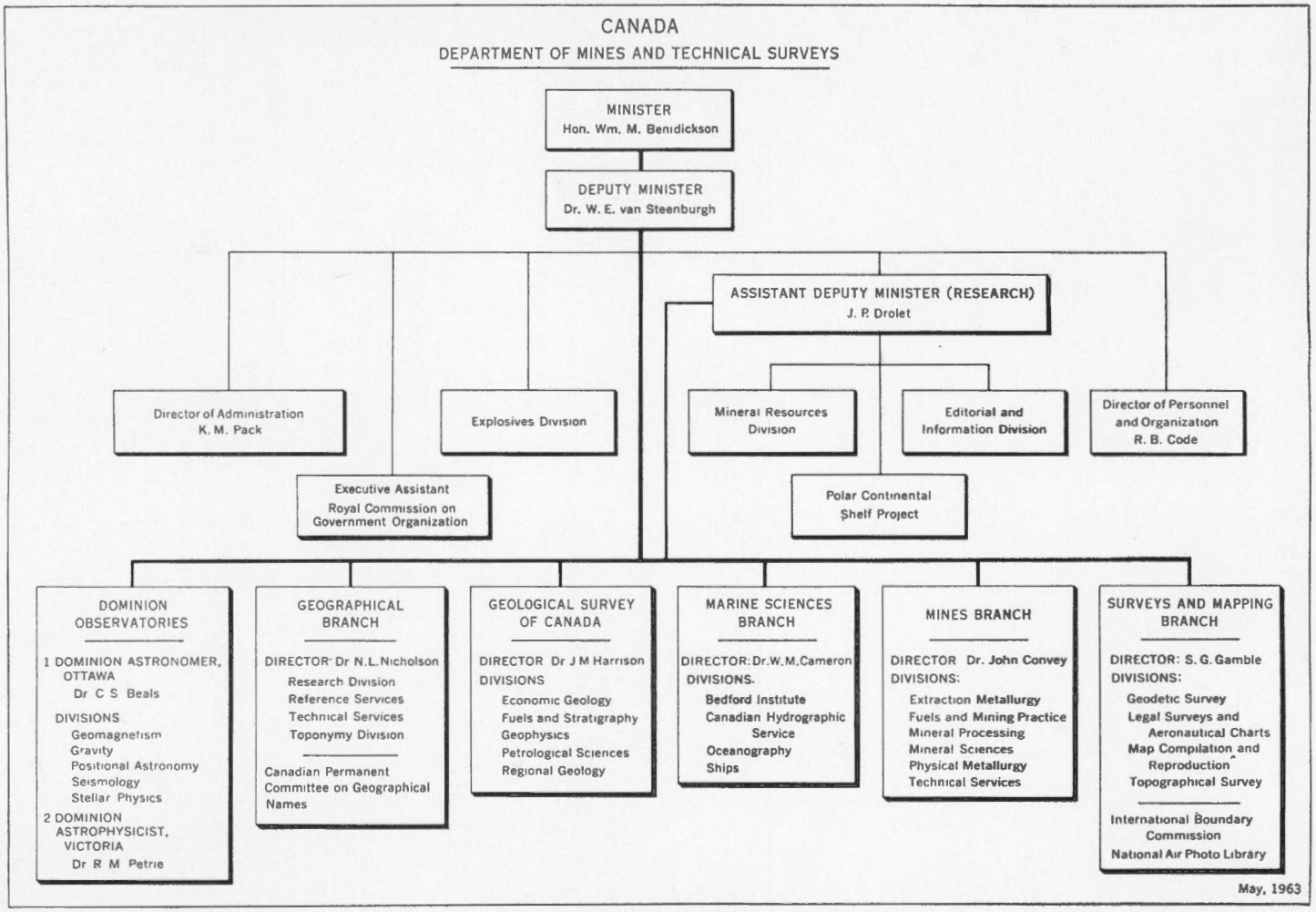
CANADA
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K. M. Pack
Explosives Division
Mineral Resources Division
Editorial and Information Division
Director of Personnel and Organization
R. B. Code
Executive Assistant
Royal Commission on Government Organization
Polar Continental Shelf Project
DOMINION OBSERVATORIES
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Dr C S Beals
DIVISIONS
Geomagnetism
Gravity
Positional Astronomy
Seismology
Stellar Physics
2 DOMINION ASTROPHYSICIST, VICTORIA
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Fuels and Stratigraphy
Geophysics
Petrological Sciences
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Canadian Hydrographic Service
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Fuels and Mining Practice
Mineral Processing
Mineral Sciences
Physical Metallurgy
Technical Services
SURVEYS AND MAPPING BRANCH
DIRECTOR: S. G. Gamble
DIVISIONS:
Geodetic Survey
Legal Surveys and Aeronautical Charts
Map Compilation and Reproduction
Topographical Survey
International Boundary Commission
National Air Photo Library
May, 1963

introduction

IN AN ALL-EMBRACING SURVEY and reseach program the Department of Mines and Technical Surveys continued to obtain information basic to the development of Canada's natural resources (particularly her mineral resources) and to her economic, scientific and technological progress. The work involved every province and the territories—even the undersea areas of the continental shelf—and touched a variety of disciplines. The field program was one of the largest of recent years; the laboratory studies revealed many new and promising avenues of research. And, in one way or another in 1962 the Department made many vital contributions to Canada's growth and scientific stature.

An outstanding historical event during the past year was the long-awaited opening of the Bedford Institute of Oceanography near Halifax, N.S. This opening, which followed the reorganization of the Department's maritime surveying and research units into the Marine Sciences Branch, reflected an acute appreciation of what better knowledge of the sea and the continental shelf areas can do for Canada, both economically and scientifically.

Meanwhile, the Polar Continental Shelf Project was in its fourth season of exploration in and around the islands of the extreme Arctic. This centrally directed research effort, in which most of the Department's branches participate, has gone well past the initial stages and has already made valuable findings concerning the nature of the submarine shelf, the physiography of the land, the formation and movement of ice, and other features on and around the Queen Elizabeth Islands and out to sea.

Another joint scientific endeavor is the investigation of the earth's lower crust and upper mantle, in which the Department takes part within

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the framework of the International Upper Mantle Project 1962-64. This undertaking, which particularly involves the Geological Survey of Canada and the Dominion Observatories, calls for the investigation of ultrabasic rocks and other intrusions; seismic and geomagnetic and conductivity studies; temperature measurements within the earth; and many other scientific observations. In 1962 plans were made for drilling several deep holes in the Northwest Territories and in Gaspé, Quebec.

The Geological Survey of Canada sent 94 parties to the field and completed reconnaissance bedrock and surficial geology mapping of approximately 175,000 square miles of Canada's northland. By the end of the year it had published geological maps covering about 61 per cent of Canada and completed preliminary field mapping of a further 10 per cent.

The Department's geographers continued to study northern ice formations and land features, and, in the densely inhabited south, they accelerated their mapping of land use.

The Surveys and Mapping Branch expanded its trilateration network in the Arctic and its triangulation in the southern part of the country, and continued to carry a heavy topographical-mapping load.

No less important and productive was the work in the laboratory and the observatory. The Mines Branch made progress in the search for new or better uses for important Canadian resources, and in devising more efficient techniques for mining and processing metals, minerals and fuels. Mines Branch technicians completed the construction of the first structural mine model, permitting the duplication of rock stresses in the laboratory. An example of the close cooperation between private industry and Department scientists was provided by the conference of gold mine superintendents and Mines Branch personnel who discussed gold mill metallurgy.

At Penticton, B.C., astronomers of the Radio Astrophysical Observatory worked on the design and construction of a 'telescope' consisting of an array of aerials in a collecting area covering 700,000 square feet. At the Victoria Astrophysical Observatory the first observations were made with the new 48-inch telescope, and new auxiliary equipment for use with the two telescopes was built in the Observatory shop.

The Surveys and Mapping Branch successfully introduced a new aid to mapping, Aerodist, used in trilateration. Field trials have yielded promising results. In the laboratories of the Geological Survey, scientists continued to develop highly advanced methods and instruments to further the survey's work both in the field and the laboratory. They designed and constructed a direct-reading nuclear precession magnetometer and successfully tested it on a hydrographic vessel. Age determinations through isotope analysis are becoming more important every year, and Survey personnel designed two mass spectrometers, one of which was completed in 1962, permitting simultaneous stable isotope studies and age measurements.

The Department's services and the fruits of its efforts were used in many areas of Canadian endeavor; and it sought constantly to ensure that results of its work were readily available. In 1962, for instance, the Department continued to enlarge its services to Quebec through its recently-opened offices in Quebec City.

On November 8, 1962, the Deputy Minister, Dr. Marc Boyer, succumbed to a heart attack at his desk. The death of Dr. Boyer, who had administered the Department since its formation in 1950, was a heavy loss not only for the Department but for all those engaged in scientific and technical research in Canada.

Details of the research and exploration carried on by the Department's six branches and other units will be found under the appropriate headings.

Polar Continental Shelf Project

The Polar Continental Shelf Project, inaugurated in 1959, was conceived as a long-term study of the waters and submarine features in that relatively shallow part of the Arctic Ocean which, according to new international legal definitions, is considered the property of Canada. In practice, the project has become a centrally directed joint research effort of all the Department's branches, and will take in all parts of the Arctic Archipelago not investigated by other agencies in this field.

The past field season was devoted to the geographical expansion of investigations, in line with the policy that systematic research and surveying be shifted along the Arctic Ocean front about 150 kilometers annually. Field work was coordinated from Isachsen on Ellef Ringnes Island, and the field personnel numbered 92.

Here are some of the highlights of the 1962 field season:

Hydrography—Hydrographers continued their bathymetric mapping of the ice-covered waters surrounding the archipelago. By the end of 1962, about 100,000 square kilometres had been sounded on a scale of 1:500,000. The technique of echo sounding through the ice was developed further, and was carried out by helicopter-transported crews. The first successful Arctic field trials were carried out with echo sounders towed by helicopters on open water inaccessible to boats.

Submarine Geology—Geologists attached to the project continued to study submarine sediments on the shelf. Three main studies were undertaken in 1962: (1) Cores and grab samples were taken from the ocean floor northwest of Borden Island; (2) traverses to collect bottom material were run across Gustaf Adolf Sea and Maclean Strait, and on rivers that deposit such sediments from Ellef Ringnes Island; and (3) inshore sediments along the east side of Prince Gustaf Adolf Sea were studied as to fossil content and age. One of the chief questions agitating geologists is whether oil will be found in the extensive sediments of the Arctic.

Seismic Surveys—The gravity control network was extended in 1962 with 'base loops' linking stations 130 to 240 kilometres apart, covering Melville, Devon, Ellesmere, and Axel Heiberg islands. This, with a few exceptions, completed the control work on the Queen Elizabeth Islands. A regional gravity survey continued over the continental shelf in numerous areas.

Geomagnetism and Aeromagnetic Surveys—The recently discovered magnetic anomaly around the northern tip of Ellesmere Island was investigated with multiple magnetic stations. Approximately 50,000 line kilometres of aerial magnetic surveys were flown in 1962, both over the archipelago and over the continental shelf. Information obtained in these surveys clarified the structure and extent of basement rocks.

Physiography and Glaciology—Geographers again studied the genesis of landforms in regions of strong glaciation, past or present, especially on Meighen Island, and the behavior of ice-masses. They began an investigation of the physiographic history of Melville Island. Reconstruction of the history of physiographical changes on the islands may yield information on the climate in past ages.

Sea-ice Studies—All major waters around the Queen Elizabeth Islands and the adjacent ocean were patrolled in order to investigate the formation, nature, break-up, amount, distribution, and dispersal of sea ice. The 1962 season saw an unusually heavy southwestward drift of ice, together with extensive break-up and dispersal. As a new experiment, a radar-reflector target was placed on a large 'ice island' that broke off from a far northern ice shelf, and scientists hope to trace the drift of the island by radar operated on patrolling aircraft.

Topographical Mapping—Topographical surveyors continued to extend the control network needed as a basis for mapping and for coordination of aerial photography. A trilateration-survey network was also run as an aid to seismic studies, to establish the exact distance between explosion and recording station.

Historical Find—Two prehistoric Eskimo camping or dwelling places were found on Melville Island during physiographic investigations, and they appear to contain sufficient material to warrant further archeological study.

Mineral Resources Division

Canada's 1962 mineral production set a record high of $2.84 billion, roughly 10 per cent above the previous high of $2.58 billion of 1961. The large gains in value of petroleum, iron ore, copper and natural gas shipments, and somewhat smaller gains for nickel, platinum-group metals and silver, more than offset the decrease in value of uranium shipments (from $196 million to $151 million) and of lead (from $47 million to $37.8 million). The leading mineral commodities in value of output were: crude

petroleum, $583 million; nickel, $385 million; copper, $283 million; iron ore, $264 million; gold, $155 million; uranium, $151 million; and asbestos, $132 million.

As the mineral industry continues its growth and diversification, and as the processing of minerals to prime metal and secondary manufactured products becomes ever more important to the economy, the work and services of the Division increase. One of its primary functions is to collect, compile and prepare material on the mineral industry, in a form suitable for general distribution. A second important function of the Division is to advise other government departments, Crown corporations, foreign governments and agencies, industry and the general public on the domestic industry and its future and problems. Attention to such problems through participation in national and international organizations, and the preparation, or assistance in the preparation, of studies, briefs and supporting statistical and relevant material, continued to form a large part of the Division's work.

International Activities—Detailed economic and statistical data were prepared for the Canadian delegation at three meetings of the International Lead and Zinc Study Group, held in Geneva, Switzerland, in March, May and October. A senior officer of the Division served as a member of the delegation to the meetings. The study of the effect of United States lead and zinc import quotas on Canadian production was continued and an assessment made of domestic lead and zinc productive capacities to 1967.

Canada became a member of the Organization for Economic Cooperation and Development (OECD) in September 1961. Officers of the Division since then have been responsible for preparing information on the Canadian ferrous and nonferrous industries and in providing the National Energy Board with material for its reports to OECD on oil and gas. One officer was a member of the delegation to the three Paris meetings of the OECD Special Committee for Iron and Steel; another was a member of the delegation at one of two meetings of the Special Committee for Nonferrous Metals.

Another officer of the Division continued to act in an advisory capacity on matters relating to Canada's membership in the International Tin Council. He prepared a report, based on a Council meeting attended in London, England, in 1961, analyzing production, markets, 'control schemes' and factors, both political and economic, that affect the production and marketing of tin.

Transportation—All agreements between the provinces and the federal government under the 'Roads to Resources' program were completed in 1961, and the formal Interdepartmental Roads Appraisal Committee was dissolved. However, officers of the Division continued, in 1962, to advise on road projects that would encourage exploration and development of the country's mineral resources.

Two studies were prepared for the St. Lawrence Seaway Authority and a third was under way at the year's end. The two completed studies dealt with petroleum and iron-ore traffic through the St. Lawrence Seaway to 1961, forecast to 1967 and 1970 respectively; the third study concerned coal and coke traffic through the Seaway to 1961, with a forecast to 1970.

Energy Resources—Division officers continued close association with the National Energy Board on matters concerning Canada's petroleum and natural gas industries; with the Dominion Bureau of Statistics on gathering and compilation of oil and gas statistics; and were represented on the Interdepartmental Committee on Coal that was formed pursuant to Recommendation 14 of the Royal Commission Report on Coal, issued in September 1960. Studies were made of energy supply and demand in the Atlantic Provinces, forecast to 1980 and of markets for coke in Latin American countries. The Division continued to be represented on the Interdepartmental Advisory Committee on Energy Statistics, the Oil Working Committee of the Emergency Supply Planning Branch (ESPB) and the Maritime Region Study Group.

Income Tax Act and Regulations—The Division continued to provide information and recommendations to the Department of National Revenue with respect to certain benefits available to the mineral industry under the Income Tax Act. Applications from eighteen companies for a tax exemption under Section 83 of the Income Tax Act were reviewed and reports prepared. Three applications for certification as operators of an industrial mineral mine on a non-bedded deposit were processed.

Services to Government Departments and Agencies—Federal government departments and agencies provided with information in 1962 included Trade and Commerce, National Revenue, Defence Production, Public Works, Transport, Finance, St. Lawrence Seaway Authority, Central Mortgage and Housing Corporation and the Industrial Development Bank.

Two extensive studies were prepared for the Committee on Manitoba's Economic Future. "The Feasibility of Establishing Custom Metallurgical Plants in Manitoba" was prepared in collaboration with Mines Branch officers; "The Feasibility of Establishing an Integrated Iron and Steel Facility in Manitoba" was prepared by the Mineral Resources Division.

Emergency Measures Organization (EMO)—The Division's senior mining technologist completed a detailed field appraisal program on the suitability of underground mines in Canada as emergency fallout shelters or storage areas. He was assisted in the field program during the summer months by three university instructors of mining engineering.

Foreign Mineral Industry Studies—The long-range appraisal program, begun in 1960, of relating the Canadian mineral industry to markets in Britain and the European Economic Community (EEC) was continued. The effect of Britain's potential entry into the EEC on Canadian mineral exports

was under continuing review. Officers conducted ferrous and nonferrous field investigations in European countries as opportunity permitted, emphasis being placed on iron ore, iron and steel and the major nonferrous metals. Officers also visited some Latin American countries and the United States to study the mineral-resource and marketing outlook in these countries.

Wartime Oils Limited—The Division continued administration of the agreements made by Wartime Oils Limited, a former Crown company, with oil-well operators in Turner Valley, Alberta, during World War II. Total payment received to December 31, 1961, including repayment of advances and payment of interest and royalties, was $4,113,863.22, which was $56,309.97 more than advanced by the federal government during World War II.

Foreign Aid Training—The Division, on behalf of the External Aid Office of the Department of External Affairs, arranged fourteen new technical training programs for foreign trainees. Most of the programs were sponsored under the Colombo Plan. For twelve of them, training was arranged in the Department of Mines and Technical Surveys and for the other two with an exploration diamond-drilling company.

Eighteen trainees completed studies in 1962 under programs previously arranged. At the end of 1962, five trainees were still on study courses and seven programs had been set up awaiting allocation of funds.

Twenty-seven foreign students attending Canadian universities under various technical aid programs were given summer employment in the Department in fields related to their academic courses.

Publications and Filmstrips—Fifty-one annual mineral reviews on metallic minerals, industrial minerals and energy minerals were issued. Map 900A, "Principal Mineral Areas of Canada", which is revised and reprinted annually, was issued in the 12th edition. Also released for general distribution were ten mineral information bulletins, ten operators' lists, one mineral survey, one mineral report, and the annual report on the administration of the Emergency Gold Mining Assistance Act. The Division sponsored, and collaborated with the National Film Board on, a color filmstrip on copper and a filmstrip on the Canadian natural gas industry. Additions were made to the mineral industry photographic reference file, and work continued on additions to the mineral occurrence index.

There were 150,626 divisional publications and maps and 18,134 Mines Branch publications distributed by the Division in 1962.

Each month a summary of important developments in the Canadian mineral industry or developments that affect the industry was prepared and distributed to senior officers of government departments and agencies, to deputy ministers of provincial departments of mines and to senior Canadian trade officers in foreign countries.

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Field Investigations—Officers of the Division conducted field investigations throughout Canada that covered mining, smelting, refining and fabricating facilities, and oil and gas fields along with their processing plants and certain refineries. Continuing periodic visits to all domestic mining and processing facilities are necessary to ensure that the operational and advisory functions of the Division are current, well-informed and competent.

Periodic field investigations are also made of mining and processing facilities in other countries because of the influence that their production might have on Canada's trade in minerals and metals in the Free World's major markets. Countries visited in 1962 included the United States, Jamaica, Trinidad, British Guiana, Surinam, Bolivia, and certain European countries.

The Emergency Gold Mining Assistance Act—The administration of the Act is conducted in the Division under the direction of the Deputy Minister. Gold mines receiving assistance are visited by inspection engineers from the Division who determine the proper classification of exploration and development expenditures. They review and report upon the allowance of costs which are in question, mining and milling practices and review production and ore reserve records. The Audit Services Division, Office of the Comptroller of the Treasury, examines interim applications and carries out the final audit of each applicant's books of account.

The Act was last amended in 1960, at which time its operation was extended for three years to December 31, 1963.

The amount of assistance payable to an operator is computed under the current formula by adding 25 per cent to the product of the rate of assistance and the number of assistance ounces. The number of assistance ounces is two thirds of the total number of ounces produced in the assistance period. The rate-of-assistance factor is determined by taking two thirds of the amount by which the average cost of production per ounce exceeds $26.50. The maximum rate of assistance is $12.33 per ounce. Thus a gold mine which has an average cost of production less than $26.50 per ounce is not eligible for payment of assistance.

There were 41 lode gold mines and 23 placer gold mines in receipt of assistance during 1962. Twelve gold mines had average costs of production less than $26.50 per ounce.

The economic position of the gold mining industry is kept under review. A significant development in 1962 was the increase in the price paid for gold by the Royal Canadian Mint. The Minister of Finance announced on May 3 that the value of the Canadian dollar has been set at $0.925 United States funds. Since the price of gold is related to the fixed price of $35 paid by the United States Treasury, the Mint buying price became $37.84 per ounce in Canadian funds. The annual average of the weekly Mint buying prices in 1962 was $37.41, compared with $35.46 in 1961, and $33.95 in 1960.

Lode gold mines usually apply for assistance payments on a quarterly basis, while a single annual payment is generally made to operators of placer gold mines. Two hundred and forty-one separate applications were examined by the Audit Services Division, approved by this Department and transmitted to the Chief Treasury Officer for payment.

The amount of assistance paid per calendar year since the Act was introduced is as follows:

1948—	$10,546,315.84	or 3.33	per	ounce	produced
1949—	12,571,456.90	or 3.48	"	"	"
1950—	8,993,490.51	or 2.55	"	"	"
1951—	10,728,503.71	or 3.30	"	"	"
1952—	10,845,978.62	or 3.76	"	"	"
1953—	14,680,110.42	or 4.62	"	"	"
1954—	16,259,179.23	or 4.29	"	"	"
1955—	8,885,478.73	or 2.97	"	"	"
1956—	8,667,235.38	or 3.46	"	"	"
1957—	9,679,753.32	or 3.53	"	"	"
1958—	11,420,463.70	or 4.29	"	"	"
1959—	12,001,753.43	or 4.91	"	"	"
1960*–	12,346,470.64	or 4.97	"	"	"
1961*–	12,411,391.18	or 5.19	"	"	"
1962†–	9,079,753.93	not available			

Explosives Division

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

During the year the Division issued 23 factory licences, 1,498 magazine licences, 97 registered premises certificates, 269 transportation permits, and 1,407 importation permits. Four new factories were licensed, two for the manufacture of shotgun cartridges and two for the manufacture of blasting explosives based on ammonium nitrate.

The number of inspections carried out during the year, including those by deputy inspectors of the Royal Canadian Mounted Police, was 2,478. The laboratory tested and analyzed 158 samples of explosives, and 24 samples of Chinese firecrackers were tested in Vancouver by the R.C.M.P.

There were 26 prosecutions for infractions of the Act and Regulations. Sixteen of these involved illegal and improper storage, and the other ten were various infractions of the Regulations governing transportation by road.

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* Final audits are not completed.

†Advance payments made during 1962.

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The use in underground mines of explosives based on ammonium nitrate has largely passed the trial stage and the explosives are now in regular production, accounting for the licensing of two new factories.

Accidents—There were no serious accidents in the manufacture or storage of explosives.

In transportation there were two accidents which gave concern. In one, the driver of a truck loaded with 10,000 pounds of explosives failed to negotiate a curve and upset in the ditch. There were no injuries and, although the packages of explosives were scattered and some badly damaged, there was no fire. In the other, a truck loaded with 10,000 pounds of explosives skidded into the path of a bus carrying fifty passengers. Once again there was no fire or explosion, although several bus passengers were severely injured by the collision. These accidents emphasize the Division's feeling that the Explosives Act Regulations governing transportation should be reinforced by provincial legislation.

Accidents in the misuse of explosives are a continual source of concern to the Division. Educating the public on the hazards of explosives is considered the most effective preventative, and with this in mind a new pamphlet "Explosives Are For Experts" was published. Of the twenty-six accidents from misuse of explosives, eleven were caused by playing or tampering with detonators. Fifteen children suffered hand or eye injuries from these small but dangerous devices. Home-made explosives caused two serious accidents. In one a 14-year-old boy was killed by the explosion of a home-made bomb. In the other, a fire causing $100,000 damage was started by a group of adults engaged in amateur rocketry in a public building.

Five fireworks accidents caused injury to six boys. Another involved a special type of firework. In it, two men were severely injured and $5,000 damage was done to a dock by the explosion of three cartons of seal salutes—an underwater firecracker used to scare seals away from fish nets.

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

surveys and mapping branch

THE SURVEYS AND MAPPING BRANCH again carried on a heavy program of surveying, mapping and air charting. Geodetic control was extended in the Northwest Territories, and in cooperation with the provincial governments precise control was established in several metropolitan areas. Topographical control for mapping of the eastern Arctic Islands was completed. Substantial progress was made in the 1:25,000 mapping of major Canadian cities in cooperation with the Directorate of Military Survey. Numerous lot and subdivision surveys were carried out at various localities in the Yukon and Northwest Territories. The demand for air charts of various types for military and civil purposes has been very heavy and has imposed an almost unmanageable load on the section concerned.

On April 1, 1962, the Canadian Hydrographic Service became part of the new Marine Sciences Branch, and its activities are covered in the report of that branch. Subsequently, to improve efficiency, a study was made of the remaining organization, and the report is being studied by departmental and branch officials.

The official opening of the Surveys and Mapping Building took place on February 6, 1962, being timed to coincide with the annual meeting of the Canadian Institute of Surveying. Advantage was taken of the presence of provincial survey officials to discuss survey problems.

The Branch continued to provided technical advice and inspection service to the Director General of External Aid in connection with survey projects.

Seniors officials of the Branch attended meetings in Europe of the International Map of the World Conference, the International Cartographic Association and the Federation Internationale des Geometres.

Geodetic Survey

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

The extension of the network of first-order triangulation was carried on in the Northwest Territories, British Columbia, Alberta, Saskatchewan, Quebec, New Brunswick, Nova Scotia and Labrador. The 'chain-of-triangles' method which proved successful on the Cambridge Bay-Beechey Lake arc in 1961 was continued in that area, and a number of new arcs were laid out to use the same method. A chain of triangles consists of a series of single triangles, instead of the usual series of quadrilaterals, and in addition to the measurement of all angles the lengths of all sides of the triangles are measured with tellurometers.

In the Northwest Territories the isolated arc between Cambridge Bay and Beechey Lake was connected to the main network near Whitefish Lake, east of Fort Reliance. A new arc, consisting of a chain of triangles which will extend from a point north of Fort Resolution through Yellowknife to Coppermine and Cambridge Bay, was completed to the vicinity of Yellowknife. The reconnaissance of a chain of triangles around the west side of Great Slave Lake was 70 per cent completed. In the eastern part of the Northwest Territories the Dubawnt Lake-Baker Lake-Chesterfield Inlet arc was completed to a point some 80 miles northeast of Dubawnt Lake. In central British Columbia the reconnaissance of a chain of triangles from Williams Lake to Bella Coola was completed. In northern British Columbia and Alberta the reconnaissance of a chain of triangles from Fort Nelson to the Mackenzie Highway was completed. In Saskatchewan the Brandon-Beatty arc was completed. Also in Saskatchewan, three tellurometer-geodimeter traverses were run, two near Saskatoon and one near Regina, to provide mapping control for the Topographic Survey and to test the accuracy of such traverses.

In Quebec the reconnaissance of a 26-station control network for the Greater Montreal area was completed. In northern Quebec the Kaniapiskau Lake-Richmond Gulf-Fort Chimo arc was extended from Clearwater Lake to the western end of Lake Minto. In New Brunswick the Fredericton-Newcastle arc was completed, and the reconnaissance of an eight-station network in the Bathurst vicinity was also completed. In Labrador the Nain-Strait of Belle Isle arc was completed, including a 75-mile spur to the coast south of Cartwright. In Quebec and the Maritimes, 414 existing triangulation stations were inspected. The reconnaissance and station preparation of a small network in Cape Breton Island was completed in November. This work was done at the request of the Department of Transport to provide survey control for the establishment of a satellite data-acquisition facility.

During the past season, three double parties and one single party extended the precise-level net. In addition, a small party inspected some 1,200 bench marks in Alberta and Manitoba, and another small party established 44 bench marks along the Peace, Slave and Athabasca rivers near Fort Chipewyan, Alberta, in preparation for a winter levelling operation. The double party in British Columbia completed three lines in the Cariboo district and started on the line from Prince George to Prince Rupert. The double party in the Prairie Provinces ran levels in the City of Moose Jaw, two lines near Winnipeg, two lines in the Interlake area between Lake Winnipeg, Lake Manitoba and Lake Winnipegosis, one line south of The Pas, Man., one line near Hudson Bay, Sask., and started the re-levelling of the line from Hudson Bay to Prince Albert. The single party in Ontario and Quebec ran a short line to connect a water-level gauge at Little Current, Ont., connected water-level gauges for the Department of Transport near Sorel, Que., and ran a line from Chapais to St. Felicien, with a branch line to Chibougamau. The double party in Quebec connected water-level gauges on the Ile d'Orleans, re-levelled the secondary line from La Malbaie to Port Alfred and completed the line from Baie Comeau to Sept Iles. Four small jobs were also done during the season: a water-level gauge was connected at Kingston, Ont., the annual check of the Quebec bridge piers was made, additional gauge connections were made near Sorel, Que., and a line was levelled through the eastern part of the City of Ottawa.

Three base lines, which serve as control for triangulation, were measured with the Model 2 geodimeter: at North West River, Labrador, and at Lac Bienville and Clearwater Lake in northern Quebec. Three lines between existing stations in New Brunswick were measured with the Model 2 geodimeter for investigational purposes.

Eight Laplace stations were established to control triangulation nets in the vicinities of Beechey Lake, Sifton Lake, Beaverhill Lake and Dubawnt Lake, all in the Northwest Territories, Usherville, Sask., Lac Bienville and Clearwater Lake in northern Quebec, and North West River, Labrador. Astronomic latitudes and longitudes were determined for investigational purposes at five triangulation stations.

The Survey made increasing use of specialized electronic equipment in the field and laboratory. During the field season, three officers, specially trained in the use and maintenance of electronic equipment, worked with triangulation parties. The development and improvement of crystal frequency calibration systems has been continued. The precise system is now in operation in the laboratory, and improvements to the portable field systems are being tested. The series of tests for the determination of the cyclic zero error of tellurometers has been continued; and a series of tests to determine the curvature of the microwave path over large bodies of water has also been conducted. The laboratory is handling the repair and maintenance of

a steadily increasing amount of the Branch's radio and electronic survey equipment.

During the year the Survey continued its interest in international geodetic organizations. In June, one staff member completed his work at the Institute of Geodesy of the Royal Technological Institute, Stockholm, Sweden, and has returned to office duties. He studied methods of applying gravity and potential data to the problem of determining the shape of the earth.

Topographical Survey

The Topographical Survey, as the federal agency charged with providing mapping required for resources development, in 1962 directed its greatest efforts toward two objectives: early completion of map coverage of Canada at a scale of 1:250,000, and completion of a two-year program of 'survival' mapping at a scale of 1:25,000, covering seven urban centres.

Although output of 1:250,000 mapping has not yet reached the desired volume, the rate of compilation has reached a level that promises complete coverage of Canada at this or larger scales by 1967. In the survival mapping program, 78 of the 93 sheets undertaken by the Survey have been transmitted to the Army Survey Establishment for reproduction; the rest is to be done shortly.

Detailed mapping at the scale of 1:50,000, favored by many agencies for development of resources, was restricted to urgent requirements, and output was about 50 per cent of normal. Only a token effort could be made in revising outdated maps.

Generally favorable weather permitted successful completion of all field assignments, although the three winter parties encountered severe snow and storms. The field work was done by forty-two officers from the field staff and six from the office staff, and was remarkable for a greater diversification of control surveys.

The objective of three years of field work and more time in planning was achieved in 1962 with the completion of control for 1:250,000 mapping in the eastern Arctic Islands. The final effort in establishing control for Baffin, Devon, Ellesmere and contiguous islands consisted of 2,300 miles of tellurometer traverse, rounding the north of Ellesmere Island and making necessary connections with Greenland. The operation was again greatly facilitated by having a field officer visit the area before spring break-up to ensure that gas caches were placed in strategic locations and that interested authorities were made aware of the season's project. It is no exaggeration to say that this exploration survey was a magnificent achievement by a small group of surveyors who overcame, without untoward incident, tremendous problems of supply, communication, and travel over vast arctic regions.

Another significant accomplishment of a different kind was the successful use of a new aid to mapping—Aerodist. After two years of disappointing

experience with its own adaptation of airborne tellurometers, the Topographical Survey secured the use of an Aerodist system, and by the line-crossing technique established a net of trilateration, fixing 32 positions in the low-lying coastal region of northern Ontario. This is believed to be the first operational use of this system, and preliminary computations of results are most encouraging. Further exploitation of the system is foreseen in securing control for 1:50,000 and 1:250,000 mapping in densely wooded regions and for offshore islands where other means are either too costly or ineffectual.

Also noteworthy is a routine assignment of altimetric heighting in northern Ontario and Manitoba, carried out by a field party that later operated the Aerodist equipment. This assignment, covering 90,000 square miles, virtually completed the vertical control required for reconnaissance mapping of the Canadian mainland. The only remaining area in which this method may be needed for original mapping is the northeastern part of Quebec and Labrador, which is still under contract for vertical photography.

A field party using helicopters established control for 1:50,000 mapping at the request of the British Columbia provincial government in the Alice Arm district and along the Alberta-British Columbia boundary, south of Jasper—both in exceedingly rugged country.

Two winter parties and one summer party established a line of spirit levels in northern Yukon, extending from Dawson via the Klondike, Blackstone, Peel, Eagle, Bell and Rat rivers to the Mackenzie River, with another line from the Eagle-Bell confluence down the Porcupine River to the Alaska boundary. The establishment of this 825-mile net of levels, undertaken to assist the Department of Northern Affairs and National Resources in investigating potential water power in the Porcupine River system, provides the first basic vertical control for future mapping in a large area.

Another winter assignment—traverse and spirit levelling along the Attawapiskat River—completed the field control program in the interior of northern Ontario. This traverse and others done previously were successfully tied together by the Aerodist operation. Computation and adjustment of several years' field work will now permit compilation of the whole of northern Ontario at the 1:250,000 scale. These maps are now urgently needed by the Geological Survey for the federal-provincial aeromagnetic program.

Two parties equipped with tellurometers continued to correlate geodetic and Dominion Land Survey systems in the Prairies in preparation for revision mapping.

In the continuation of 1:25,000 mapping, control surveys were made at Chicoutimi, Que., and at Regina and Saskatoon, Sask. Interpretation of culture and field checks were carried out on the remainder or the 'survival' maps at Winnipeg and Edmonton. Field interpretation was also done at Port Hawkesbury, N.S.

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Great interest is being shown in plane co-ordinate systems of survey control, and the services of the Topographical Survey and the Geodetic Survey have been enlisted to establish control of a high order in well-developed areas, to which municipal and utility surveys can be adjusted. In 1962 a start was made in establishing a dense net of control for Metropolitan Toronto, and similar surveys were made for Montreal, Regina, and Saskatoon. Preliminary planning was done for surveys of Calgary and Moose Jaw in 1963.

Computation and adjustment of control required for map production made use of 60 hours on the departmental IBM-1620 computer, which has given excellent service. The new records system now covers more than 55,000 cards, each containing a record of the co-ordinates, elevation, description, sketch or photo-identification and pertinent details of a permanent monument. The system has greatly facilitated supplying these valuable data to interested agencies. Some 10,000 copies were distributed during the year.

Special mapping projects undertaken for other branches and departments took up an estimated 8 per cent of compilation capacity. Among the most important of these were the mapping of Ellef Ringnes Island at 1:50,000 for the Polar Continental Shelf Project; plots of coastlines in Nova Scotia, Georgian Bay, British Columbia, and in the Arctic Islands for the Hydrographic Service; plots for studies of water-power resources and of northern settlements for the Department of Northern Affairs and National Resources; and various projects for the Dominion Observatories.

Inspection of mapping undertaken by private Canadian firms in the lower Mekong River basin in Indochina under the Colombo Plan required the full attention of three staff members throughout the year. Although the original 750 maps have been completed, there is a secondary program in the same area and a similar one in Nigeria under the Special Commonwealth African Assistance Plan which will continue to need supervision and final inspection for acceptance.

Technical equipment acquired during the year consisted mainly of one master set and antennae of the Aerodist system, three theodolites, and plotting equipment for office use.

Distribution of advance information prints has decreased somewhat, owing to a smaller output of new maps.

Two survey officials from Indonesia completed a long period of training in photogrammetric plotting, and three from Sarawak spent some time observing field and office procedures used in Canada. Two Soviet survey officials visited Canada for about two weeks in October and were given a guided tour of mapping organizations.

Legal Surveys and Aeronautical Charts

The need of other federal departments for legal surveys in Indian reserves, national parks and territorial lands, and the interest in Indian lands on the

part of private and provincial agencies continued unabated in 1962. A new "Manual of Instructions for the Survey of Canada Lands" was published. It was prepared to meet present needs and is intended to cover all surveys made under the instruction of or subject to the approval of the Surveyor General of Canada Lands. The demand for special aeronautical charts continued and the need for more information on and more frequent revision of charts steadily increased.

Four interprovincial and territorial boundary commissions were active in 1962. The printing of the map sheets of the northern British Columbia boundary was completed and the binding of the atlas was started. The demarcation survey of the northerly section of the Manitoba-Saskatchewan boundary was completed and the survey returns examined. The northerly terminal of this boundary is a corner common to Manitoba, Saskatchewan and the Northwest Territories. The placing of this terminal monument also effected the completion of the survey and demarcation of the Saskatchewan-Northwest Territories and the Manitoba-Northwest Territories boundaries. Work was started on the preparation of the Manitoba-Northwest Territories atlas and six map sheets were completed.

At the request of the Indian Affairs Branch of the Department of Citizenship and Immigration, legal surveys were carried out in Indian reserves in all of the provinces except Newfoundland. Lands for the use of that branch were also surveyed in the Territories. The surveys consisted of section, village and lot subdivisions, boundary retracements, roads, parcel surveys and school sites, as well as the survey of six new reserves in British Columbia and two new reserves in Quebec. They engaged twelve survey parties for the full season and three other parties for much of it. One party carried out a winter survey to re-establish the boundaries of two reserves in northern Saskatchewan where swampy terrain made summer work impracticable.

Two legal survey parties operated for the full season and two for part of it in the Territories on surveys requested by the Resources Division of the Department of Northern Affairs and National Resources. Additional surveys were carried out by a Department of Transport survey party, and others by contract. In the Yukon and Northwest Territories, lot and subdivision surveys for the expansion of towns and settlements were carried out at Whitehorse, Watson Lake, Pelly Crossing, Marsh Lake, Kookatsoon Lake, Carmacks, Fort Smith, Fort Resolution, Hay River, Wrigley, Fort Simpson, Fort Providence, Jean Marie River, Lac la Martre, Stagg River, Rae and Nahanni Butte. Other surveys in the north were connected with public services relating to transportation, communication and tourist facilities.

Surveys in national parks and historic sites were carried out at Kootenay, Jasper, Fort Langley, Port Royal, Grand Pre, Fort Anne and at the grave of Chief Yellowface of the O'Chiese Indian Band in Alberta.

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Technical instructions for surveys on Crown Canada Lands for private interests were issued to private surveyors for 113 legal surveys.

In the course of aeronautical charting, a new chart designed for use in conjunction with Air Traffic Control and several charts to accompany regulatory releases were issued at the request of the Department of Transport. For the Department of National Defence, air information was compiled for 37 new pilotage and plotting charts. The civil pilots' handbooks—Canada Air Pilot—were converted to a smaller, more convenient publication.

Survey documents recorded in the Canada Lands Surveys Records numbered 505 plans and 63 field books, and about 23,000 document extracts, publications, and astronomical field tables were sent out, as well as other information.

The Board of Examiners for Dominion Land Surveyors held five meetings. Seventy-one candidates wrote examinations, and of these, twenty were successful in the combined categories. Revised "Regulations, Rules and Instructions of the Board of Examiners for Dominion Land Surveyors" was published.

Map Compilation and Reproduction

The production of maps and charts in 1962 increased markedly over 1961, even though there was a decrease in staff. Some organizational changes were made to simplify procedures and to decrease costs.

The only large piece of equipment acquired during the year was a photo typesetter.

Special attention was given to the continued production of low-level pilotage charts for the RCAF, along with another requirement for a group of Mu-Sigma plotting charts.

Other highlights of the year were:

Conversion of the 221 eight-mile maps to a scale of 1:500,000 continued, and 46 per cent were completed.

Published were 44 per cent of the 1:250,000 map series, and 24 per cent of the 1:50,000 map series.

A new price structure, in line with current costs, was established.

Maps and charts printed during the year numbered 4,303, compared with 2,846 in 1961. Maps distributed totalled 1,093,578 copies, up from 897,227 the previous year, an increase of 21 per cent.

The map depot's stock of maps and charts increased from 9,116,683 to 10,220,857 copies.

New procedures were evolved for the transfer of names to maps, and for map layout.

Exhibits were set up at two exhibitions in Ontario.

Revenue from map sales amounted to $132,499, up from $123,667 in 1961.

Maps received for reproduction numbered 197, against 196 the year before.

International Boundary Commission

The Commissioners for Canada and the United States made a joint inspection of various points on the International Boundary along the provinces of New Brunswick, Quebec, and British Columbia. The Canadian Commissioner also inspected conditions along the Yukon-Alaska boundary. On the New Brunswick-Maine boundary the Commissioners inspected that section of the line which had been chemically treated to retard growth during the field seasons of 1958 and 1959. The Commissioners inspected the work of the United States parties working on the St. John River, the Quebec-Maine, and the Quebec-New York boundaries. They also inspected the work of Canadian parties on the Quebec-Vermont, and the British Columbia-Washington boundaries.

The Canadian party working on the Quebec-Vermont boundary inspected monuments and recleared the 20-foot boundary vista along 28 miles of boundary line. They also chemically treated 22 miles of boundary line to retard growth. Measurements were made along 20 miles of boundary line to verify the position of monuments.

The Canadian party working on the British Columbia-Washington boundary inspected monuments and recleared the vista to a skyline width of 20 feet along 13 miles of boundary line. Chemicals were applied to four miles of this section following reclearing, and an additional 20 miles of vista, not recleared, was chemically treated by helicopter in an effort to eliminate growth.

The field officers working on the British Columbia-Washington boundary also assisted in a photo-reconnaissance flight along the Yukon-Alaska boundary.

A minor survey was carried out to check the position of boundary buoys in Lake Erie.

The Canadian parties covered a total of 75 miles of boundary line in the course of their season's work. They inspected 124 monuments, repaired six monuments, checked the position of 72 monuments and two boundary buoys. A total of 41 miles of vista was recleared, and 48 miles were chemically treated to retard growth, during the 1962 field season.

National Air Photo Library

During the year, 4,900 requisitions for photographic work were prepared and forwarded to the Photographic Establishment of the RCAF. It was the highest total in the Library's history, and 4 per cent higher than that of 1961.

Revenue from photographic orders amounted to approximately $250,000. The Library received 49,409 new photos, bringing the total to 2,940,000.

In addition to the air-photo requirements of the various federal government departments, the Library filled requests from other governmental and private agencies and individuals. More than 4,000 requests and inquiries were received by mail, one tenth of them from outside Canada. Throughout the year, the RCAF Photographic Establishment gave unfailing cooperation.

The second edition of the Air Photo Coverage Map of Canada (1961) was issued late in the year, after certain corrections and changes in format. The Mosaic Coverage Map was corrected to October 1962. Copies are supplied free of charge on request. A brochure presenting a brief outline of the history and function of the Library was published in December.

Among the requests filled by the Library were the following:

An estimate of the cost of air photo coverage prepared for a Crown corporation involved the assembly of some 70,000 photos covering areas in five provinces, together with plans and maps, and the shipment of these materials to field offices.

A newspaper was supplied with old and new air photos showing the development of a large urban area.

A provincial government was supplied with 400 enlargements on which specified land sections were marked.

Several hundred vertical photos were supplied in connection with a quality check for census records and for studies of farm management.

A commercial research and development firm obtained 18,000 photos of most of the Arctic Islands.

Many purchasers of cottages and recreational facilities obtained air photos of their new lots.

In order to preserve old air-survey photographs taken before 1938, steps were taken to copy all the old prints in the possession of the Library, as the old negatives have in many cases deteriorated. The Library was also negotiating for the acquisition of low-altitude oblique photos made by the RCAF between 1939 and 1950, which would be of great interest to the general public.

marine sciences branch

THE INCREASE of the Department's marine investigations was recognized with the establishment of the Marine Sciences Branch on April 1, 1962. The Branch was formed from the marine organizations previously in the Surveys and Mapping Branch—namely, the Canadian Hydrographic Service and the Division of Oceanographic Research.

The Branch carries out hydrographic and tidal surveying, water-level gauging, and the publication of nautical charts and associated documents; and it is gradually assuming a greater share of the total Canadian oceanography, with emphasis on the physical aspects of the science. It provides facilities and support for marine studies in geology and geophysics carried on by other branches of the Department.

The Branch is organized into three functional divisions—the Canadian Hydrographic Service, the Division of Oceanographic Research and the Ship Division—representing the specialties of hydrography, of oceanography and of ship operation and maintenance. Components of each of these divisions are being integrated into regional operational units in the eastern, central and western regions of Canada. This integration is most advanced in the eastern region where the Branch activity is centred in the Bedford Institute of Oceanography at Dartmouth, N.S., formally opened on October 25, 1962. A similar institute is planned for the western region as oceanographic research extends in the eastern Pacific Ocean. For the immediate future, operational responsibility in the central region will be assumed by headquarters personnel based in Ottawa.

Ships

To indicate their broader role, the Branch ships have been re-designated by the prefix "CSS", representing their function as Canadian Survey Ships or Canadian Scientific Ships, as appropriate.

The Marine Sciences fleet was strengthened by the addition of two new inshore survey vessels. CSS *Maxwell,* designed for work on the Atlantic Coast, is 115 feet long, carries a crew of twelve, and eight hydrographers, two 26-foot sounding launches and has a small laboratory. CSS *Richardson,* is 65 feet long, carries a complement of six and was built for work in the western Arctic. She will be laid up each winter, frozen into the ice at Tuktoyaktuk. It is intended that she will return to Victoria for refitting every four years.

Construction continued on CSS *Hudson,* a new major oceanographic-hydrographic research ship, which will join the fleet in 1964. Design work continued on CSS *Parizeau,* a tidal-current survey ship for the west coast, and replacements for CSS *Acadia* and CSS *Cartier.*

Oceanography

The main emphasis in oceanography continued to be that of recruitment and training of scientific personnel and their technical support staff. Recruitment was temporarily interrupted in mid-summer but was renewed toward the end of 1962. At the year's end the professional staff in oceanography numbered thirty.

Although interrupted by the move into new quarters in the Bedford Institute, where oceanographic activity is now primarily centred, research continued to strengthen and to approach a stage where certain definitive results are beginning to emerge.

Major research programs now under way are aimed at studying the circulation and mixing in the deep waters south and east of the Grand Banks and the oceanography of the Gulf of St. Lawrence, in cooperation with the Atlantic Oceanographic Group of the Fisheries Research Board, which is also housed in the Bedford Institute. Data for the first of these programs were gathered during two cruises by CNAV *Sackville* and one by CSS *Baffin.* Exploratory surveys of Arctic waters continued with oceanographers assigned to USS *Atka,* CCGS *Labrador,* and CCGS *John A. Macdonald.*

Work was also carried out on the development of a three-component anemometer for use in air-sea interaction studies. Accelerometer floats were developed for wave recording; several weeks of useful observations were spent at three points in the Gulf of St. Lawrence. Work proceeded on several other instruments and the calibration facilities that will be required for the full-scale operation of the Institute. Two chemical laboratories are now operating, one for determining salinities, the other for the further analysis of sea water. A detailed study was made of the requirements for an intensive, year-round oceanographic program in the Arctic. Progress continued on the development of techniques for the description and forecast of the oceanographic environment.

The first phase of a study of wave conditions in the Gulf of St. Lawrence and Lake Superior was completed. Assistance was provided to the

National Research Council in its study of air-bubbler systems. The source data for all oceanographic observations on the east coast and in the Arctic were transferred to punched cards by the Canadian Oceanographic Data Centre. A new program for processing these by electronic computers has now been developed.

Eight of the Branch's staff were given educational leave to carry out postgraduate studies as part of the program to build up its professional strength.

CSS *Ehkoli* made sixteen cruises for the Institute of Oceanography, University of British Columbia, studying botany, zoology and coastal inlets. Three cruises were also made for the Fisheries Research Board's Biological Station at Nanaimo, B.C.

Charts and Publications

The number of charts maintained by the Canadian Hydrographic Service rose to 839, with the publication of 26 new charts and 176 revised editions. The number of charts issued was 156,000, an increase of 50 per cent over 1958. Two books of charts were issued, covering the Athabasca and Slave rivers from Waterways, Alberta, to Great Slave Lake. These present topographical information in the form of air photo mosaics. These charts were well received, and a similar procedure will be followed for other series of charts designed for use in small boats.

On January 1, 1962, the Department of Transport began publishing a *National Weekly Notice to Mariners* which has made it substantially easier for mariners to keep their charts corrected. The Canadian Hydrographic Service plays an important role in the production of this notice.

A new edition of *Great Lakes Pilot, Vol. II* and a French edition of *St. Lawrence River Pilot* were published, and supplements to ten other pilots were issued.

Hydrographic Surveys

Twenty-two parties carried out surveys across the length and breadth of Canada in 1962. Five ships, including one on charter, and two launch parties worked on the east coast and in the eastern Arctic. Hydrographers were also assigned to two Department of Transport icebreakers. CSS *Baffin* carried out offshore surveys east of Halifax, extended the survey of Barrow Strait westwards, made a reconnaissance survey of Duke of York Bay, Southampton Island, and surveyed Alexis River on the Labrador coast.

CSS *Kapuskasing* almost completed the survey of the Nova Scotia shelf, surveyed the approaches to Country Harbour, N.S., and calibrated the East Newfoundland decca chain. CSS *Acadia* surveyed the waterfront at Pictou, N.S., Caribou Ferry Terminal, Victoria, P.E.I., Carmenville, Long Pond, and the new harbor facilities at St. John's, Newfoundland, and a new wharf at

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Point Tupper in the Strait of Canso. CSS *Maxwell* surveyed two new wharves in the Strait of Canso, Black Cape Wharf in Chaleur Bay, and started a survey of Baie Comeau, Que., and its approaches.

The chartered ship *Arctic Sealer* completed the survey of Lake Melville on the coast of Labrador, and carried out surveys of the approaches to Split Island and Flaherty Island, in the Belcher Islands. A reconnaissance was made of Long Island Sound and a survey made of Port Harrison, both on the east side of Hudson Bay. Two launch parties worked on the coast of Nova Scotia, one in the area of Country Harbour to Ship Harbour and the other between Cape Sable Island and Seal Island.

A team of hydrographers carried out surveys at Cape Dorset, N.W.T., and Churchill, Man., from CCGS *C.D. Howe,* then transferred to CCGS *Labrador* for their main assignment—a detailed survey of Smith Sound, between Ellesmere Island and the coast of Greenland. One hydrographer was assigned to CCGS *John A. Macdonald,* and more than 1,100 miles of soundings were obtained in unsurveyed waters. These included a survey of Tanquary Fiord (the northernmost point ever reached by a Canadian icebreaker) and the first passage through M'Clintock Sound.

CSS *Cartier* was assigned to training duties, and sixteen junior hydrographers were given instructions in the vicinity of Kingston, Ont., and Quebec City.

Seven launch parties worked on Canada's inland waters. One completed the surveys of Lake St. Louis and Lake St. Francis on the St. Lawrence Seaway and another started on a survey of the Ottawa River from Ottawa to Carillon, Que. A reconnaissance survey was made of Lake St. John, Que. CSL *Bayfield* made several small surveys in the North Channel of Lake Huron, then continued the survey of the small boat route along the northeastern shore of Georgian Bay.

CSL *Sandpiper* continued the survey of Lake Winnipeg and CSL *Rae* worked on the Athabasca-Mackenzie waterway. A survey of Kootenay Lake, B.C., was made by CSL *Owl.*

Two ships and one launch party worked on the coast of British Columbia. CSS *Wm. J. Stewart* continued her offshore surveys in Hecate Strait, and small surveys were carried out in Harriet Harbour and Copper Bay on the east coast of the Queen Charlotte Islands. At the end of the season a start was made on a new survey of Vancouver harbor. CSS *Marabell* continued her survey of the Gulf Islands and the channels leading off Portland Inlet. CSL *Curlew* was used for surveys in the Chemainus area.

CSS *Richardson* sailed from Victoria, B.C., on July 7 and arrived in Tuktoyaktuk, N.W.T., at the mouth of the Mackenzie River, on August 6. From then until the end of the season, surveys were carried out between Tuktoyaktuk and Liverpool Bay. Two hydrographers were assigned to CCGS *Camsell* and carried out surveys along the main supply route in the western Arctic.

Tidal Current Surveys and Gauging

The Branch operated 101 permanent gauging stations on the coast and in the St. Lawrence-Great Lakes waterway. Most of these have been re-equipped with gauges producing an identical type of strip chart which is read by a semi-automatic tabulator, designed by the National Research Council. This produces a permanent record on punch cards which can be analyzed automatically on an electronic computer. It has led to better use of existing manpower, as well as recording the information in a form readily usable in further studies.

The chartered ship *North Star VI* was used for a detailed study of tidal currents at all depths in Gaspé Strait, using self-recording current meters. This is part of the long-term study of the circulation in the Gulf of St. Lawrence which will be of great value for ice forecasting and other studies to facilitate winter navigation. Data on the movement of ice were also collected from the captains of sealing vessels to assist in the same study. *North Star VI* and its equipment were made available to the Dominion Observatory for two weeks to carry out a study of gravity in the Gulf of St. Lawrence.

Surveys were made by CSS *Parry* of the tidal currents in five narrow coastal passages on the coast of British Columbia. Small current surveys were also made in Vancouver and Esquimalt harbors. CNAV *Whitethroat* was used for a short period in Juan de Fuca Strait to gain experience in handling self-recording current meters.

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geological survey of Canada

In 1962 the Geological Survey placed 94 parties in the field. Of these, 28 parties conducted systematic bedrock mapping, much of which was reconnaissance mapping of remote or little-known areas; 17 parties mapped surficial deposits or investigated groundwater and engineering geology problems; 16 parties examined mineral deposits or made mineralogical and petrological studies of granitic, basic, and ultrabasic rocks; 13 parties undertook stratigraphic and palaeontological investigations; 10 parties conducted geophysical studies; and 10 parties were active in geochemical, structural, marine geology, and other projects.

Field work was completed (or nearly so) on 39 of the 94 field projects, covering more than 200,000 square miles. Three projects alone completed the reconnaissance bedrock and surficial geology mapping of approximately 175,000 square miles of Canada's northland. Several thousand square miles are under investigation in mapping projects not yet completed.

Parties used helicopters and fixed-wing aircraft for reconnaissance mapping in the Arctic Islands, Northwest Territories, Yukon, and British Columbia. Seven parties used helicopters on a full-time basis during the summer months; others used fixed-wing aircraft for periodic transportation within their field areas. Use of such aircraft for geological mapping during the past several years has brought much closer the day when all of Canada will have been mapped systematically to a scale of 1 inch to 8 miles or better.

At the end of 1962 the Geological Survey had published geological maps on about 61 per cent of Canada, and had completed the preliminary field mapping of about another 10 per cent.

In the past few years, the Geological Survey's field program has been undergoing a gradual change in emphasis from the geological mapping of specific geographic areas to investigations of geological problems in several or many areas, and many staff geologists are now undertaking geological investigations other than systematic bedrock mapping. This change in emphasis is reflected in the Survey's publications, with the appearance of an increasing proportion of Bulletins (which deal with special studies), to Memoirs (which deal largely with a real studies). In 1962, just over one third of the Survey's geologists were on reconnaissance or detailed bedrock-mapping projects, involving almost two thirds of the money allotted to the Survey's field program.

Grants-in-aid by the Geological Survey of Canada to Canadian universities have been increased more than sevenfold since their initiation in 1951. In 1962 they amounted to $75,000, contributed to 16 universities in support of 28 new projects and 15 continuing studies. The grants are awarded on the advice of the National Advisory Committee on Research in the Geological Sciences, and are a valuable extension of the research undertaken by Survey officers in the field and laboratory.

By the end of 1962, most basic data required for the preparation of the tectonic map of Canada had been compiled. These should be assembled and readied for submission for publication by late 1963.

Completion of 198 potassium-argon age determinations from many parts of Canada during 1962 brought to 654 the number of such determinations completed by the Geological Survey since 1959. During 1962, efforts were made to broaden the activity in this field to embrace the measurement of the ratios of rubidium and strontium in whole rocks and minerals, and the lead, uranium, and thorium concentrations in zircons. Some 58 strontium-rubidium age determinations were made during 1962. Radiocarbon dating, which the Survey commenced early in 1961, provided 85 age determinations in 1962.

The International Upper Mantle Project is a program of studies initiated for a 3-year period (1962-64) to obtain and interpret geophysical and geological data on the upper mantle of the earth. The Geological Survey's contribution to this project during 1962 included planning for the drilling of several deep holes, geophysical surveys, and laboratory studies of ultrabasic rocks and minerals to provide quantitative data needed to fill gaps in our knowledge of 'mantle' material. Detailed surveys were made over the proposed drilling areas in the Muskox Intrusion in the Northwest Territories, and at Mount Albert in the Gaspé region of Quebec. These combined detailed mapping and magnetometer surveys, and in places gravity surveys by the Dominion Observatory, to determine features that might affect the drilling. A seismic survey in the Mount Albert area determined the depths of overburden. Plans for 1963 call for two 5,000-foot drill-holes in the Muskox

Intrusion. Detailed petrographical and mineralogical studies of both the Mount Albert and Muskox Intrusions continued during the year.

The $18 million cooperative federal-provincial program, inaugurated in 1961, to complete within about twelve years an aeromagnetic survey of most of the Canadian Shield and adjacent areas, was in full swing in 1962. Six 4-year contracts were let—in Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and the Northwest Territories—totalling more than a million line-miles of survey. Of these, 404,700 line-miles were completed in 1962.

Field Work

Northwest Territories

In the *District of Franklin* four parties conducted field work.

As Operation Prince of Wales, four staff geologists with the aid of a helicopter and a small aircraft equipped with large low-pressure tires, commenced and completed the bedrock and surficial geology mapping of some 40,000 square miles of Boothia Peninsula, and King William, Somerset, and Prince of Wales islands. Mapping was conducted for publication on a scale of 1 inch to 8 miles. The Boothia Arch, a structural and topographic high composed of Precambrian igneous and metamorphic rocks, dominates the area mapped. Many of the gneissic rocks dip steeply and strike northerly. Cambrian to Silurian and/or Devonian Formations, in places flat-lying, overlie the Precambrian rocks in parts of the area. Along the eastern margin of the Boothia Arch the contact between Precambrian and Palaeozoic rocks is marked by numerous block faults, whereas along the western margin the Palaeozoic beds are upended and juxtaposed against the Precambrian rocks, apparently by steeply dipping thrust faults. Extensive gossan zones, derived from pyrite, and commonly containing graphite, are present in northern Boothia Peninsula. Evidence of glacial activity was found throughout the area, with the last ice-movement being northerly. Evidence of marine submergence to about 500 feet elevation following the retreat of the ice was found on King William, Somerset, and Prince of Wales islands, and parts of Boothia Peninsula.

Two Survey parties conducted marine geology investigations in connection with the Polar Continental Shelf project. One studied sedimentation in Prince Gustaf Adolf Sea and Maclean Strait, collecting samples from near-shore and offshore bottom zones as well as from outcrops and stream beds of the adjoining shore areas. The other party continued submarine topography and sedimentation studies of the continental shelf in the western part of the Queen Elizabeth Islands, a project begun in 1960. The shelf between Ellef Ringnes and Borden islands was found to be fairly uniform in relief, with depths between 400 and 650 metres. Submergence of this region to depths of about 400 metres is indicated, but the area is now slowly emerging.

The fourth party, aided by a helicopter and an aircraft equipped with low-pressure tires for landing on unprepared terrain, nearly completed reconnaissance bedrock mapping of the Palaeozoic and younger rocks on Axel Heiberg and Ellesmere islands, a project started in 1961. Part of the mapping conducted was suitable for publication at a scale of 1 inch to 8 miles, part for the 1-inch-to-4-mile scale. Structural and radiogenic evidences indicate major periods of deformation in northern Axel Heiberg Island in both Silurian and Devonian times. Pennsylvanian and Permian rocks were measured between Baumann and Tanquary fiords, Ellesmere Island, and on eastern Axel Heiberg Island. A substantial Mesozoic section occurs in northern Ellesmere Island.

An extensive aeromagnetic survey was conducted by Hunting Survey Corporation, under contract, over the continental shelf in the northwestern part of the Queen Elizabeth Islands. The results of this survey will be of considerable aid to workers on the Polar Continental Shelf Project.

In the *District of Keewatin* a party conducted systematic bedrock mapping of Proterozoic sedimentary rocks in the southwestern quarter of Kognak River map-area, examining areas that proved of critical interest from the reconnaissance studies of Operation Keewatin in 1952. Refinements were made to the stratigraphic and structural data published on the area.

A second field party commenced a marine geology study of the Churchill River estuary and the adjacent area of Hudson Bay, the results of which are expected to provide material for a doctoral thesis. This study is part of an over-all investigation, along the shoreline as well as in near-shore and estuarine areas, of the factors contributing to the sedimentation patterns within Hudson Bay. Samples of sediments in cores and bottom grabs were collected for further study.

In the *District of Mackenzie,* eight field parties were active during the field season. The Survey's resident geologist at Yellowknife commenced a geochemical and petrographical study of greenstones in the Yellowknife district in order to provide reliable chemical data representative of the volcanic belts of the Canadian Shield, presented in a proper petrological framework.

A second party made special petrographical and geophysical studies on parts of the Muskox Intrusion, Coppermine River area, related to the selection of sites in this ultrabasic body that will be drilled as part of the Upper Mantle program. Sulphide samples were collected for sulphur isotope studies.

Five staff geologists, as Operation Bathurst, commenced and completed bedrock and surficial geology mapping of about 55,000 square miles in the Bathurst Inlet region. The operation was aided by the use of two helicopters and a fixed-wing aircraft. Mapping was done for publication on a scale of 1 inch to 8 miles. Most of the area is underlain by massive and gneissic granitic rocks; some early Precambrian sediments and volcanic

rocks, and Proterozoic and younger rocks comprise the remainder. Structural trends in the basement rocks are mainly northerly, but Proterozoic rocks along Bathurst Inlet are preserved in down-faulted blocks between faults that strike northwesterly. Fold axes in these sediments also strike northwesterly. Zones of sulphide were observed in metasediments and greenstones exposed in the western quarter of the area mapped, and magnetite-bearing iron-formation occurs at the mouth of Perry River, on the west shore of Chester Bay, and just south of James River at longitude 111°W. Glacial ice flowed northwesterly across much of the area, and well-developed raised beaches near the coast indicate that at Bathurst Inlet more than 700 feet of uplift of the land relative to present sea-level has occurred since deglaciation.

A fourth party commenced 1-mile mapping in Benjamin Lake map-area, a potential lead-zinc region northeast of Great Slave Lake. Metamorphosed sedimentary and volcanic rocks form a north-trending belt bounded by biotite granite within this part of the Canadian Shield. No important new mineral occurrences were discovered during the field season, although some pyrite and chalcopyrite were observed near a small granite plug on the southwestern side of Benjamin Lake.

Another party carried out a stratigraphic and petrographic study of Upper Devonian rocks in the Hay River area.

A party continued a regional study of Precambrian rocks northwest of Yellowknife, with 1-mile mapping in Arseno Lake (east half) map-area. It obtained much useful information on the structural and stratigraphic relationships of the Yellowknife and Snare Groups.

In the Basler Lake area, a party undertook detailed petrographical studies of a large granite mass in the southwestern quarter of Indin Lake map-area.

A staff geologist commenced detailed investigations of certain geological features in Beechey Lake map-area, which had proven to be of critical interest from work done on Operation Thelon in 1955. Magnetite-bearing iron-formation occurs west of a major northwesterly trending fault, and minor amounts of chalcopyrite are present in gabbro near this fault.

The *Yellowknife Office* added a scientific officer to its staff in April, and 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. The office added a spectrometric analyser early in 1962, which permits provision of rapid qualitative or semi-quantitative spectroscopic data for the mining public, as a guide to assaying.

Yukon

Three parties operated in Yukon during 1962, and two other staff geologists made independent field studies.

Nine staff geologists, aided by two helicopters and a fixed-wing aircraft, carried out reconnaissance bedrock and surficial geology mapping of approximately 80,000 square miles of the northern part of Yukon and adjacent District of Mackenzie. This large-scale operation, known as "Operation Porcupine", mapped for publication on a scale of 1 inch to 8 miles, and measured about 140 stratigraphic sections, involving several thousand feet, of Precambrian, Palaeozoic, and Mesozoic strata. The rocks are extensively folded, and some of the folds are modified by later faults. Only one major thrust fault was recognized. Wolframite (an iron-manganese tungstate) and molybdenite occur near Mount Fitton on the east flank of Barn Mountains. Hematite-bearing iron-formation in stratigraphic intervals up to 200 feet thick and probably of Cambrian or Ordovician age, occurs over an area of about 200 square miles in the upper reaches of Snake and Cranswick rivers. It was recently staked by a subsidiary of a U.S. firm. Three glacial tills are present in a few places along Snake River, but do not contain intervening deposits of interglacial rank. Evidence for three valley glaciations was recognized in central and northern Ogilvie Ranges, and for some valley glaciation in Richardson and British mountains. Extensive areas that were not glaciated occur in the southwestern and west-central parts of the area mapped.

Another party commenced detailed studies of the Palaeozoic stratigraphy, regional structure, and economic geology around the Canada Tungsten property. The tungsten minerals occur in Lower Cambrian rocks, which seem to have been the most favorable host rocks and therefore offer inducement for further prospecting.

A third party continued, from 1961, heavy-mineral sampling of the gravels and soils in the Klondike area. Samples of decomposed bedrock and gravel were taken over various rock types in order to determine the suite of heavy minerals each rock unit has contributed to the gravels of the area. Geochemical studies on some magnetites from tributaries on the right limit of the North Klondike were high in zinc; some were also anomalous in copper and nickel. Present work suggests that some of the lobe gold deposits of the Klondike could be associated with strong shear zones in the Klondike schists.

Study of the copper deposits of the Yukon and northern British Columbia continued from 1960, with studies being largely in areas near the Canadian National railway between Smithers and Burns Lake. A geological map showing copper occurrences in the Whitehorse area was submitted in the fall of 1962 for publication by the Geological Survey on the scale of 1 inch to 1 mile.

The *Whitehorse Office,* with a resident geologist, a scientific officer, and a clerk, provided geological and geographical information and advice to prospectors, exploration companies, government departments, and the

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general public. During the year the office distributed 5,723 topographical and 1,565 geological publications, and had 2,037 visitors.

British Columbia

Eighteen parties conducted geological investigations in British Columbia in 1962. Of these, seven undertook systematic bedrock mapping, three surficial geology mapping, and five made mineralogical and petrological studies.

Five parties shared two helicopters in southern British Columbia, chiefly for reconnaissance bedrock mapping. Field work in other areas was completed for publication of maps on a scale of 1 inch to 4 miles.

Two parties commenced systematic reconnaissance bedrock studies of parts of the Coast Mountains, one in Bella Coola map-area, the other in Port Essington and Prince Rupert map-areas. Rocks in the Bella Coola area include highly metamorphosed schists and gneisses with a consistent northwesterly orientation, and less metamorphosed clastic sediments and lavas of Mesozoic and Tertiary ages. In the Prince Rupert region are strongly folded sedimentary rocks in several stages of metamorphism, and foliated granitic rocks. A small rubber boat was used successfully for examining the rocks along some of the coast in this region.

A party completed detailed bedrock mapping of the mineralized Rossland-Trail map-area. It succeeded in sorting out some of the stratigraphic relations in the area.

Another party completed the surficial geology mapping of Nicola map-area. Stagnant tongues of glacial ice remaining in the valleys in this area after the uplands were free of ice played an important role in the late glacial history by blocking the normal drainage and controlling the deposition of outwash.

Surficial deposits were also studied in the Nanaimo-Duncan-Gulf Islands region of Vancouver Island. Interglacial deposits with plant remains and fossil wood have been found, and many aspects of the glacial history of the region worked out. Meltwaters from a tongue of ice that advanced down the Cowichan River valley left extensive kame and outwash deposits, which are a source of gravel and sand for the Duncan area.

A field study of sand and gravel deposits in the lower mainland of British Columbia and part of the east coast of Vancouver Island was completed in 1962.

A party completed the bedrock mapping of part of Nakusp map-area, where special study was made of the granitic and associated metamorphic rocks as part of the Survey's general study of granites in Canada. Various units within the Shuswap and Slocan Groups were separated and structural relationships ascertained.

Stratigraphic and sedimentation studies, begun in 1959, of the Triassic formations in the Foothills of northeastern British Columbia, were completed.

The work includes detailed descriptions of more than sixty sections, mapping of the Triassic systemic boundaries in certain areas, gathering of palaeontological collections, and some 2,500 observations on primary current structures. Field work in 1962 was between Peace River and Kluachesi Creek, in Halfway River and Trutch map-areas. As a result of these studies it may be profitable to extend petroleum and natural gas exploration to the southeast, where potential producing horizons may occur beneath the plains region.

A study of the environs of the eastern contact of the Kuskanax Batholith was undertaken in 1962 as part of the general study of granites in Canada, currently receiving concentrated attention in southern British Columbia under the jurisdiction of a staff geologist.

The study of contact metasomatic magnetite deposits in British Columbia, which was started in 1961 as part of a general study of iron in Canada, continued in 1962 with the detailed mapping of five deposits on Vancouver Island and the Queen Charlotte Islands.

The Lower Cretaceous Bullhead and Fort St. John Groups were studied in outcrop in northeastern British Columbia between Graham and Buckinghorse rivers, and the general distribution and structures of these rocks were mapped in Trutch map-area. A helicopter was used for some of this work, with much success, and was shared with the party studying the Triassic rocks in the same general region.

Six members of the Survey's geophysical staff developed, and tested in northern Vancouver Island, a method for conducting airborne magnetometer surveys in mountainous terrain. A small aircraft was used for low-level contour flying, and the magnetic data were transmitted to a base station for magnetic diurnal correction via a repeater station, carried in another plane cruising at 8,000 feet. The method proved both versatile and satisfactory, although some difficulty remains in recovering the aircraft's flight path for data compilation.

A study of the Blue River ultrabasic intrusion in the Cassiar district was completed and forms part of the Survey's study program of Canada's ultrabasic rocks. The ultrabasic rocks are dunites, peridotites, and serpentinites, and were intruded by the Cassiar granite batholith, with the production of a broad contact zone containing talc, serpentine, and tremolite. Regenerated (secondary) olivine is widespread, probably the result of thermal metamorphism of serpentine by the intrusive granite.

The *British Columbia Office* at Vancouver recorded 9,650 visitors, 24,724 publications distributed, and 1,382 collections of rocks and minerals sold.

Alberta

Six field parties were active in Alberta, or in Alberta and British Columbia, of which four were stratigraphic or palaeontological parties. One party

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studied the pre-Devonian rocks of the southern Rocky Mountains, and established the presence of a major unconformity at the base of the Cambrian sequence in the Lake Louise area.

A second party completed a study of Carboniferous strata in the southern Rocky Mountains, recognizing several facies and subdivisions of the formations studied. It collected many spirifirid brachiopods, which may provide the basis of a Mississippian-Pennsylvanian standard for Western Canada.

Another stratigraphic party studied the Triassic rocks near the northern boundary of Jasper National Park, described and sampled many sections, and established that the two Triassic formations present in this region thicken markedly westward.

A study of Upper Devonian reefs in the eastern Rocky Mountains was completed.

A party completed the surficial geology mapping of the Blood Indian Reserve in Fort McLeod map-area. More than 75 per cent of the reserve is covered with quiet-water deposits of lacustrine silt and clay; the rest is covered with rather featureless till. As a result there is a singular lack of surface deposits of gravel and sand for economic development; gravels in buried preglacial valleys that cross the reserve are important for groundwater supply.

The sixth party commenced a detailed investigation of the stratigraphy, structure, and oil and gas possibilities of Burnt Timber map-area. Two major southwesterly dipping thrust faults occur in the eastern half of the map-area, imposing Cretaceous rocks onto Tertiary rocks. Gas is recovered from Mississippian strata in the area, and the gas potential appears to be good.

The *Western Plains Oil and Gas Office* in Calgary studies stratigraphic problems related to the oil and gas developments in Western Canada and collects and stores drilling samples, cores, and information about wells drilled in the region. The office also assumes custody of all cores and drilling samples from wells in the Yukon and Northwest Territories. Space was acquired this year in the Fairmore Building for housing these cores and making them available for examination by geologists from the oil and gas industry. Office and laboratory space was also obtained in the building, and is now occupied by several stratigraphers transferred from Ottawa during the year. The Western Plains Oil and Gas Office received 223,146 samples and 5,683 electric and other mechanical logs during the year. It received 2,571 visitors and distributed 3,888 publications in the first 11 months of 1962.

Saskatchewan

Five parties were active in Saskatchewan in 1962, four of them investigating groundwater and/or related engineering geology conditions.

In the Old Wives Lake drainage basin, preliminary results suggest a considerable upward groundwater flow into the saline flats and alkaline lakes occupying large preglacial (or glacial spillway) valleys, and that chemical modification of groundwater by materials in the various geological formations through which it flows is rapid.

Study of groundwater conditions in the headwaters region of Qu'Appelle River was directed towards the evaluation of a groundwater flow system in this typical prairie drainage basin. Knowledge of the prairie vegetation proved indispensable in distinguishing between areas of recharge and areas of discharge. Playas, saline soils, and a high salinity of surface waters are distinct features of many areas of groundwater discharge, and can be used successfully in the mapping of various parts of the groundwater flow system.

Engineering geology and groundwater studies in the Frenchman River drainage basin established the presence of low-yield aquifers at the base of the glacial drift and within the Cypress Hills, Ravenscrag, and Frenchman formations. Groundwater movement within, and clay mineralogy of, the Cretaceous Bearpaw Formation appear to be important factors contributing to slope instability and landslides in the upper reaches of Frenchman River valley.

Studies of the flow system and chemistry of groundwater were commenced in the lower part of the Eaglehill Creek drainage basin between Asquith and the North Saskatchewan River. The groundwater table was defined and piezometers installed to provide data for studies of the flow system near some intermittent streams.

Field work was completed in 1962 for a surface bedrock map of the 32-square-mile Coronation-Birch Lake area, which is the principal direct commitment of the Geological Survey to the comprehensive cooperative study of the Coronation Mine of Hudson Bay Mining and Smelting Co. Additional studies begun in 1960 and 1961 continued.

Manitoba

Five Survey parties operated in Manitoba in 1962, two of them doing reconnaissance bedrock mapping.

One party carried out reconnaissance bedrock mapping of Wekusko Lake map-area, which straddles the Superior and Churchill structural provinces in the Canadian Shield, and clarified stratigraphic relationships in the region. Base-metal deposits in the area are undergoing development at present.

A second party did reconnaissance bedrock mapping of Munroe Lake map-area, which contains remnants of a broad easterly trending belt of metasediments associated with gneissic granite. An aeromagnetic anomaly near Nueltin Lake is caused by a small ultrabasic body.

A field party continued from 1959 the hydrogeological study of the Red River valley. Potable groundwater is available at various depths throughout the northern and eastern parts of the area; the region south of Assiniboine River and west of Red River lacks potable groundwater. A large-yield groundwater supply was established around Winkler.

The study of surficial deposits in the Manitoba part of Riding Mountain area continued from 1961. The most common type of drift mapped is a recessional-type moraine, which south of Assiniboine River exhibits a marked pattern of depressions and ridges aligned in a northeast-to-southwest direction.

A resistivity geophysical party outlined and drilled a major fresh-water aquifer in the Plum Coulee area, the presence of which had been suspected from groundwater studies made during the preceding few years. This geophysical work suggests that in the Red River Plains area, resistivity can accurately locate fresh-water aquifers, and may also be capable of delineating boundaries between various soil types in the area.

Ontario

Six field parties operated in Ontario in 1962.

A geochemical study of the Kirkland Lake mineralized belt and surrounding region was initiated to appraise the possibilities of applying geochemical techniques to mineral exploration and to the elucidation of the geology of the district. Trace amounts of thirteen elements in several hundred rock samples collected from various parts of the region were estimated by emission spectrography. No significant geochemical peculiarities of the rocks were revealed that might provide direct or indirect criteria of the proximity of gold veins or their host rocks, but further analytical work is planned.

A final examination of several parts of the eight map-areas that constituted the 1959-1961 "Roads to Resources" project revealed more extensive iron-formation at the east end of North Spirit Lake than was known, and a new band of iron-formation near Greenmantle Lake.

Reconnaissance study of the Pleistocene geology of the Kirkland Lake-Larder Lake gold belt was commenced to see if this branch of geology could be helpful in furthering mineral and industrial development in this region. Extensive areas of clay, which represent potential farmland, were recognized in McElroy township.

Seismic refraction surveys were conducted over the Oak Ridge Moraine of southern Ontario and over an extensive area in the Kirkland Lake-Larder Lake gold belt. Large velocity contrasts between drift and bedrock created a favorable model for depth determinations to bedrock under the moraine, and buried channels and escarpments can be delineated. A depth of approximately 1,680 feet to the Precambrian surface was calculated from tests on Long Point in Prince Edward county.

A party studied the surficial deposits of three 1-mile map-areas, along the north shore of Lake Ontario, finding these deposits commonly less than 3 feet thick. The deposits include drumlins, the Dummer recessional moraine, clays and silts bordering the Lake Ontario basin and extending up creek and river valleys to the margin of the Canadian Shield, and well-developed gravel bars.

Another party completed the detailed bedrock mapping of the Precambrian rocks of the Frontenac Axis in the west halves of Brockville and Mallorytown map-areas. The rocks of the axis are well exposed and readily accessible, and are ideal for the study of structure in high-grade metamorphic rocks. They belong to the Grenville structural province, and include layered gneisses, marbles, granulites, and quartzites, with associated gabbro, diorite, syenite, and granite. Three stages of a single continuous deformation affected the metasedimentary rocks, and two main types of granitic rock have been distinguished.

Quebec

Five field parties operated in Quebec in 1962.

A surficial geology study in the Quebec-Thetford-Beauceville district established the distribution and stratigraphic relationships of the Pleistocene glacial and marine deposits, and collected enough data to unravel the last part of the glacial and post-glacial history of the region.

Study of the surficial deposits in Vaudreuil map-area continued from 1960 and 1961, with emphasis placed on mapping the stratigraphy of such deposits in the eastern half of the map-area. A large Champlain Sea delta composed largely of sand was recognized between Oka Mountains and Rigaud Mountain. A smaller deltaic deposit is also present near Rigaud, but the material in it is coarser.

A party completed preparatory work on the selection of a site for a 10,000-foot diamond-drill hole in the Mount Albert Intrusion, as part of the International Upper Mantle Project study. This work included a magnetometer survey to locate possible shear zones in the peridotite (none were found), and a hammer seismic survey to determine the depth of overburden in the valley of Rivière Diable. Surface samples of the intrusion were collected for statistical analyses of chemical trends.

A staff palaeontologist collected material for a micropalaeontological study of the Silurian-Devonian boundary in a narrow belt of rocks extending the length of the Gaspé Peninsula, from Cap Bon Ami to west of Lac Matapedia. A zonal classification of these rocks may result from this study.

A party examined the New Quebec crater and found evidence that the rim of the crater had been glaciated, but found no new evidence of impact origin for the crater. Structures in the rock foliation and the presence of hydrothermal alteration products do not agree with the widely circulated hypothesis that the crater originated through the impact of a meteorite.

New Brunswick

Three field parties were active in New Brunswick in 1962.

One party continued from 1960 groundwater studies in the Moncton area. Four well sites were drilled in 1962 to assist these studies. No areas yielding large quantities of water and no areas having high values of transmissibility were found, which suggests that the possibilities of finding wells yielding large quantities of water near the city of Moncton are poor.

A second party continued the geochemical study of the mineral deposits and associated rocks of the Bathurst-Newcastle base-metal district. Subparties conducted detailed geochemical investigations in the Rocky Brook-Millstream area, of molybdenum, of stream sediments and waters, and of the Nigadoo, Orvan Brook, and Captain Yellowknife sulphide deposits. Trace-element studies, petrographic studies, and sulphur isotope analyses form part of the program being undertaken by the various sub-parties.

The third party commenced the 1-mile bedrock mapping of Upsalquitch Forks map-area. The area contains Ordovician (?), Silurian, and Devonian sediments and volcanic rocks, some of which have been metamorphosed by small intrusive bodies.

Nova Scotia

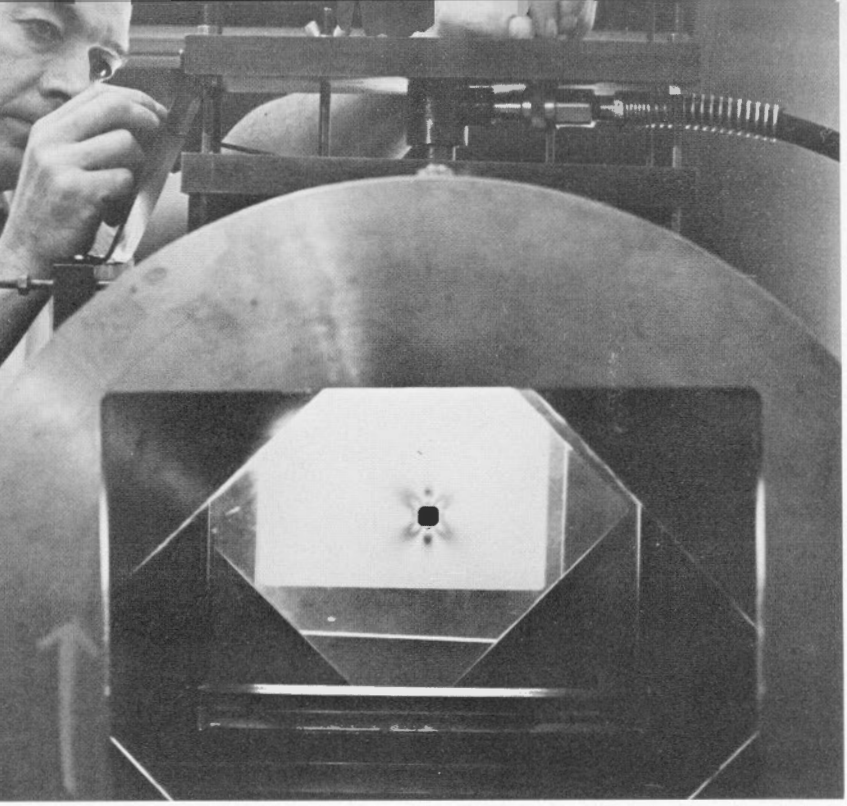
Three bedrock-mapping field parties and a marine geology field party operated in Nova Scotia.

One party commenced 1-mile bedrock mapping in Lochaber map-area. Most outcrops are found in stream valleys, for glacial sand and gravel up to 70 feet thick covers most of the interstream areas. Traces of gold were seen around some old prospecting pits and shafts near the margins of Devonian granite bodies.

Another party commenced and completed 1-mile mapping of New Glasgow map-area and Pictou Island. Intermixed metasedimentary, metavolcanic, and granitic rocks of the pre-Carboniferous Cobequid Complex are exposed in the southwestern part of the map-area, Ordovician and Silurian strata in the southeastern part. Carboniferous rocks, including Pennsylvanian coal beds, occur within the area, barite is found at several localities in the Pennsylvanian Pictou Group, and copper minerals are found at scattered localities in the Browns Mountain and Arisaig Groups, the Cobequid Complex, and the Canso and Riversdale Groups.

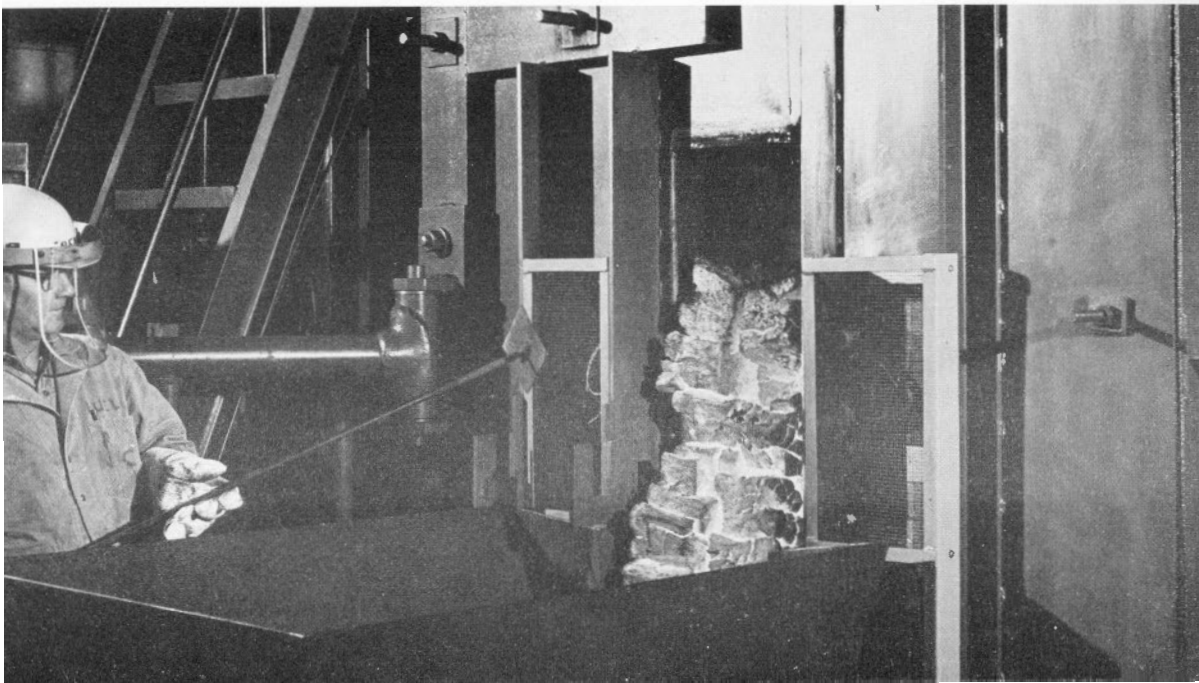
The third bedrock field party continued from 1961 the 1-mile mapping of the Cobequid Mountains. Sedimentary and volcanic rocks underlie more of the Cobequids than was previously known, including fossiliferous Silurian and Devonian rocks that resemble those of the better-known Arisaig section in Antigonish county.

A marine geology field party commenced detailed study of bottom sediments and microfauna in St. Margaret's and Mahone Bays, an area in which there are many variations in environments, depths, salinity, and currents.



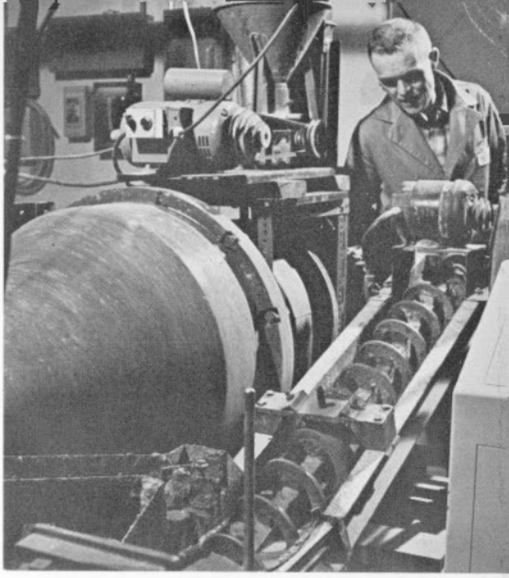
Mines Branch technician uses laboratory equipment that simulates rock stress normally developing around a mine opening. Photoelastic technique permits visual inspection of stress pattern (black dot in centre). *(George Hunter #13754)*

Coal research occupies important place in Mines Branch work. Here, coke is being pushed from 500-pound movable-wall test oven. *(George Hunter #13771)*



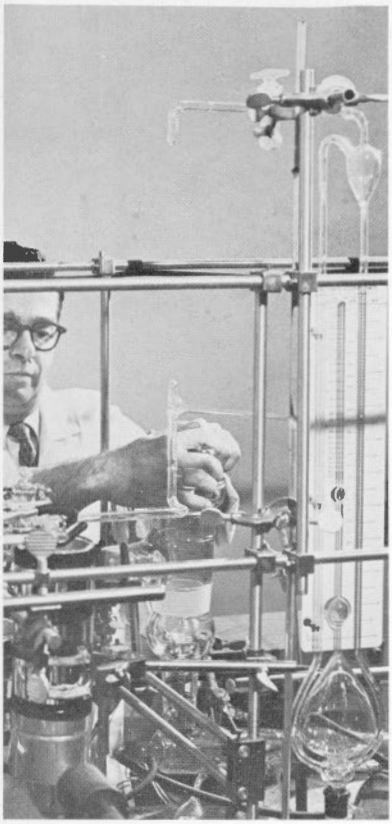
Mines Branch scientist prepares to study an ore sample in the electron probe micro-analyzer for identification and estimation of elements present in the microstructure. *(George Hunter #13740)*

A tungsten ore concentrate is "tabled" on laboratory-scale equipment used for gravity separation of heavy minerals such as tin, tungsten, galena, silver, gold, and niobium. *(George Hunter # 13766)*



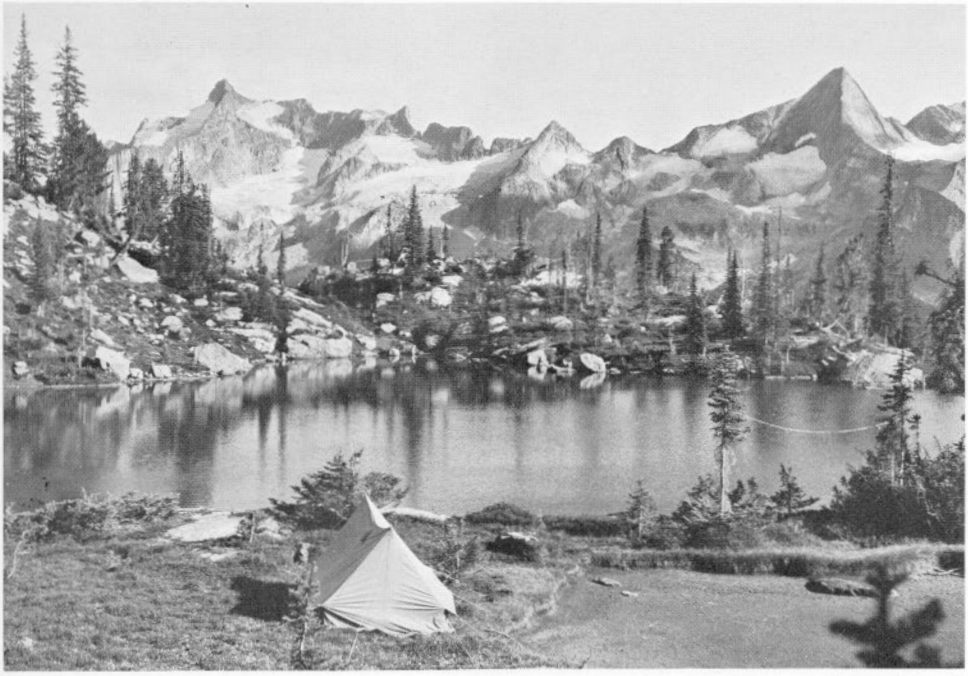
Experimental ore-grinding unit uses microphone to pick up grinding noise. Noise characteristics automatically control feed of material and water to achieve maximum efficiency. *(George Hunter #13763)*

New highly advanced refining apparatus uses narrow band of intense heat, through which metal sample passes, to melt and eliminate impurities, not unlike water being pressed from wet garment that is passed through washing machine wringer. *(George Hunter #13742)*

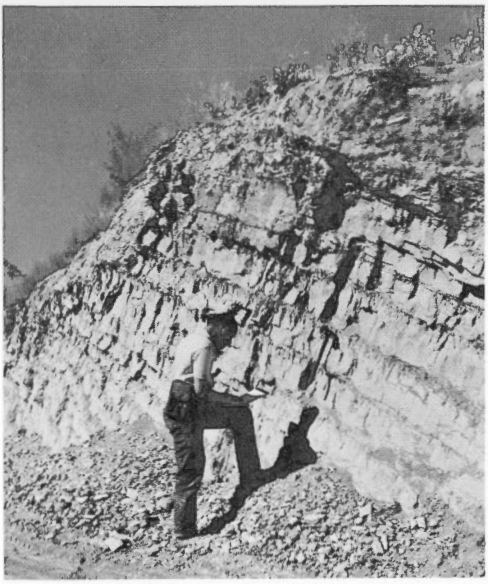


An unusual type of research, of great interest to metallurgical industry, is the study of surface tension of molten metals. Here a technician determines surface tension of molten zinc in Mines Branch laboratory. *(George Hunter #13744)*

Geologists attached to the Polar Continental Shelf Project drill through Arctic sea ice in order to obtain samples of sea bottom. Drill is powered by mobile generator on toboggan. *(G.S.C. 2–9–63)*



Annual field trips take scientists of the Geological Survey of Canada into some of the country's most picturesque regions. The party which has pitched its tent in the Valhalla Mountains of southern British Columbia is studying mixed gneisses. *(G.S.C. 8–6–58)*

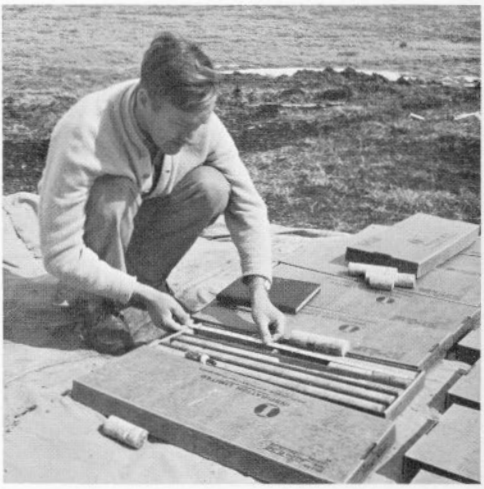


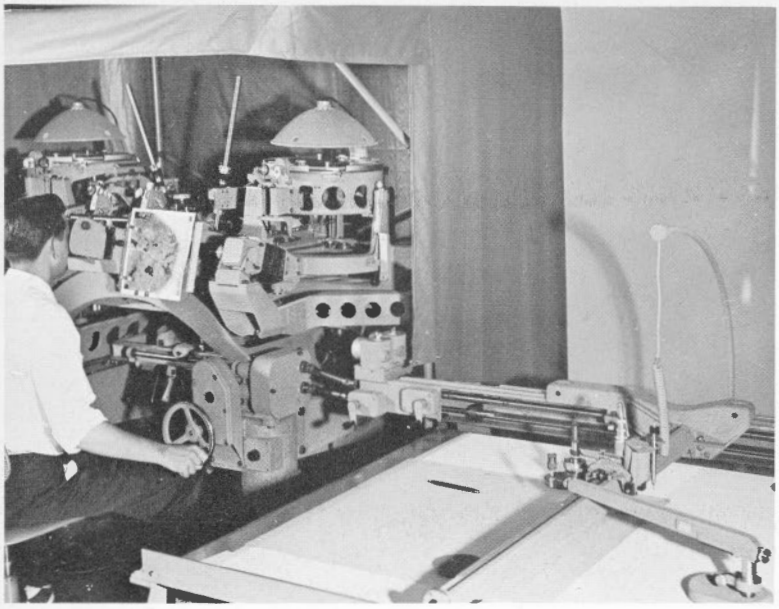
Pleistocene geologist examines cut in glacial lake sediments in the Vernon area, British Columbia. *(G.S.C. 2–9–63)*

Portable drill is used by geologists to obtain rock core which is to be analyzed for magnetic orientation and structure as part of a micromagnetic study. *(G.S.C. 2–2–63)*

Young master of science candidate attached to geological field party uses new portable fluxgate magnetometer during micromagnetic survey of an iron-ore body. *(G.S.C. 1–22–63)*

Scientist working on the Upper Mantle Project examines cores obtained by diamond drilling in the Muskox Intrusion, Northwest Territories. *(G.S.C. 3–6–63)*





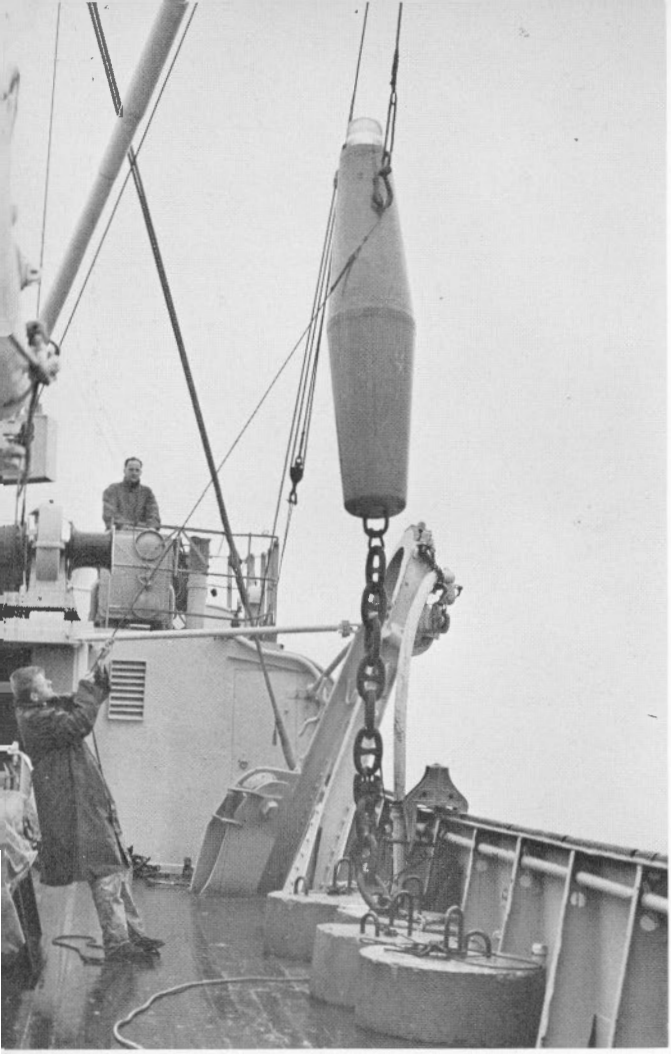
Surveys and Mapping Branch technician operates plotting machine which transfers topographical details from stereo photographs to map sheet. The plotter accurately determines both elevations and co-ordinates from airphotos.

New oceanographic and hydrographic ship, C.S.S. *Hudson*, was launched in St. John, N.B., in March 1963. The 4,800-ton ship is the Department's largest; it is also the largest vessel in the free world designed for oceanographic research. *(M & T S photo)*

Airphoto shows vista cut through forest along 141st meridian boundary between Canada and Alaska, at the point where the boundary crosses the Yukon River. Boundary vistas are maintained by the International Boundary Commission. *(Intnat. Bdy. Comm. photo)*

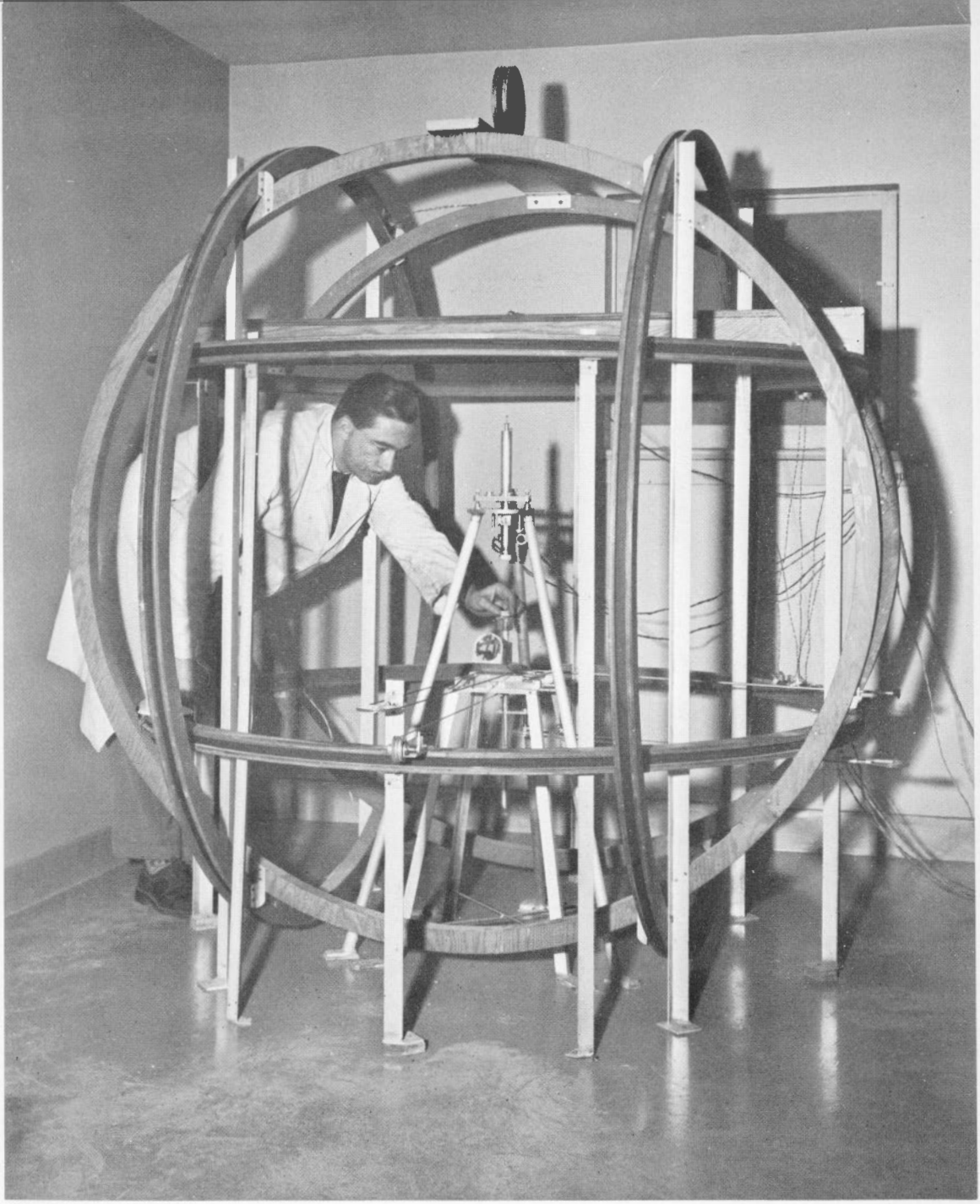
Bedding down under the midnight sun in the Arctic. Scientists attached to the Polar Continental Shelf Project on Axel Heiberg Island cannot be choosy about camp site. *(G.S.C. 12–8–60)*

The Bedford Institute of Oceanography at Dartmouth, N.S., was officially opened in the fall of 1962. It provides offices and laboratories as well as shops and deepsea docks for a wide range of maritime research.



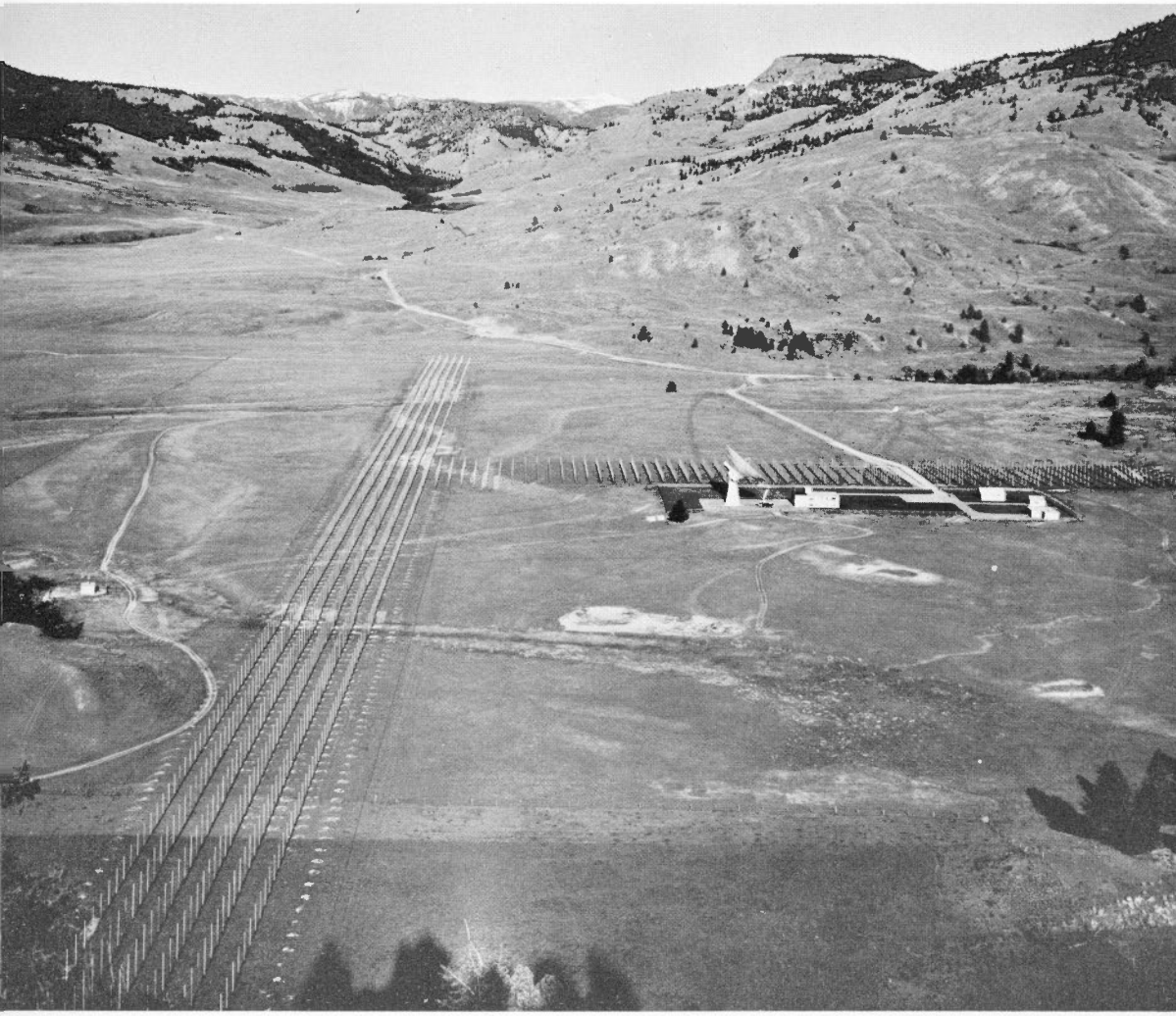
Oceanographers are preparing to put overboard buoy which will indicate position of current meter, one of a series planted in the Gulf of St. Lawrence. (G.S.C.)

On an Arctic island geographers dig deep into permafrost to study its characteristics.



Dominion Observatories scientist places rock specimen for measurement in astatic magnetometer. The apparatus, which cancels the earth's magnetic field, permits measurement of weak magnetic current within the specimen. *(Dom. Obs. 5695-1)*

Bird's-eye view of T-shaped array of radio telescope in preparation at the Dominion Radio Astrophysical Observatory near Penticton, B.C. The observatory's 84-foot parabolic telescope and buildings are in right centre.



Coarse sediments along the shoreline grade rapidly into a rich sour-smelling black ooze in the less turbulent areas that characterize the bays. Bottom samples were collected by both standard oceanographic sampling and by SCUBA diving.

Prince Edward Island

One party, comprising two sub-parties, operated in Prince Edward Island in 1962. One sub-party continued glacial studies of the west half of Rustico map-area, which contains much clayey sand till derived from sandy bedrock. Most valleys contain glacio-fluvial deposits laid down during the stagnation and down-melting of the ice-sheet on the island. Striae and till fabrics indicate that the ice moved generally eastward from a centre of glaciation in New Brunswick. The other sub-party continued bedrock studies of Montague map-area and parts of the east half of Charlottetown map-area. Three major stratigraphic units are exposed there, the oldest of which is of Permian age. It is overlain by sandy and conglomeratic sediments of unknown age.

Newfoundland (Island and Labrador)

Two bedrock-mapping field parties and one geophysical party operated on the Island of Newfoundland in 1962, and one party commenced reconnaissance mapping in Labrador.

A party continued from 1960 and 1961 the reconnaissance mapping of Belleoram map-area. Late Precambrian quartzitic rocks are apparently conformably overlain by Lower Cambrian rocks on Burin Peninsula, and disconformably by Middle Cambrian beds on the north shore of Fortune Bay. Four ages of granitic rocks are recognized in the northwestern part of the map-area, the youngest of which is either Late Devonian or early Carboniferous age. Two new clay deposits were found.

Another party completed the 4-mile (reconnaissance) bedrock mapping of the west half of Botwood map-area, a project commenced in 1961. Rocks are chiefly closely folded Ordovician and Silurian sedimentary and volcanic rocks, which are cut by younger intrusive granitic rocks. Several formations defined 20 to 30 years ago in Notre Dame Bay can now be correlated. Some fifty fossil localities found in 1962 have greatly aided the unravelling of the regional stratigraphy. There seems to be no evidence of deformation at the close of the Ordovician Period in the rocks in this region.

A geophysical party collected 253 oriented samples from igneous and sedimentary rocks of Cambrian to Carboniferous age from central and western Newfoundland and the south coast of Labrador, to add to and refine the polar wandering curve during the Palaeozoic Era, as determined from palaeomagnetic studies.

One party commenced reconnaissance mapping in Labrador in the Michikamau Lake area, east of the Labrador Trough. The area is underlain by granitic rocks, gneisses, minor metasedimentary rocks, and anorthosite. Glacial

features trend southeasterly across the area. Detailed examination was made of the extensive Michikamau anorthosite body.

General

Nearly two dozen Geological Survey staff members undertook specialized field projects in several parts of Canada. Some studied Canada's mineral deposits and others specific ages of rocks and their contained fossils. Still others did groundwater and engineering studies, petrographical and geochemical studies, palaeobotanical, mineralogical, and geophysical studies.

Studies of iron-formation in Eastern Canada continued, with the examination of the unmetamorphosed Precambrian iron-formation of Temagami and Moose Mountain in northern and western Ontario, in order to find out their primary sedimentary features. Systematic sampling also was done, from Mount Reed to Lac Jeannine in the Labrador geosyncline. Evidence of concentration of iron ore by the leaching of silica was observed in both Wabush Lake and Knob Lake areas. Secondary manganese enrichment in the iron ores originated in manganese-bearing anthophyllite and mangano-cummingtonite.

A party spent five weeks in eastern Quebec and southern New Brunswick investigating the mineral assemblages of various types of mineral deposits, as part of a newly initiated metallogenic study of the Canadian Appalachians.

Another party continued from 1961 the investigation of the geology of tin deposits and occurrences in Canada. Tin deposits in the Yukon, British Columbia, Manitoba, and southern New Brunswick were examined during the field season. As the tin minerals are generally difficult to recognize by eye, spectrographic checking of samples thought to contain them was generally necessary.

An engineering geology party continued studies of potential dam sites in Yukon Territory and the Northwest Territories. Two sites were examined in the Yukon River drainage basin, and thirteen in the Mackenzie River drainage basin. This project was commenced in 1959 at the request of the Water Resources Branch, Department of Northern Affairs and National Resources. To date 47 possible dam sites have been investigated. The Survey officer in charge of this project spent three weeks at the end of the field season in the Welland Canal area, Ontario, consulting with the St. Lawrence Seaway Authority regarding foundation conditions beneath the proposed new lock and approach wall structures.

Field work continued from 1960 on a project to publish a series of popular accounts of the geology of each of Canada's National Parks. In 1962, Riding Mountain (Manitoba), Prince Albert (Saskatchewan), Elk Island (Alberta), and Mount Revelstoke and Glacier (British Columbia) National Parks were visited. The first four booklets resulting from this project—on Cape Breton Highlands, Prince Edward Island, Fundy, and Yoho National Parks—were published in 1962.

A party commenced a reconnaissance study of groundwater conditions in parts of Prince Edward Island, Nova Scotia, and Newfoundland. Field work included measuring of springs, sampling of wells, and making notes on the relation of topography, geology, and vegetation patterns. All water supplies for towns and farms on Prince Edward Island come from wells, and the studies showed that more well fields can be safely installed in valleys without causing any serious depletion of water levels. In Truro map-area, Nova Scotia, water supplies sufficient for small towns and light industries are available in the Triassic rocks and from glacial deposits and alluvium in some localities. Groundwater conditions at the St. Lawrence Fluorspar mine, Newfoundland, and in the Grand Lake basin, Newfoundland, were also studied briefly.

A study of diabase dykes in the Canadian Shield commenced in 1962, with the examination and sampling of two hundred such dykes in three parts of the Shield, the Noranda-Val d'Or region of Quebec, southern Ontario, and western Northwest Territories.

Sea magnetometer studies were made by two parties off Halifax, Nova Scotia. Measurement of the earth's magnetic field is done by the use of a nuclear-precession direct-reading-type magnetometer, the sensing head of which is towed 400 feet behind the ship on which it is installed. The position of the ship is plotted using the Decca navigator. One party traversed about 10,000 line miles using the CSS *Kapuskasing*, the other approximately 5,000 line miles using the CSS *Baffin*.

A hammer refraction seismic survey was almost completed in Moncton map-area, New Brunswick, to determine thickness of overburden. The survey outlined several buried features, which might be aquifers. Similar seismic studies were made in part of Prince Edward Island to outline the bedrock profile across selected rivers and streams and across certain inland geological features.

A geophysical party conducted a hammer refraction seismic survey along the centre line of the Greater Winnipeg Floodway to study Pleistocene materials as detected by seismic velocities and to produce a profile of the bedrock surface underlying the floodway.

Another geophysical party conducted measurements on rock specimens in Gatineau Park, just north of Ottawa, to investigate the mechanism of electrode and membrane polarization effects.

A party examined silver deposits and occurrences in western Ontario and various lead-zinc-silver deposits in central and southern British Columbia, as part of a study of silver deposits of Canada. By the end of 1962, sufficient data had been collected to permit the start of a metallogenic map of silver in Canada.

A staff geologist made Pleistocene palynological studies of cores and bottom sediments in Lake Erie, collected by the research vessel *Porte*

Dauphine. These will provide information of glacial and post-glacial climatic conditions in this part of Canada.

A Survey mineralogist visited mineral-collecting areas along the Trans-Canada Highway between Sudbury, Ontario, and Falcon Lake, Manitoba, to provide information for a Survey report suitable for tourists and amateur mineral collectors.

A staff palaeontologist continued studies of Jurassic rocks in British Columbia and Alberta, with detailed studies of the Upper Jurassic beds belonging to the upper part of the Fernie Group in parts of the Rocky Mountains and Foothills.

Staff geologists made rock, soil, and fossil collections in several parts of Canada. A coal geologist collected samples of coal from the Michel-Natal area in British Columbia for petrographic and coking studies. A palaeontologist collected samples of Mesozoic strata and fauna in the area mapped by Operation Porcupine in the Yukon, and also Lower Cretaceous strata from two areas in British Columbia. A National Research Council post-doctorate fellow attached to the Geological Survey collected soil samples over oil and gas fields in southwestern Ontario and Alberta, as part of a study of the geochemical methods of prospecting for oil and gas. Early results of this study appear to offer a useful new prospecting technique.

A specialist in palaeomagnetism collected 330 oriented specimens of diabase dykes and sills in northern Ontario, northwestern Quebec, and from the Grenville structural province north of Ottawa. Another Survey geologist collected about a ton of sulphide and ultrabasic rock specimens from the Muskox Intrusion between Speers Lake and Coppermine River, Northwest Territories, and more than 16 tons of minerals, rocks, and ores from forty localities in New Brunswick, Nova Scotia, Ontario, and Quebec, to be used in the preparation of various rock and mineral collections for sale to the public. Two coal geologists collected samples of Carboniferous rocks for palynological investigations from two areas in New Brunswick and Nova Scotia. A staff palaeontologist collected plant remains from the type section of the Ghost River Formation (Devonian) of Alberta, Tertiary plant remains from Driftwood Creek and Williams Lake, British Columbia, and Jurassic-Cretaceous plant remains from strata near Hazelton, British Columbia. Another palaeontologist collected plant remains from the Devonian strata at Gaspé Bay, Quebec, and on the lower part of Restigouche River in Quebec and New Brunswick, and plant remains and bone fragments from Permian strata of Prince Edward Island. A staff mineralogist collected specimens for laboratory study from mines in the Bancroft-Wilberforce area of Ontario, and a staff geologist collected samples from Labrador and from the Grenville structural province for isotopic age determinations to aid in the preparation of a Tectonic map of Canada.

Laboratory and Office Work

Much of the work of the laboratories is in the support of projects initiated by field staff, but a considerable amount of development and research is nonetheless initiated by the laboratory staff. A significant achievement of the past few years has been the increasingly productive collaboration of such diverse disciplines as chemistry, crystallography, mathematics, mineralogy, petrology, and physics in the work of the Survey's laboratories.

The analytical chemistry laboratories provide the Survey's geologists with chemical and spectrographic data on all types of geological materials, at all levels of element concentration, with particular emphasis on silicate analysis. The laboratories in 1962 completed 815 chemical and 2,093 spectrographic sample analyses, an apparent drop in production of about 45 per cent from 1961. This reduction reflects fuller analyses of fewer specimens. The production of rapid rock analyses almost trebled over that of 1961, from 149 to 401, as a result of improved methods and reorganization of the laboratory operations. This phase of the analytical work is now operating close to maximum efficiency. The total number of spectrographic determinations increased sharply from 15,000 in 1961 to 26,353 in 1962; most of these (17,572 determinations) were quantitative spectrographic determinations. Demand for precise rock analyses declined sharply, and is being replaced by an increasing demand for mineral analyses. The nature of the samples now being submitted has shown an increasing complexity, necessitating the use or development of new methods of analysis.

Major emphasis in the isotope and nuclear research laboratories during the past few years has been concentrated on the application of the potassium-argon method of age determination, and the addition of 198 new age determinations during 1962 brought the total number of samples processed by these laboratories to 654. During 1962, efforts were made to broaden the activities to embrace the measurement of the ratios of rubidium and strontium in whole rocks and minerals, and the lead, uranium, and thorium concentrations in zircons, from which age can be calculated for a much wider variety of rocks and minerals than heretofore. Some 58 strontium-rubidium age determinations were completed in 1962. To permit renewed studies of stable isotopes, plans were made for construction of two new mass spectrometers, bringing the number at the Survey to four. One of the two was built during 1962 and is undergoing testing. The second is scheduled for construction early in 1963. The radiocarbon (C-14) dating laboratory completed 85 age measurements in 1962, bringing its total to 147 since its inauguration in 1961. These have been completed on a 2-litre proportional counter; a larger 5-litre counter has now been designed and assembled and was undergoing tests at the year's end. Dating of specimens to a maximum of 50,000 years before present is expected from this new instrument.

The output of service work from the mineralogy laboratories in 1962 surpassed the all-time high reached in 1961, including some 3,293 mineral identifications. A single crystal precession camera was added to the X-ray diffraction laboratory during the year, which will permit the laboratory to do detailed work on mineral species of special interest. The X-ray spectrography laboratory made 3,663 quantitative and 127 semi-quantitative determinations on 654 samples received for X-ray spectrochemical analysis during 1962. This laboratory also undertook the development of an accurate method for the determination of rubidium and strontium in rocks and micas, as part of the Survey's age-determination program.

The sample-preparation and mineral-separating laboratory showed an increase in production for the fourth consecutive year. The number of mineral concentrates produced was 2,504, an increase of 28 per cent over the 1961 output.

During 1962 the number of mineral and rock collections prepared for sale to the public increased from 7,072 sets in 1961 to 8,580 sets. The total number of mineral and rock specimens in these sets was 304,860. Personnel preparing these collections also made over 700 identifications of rocks and minerals in response to almost 300 public enquiries.

Research studies on the rock-forming micas neared completion and scientific reports were being prepared during 1962. Installation of an electron probe microanalyzer for microanalysis of geological specimens began late in the year.

Expansion of the systematic reference series of the National Mineral Collection, which was formally established in 1961, continued in 1962. This series is the responsibility of the Geological Survey of Canada and is being built up to provide as full a representation as possible of all known mineral species and varieties. Some 26 exchanges of minerals were arranged during the year with individuals and organizations in Canada and abroad. This phase of activities is expected to increase in the future. Many of these exchanges were aided materially by overseas officers of the Department of Trade and Commerce, who approached approximately 125 museums, government agencies, and other prime sources concerning the Survey's interest in building up its mineral collection. Some 184 specimens or groups of specimens were added to the systematic reference series during 1962, by exchange, donation, purchase, or collection in the field.

Public interest in meteorites increased in 1962 through newspaper articles on meteorite recovery and the sighting of two spectacular fireballs over Western Canada. As a result, 140 pseudometeorites have been received by the Survey since early April, 1962.

As part of the International Upper Mantle Project—a 3-year (1962-64) program of studies designed to obtain and interpret geophysical and geological data on the upper mantle of the earth—officers of the Survey are

carrying out petrographic, mineralographic, chemical, and isotopic studies related to basic and ultrabasic intrusions. These intrusions provide an indirect means of sampling and studying the chemical and physical conditions and processes existing in the mantle itself. Two large intrusions—the Muskox Intrusion in the Northwest Territories and Mount Albert in southeastern Quebec—are under investigation; bedrock and geophysical studies have been made and immediate plans call for two 5,000-foot diamond-drill holes into the Muskox Intrusion in 1963.

Studies have commenced on the textural and mineralogical constitution of bottom sediments obtained from the eastern part of Prince Gustaf Adolf Sea, District of Franklin. Similar studies are under way on inshore sediments and microfauna from Deer Bay, Ellef Ringnes Island and adjacent parts of the floor of Prince Gustaf Adolf Sea, and on bottom sediments, topography and/or fauna from Exeter Bay on the east coast of Baffin Island, District of Franklin, around the Churchill River estuary in Hudson Bay, and on the Scotian shelf off southeastern Nova Scotia. These studies are conducted by the Marine Geology unit, the most recently formed (1959) part of the Geological Survey's organization.

In addition to geophysical surveys in various part of Canada, the Geological Survey carries out research into the development of new geophysical methods and instruments.

Geologic-aeromagnetic interpretation of data obtained from both aeromagnetic surveys and sea-magnetometer surveys continued during 1962. Data from sea-magnetometer surveys in Hudson Bay indicate a Palaeozoic-Proterozoic contact about 20 miles west of the Belcher Islands, and that depths to basement rocks under Hudson Bay are as much as 10,000 feet in places.

The palaeomagnetic laboratory continued the measurements of remanent magnetism of oriented rock specimens from several selected locations in Canada, and constructed an air-driven turbine spinner magnetometer for palaeomagnetic measurements. Development of an Astatic-type magnetometer continued.

Geophysical instruments not available commercially are designed and constructed in the Geological Survey's geophysical laboratories, and modifications to and maintenance of other electronic equipment are also done in these laboratories. A direct-reading nuclear precession magnetometer constructed in the Survey's geophysical laboratories was installed in 1962 on the CHS *Baffin* and operated sucessfully over the continental shelf off Halifax, Nova Scotia. Two other instruments of this kind were employed on similar sea-magnetometer surveys. Other electronic equipment designed, constructed, or modified in these laboratories during the year include parts of the spinner-type magnetometer used in palaeomagnetic studies, and very low frequency induced polarization equipment.

In the mineralographic (metallogenic) laboratory established in late 1961, the following new pieces of equipment were added: a Frantz isodynamic magnetic separator, for heavy mineral studies and other projects requiring clean mineral separations; a photometer for reflectivity measurements on polished sections; a Durener polishing machine, capable of polishing six ore-sections at one time; and a cut film adapter for Polaroid P N film to assist in the making of photomicrographs of ore specimens.

Investigations stemming from field studies of barite deposits in Canada commenced on the possible interrelation of geological environment, temperature of formation, major and minor element variations in megascopically pure barite, and the presence or absence of economic sulphide minerals in or near barite deposits.

Laboratory research on the chemistry of ore deposition, metamorphism, isotope geochemistry, radiochemistry, geochemical prospecting, and sedimentary geochemistry, continued and expanded in 1962. Work proceeded on the design and installation of high temperature-high pressure apparatus for the study of metamorphic and igneous processes, and in December work commenced on the installation of specialized equipment in the greenhouse on the roof of the Survey building. The trace-elements laboratory analyzed 3,379 samples of rocks, soils, stream sediments, minerals, natural spring precipitates, water, and biological materials, comprising 19,291 determinations in all. A long-term project on the trace-element content of various biological materials in the ocean, particularly oysters, quahaugs, and scallops was continued in 1962, in cooperation with the Fisheries Research Board. The results will clarify the role of living creatures in concentrating metals such as zinc, cadmium, copper, lead, arsenic, and antimony, in a sedimentary environment. It has been found that oysters and other shell fish concentrate up to 10 per cent zinc in the ash of their living parts. Development work on spectrophotometric methods for the determination of arsenic and silver neared completion and should soon be ready for field applications.

The sedimentology laboratory provides data of value for improvement of the classification and precision of nomenclature of clastic sediments, in correlation problems, and in basic research into the behavior of sediments. Services provided by this laboratory included 145 sieve analyses, 277 sieve and pipette analyses, 270 heavy mineral separations, and 1,149 heavy mineral slides—a considerable increase in production over 1961.

The palynology laboratory prepared 24 reports for members of the Geological Survey and 16 reports for other government, university, commercial and private personnel, and answered many enquiries on sampling, preparation, and examination of sediments for plant microfossils.

Groundwater and engineering projects are mostly related to field work, but late in 1962 space was made available for a groundwater model laboratory and experimental studies were started on conductive paper analogue

models. Development of a rapid sediment analyzer had reached the testing stage by the end of the year. Groundwater personnel of the Geological Survey provided advice to the Department of Public Works on a variety of projects varying from foundation investigations to sources of aggregate and water supply, and gave direct assistance or advice on engineering geology or groundwater problems to other federal and provincial government departments and to the city of Regina.

The well-sample preparation laboratory was reorganized in 1962, which resulted in a 35-per-cent increase in the number of samples processed, mostly from Alberta.

Specialists in stratigraphic palaeontology prepared 161 reports on 1,746 lots of fossils, 1,086 of which were submitted by Survey officers. Some 192 lots of fossils were submitted by other government departments, 426 by industry, and 42 by miscellaneous sources. Loans totalling 800 fossil lots were made to 28 individuals or institutions throughout the world, and 131 fossil lots and 110 plaster replicas were sent as gifts or exchange material to 14 individuals and institutions. A total of 1,059 fossil types described in Survey and other publications were added to the type collection of the Survey in 1962, and numerous type specimens of this collection were refigured and/or redescribed during the year. A micropalaeontology laboratory was established in the Calgary office of the Geological Survey. The palaeontology preparation laboratory completed a project commenced in 1961 to clean, file, and cross-reference all fossil plants in the Survey's collections. More than 6,400 plant localities were checked during this undertaking. Work commenced on the sorting, indexing, and cleaning of collections of Silurian invertebrate fossils.

The Geological Survey cooperates with the Mines Branch on research on the coking characteristics of coals. These studies may permit the correlation of low-rank, high-moisture coals by means of petrographic profiles.

Geological Survey publications are made available to the public through the Survey's offices in Ottawa, Calgary, Vancouver, Yellowknife, and Whitehorse, as well as from a departmental office in Quebec and the Queen's Printer. The Survey's publication distribution office in Ottawa, during 1962, received 24,212 requests for publications and information, nearly twice the number of 1961, and sent out 278,364 publications, consisting of 139,401 maps, 82,413 reports, and 56,550 miscellaneous items.

mines branch

THE MINES BRANCH, in 1962, intensified and enlarged its research program toward better production methods and wider use of Canadian metals, minerals and fuels. Laboratory tests, pilot plant runs and other procedures carried out on many substances submitted by private industry and government agencies, yielded a growing mass of useful data, conclusions and recommendations. The Branch made progress in the search for new or better uses for coal and uranium and various low-grade ores of which Canada has an abundance. Promising results were also obtained in the work on low-grade crude oils, a matter of special importance to the development of western Canadian oil sands. New research instruments and equipment were built by Branch personnel including a mine model for studies in rock mechanics. Constant improvements were made in present techniques in extraction and processing of metals and minerals. A special section of the Branch continued to work on underwater acoustic devices for the Royal Canadian Navy, studying various piezo-electric ceramics, ferrites, and magneto-strictive materials.

Physical Metallurgy

Research in physical metallurgy was concentrated chiefly on the solution of problems that might give early benefits to the Canadian mining and metallurgical industry. Long-term fundamental research was also carried on. Non-nuclear metallurgical uses for uranium continued to be investigated in co-operation with uranium and steel producers. In its capacity as consulting agency on metallurgical problems, the Branch issued 221 reports to private and public organizations. Senior staff members took part in the work of many national and international scientific bodies concerned with theoretical and applied physical metallurgy.

During the year, some 36 requests were received from companies and individuals that required laboratory investigation, and over 145 requests for recommendations, advice, or practical help were dealt with. Among these were studies on the quality of pig iron, metallurgical evaluation of grinding balls of new composition, and welding of critical joints of a large floating crane for the St. Lawrence Seaway.

In other instances, service failures of components were investigated and changes were recommended, such as the fatigue behavior of carbide drill bits, and material selection for mining equipment in northern Quebec which had to withstand hard wear and low temperatures.

The Branch examined corrosion products on various metals by X-ray diffraction analysis, and ran vacuum fusion gas analyses on ferrous and non-ferrous metals to evaluate quality and production controls. Tests of many cast, welded, and fabricated metal parts were carried out by non-destructive X-ray, ultrasonic, and magnetic particle inspection.

Apart from the investigational work on behalf of private industry, 17 requests were received from other government agencies, not counting the armed services. Included among these were an investigation of the quality of 30-inch gas transmission pipe at the request of the National Energy Board, and damaged or defective metal items were examined for the Department of Public Works, the National Harbours Board, and the Northern Canada Power Commission. Atomic Energy of Canada Ltd. asked the Branch to study stress qualities in a medical therapy unit, and the Tripartite Committee on Standardization of Methods of Tests of Ferrous Materials requested studies of national standards of hardness tests of steel. Aircraft impeller gears and samples of carbon steel tubing used on destroyer escorts were examined for the Royal Canadian Navy, which also received advice on the elimination of failures in the low-pressure stage of a turbine. The Army submitted eight items requiring metallurgical investigation, and 32 inquiries were dealt with. The cause of tool damage in machining armor-piercing shot was traced to arc burns made during magnetic particle inspection. There were four investigations on behalf of the Air Force, and fifteen inquiries. RCAF inspectors were given a course of instruction on theoretical and practical industrial radiography, and some 2,000 aluminum and stainless-steel spot and seam welds were X-rayed in connection with RCAF approval of welding equipment and methods.

The cracking of sheave wheels on three vertical-lift bridges was examined for the St. Lawrence Seaway Authority, and this serious danger was dealt with through recommendations concerning the weldability of various steels to be used in repairs. Nine investigations were carried out for the Department of Transport, among them examinations of components of crashed aircraft and cracked boiler plate. Of historical interest were investigations of old copper plaques from the Pacific coast for the National Museum,

and other copper specimens of Indian origin for the Strathavon Indian Museum of Ontario.

Research in physical metallurgy is carried out along fundamental lines, aiming at fuller use of Canada's abundant resource metals, and along lines of practical application on problems stemming directly from investigations to assist metal producers and users.

During the past year, research in alloy development was carried on with a number of metals. In the study of ferrous alloys, attention centred on the development of steel particularly suited for main steam turbine rotors. This work has progressed favorably to the stage where prototype forgings are to be prepared and tested, following the selection of composition and heat treatment. Experiments on steels for use at low temperatures showed that promising results can be achieved with niobium additions. In non-ferrous alloy research, studies were carried out on copper-base casting alloys and magnesium alloys in connection with the effects of metallurgical processes on structure and properties. Work was continuing on establishing the constitutional phase diagram of the ternary titanium-aluminum-molybdenum system with a view to evaluation of a system for designing heat-treatable alloys.

Uranium again received much attention, particularly as a potential alloying element in various steels. Research concerned the partition of uranium between the oxide, carbide, and intermetallic phases in steel, the effect of uranium additions to a number of alloy steels, and resultant welding, corrosion, and mechanical properties. Some 3,000 specimens were being tested in these experiments. Also under investigation was the effect of uranium additions to free-machining steel, particularly with respect to size and shape of sulphides in resulphurized grades. Tests showed that transverse ductility and machinability may be improved by such additions.

Studies of the effect of uranium additions to copper and nickel have shown that uranium can offset loss of ductibility from contaminants.

In the study of melting and refining processes, vacuum degassing of molten metal and the relationship of gas content to structure and mechanical properties of carbon steel produced by various methods received special attention. A study of the effects of alloy additions on the activity coefficient of oxygen in molten iron was being conducted for the better understanding of the thermodynamics in steel-making.

Research on casting was carried out in several ways. These included water-spray chilling of aluminum alloys in shell moulds, aluminum test bar designs, and hot tearing in copper alloys.

The increasing industrial importance of powder metallurgy was taken into account by research into insoluble phase dispersion hardening, embracing high-silicon aluminum alloys and the recently developed oxide-coated aluminum powder product SAP.

Much interest has lately been shown in refractory metals, such as titanium, niobium (columbium), molybdenum, and tungsten, in connection with their use in space craft. Among the problems investigated by the Branch were techniques for consolidation into ingot, and conversion of ingot into wrought products such as sheet and bar. Also studied were such methods as extrusion, particularly difficult with these highly resistant metals.

In welding research, considerable attention was again given to the welding of structural steels at low temperatures. This involves the study of uranium additions, and especially an investigation of metal transfer in the inert-gas metal-arc welding process. The last-named research involved the use of high-speed motion pictures and calculations based on theoretical and observed transfer modes.

In corrosion studies, results of tests on galvanized coatings on steel are being re-examined, and research is proceeding on improved uranium-bearing steels.

The mechanical properties of metals and alloys were investigated through fatigue-damage research, especially important for the design of aircraft and regulating or control equipment and components. The mechanism of fatigue was studied with the use of transmission electron microscopy of bending fatigue behavior of aluminum bicrystals. Flat specimens of polycrystalline pure aluminum were subjected to cyclic plane bending to test the use of ultrasonic surface waves as a means of detecting fatigue damage.

In liquid metal research, particular attention was given to zinc, an abundant Canadian metal whose market possibilities might benefit from better knowledge of die-casting techniques. Radio-isotopes of alloying elements were used as a means of studying metal distribution during solidification of cast metals.

Research in the field of pure metal physics embraced continuing studies of grain boundaries, lattice imperfections, deformation twinning, and secondary hardening. The transmission electron microscope technique was a powerful tool and was used to advantage to reveal dislocations and precipitate particles in the very early stages of formations. More recently, research was begun on ion bombardment technique, with particular attention to the mechanism of atom ejection from single crystals. The work has yielded a method for the rapid and inexpensive determination of the orientation of face- and body-centred single crystals.

Fuels and Mining Practice

The Branch continued its research in fossil fuels, mining and explosion hazards, with considerable emphasis on studies and experimental work in process engineering. The foresight in concentrating on the long-term

research on the chemical structure and refining of impure low-grade source materials like the Athabasca bitumen is being justified by the increasing interest shown in this valuable Canadian resource by industrial groups.

The work in coal continued to reflect the urgency of developing alternative and specialized markets for coal; studies in combustion and metallurgical application were vigorously pursued. An annual publication of sample analyses was inaugurated to supplement the periodic publication of the "Analysis Directory of Canadian Coals".

Further studies were made on carbonization for the Maritime Region Study Group and various methods of transporting solids, including by pipelines, for the Western Region Coal Study group.

The analytical laboratories analyzed 2,069 samples of solid, liquid and gaseous fuels, involving 34,848 determinations.

The Mines Branch assisted in the "First Canadian Rock Mechanics Symposium", held at McGill, and was able to make the first grants-in-aid in mining research to three Canadian universities.

The Electric Equipment Certification Laboratory completed 76 investigations of equipment. Progress was made on several research projects concerned with flame propagation, stresses due to pressure piling, and determination of minimum values of currents in a resistive circuit to cause ignition by the fusing of various sizes of copper wire.

The Explosives Laboratory investigated 158 samples of explosives, fireworks and accessories; research included correlation of impact-sensitivity tests and the phenomenon of static electricity from ammonium nitrate and fuel oil explosives when loaded by means of a jet loader.

The latest report of the United States National Academy of Sciences indicates that the world supply of oil and natural gas, which is much less abundant than coal, will be 80 per cent depleted in the next 80 years. Fully aware of this situation, the major oil companies have seriously turned their attention to the shale oils and bituminous sands of North America. Several companies have made application to the Alberta Oil and Gas Conservation Board for permits to extract petroleum from the Athabasca oil sands.

Branch scientists, realizing that tar sand development would require multi-million-dollar investments, have studied the refining of this material to prevent the enormous waste that would ensue if this petroleum were refined by conventional methods.

One of the most significant advances made during the year is in the improvement of the exhaustive reduction technique which permits the asphaltenes to be completely saturated with hydrogen at temperatures around 150°C, that is to say 200°C below the best previous methods. This new technique opens up many new avenues for the determination of the structure of these substances. Knowledge of the structure of the asphaltenes plays

a fundamental role in the processing of heavy crude oils. Not only has the knowledge of the structure of the asphaltenes significance in the field of petroleum refining, but it also has widespread implications in highway construction, pipeline coating, roofing, and many vital areas of the economy. In addition, it has been possible to distill the completely saturated asphaltenes to secure information on the molecular weight distribution of the component parts of the asphaltene molecule. The decomposition of the asphaltenes into distillable saturated fractions should throw considerable light on the component fats and waxes that originally built up these substances.

A detailed study has been made during the year of the physical and chemical properties of numerous vein hydrocarbons and sedimented organic matter. One objective was to develop an improved classification scheme, and the other was to attempt to lay a foundation for the study of fossil hydrocarbons in sedimentary and metamorphic rocks. Such a foundation would pave the way for a study of the genetic aspects of natural bitumens and pyrobitumens which in turn may contribute to the techniques for oil exploration.

The emphasis in applied research is on the development of improved techniques for refining heavy asphaltic oils and residual oils from the catalytic cracking operation. The coker distillates of Athabasca bitumen, as well as the bitumen itself, fall into this class of material.

Catalytic cracking is one of the most widely used refining techniques for reducing the molecular weight of feed stocks for use as automobile and diesel fuels. A pilot plant unit with continuous catalyst recirculation and regeneration has been under design and fabrication for nearly 4 years. Installation should be completed by mid-1963. This will be the only plant of its kind in Canada.

One of the principal deficiencies of heavy oils is the lack of sufficient hydrogen. It is, therefore, understandable that in the refining of such oils the process of adding hydrogen plays a cardinal role. The Branch carries out fundamental research on hydrogenating pure compounds to understand the mechanism of the reactions taking place, and applied research in both vapor-phase and liquid-phase hydrogenation.

In the field of vapor-phase hydrogenation, research continued on the influence of the hydrogen pressure upon the rate of coke deposition on the catalysts. It has been found that the hydrogenation exerts a profound influence on deposition of coke and asphaltic material on the catalyst, and that the elevation of the pressure above 3,000 pounds per square inch increases the life of the catalyst very substantially.

The results of liquid-phase autoclave experiments which have been conducted during the year have shown that the hydrocarbon gas formation from the residue from Weyburn crude oil is in good agreement with German

experience. This is encouraging and lends confidence to the view that published German data on Middle East crude oils can, to a considerable degree, be extended to Canadian residual oils.

In the development of catalysts and catalyst carriers, there are two aspects which are of dominant interest at the moment: the chemical nature of the catalytic surface, and the texture of the surface.

During the year the mechanism whereby the organic additives modify the pore structure in gels was studied. Evidence has been obtained indicating the formation of a four-membered coordinate complex compound between aluminum ions and the polyacrylamide and polyvinyl alcohol polymers. Recently, considerable improvements have been made in the technique of making porous aluminas with the polyvinyl compounds. As little as 25 to 50 per cent of organic matter relative to the weight of the final oxide has been found to increase the porosity as much as ten times.

The study of the chemistry of catalytic surfaces was confined during the year to the measurement of the acidity of silica-alumina catalysts. The most widely used method for the determination of the number of acid sites present at the surface of a catalyst is the chemisorption of the ammonia from the gas phase. It has been found that the extent of chemisorption of ammonia by a sample of silica-alumina catalyst is largely dependent upon the temperature at which it has been degassed.

In the cooperative research program with a private coal company, the redesigning of fire-grate bars to improve the combustion of Atlantic region coals was completed except for special sizes. Two Canadian companies have been licensed to manufacture these redesigned grate bars. Further progress was made with the distinctive high-frequency oscillating grate stoker.

Previous experience with compressed air - hydrocarbon jet burners with high-speed flames led to tests of a submerged burner. The principle of pulsating combustion was supplied by a Canadian manufacturer in developing a novel high-efficiency domestic heating unit; high noise was eliminated by the combustion group, opening the way for foreign sales.

Research was carried out for the RCN to overcome slag deposition on super-heater tubes of furnaces in destroyer-escort vessels which use high-vanadium-content fuel oil.

Considerable emphasis was given to the cleaning of fine coals and effluents by the research group at the Western Region Laboratories at Edmonton. During 1962 a compact two-stage compound water cyclone pilot plant was developed.

Peat moss has increasingly been in demand for Canadian horticulture and agriculture and has now reached an export volume of more than $10 million annually. In cooperation with a consultant, an extensive examination was made of fourteen southern Ontario bogs.

Carbonization studies, some in cooperation with the Canadian ferrous industry, were conducted on various blends of coal. The 500-pound movable-wall oven was commissioned during the year and used in these studies. Branch engineers assisted a western producer in the examination of mechanized non-recovery ovens which are becoming again popular because of loss of traditional by-product markets.

Following the construction of an electrically heated pilot-scale vertical-shaft reactor in the Branch laboratories to demonstrate the feasibility of carbonizing coal briquettes, a western coal company erected a full-scale plant with an annual capacity of 30,000 tons. In this process, a blend of semi-anthracite and low-volatile coking coal is formed into briquettes in the conventional way, carbonized in the new vertical shaft reactor, and the coke product sized for applications in the phosphorous and other industries.

Concurrently with the development of this process, an investigation was begun during 1962 to determine if the cheaper pelletizing process could be substituted for the briquetting step.

During the past year, ground control studies were conducted in ten mines. Five were in coal mines, four in metal mines and one in an industrial mineral strip mine.

Construction of the first structural mine model was completed, and initial loading tests have been conducted. Strains during loading are observed with internal and external electric resistance strain gauges, and a switching system has been designed with a capacity for observing a total of 192 gauges. A major development in the model studies to date has been the knowledge gained in simulation of rock materials by the selection of plaster-of-paris mixes.

Two types of borehole extensometers were designed for deformation measurements in potash and gold mines. A water-sensing device was also designed for studies in boreholes drilled around an open-pit mine.

Loading systems of high stability and precision, as well as accurate systems for measuring strain, were developed for time-dependent deformation studies of rocks. To this end, an electric hydraulic loading system has been developed to apply or remove a full load of up to 20,000 pounds in half a second and to maintain a full load constant to within 0.02 per cent for long periods.

The long-term study of the propagation of stress waves in rocks should yield important information about their mechanical properties. Equipment has been constructed for studying the vibration of cylindrical rock specimens under confining pressures up to 20,000 pounds per square inch. A regenerative electronic circuit is used to sustain the vibrations. The last two projects should provide fundamental information on properties of geologic materials in relation to the study of the Upper Mantle.

Mineral Sciences

Mineral sciences research is conducted through four main groups that specialize in mineralogy, chemical and spectrochemical analysis, physics and radiotracer studies, and physical chemistry.

Mineralogical examinations of ores and mill products in support of the Branch's ore-dressing program yielded 36 reports.

Detailed regional studies of new and unusual deposits continued. Some of these deposits may not have immediate economic value, but their study may help to assess future potentialities. Work was completed on the investigation of niobium ores from Oka, Que., with emphasis on the distribution of niobium relative to titanium and radioactive elements in pyrochlore and perovskite. The study of tantalum-tin minerals found in association with the cesium deposits at Bernic Lake, Man., has led to a general review and reappraisal of the crystallography, structure, and composition of the tantalum-containing minerals in general. Further studies of the unique and complex beryllium-niobium-barium deposit at Seal Lake, Labrador, have led to the identification of eleven minerals of known varieties, and five other minerals, possibly new species.

The Branch continued to develop better techniques for mineralogical research. X-ray diffractometry studies were made for improving the accuracy of determining the amounts of minerals present in mixtures in powder form. Studies were also made of iron-containing chlorites of known composition to correlate iron content with magnetic susceptibility and the intensities of X-ray reflections from the basal plane of the mineral.

During the year, approximately 7,200 samples were analyzed and 26,500 constituents determined in the wet chemical and fire assay laboratories. In spectrographic work, approximately 1,200 samples were tested, resulting in 9,500 determinations.

In the project on the analytical chemistry of the platinum group of metals, liquid-liquid extraction procedures were developed as a means of separation of individual metals. It was found that separation could be simplified without loss of accuracy. Other fields of analysis development included work on the selective solution of metallic inclusions in slags and furnace products, and the application of the polarographic method to the determination of minor metallic impurities in copper alloys, and to zinc in aluminum-magnesium alloys.

Emission and X-ray spectrographic methods were developed to meet demands from the metallurgical development program. Satisfactory determinations were made of aluminum and titanium in zinc alloys, metal additions to cobalt and nickel alloys, copper in aluminum-alloy turnings and additives in the new Mar-Aging ferrous alloy of nickel, cobalt, and molybdenum.

In international standards work the Branch continued the program on determining impurities in four refractory metals of strategic significance (AGARD group of NATO), and determination of copper and other impuri-

ties in magnesium (International Standards Organization). For the American Society for Testing and Materials, investigations were made on the sampling and analysis of iron ores, fluorspar and chromite; emission spectrography assignments on the determination of minor impurities in cast iron by the spark-to-plane technique; and the analysis of plain-carbon and low-alloy-steel pellets. Late in the year, the laboratory was asked to undertake certain work for the National Bureau of Standards in Washington, D.C.

In the field of instrumentation development the Branch continued construction of the electron probe microanalyzer.

In physics and radiotracer research, instruments were developed for industrial process recording and control, such as the conductivity probe for controlling lime additions to cyanide circuits in gold extraction and in base-metal milling, in consultation with two private companies. Progress was made on the design and application of a magnetic susceptibility tester for the rapid analysis of magnetic iron ore, which has aroused considerable interest. A project for designing and building an electronic scanner for dust counting was sponsored by the Mines Accident Prevention Association of Ontario, and a promising prototype was built.

In radiochemical research, the long-term project of investigating surface adsorption phenomena in froth flotation of iron ore and quartz continued, with the use of oleic acid tagged with radioactive carbon-14. Studies were nearing completion of the exchange and surface diffusion of silver between aqueous solutions and surfaces of oriented single crystals. Similar studies were conducted with nickel.

Radiochemical studies that dealt with the effect of irradiated catalysts containing zinc or chromium on the course of certain organic gas phase decompositions were completed. A second project concerned the chemical separation of the rare-earth elements of the lanthanide group from one another and from thorium, through the use of phosphonate complexing reagents.

The semi-conductor program continued, and measurements were obtained on the diffusion and solubility of silver and gold in single crystals of bismuth telluride. Radioactive silver or gold were plated on oriented faces to establish diffusion rates along major crystal axes. This project has provided valuable data on the effect of constituents of contact materials used in the assembly of semi-conductor components.

During the year, 973 radiometric assays were made. Neutron activation analyses with the neutron generator were made on various metals and minerals, after operational difficulties were overcome.

In physical chemistry work, a major investigation was completed on the identification of compounds formed in anode slimes, on behalf of a copper refinery. Among other identifications made for private industry were constituents in kiln-roasted ilmenite ore from Allard Lake; non-metallic inclusions in steel; residues from a white case iron furnace; and reaction products at

the interface of steel with moulding sand. Thermal decomposition investigations were made on mica, uranium oxides, and other materials for various organizations.

The Branch continued research on phase equilibrium systems with complex oxide assemblages of lime-alumina-ferric oxide and magnesia-alumina-ferric oxide, concerning problems on basic refractory compositions. Work on the lime-niobia-silica system was extended to give more precise data on the location and temperatures of the ternary eutectics and peritectics. New projects were started on the lime-niobia-titania system and on the system ferrous oxide-manganous oxide-tantalum oxide.

A good deal of attention was given to work on electronic ceramic materials of the lead zirconate-lead titanate type, for use of ferroelectric components.

The program on thermal decomposition of sulphates was continued.

Extraction Metallurgy

The activities of the Mines Branch in the field of extraction metallurgy include both hydrometallurgy and pyrometallurgy, and range in scope from metallurgical process development and application, to basic research. In addition, corrosion investigations are conducted for industrial and government organizations.

The general study of the cyanidation process for the treatment of gold ores continued. An important feature has been the accumulation and analysis of mineralogical and metallurgical data from operating mills, and during 1962, eighteen gold mills were visited by the staff. In some cases the results indicated a need for better control of the cyanide circuit with respect to reagent concentration and aeration. Where further information was needed, mineralogical and metallurgical investigations were made on representative samples in the laboratories.

It is apparent that efficient cyanidation of some gold ores requires close control both of the grinding conditions and of the concentration of reagents in solution, and automatic measurement and control of these may be the best way to maintain the desired cyanidation conditions. A pilot plant unit, consisting of a grinding unit with electronic devices to measure and control circuit variables so as to maintain predetermined conditions of grind and alkalinity, has been set up to study ways to achieve such control, and to help mill operators evaluate the economic advantage of installing automatic controls in their plants.

To assist Ontario provincial authorities investigating a fatal accident resulting from cyanide poisoning at one of the mines, a study was made of the stabilities of commonly used cyanide reagents under various conditions. It was found that a commonly used calcium-cyanide product was inherently

less stable under humid conditions than sodium cyanide, and requires special precautions in handling.

A conference of twenty mill superintendents of Eastern Canada gold mines was held at the Mines Branch in January 1962 to review current investigations in gold metallurgy, and to discuss gold mill operations. The exchange of information and close liaison attained by this meeting with the gold mills operators provided the basis for the development of a cooperative program of research on gold mill metallurgy. A similar meeting was requested by the gold mill operators for January 1963.

Liaison with the uranium producers continued both through the Canadian Uranium Producers Metallurgical Committee and its Analytical Subcommittee, and by informal visits to the uranium mines. Research on uranium-ore treatment was pursued in Branch laboratories, and the exchange of research and operating information between the various uranium producers was promoted by holding regular meetings of the technical representatives, and by circulation of relevant reports. The Branch continued to provide umpire analyses as requested by the uranium producers.

A small but valuable market for metallurgical products is provided by electronic ceramics, which are finding increasing use in the electronics industry. An important factor affecting the performance of such materials is purity and uniformity of the primary materials. For some years, work has been carried out at the Mines Branch on the production of piezo-electric ceramics, but difficulty has been experienced in preparing uniform mixtures of the primary materials without introducing contamination from the grinding media. To overcome this difficulty, production of the mixed compounds by simultaneous chemical precipitation of the hydroxides was investigated. Promising results have been obtained from small lots prepared in this way. Equipment is being assembled to produce larger lots required for an exhaustive study.

The niobium deposits near Oka, Que., are becoming increasingly important, but the deposits are low-grade, and suffer from competition from foreign niobium producers. A process for obtaining an improved niobium product from Canadian concentrates was developed at the Mines Branch in 1961. Further studies made in 1962 resulted in a process yielding a product containing 98 per cent Nb_2O_5 with a 93 per cent recovery, at a moderate cost.

In recent years considerable interest has been shown in the metal cesium because of possible applications as a fuel for space rockets, and for thermionic convertors. A major source of cesium is the pollucite deposit of Bernic Lake, Manitoba, and in 1961 a process was developed to a pilot plant scale in the laboratories for the production of high-purity cesium chloride from this ore. In 1962 the investigation was carried further to produce the highly reactive cesium metal by a two-stage electrolytic re-

duction-vacuum distillation process. In the first stage a cesium-lead alloy, containing 8.4 per cent cesium, was produced by electrolysis of the fused cesium chloride at 700°C, using a molten lead cathode. In the second stage the cesium metal was recovered from the cesium-lead alloy by distillation at elevated temperatures and high vacuum. By this process, cesium metal was obtained with impurities of 0.002 per cent lead, 0.17 per cent rubidium, 0.09 per cent potassium, 0.01 per cent sodium and 0.02 per cent lithium.

The use of high-strength steel, plated with zinc or cadmium to increase corrosion resistance, has been increasing in the aircraft and other industries. In one industry manufacturing plated fastening pins, a high level of failure in bending was occurring. This was attributed to embrittlement caused by hydrogen given off during plating, which could obviously have serious effects on aircraft parts designed to limited safety factors. An investigation established that hydrogen embrittlement could be greatly reduced, if not overcome, by increasing the alkalinity and cyanide strengths of the plating baths over the normal industrial levels and by altering the ratio of alkali to cyanide, by careful cleaning of the surface of the steel, and by using suitable current densities. These findings will enable electroplaters to operate their electroplating baths at greater efficiency than heretofore, and to electroplate articles which have hitherto been treated by the more expensive vacuum-deposition techniques.

Long-term basic research studies linked with extraction metallurgy continued, for the better understanding and control of reactions used in the processing of Canadian minerals. The program included research on the stability of niobium pentachloride in moist atmospheres, on the oxidation of ferrous ion in acidic solutions, on the thermal stability of metal sulphates, on the thermal decomposition of calcium carbonate and calcium hydroxide, on the heats of crystal transitions from DTA measurement, and research on the operating variables of a hydrocyclone.

The instability of niobium pentachloride in moist atmospheres could be troublesome in chlorination-reduction processes used for the production of niobium metal from niobium ores. It was shown that deterioration of niobium pentachloride probably occurs in two stages. In the first stage the niobium pentachloride is converted to niobium oxychloride, and in the second stage the niobium oxychloride is altered to niobium pentoxide, with both reactions taking place at about the same speed. Temperature has little effect on the rate of these reactions.

Ferric ion in acid solutions is an important agent in various acid-leaching operations. Typical of these is the treatment of uranium ores or oxidized copper ores. It had been found earlier in these laboratories that the oxidation of ferrous ion to ferric ion in acid solution by aeration can be promoted to a high degree by the use of activated carbon as a catalyst. Subsequent work has shown that the process is essentially electrochemical and that

the oxygen-saturated activated carbon behaves as an electrode in the system. A mathematical relationship consistent with experimental results was derived for the reaction. The information obtained in this work can serve as a basis for further development of the process.

For the treatment of some highly disseminated complex base-metal ores, differential sulphate roasting followed by leaching offers a workable process. As a contribution to the necessary background, a study in the zinc-sulphate system was completed, and the thermodynamic data were compiled for publication.

The hydrocyclone is an ore slurry classification device which is gradually supplanting old forms of classification equipment in ore-treatment plants. To correlate flow relationships, experimental hydrocyclones were studied systematically to resolve the effects of changes in pressure, viscosity, density and orifice dimensions on throughputs when operated with a homogeneous liquid medium. Work with a precision-machined hydrocyclone equipped with a transducer pressure measurement device, based on a comprehensive experimental design, has given highly reliable results. Sufficient data were obtained to indicate interesting mathematical relationships between the underflow, overflow and throughput which can be used to predict the behavior of a hydrocyclone under a wide variety of operation conditions.

Mineral Processing

In spite of a slight reduction in the number of samples received, both personnel and facilities for mineral processing were engaged to capacity. The complexity of the problems presented by industry continued to make great demand on the mineral processing laboratories in both the metallic minerals and the industrial minerals fields.

Forty-four samples, ranging from a few hundred pounds to several carloads, were processed in the metallic minerals laboratories. While fewer iron ores were investigated, there was a notable increase in other ores. There were eleven investigations on iron ore, seven on gold ores, three on molybdenite, and the remainder on special products or base metal and less common metal ores.

The Branch processed, in its pilot plant, a large sample of a high-grade tungsten ore (scheelite) to obtain information for the design of a milling plant. In collaboration with the interested company's technical staff, a flow sheet was developed. As a direct result of this investigation, a mill has been erected and is now in commercial production in the Northwest Territories. In another pilot plant investigation a process for recovery of a concentrate from a molybdenite ore was developed.

Eighty tons of hematite ore from a producing mine in northwestern Ontario were processed through the pilot plant. The problems of floating silica from hematite and preparing a suitable feed for pelletizing were in-

vestigated. In another case silica was removed from an iron ore by Humphreys Spirals.

In an extensive pilot-plant operation, the recovery of a tin concentrate from a complex ore was investigated. Experimental processing of 122 tons of ore from a deposit in New Brunswick provided considerable technical information towards the solution of a difficult mineral-dressing problem. There are no Canadian mines producing tin directly, and this might become the first direct tin-producing mine in Canada.

Research in processing of metallic minerals is an active part of the Branch's program of assistance to the mining industry. Particular attention has been directed towards the recovery of high-purity concentrates from iron ores. Application of the flotation process in combination with magnetic concentration has proven of interest in the removal of siliceous material from impure hematite. Concentrates containing as little as 0.1 per cent silica were consistently obtained.

Five metallurgists from private industry collaborated with scientific officers on pilot plant investigations. Four mining companies took advantage of the Branch's facilities for pilot plant processing of their ore.

The Mines Branch industrial mineral program continued to be active, with 640 samples received in the laboratory for examination, testing and investigation. Scientific personnel were consulted frequently by industry on technical problems.

Five major investigations were completed on structural clay products. These were directed towards improvement in ceramic processing and included studies on the effect of additives on three local clays and shales. An extensive study of thermal properties of local raw materials provided technical data for the design of a new tunnel kiln by a Quebec company.

In another investigation a western manufacturer was assisted in improving the strength of an electrical porcelain. A novel means of processing lithium fluoride into dense compacts was developed for Atomic Energy of Canada Limited.

In an extensive investigation for the brick-making industry, causes of inconsistencies in measuring compressive strength of face brick were established. A suitable procedure was recommended to provide more meaningful data.

The Mines Branch is conducting an investigation of service durability of ceramic walltile for the Canadian Government Specifications Board. The relationship of resistance to expansion and glaze-crazing in environments simulating service conditions is being studied in the Branch's ceramic laboratories.

As part of the long-term program on ceramics, a study of mineralogical aspects of Canadian clays and shales, potential raw materials, continued. The work was concentrated on samples from four provinces.

Development of data on the thermal properties of ceramics and other non-metallic materials continued. Of particular interest is a study on the measurement of thermal conductivity by a comparative method. The Branch is also participating in a round-robin program on the ASTM high-temperature method.

The Mines Branch continued to develop piezo-electric compounds for the Defence Research Board. During the year the program was expanded to give more attention to the preparation of oxides, and the development of compacts with improved electrical properties.

In the construction-materials field, most of the work concerned problems on mineral aggregates and building stone. The relationship between concrete-making properties and particle shape of two manufactured sands was investigated.

The Mines Branch was assisting in the evaluation of the mechanical and physical properties of experimental concrete mixes for the Manicouagan River project of Hydro-Quebec.

The construction materials laboratories were studying, as a long-term project, the effect of environment on concrete with aggregates of different types. The effect of moderate temperatures on properties of aluminous and Portland cement concrete was established for different aggregates.

The Branch continued to coordinate a cement-testing program sponsored by the Canadian Standards Association. The first phase of the study was completed, and a statistical analysis of the results was distributed to the participating laboratories.

During 1962, beneficiation of several industrial minerals was studied. Processes were worked out for the recovery of fluorite, silica, and gypsum. The long-term project on the flotation of pure non-metallic minerals continued with non-ionic, anionic and cationic collectors. Work on processes for separating fine granular particles from kaolin also continued.

The Branch is engaged in an intensive laboratory study of bentonites from Western Canada, with particular reference to their possible application in pelletizing iron ores. It continued its work on silica beneficiation and saw techniques developed in the laboratory incorporated in a commercial operation in Quebec.

During 1962 the industrial waters laboratories analyzed 3,400 samples, substantially more than in 1961.

The long-term survey of chemical quality of surface waters in Western Canada continued. Information was being obtained at the request of the International Joint Commission. Other long-term surveys were in progress dealing with the Winnipeg and Ottawa areas.

The Branch continued to assist the Department of National Defence in solving problems in water supply and treatment and in boiler-water treatment. Thirty military central-heating plants and three DPW heating plants are now included in the program.

River waters and mine wastes from New Brunswick were analyzed as part of a cooperative study on stream pollution.

In cooperation with the National Association of Corrosion Engineers, the Branch continued to participate in a study to correlate water quality and the corrosion of water-distribution systems at selected locations.

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

In mineralogy, an investigation of fluorite-bearing rock from British Columbia led to the discovery and use of autoluminographs in the study of rare materials in rocks and ores.

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

dominion observatories

THE NATURE of the physical universe as revealed in studies of the stars and the earth and its practical application to problems of time, navigation, surveying, telecommunications, earthquake hazards, and mineral exploration, continued to be the main part of the work of the Dominion Observatories.

The International Upper Mantle Project, aimed at a clearer understanding of the earth's crust and mantle, received a good deal of attention from the Branch's geophysicists. Gravity observations were made in the Northwest Territories and Quebec at locations where dense mantle material is believed to have broken through the crust to the earth's surface; the conductivity of material in the upper mantle beneath the earth's crust was studied by geomagnetic induction methods at locations in the Northwest Territories and Alberta; while seismological studies of the thickness of the earth's crust were made in Quebec, British Columbia and the Arctic Islands.

In the field of astronomy a series of observations of 6,200 stars for use in time and navigation, begun in 1953, was brought to completion and is now being prepared for publication. Radio astronomy observations, carried out at Penticton, B.C., brought to light interesting new information on the structure of the gas clouds of the galaxy, while studies at Victoria of the motions of 500 very distant stars made possible a new and more accurate indication of the structure and rotation of the galaxy. Preparations were made to observe the eclipse of July 20, 1963, making use of an aircraft at an altitude of 30,000 feet as an observing platform. Since the path of this eclipse passes across Canada from the Yukon to southern Nova Scotia, information services are being made available to foreign scientists wishing to make observations in this country.

Several additional seismic recording stations were brought into operation during the year, and it is expected that in the relatively near future it will be possible to speak with confidence of the seismicity of Canada as a whole. Liaison was maintained with the construction industry and with building research scientists on matters of earthquake hazards.

Gravity and magnetic mapping activities were continued both in southern Canada and in the Arctic regions, making use of helicopter and fixed-wing aircraft transportation. Some of the most interesting gravity anomalies ever seen in Canada have been shown to exist in the Queen Elizabeth Islands and surrounding waters, while similarly interesting conductivity anomalies have been revealed in these same latitudes by geomagnetic methods. Large amounts of geophysical data have been made available to geophysical prospecting companies operating in all parts of Canada, including the northern regions.

Positional Astronomy

What is the exact position of a star? Where was it in the past? Where will it be in the future? These questions are fundamental to an understanding of the size, shape and evolution of our galaxy. The answers are acquired, star by star, at the cost of many years of observations using a transit telescope. The peculiar attribute of this instrument is its ability to resolve angles. In the east-west coordinate the stellar positions are resolved according to the exact time of transit. North-south positions are resolved by a large graduated circle attached to the telescope.

The Ottawa Meridian Circle telescope has finally completed half a century of positional astronomy operation, and at the end of 1962 was retired from active service. Observations accumulated over the past six years will be collected to form the fifth catalogue of star positions to be published in Ottawa. They form a valuable contribution to the international program aimed at the steady improvement of our fundamental star catalogues.

Ten years of research and development have culminated in the construction of a new transit telescope called a Mirror Transit. It consists of two fixed horizontal telescopes facing each other with an accurately formed flat mirror at mid-point. Stars which cross the meridian in the northern half of the sky are reflected into the northern telescope, those to the south into the southern telescope, with some freedom of choice for stars which cross near the overhead position.

Many modern technological improvements have been incorporated in the Mirror Transit, and many tests have been made of its component parts. All indications are that it is a significant contribution to astronomical instrumentation. One unfortunate circumstance is a defective graduated circle which must be replaced, and will delay the operation of the telescope by a full year.

The Photographic Zenith Telescope, used to measure astronomical time and latitude, continues to demonstrate the great advantage in the proper housing of astronomical instruments. Since being moved from its temporary location in the transit room to a hut on the lawn in front of the observatory, it has consistently produced results that are unsurpassed by similar instruments elsewhere. The Ottawa PZT is entirely automated, and guarded against both a bright sky and precipitation. More than half the nights in 1962 provided observations. Small variations in earth rotation were noted, with their consequent effect on Universal Time (UT2) which is the system of time determined from the period of the earth's rotation by star transit observations. Weekly summaries of time and latitude determinations have been sent to the Bureau International de l'Heure, and the International Polar Motion Service, world data centres.

Canada's Time Service has been able to conform to the international unified system since its inception in January 1961. A cesium beam resonator at the National Research Council, when combined with a high-quality quartz clock, forms a so-called 'atomic clock'. This is rated according to UT2, and then is left to run with no change in rate for a year. If a change in earth rotation causes UT2 to drift away from the uniform atomic time, a change in the atomic-clock reading of a few hundredths of a second is made simultaneously by all the national time services adhering to the unified system. At the end of the year a change in the rate of the atomic monitored clock is adopted if necessary. In January 1962, the rate of the clock was increased by about two ten-thousandths of a second a day. No change is to be made at the beginning of 1963. The unified system means that seconds' pulses are radiated simultaneously within a thousandth of a second, from Ottawa, Washington, Greenwich and elsewhere, whereas formerly they might have differed by several hundredths of a second. For modern space-age research, this time control is a significant improvement.

Radio CHU, the direct output of Dominion Observatory time, is a 24-hour time service on three short-wave frequencies (14,670 kc, 7,335 kc, and 3,330 kc) together with a voice announcement of time each minute. Seconds' pulses are emitted with a uniformity of a ten-thousandth of a second a day. In addition, time is distributed by direct wire to the railways, the CBC, the Bell Telephone Company, and to several laboratories.

Ephemeris time, from which the unit of time, the second, is derived, is based on the motion of the earth around the sun and observed by the motion of the moon about the earth. Moon pictures taken with the Markowitz moon camera at each lunation have been reduced and compared with UT2, showing a loss of about 35 seconds in the last 60 years because the earth is lagging slightly on its axis of rotation. The plates are then forwarded to Washington, D.C., to be combined with observations from other parts of the world.

Satellite observing was maintained on a reduced scale during 1962, with plans for an expanded effort when the geodetic satellite Anna becomes available.

Several meetings with the RCAF were held to develop plans for the airborne observations of the eclipse July 20, 1963. In addition, reports of proposed activities have been received from scientific groups in Canada and abroad and summary statements issued.

Site testing for a proposed new site for the Dominion Observatory was pursued in the Gatineau Park area. A small hut has been built and meteorological instruments installed.

Two 12-inch reflectors have been acquired, one for use on the roof on visitors' nights to ease the pressure on the 15-inch reflector, the other for field use. The two will be brought into uniform adjustment and used, not only to test seeing in the Gatineau, but also to explore seeing conditions in other parts of Canada.

Stellar Physics

The Dominion Radio Astrophysical Observatory, near Penticton, B.C., completed the initial phase of a detailed study of the distribution of galactic hydrogen in the anti-centre direction, i.e. in directions away from the nucleus. This study, made with the 84-foot radio telescope, has revealed information about the manner in which the material moves about the nucleus and the relation of the invisible hydrogen to optical objects such as associations of hot stars, emission and obscuring nebulae. Of particular interest was the discovery that the present optical appearance of an ancient supernova (IC443) can be explained by the existence of an invisible hydrogen cloud into which the star exploded.

Work proceeded on the design and construction of a multi-channel receiver for the hydrogen-line work. This receiver, which is based on the interference principle, is expected to increase the efficiency of the collection of data by a factor of one hundred. Procedures for automatically recording the data and reducing the observations with electronic computers were worked out.

During 1962, work advanced on the construction of the large telescope for radio-astronomical observations at 22.25 mc/s (wavelength 13.5 metres). This telescope consists of an array of aerials supported on poles arranged in the shape of a "T". The long crossbar is about 4/5 mile long and the collecting area of the entire array is about 700,000 square feet. The supporting poles, 1,700 in all, were installed and work started on the installation of the aerial elements. Completion, which is expected late in 1963, will be in time to take advantage of the reduction in interference from terrestrial transmitters which occurs near sunspot minimum. The instrument will be used to survey the galactic emission and study the intensity of radio sources at a lower fre-

quency than has hitherto been used in the northern hemisphere. Data at low frequencies are urgently required to supplement the high-frequency data such as are obtained with the 84-foot telescope. Studies of the physical nature of the sun are carried on at the Ottawa observatory with the aid of a 20-inch solar telescope used in connection with a powerful solar spectrograph. In addition to the spectrographic work the incidence of flares on the solar surface is being investigated with the aid of a monochromatic telescope observing in the light of $H\alpha$ line of hydrogen. The purpose of this program is to obtain observations of the activity in the solar chromosphere by time-lapse photography of the entire disk of the sun as seen in monochromatic light. The activity is studied not only for its own sake, for it is still poorly understood, but because it has a profound influence on the earth's upper atmosphere and on the geomagnetic field. Optical data on chromospheric activity are therefore of great interest in geophysics and the new space sciences, as well as in astrophysics. For the first ten months of 1962 the flare patrol was carried out on a part-time basis. Beginning in November 1962, in cooperation with scientific institutions in the United States, including the High Altitude Observatory in Boulder, Colorado, and the National Aeronautical and Space Administration, the observations of solar flares was placed on a full-time basis so that the sun will be photographed in the light of hydrogen alpha absorption every 30 seconds from sunrise till local noon, weather permitting. Observations are transmitted daily to the Regional Warning Centre at Fort Belvoir, West Virginia, and monthly to world data centres in the U.S.A., France and the Soviet Union.

A cooperative study was carried out with the Solar Radio Noise Section at the National Research Council, of the records of a flare surge that occurred on the western limb of the sun on July 20, 1961. This flare surge is especially notable because it produced a very small increase in the flux of cosmic-ray particles received at sea-level, an effect that has been observed for little more than a dozen flares in the last 15 years. The sequence of events in the optically observed disturbance was found to bear an interesting relation to the sequence of radio bursts observed throughout the radio spectrum from 18 mc/s to 2,800 mc/s. Some preliminary tests were made in connection with this study to establish the feasibility of using motion-picture techniques to analyze the Ottawa Flare Patrol films. The tests established the value of this technique for studying the dynamic aspects of all chromospheric activity, and plans have been made to equip the Flare Patrol instrument with an accurate cine pulse camera.

Further progress was made on the construction of a solar magnetograph —a device for automatically mapping the strength of the magnetic fields in the vicinity of sunspots. A prototype electronic device was constructed and successfully tested for selecting specific values of the magnetic field strengths and plotting them as a set of contours with an electromechanical coordinate plotter.

Some basic alterations were made to the servo system that is used to automatically control the position of the solar image for the solar magnetograph. The system is designed to either scan the solar image across the analyzing slit of the magnetograph, or to hold it fixed at any desired position relative to the analyzing slit.

Photographic observations of meteors and their spectra were continued during 1962 at the Meanook and Newbrook Meteor Observatories in northern Alberta. These observations are used for studies of the upper atmosphere at heights of about 50 miles as well as for studies of the physical properties of meteors and their importance in the solar system.

During the year some new instruments were constructed and installed. They were designed to record the spectrum of the glow which persists after some meteors for periods ranging from less than a second to several minutes. The phenomenon is poorly understood at present but appears to be associated with the chemical and electrical components of the atmosphere. These new spectrographs supplement a group of other instruments already in operation whose purpose is to photograph the spectrum of the moving meteor itself.

A field survey of West Hawk Lake in southeastern Manitoba was conducted by members of the Division. Geophysical observations made from the lake-ice lend support to the hypothesis that this lake is another of Canada's ancient meteorite craters.

Geomagnetism

One of the duties of the Branch is to publish every 10 years a set of charts showing the direction and intensity of the geomagnetic field in all parts of Canada. The chart which is in greatest demand—that of magnetic declination (or variation)—is published at 5-year intervals. The charts must be revised periodically because the earth's magnetic field changes its direction and strength from year to year. These changes can be predicted, with sufficient accuracy for mapping purposes, to about 10 years in the future; predictions further than this are unreliable since the pattern of change may itself suddenly change. In order to keep track of the pattern of change in the magnetic field, the Branch has established a system of 100 "repeat stations", scattered all over Canada. Observers visit these stations every few years, making careful measurements of the strength and direction of the magnetic field over a period of several days. During 1962, twelve such stations were occupied in Ontario, Quebec and New Brunswick.

The Branch also supplies magnetic information for maps published by other agencies. During 1962, the pattern of magnetic declination was supplied for 110 map-sheets published by the Surveys and Mapping Branch, and more than 1,200 items of magnetic data were supplied on request to government mapping agencies and geophysical prospecting companies.

Most of the information shown on magnetic charts of Canada now originates in surveys carried out with the Dominion Observatory's three-component airborne magnetometer. A 37,000-mile survey with this instrument in a chartered DC-6 aircraft had been planned for November 1962, but was postponed for a year for financial reasons. The area to be covered includes the Arctic Islands and parts of the Arctic Ocean and northern Greenland, in a series of parallel lines spaced 90 nautical miles apart, and lies approximately between 0°and 180°W longitude, and north of 70°N latitude.

A feature of special interest on Canadian magnetic charts is the north magnetic dip pole. In 1962, two observers working from the ships CCG *N. B. McLean* and *D'Iberville,* carried out a magnetic survey in the vicinity of the north magnetic pole to determine precisely its present position and rate of movement. The last survey of this type was that carried out in 1948. Measurements of the direction and intensity of the geomagnetic field were made at six temporary stations surrounding the pole and within 100 miles of it. The continuous records from Resolute Bay Magnetic Observatory, some 120 miles to the east of the pole, were also used in calculating the position of the pole. The present location is Lat. 75° 07′, Long. 100° 50′, in Austin Channel southwest of Bathurst Island.

A local survey was made at the request of the Canadian Hydrographic Service of the harbor approaches at Kingston, Ontario, where there are large magnetic anomalies. Many local surveys were carried out within 30 miles of Ottawa and within 50 miles of Toronto to find magnetically undisturbed locations for possible construction of magnetic observatories.

In 1962 the Branch operated seven magnetic observatories, where the changes occurring in the magnetic field are recorded continuously, 24 hours per day. They are at Agincourt, Ontario; Meanook, Alberta; Victoria, British Columbia; and Baker Lake, Resolute Bay, Alert, and Mould Bay, all in the Northwest Territories.

Publications of data from Agincourt, Meanook, Victoria, Baker Lake, Resolute Bay, Churchill and Yellowknife were submitted to the Queen's Printer during the year. In addition to these publications, indices of magnetic activity, mean annual values, and listings of discrete events were supplied to the appropriate international committees.

A field program to measure gradients in the time-varying part of the geomagnetic total intensity was begun in the fall of 1961. A pair of recording proton precession magnetometers were operated with a separation of about 10 miles, and later with a separation of 25 miles. The magnetometers operated on a 30-second cycle, with the readings recorded both on punched tape, and as an analog chart recording. Future work will include larger station separations, and an attempt will be made to study the effect of geological boundaries on the time variations in the magnetic field.

In order to obtain more records for magneto-telluric analysis, recording equipment was operated for one month at Meanook Magnetic Observatory with a frequency range of 0 to 1 cps. Two horizontal components of electric-field variations and three components of magnetic-field variation were recorded. Further use of this equipment is planned for 1963.

A resistivity traverse was made along the Trans-Canada Highway from St. John's, Newfoundland, to Calgary, Alberta. Measurements of resistivity and self-potential were made at 100-mile intervals, using Sharpe Type SP5R apparatus.

In an analysis of the records of temporary magnetic observatories made during the International Geophysical Year, it was observed that the magnetic disturbances recorded at Alert, on the northeast corner of Ellesmere Island, were not typical for its latitude, and were in fact quite different from the disturbances recorded simultaneously at Lake Hazen, only 100 miles away. It became evident that Alert is situated on an anomaly of magnetic disturbance. A joint operation by the Dominion Observatory and the Polar Continental Shelf Project was begun in 1961 and continued in 1962, to investigate the origin of this anomaly. In 1962, four temporary magnetic observatories were operated for several days at locations up to 100 miles southeast and northwest of Alert. Analysis of the records of these observatories, and of the permanent observatory at Alert, indicate that the peculiar features of magnetic disturbance at Alert are due to a concentration of induced electrical currents flowing underground, in a region of enhanced electrical conductivity, at depths of many tens of miles. Further studies of this interesting feature are planned as part of the Upper Mantle Project, since such investigations can supply estimates of the temperature and electrical conductivity of rocks deep in the earth's crust. A second anomaly of magnetic disturbance has been located near Mould Bay, on Prince Patrick Island. Records obtained in this area are being studied by statistical methods.

The design and construction of a new gyro-stabilized platform for the three-component airborne magnetometer continued. Improved circuits were developed for the transistorized portable fluxgate magnetometers. Some progress was made in the development of portable transistorized proton precession magnetometers.

An experimental three-component proton precession magnetometer, recording a complete set of readings every minute on punched tape, was operated for a total of about 20 days. Several programs for the reduction of this material, and the rejection of errors in the data, have been successfully tested on the IBM 1620 computer.

The semi-automatic magnetogram reader, developed at Victoria, is being tested in the production of typed hourly mean values from a complete year of Victoria magnetograms.

Gravity

Irregular variations in the acceleration of gravity over the surface of the earth are caused largely by an irregular distribution of the material in the crust of the earth. These variations in gravity—after taking elevation and curvature of the earth into account—are known as "Bouguer anomalies". When Bouguer anomalies are plotted and contoured on a map there results a pattern resembling that of a topographic map, but quite independent of topography. Areas in which gravity is greater than usual are known as gravity highs—just as areas of greater than average barometric pressure are known as "high" on a weather map. The gravity pattern is permanent within historic time, but not within geological time. The contours of a gravity high tell the geophysicist and the geologist that underneath the contour there is a geological formation composed of rock which is more dense than the surrounding rock. An indication of the area, depth, volume and density of the formation is revealed by the shape of the contours and by the gradient and the peak of the "high". In conjunction with evidence from other types of investigation, gravity-anomaly maps help us a great deal to understand the structural make-up of the crust of the earth. Such knowledge is of fundamental importance to the exploration of the mineral resources of Canada.

Although mapping the gravity field in Canada on a regional basis was initiated in 1946 when gravimeters first became available, it was not until 1958 that systematic mapping by measurements at points 8 to 10 miles apart was begun. The Bouguer anomalies at those points are plotted on maps at a scale of 1:500,000. The pattern of anomalies portrayed by the map at this scale is equivalent to a reconnaissance map; it reveals the major density features of a region, but of course does not delineate fine structure. This can only be done by a detailed survey after the major features are mapped.

These reconnaissance maps are being published in a new series known as the "Gravity Map Series of the Dominion Observatory". Each map or groups of maps will be accompanied by a report containing a discussion of the quality of the data, correlation with geology, and a preliminary interpretation of the anomaly field. The first four maps of this series accompanied by a report were released early in 1962; at the end of the year five more were in press, a few more had been scribed and several more were well along in the compilation stage.

The field technique for these surveys is well established after 5 years' experience. Motor transport is used wherever possible, float-equipped aircraft are used in regions generously endowed with lakes, and helicopters are used elsewhere. In 1962 one party completed approximately five map-sheets on the northern part of Baffin Island, using two helicopters and ski-equipped, and, later, float-equipped aircraft. Another party completed one map-sheet northeast of Great Bear Lake, in addition to making a detailed study of a high-density feature of immediate interest to scientists of the

Geological Survey of Canada. Another party, using the facilities of the Polar Continental Shelf Project, extended the survey in the Arctic to Melville and Prince Patrick islands and made 300 observations on the ice of the Arctic Ocean.

Between field work and finished map, extensive calculations and careful checking are necessary. Programs have been developed by which virtually all of the computing and most of the checking can be done on the departmental IBM 1620 computer.

In cooperation with the Marine Sciences Branch the program of underwater gravity measurements initiated in Hudson Bay in 1961 was resumed in the Gulf of St. Lawrence, where 157 stations were observed.

Control surveys in support of the regional gravity-mapping program were continued and extended across the Arctic. Development work on the bronze pendulum apparatus and on the vibration gravimeter continued through the year.

Seismology

In 1958 the Department began a program to expand and modernize the seismological network of Canada. During 1962, vaults were completed at Port Hardy, B.C., Coppermine and Frobisher, N.W.T., and Ottawa, Ont., and new and modern instruments were installed at several stations. Status of the network at year's end was as follows:

Port Hardy, B.C.—Vault completed, instruments being installed.
Victoria, B.C.—In standard operation.
Penticton, B.C.—In standard operation.
Banff, Alta.—Second-order station in operation.
Coppermine, N.W.T.—Vault completed, not yet instrumented.
Alert, N.W.T.—In standard operation.
Resolute, N.W.T.—In standard operation.
Mould Bay, N.W.T.—In standard operation.
Frobisher, N.W.T.—Vault completed, not yet instrumented.
Schefferville, Que.—In standard operation.
Halifax, N.S.—In standard operation.
Seven Falls, Que.—Standard instruments installed. Station shut down because of lack of operator due to austerity program.
Shawinigan Falls, Que.—Second-order station in operation.
Ottawa, Ont.—New vaults nearing completion.
Scarborough, Ont.—In standard operation.
London, Ont.—In standard operation.

In addition to the foregoing, the Branch helped the University of Alberta to install a station near Leduc, the Collège Jean-de-Brébeuf to operate a

station at Montreal, and assisted the Quebec North Shore and Labrador Railway Co. in the installation of a station near Seven Islands, Quebec.

There were no major earthquakes in Canada in 1962, but a large number of small ones occurred. These have been listed in a paper released to insurance companies and other interested people. A bulletin listing all the earthquakes recorded by the network has been published.

A very detailed study has been made of the seismicity of Western Canada and a paper has been sent to press; this work will modify the earthquake probability map for Canada. In order to extend this work a departmental committee has been set up composed of scientists from several different branches, with observers from the Division of Building Research, N.R.C. This committee hopes to bring the light of several different scientific disciplines to the problems of seismic regionalization.

Much progress has been made in applying the IBM 1620 computer to seismic problems. It has been used in several different ways to solve problems relating to the mechanism of earthquakes and is reducing the results of field observations more swiftly and accurately than is possible by conventional computing methods.

Seismic field studies, aimed at measuring the thickness of the earth's crust, have been made in the coastal areas of British Columbia and in the vicinity of Schefferville, Que. The Branch also supervises seismic field work on the Polar Continental Shelf. As part of the Observatory's interest in meteor craters, seismic studies have been made of a suspected crater at Clearwater Lake and a report on earlier work on Deep Bay has been prepared for publication.

The enlarged network of standard stations makes possible detailed studies of structure through surface waves. As a beginning, the surface waves produced by Soviet nuclear tests at Nóvaya Zemlyá on the seismographs at Alert and Resolute are being used to investigate the sedimentary and crustal structure of the Queen Elizabeth Islands.

Studies continue on several aspects of earthquake mechanism. This has a bearing on the problem of distinguishing nuclear blasts from earthquakes, and officers of the Branch have acted as advisors to the Departments of National Defence and External Affairs.

The Branch with the cooperation of the Department of National Defence and the Department of Public Works has assisted British scientists in installing a special array of seismographs near Yellowknife. Instruments for this array were supplied by the British; their installation was arranged by Canada. The purpose of the array is to seek a criterion for distinguishing blasts from earthquakes. It also has many important research aspects for earthquake seismology.

A section has been set up for the measurement of terrestrial heat flow and a hole has been drilled in Ottawa, adjacent to the Observatory. Prelimi-

nary measurements of temperatures have been made in this hole and these will be continued for many years to check the rate at which equilibrium is established. It is very important, if one is to understand the processes going on within the earth, to know the rate at which heat is flowing out from it. It is hoped eventually that the section will be able to drill holes throughout much of Canada and so produce a heat-flow map for the entire country.

Dominion Astrophysical Observatory

The main problems studied at the Observatory usually require observations continued over several years, and the spectroscopic programs were therefore continued during the past year. The arrival and commissioning of the new 48-inch telescope expands the observational scope of the Observatory and enables staff members to pursue researches more efficiently. The new telescope was ready for work in the late spring and is now in regular use with its associated high-dispersion spectrograph, the most powerful of its kind now available in Canadian observational astronomy. During the year observations were made with the 72-inch telescope on 175 nights, for a total observing time of approximately 1,050 hours, during which 1,000 stellar spectra were photographed. The 48-inch telescope was used on 105 nights giving 450 high-dispersion stellar spectrograms, as well as some valuable photographs of the analyzed light reflected from the planets Venus, Jupiter and Saturn. Generally speaking the observations are made for the purposes of investigating the abundances of elements existing in the outer layers of stars and the conditions obtaining in these outer parts of the sun and stars, of studying the distribution and motions of stars and interstellar matter at great distances from the earth, and of measuring the orbital velocities of double stars to find their masses, luminosities and sizes. Some special spectroscopic observations were made of the planets Venus, Jupiter and Saturn to study the composition of the planetary atmospheres and to attempt to assess the conditions prevailing on these planets. These observations now reach a new significance with the development of space-exploration possibilities.

Special equipment auxiliary to the telescopes was designed and constructed in the Observatory shop. This equipment cannot ordinarily be purchased because of its highly specialized nature, and original design has to be created and fabricated to meet the needs of the scientific programs.

Some long-continued programs approached completion during the year. A list of measured absorptions in stellar spectra containing hundreds of lines is being compiled from the most accurate measures which have been made. This material, much of which was accumulated at the Observatory, will allow a new determination of the occurrences of chemical elements in extra-terrestrial matter and will give new insight into the processes occurring in the outer atmospheres of stars. Observations and measurements were completed on a program giving the distances of nearly 600 very hot stars which are located

hundreds, and even thousands, of light years distant from the solar system. Studies were continued on stars showing instabilities in their atmospheres and on double stars of special interest. A catalogue of the line-of-sight speeds of 570 distant stars was completed and printed. This, together with the distance assignments mentioned above, concludes the observational work on a project of galactic exploration which was begun some 20 years ago.

Ten original scientific papers were prepared for printing and four printed papers were distributed to a world-wide list of observatories and libraries. Staff members attended twelve Canadian and international scientific meetings, presenting a total of eleven papers at these various conferences. The Observatory was represented on the Executive Committee of the International Astronomical Union, on the Board of Directors of the Astronomical Society of the Pacific, and on the Councils of the Royal Astronomical Society of Canada and the Canadian National Committee of the International Astronomical Union.

Some 24,000 members of the public visited the Observatory and approximately 3,000 persons attended 39 public observation periods. Seventeen education and study groups visited the Observatory and were given special tours, and staff members delivered 20 lectures to educational, scientific and service clubs in southern British Columbia. Many inquiries from the public, the press, and from business concerns were received and answered, and astronomical information was supplied to airport and meteorological authorities.

geographical branch

THE GEOGRAPHICAL BRANCH in 1962 continued its accelerated land-use mapping program and published eleven map-sheets on various topographical scales. Field work was carried out in every province except Prince Edward Island, Quebec and Manitoba. Further advances were made in the fields of glaciology and geomorphology, and the long-range investigation of the Barnes Ice Cap and vicinity on Baffin Island was expanded. Field facilities were improved with the acquisition of a permanent building at Longstaff Bluff on Baffin Island.

During the year the progress towards more detailed scientific research was reflected in the internal reorganization of the Branch into four systematic divisions: Physical Geography, Toponymy, Economic Geography and Cartology.

In all, thirty-five geographers were in the field: eighteen in the far north, one in Newfoundland, one in Nova Scotia, three in New Brunswick, three in Ontario, five in Saskatchewan, two in Alberta and two in British Columbia.

Close collaboration with international geographical research organizations was developed, and the Branch continued to maintain the Secretariat of the Canadian Committee of the International Geographical Union. The Branch director represented Canada at the meeting of the Directing Council of the Pan-American Institute of Geography and History and was appointed president of the Committee on Regional and Applied Geography of the Institute. The Branch also continued to serve as a consultative member of the Canadian National Commission for UNESCO.

Physical Geography

During 1962, terrain-analysis studies were continued in various parts of arctic Canada. These studies will contribute to an understanding of physical processes at work in the north and will permit more precise assessment of accessibility and resources.

A major manuscript on the physical geography of Mackenzie Delta was completed and prepared for publication. Field work for a reconnaissance study of the terrain and coastline features of Melville Island was completed, and the fourth field season of glaciological and terrain investigations on Meighen Island marked the completion of this phase of the field work.

Following the 1961 reconnaissance of north-central Baffin Island, detailed terrain and geomorphological studies were undertaken adjacent to, and north of, the Barnes Ice Cap. Much progress was made in evaluating the terrain types in the area covered by four 1:500,000 N.T.S. map-sheets and in investigating the history of deglaciation of the area. Specific studies included analyses of till fabrics in the peculiar morainic ridges of the area, and the use of lichenometry as a tool in evaluating the more recent deglaciation phases. Emerged marine features were examined in Tay Sound and along the outer coast fronting Baffin Bay.

Glaciological work in Baffin Island was undertaken, partly in cooperation with the Dominion Observatories. Accumulation and movement studies were initiated on the Penny Ice Cap to complement the Observatories' program of ice-thickness studies, using seismic and gravity techniques. On the Barnes Ice Cap, a camp was occupied near the ice cap's crest from May until late August. Studies of accumulation and ablation were made across a wide area, and synoptic meteorological observations were recorded throughout the ablation season. In addition, specialized studies of ice-cored moraines were undertaken, both along the margin of the Barnes Ice Cap and at the termini of selected glaciers in the eastern mountains. One sample of 900 pounds of ice was mined and brought to Ottawa for concentration of contained carbonaceous material as a basis for C^{14} dating of the moraines. At present this program is experimental; it represents the first attempt in North America to date glacier moraines by this method.

Systematic aerial mapping of sea-ice distribution between the Queen Elizabeth Islands and northwestwards over the continental shelf was carried out. This involved 180 flying hours. Additional field work embraced an aerial winter survey of ice in the Gulf of St. Lawrence and St. Lawrence River. This involved ten flights and 150 flying hours and was carried out in cooperation with the Royal Canadian Air Force and the Defence Research Board.

In Saskatchewan, two geographers continued a study of prairie landforms as an aid in understanding and explaining the detailed land-use pattern of the area between Regina and Winnipeg.

Office work included the publication of the first of a series of regional glacier inventories covering northern Baffin and Bylot islands. The main inventory was further expanded as part of the continuing commitment undertaken in collaboration with the Canadian Sub-committee on Glaciology of the Associate Committee on Geodesy and Geophysics of the National Research Council. Statistical analyses of break-up and freeze-up dates on the Nelson River system, and the pattern of ice distribution and climate in the Cabot Strait area were completed with the cooperation of the electronic data processing unit of the Department.

The Branch was represented at the 25th Anniversary Meeting of the British Glaciological Society; at the first international symposium on the history of the North Atlantic Biota, held in Reykjavik, Iceland; and at the meeting of the Commission on Snow and Ice of the International Union of Geodesy and Geophysics, held in Obergurgl, Austria.

Toponymy

The degree of standardization of geographical names and terminology is considered to reflect the maturity of a country, as it is necessary for efficient national and local development and planning, particularly when maps and charts are involved. Members of the Canadian Permanent Committee on Geographical Names, the national authority responsible for standardization of names in Canada, were provided with information on the origins, correct spelling, application and usage of 16,731 names during 1962, and over 1,500 new names were officially approved. More than 900 inquiries were answered, most of them concerned with the location of geographical features or the origin of names. All named glaciological features in Canada were listed and classified as an initial step towards a uniform glaciological terminology. The preparation of the manuscript of a gazetteer of Ontario was completed and sent for printing.

Economic Geography

The principal activity in economic geography continued to be in land-use surveys and investigations in cooperation with the provinces. This is essential in developing a solid basis for forestry, agricultural, community and industrial development.

In New Brunswick, the field-mapping of the Campbellton and Bathurst areas was completed, with the exception of the forest cover. A comprehensive report which analyzes the land-use patterns of Prince Edward Island was prepared for publication. In Ontario, a final revision of parts of the field-mapping of Niagara Peninsula was completed and field-mapping of the area from Simcoe to Windsor was commenced. A land-use study was started which deals with that section of the Peace River region of Alberta to be directly affected by the construction of the Pine Point Railway. In

the Broadview-Dauphin area of Alberta-Saskatchewan, air-photo interpretation of the land use was checked from the air with the use of a light aircraft. In British Columbia, field-mapping of the Lower Fraser Valley was completed.

In the field of urban geography, a manuscript report brought to completion 7 years of research on the relationship between land use and manufacturing in the Toronto area. A study of the origin and destination of cargoes in and out of the port of Saint John, New Brunswick, was commenced at the request and with the cooperation of the National Harbours Board. Data were compiled on 31 settlements in Northwest Territories, Yukon and northern Quebec, from field work carried out in previous years, for the planning, development and construction of settlements in the north.

Detailed information required by the International Commission on Methods of Economic Regionalization was abstracted and compiled, and a special article was prepared on economic regions of Canada for publication in the Canada Year Book, 1962.

A geographer attended a regional meeting of the International Geographical Union in Kuala Lumpur, Malaya, and participated in a symposium on land capability held under the auspices of A.R.D.A.

Cartology

As part of Canada's contribution to the work of the Commission on Population Mapping of the International Geographical Union, Branch geographers carried out research on the techniques and specifications required for a population map on a scale of 1:1M. They also continued to develop plans for the revision and updating of the *Atlas of Canada.*

The Branch continued to support the land-use program in the preparation for publication of maps from field data. Two sheets for Nova Scotia, on a scale of 1:250,000, were published, and two sent for printing. One sheet for Prince Edward Island, on a scale of 1:126,720, was published and the two remaining sheets sent for printing. A resources map of the Atlantic Provinces was published, in cooperation with the Atlantic Resources Economic Council. Six Ontario sheets, on a scale of 1:50,000, were published and five sent to be printed. One sheet on a scale of 1:500,000, covering the Moose Jaw-Watrous area of the Prairies, was sent for printing. Two sheets covering parts of southwestern British Columbia were published and five others sent to the printer.

Three manuscript resources maps were prepared in cooperation with the Department of Defence Production and the Army Survey Establishment, and one geographer prepared a list of reference coordinates of census subdivisions for the Emergency Measures Organization.

The map collection was reorganized and its cataloguing procedures streamlined in accordance with current library practice. A total of 10,046

new maps from thirty countries were acquired, mainly through exchange agreements with foreign government mapping agencies. The collection of topographic maps and plans, formerly held by the Canadian Board on Geographical Names, was incorporated into the collection, bringing the total number of maps to 180,262. Within the Branch, 1,587 maps were issued on loan, and 1,689 references were completed. From outside sources, 321 enquiries relating to cartography were dealt with, and 368 maps were issued on loan. The annual bibliography of new and revised Canadian maps was submitted to the *Bibliographie Cartographique Internationale,* and to the *Bibliotheca Cartographica.*

A geographer attended the 22nd Annual Meeting of the American Congress of Surveying and Mapping and the 28th Annual Meeting of the American Society of Photogrammetry in Washington.