Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

annual report 1971–72

Hon. Donald S. Macdonald, Minister

Department of
ENERGY, MINES AND RESOURCES
Annual Report 1971-72

Hon. Donald S. Macdonald, Minister

Cat. No. M1-5-1972

Contents

	Page
INTRODUCTION	1
RESOURCE INVENTORY AND POTENTIAL	5
Mapping	5
Search for and Evaluation of Resources	8
ECONOMIC AND SOCIAL ASPECTS	12
Economic Planning and Market Analysis	12
Regional and Special Programs	15
TECHNOLOGY AND ENVIRONMENTAL CONCERNS	18
Technology	18
Remote Sensing	23
Environmental Concerns	25
Ice Studies	29
RESOURCE ADMINISTRATION AND REGULATION	30
SERVICES AND STATUTORY RESPONSIBILITIES	32
RESEARCH AGREEMENTS	35
ADMINISTRATION AND SUPPORT SERVICES	36
INDEX	39

Artist's drawing of new EMR tower building, Booth St.

Introduction

The Department of Energy, Mines and Resources is the federal government's principal agency for the discovery and assessment of Canada's potential in a broad range of non-renewable resources—fuels, metals, industrial minerals; for the dissemination of many types of scientific and technical information; and for the analysis of economic and industrial trends in the fields of energy and mineral resources, and for policy development in those fields.

Nowhere was this responsibility better illustrated than in the stepped-up activities of EMR's energy staff, the team responsible for collecting and interpreting the relevant data that serve as a basis for governmental policy. The growing tempo of offshore exploration on Canada's continental shelves, especially on the east coast, also required constant supervision on the part of the department. The resurgence of coal use and coal exports, the ever-changing situation of nuclear power, and the ecological and social considerations attending the construction of thermal and hydroelectric power plants are placing heavy burdens on the analytical and decision-making components of the department.

Equally weighty are the developments that demand attention and decision in other mineral-resource fields. Canada has always been a large exporter of raw mineral materials. It is held to be economically and politically desirable for a nation to process its own raw materials at home; but apart from the stern realities of differential wage and price structures in the world's industrial nations, further processing may also be opposed by ecological considerations: metal smelters and refineries often release noxious gases and liquids into the air and the waters. This is only one example of the type of social and economic dilemmas with which EMR mineral experts must come to grips.

Greater social and economic awareness is also evident in the work of such essentially scientific agencies as the Geological Survey of Canada. The much-debated development proposals for the Mackenzie Valley have prompted an intense effort aimed at understanding the peculiar terrain of that area, and its potential reaction to the various stresses that advancing civilization may place on it. But in the highly populated and industrialized southern parts of Canada, too, geological research has moved into the compilation and analysis of terrain data that will provide a better basis for urban and industrial planning.

Mining and metallurgical research in EMR laboratories has for many years contributed to the technological advancement of Canadian industry and has helped many a company to make use of low-grade or hard-to-process minerals and ores. Such research and development may be particularly important in those regions that lag in economic and industrial development.

Now a significant proportion of this research capability is directed toward ways and means of reducing air and water pollution from mining and metallurgical operations. One of the most common noxious gases released into the atmosphere by smelters is sulphur dioxide. Mines Branch investigators have developed a number of modifications to existing processes that allow this gas to be turned into solid sulphur compounds, whose removal is easily accomplished. Similar aims are being pursued in improving the combustion of fossil fuels so as to reduce the emission of polluting fumes into the air.

The safety and well-being of Canadians is also an important research goal of EMR's seismologists, who record earth tremors throughout Canada and compile maps that show the probability of earthquakes in the various regions and assist builders in planning earthquake-resistant structures, as required. In an interna-

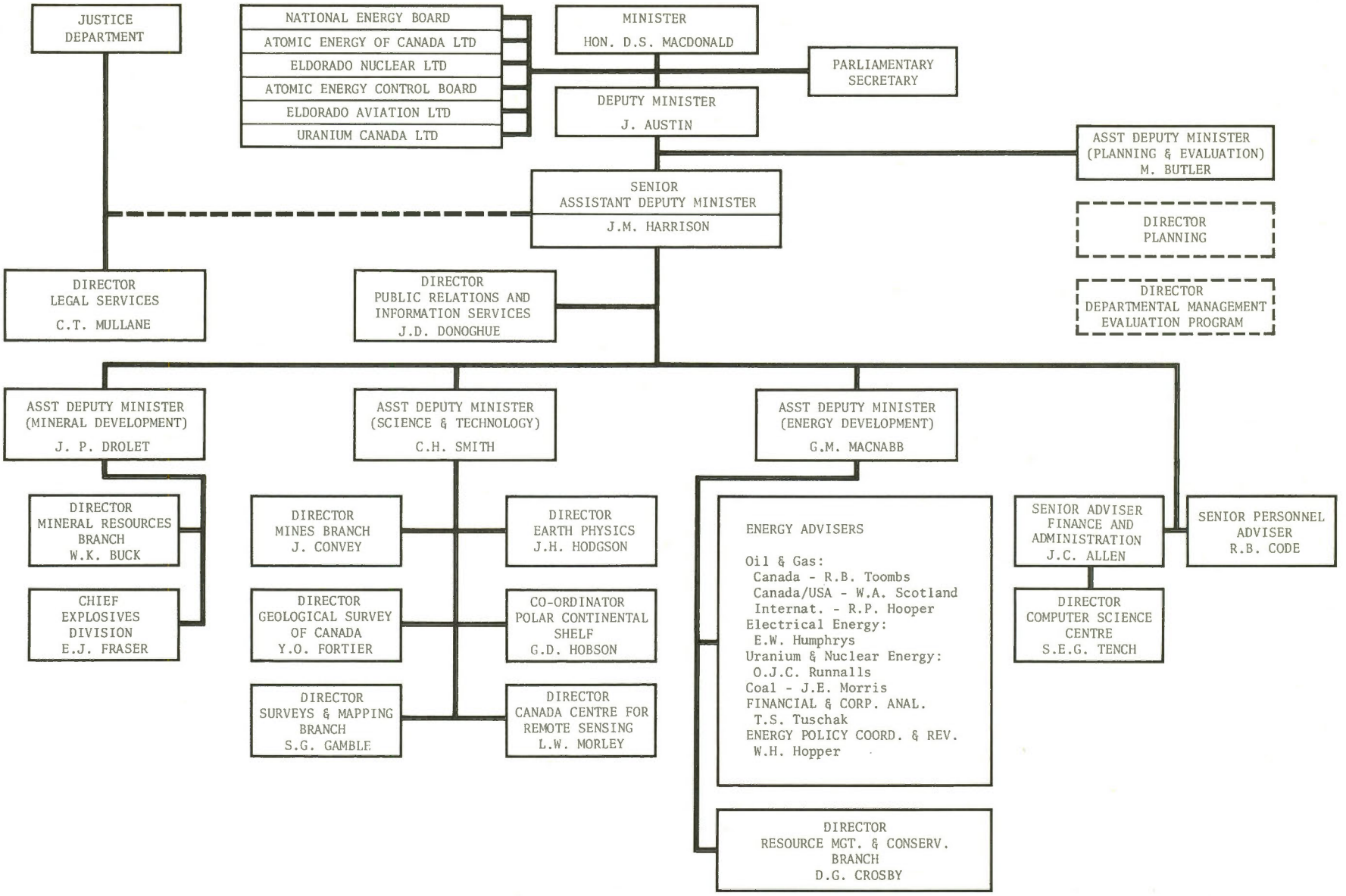
tional setting, the sensitive seismographs in the analytical methods developed by EMR's seismologists have enabled them to detect atomic explosions around the world.

A country as large and as thinly populated as Canada is particularly dependent for communications and development on the ready availability of accurate medium-scale maps of many types. These constitute one of the main products of EMR's surveying and mapping units. Over four million maps and air charts were distributed to civilian and military customers during 1971–72, evidence of increasing interest in summer homes and land investment, vacation travel, resource development, and the use of maps in education.

A new field of research closely allied to mapping is remote sensing. This activity is carried out with various types of sensors—chiefly photographic cameras and television-type scanners—that are mounted in specially equipped aircraft and in satellites. The year in review saw the establishment of the Canada Centre for Remote Sensing, which was to co-ordinate the use of airborne sensing throughout Canada and was also preparing for the reception and processing of imagery from the first Earth Resources Technology Satellite (ERTS-A) that was subsequently placed into orbit around the earth by the U.S. National Aeronautics and Space Administration. The knowledge of Canada's land and water environment that will be gained through remote sensing will be of great value to planners in the fields of agriculture, forestry, water management, transportation routes, etc.

Research planning and policy formulation in EMR benefited considerably from the deliberations of a number of advisory committees whose members are drawn from the federal and provincial governments, educational institutions, and private industry. They are the National Advisory Committees on Research in the Geological Sciences, on Control Surveys and Mapping, on Mining and Metallurgical Research, on the Mining Industry, and on Petroleum. The first three committees are concerned mainly with the exchange of information and the encouragement of scientific research in their respective fields; the last two are concerned mainly with economic trends and policies in the mining and petroleum industries.

These are only a few indications of the various types of research and analysis carried on by the Department of Energy, Mines and Resources. Greater detail will be found in the body of the report itself. Those readers who have professional interests in the various aspects of EMR activities will find them in the large variety of scientific and technical publications produced by the operating branches.


JUSTICE DEPARTMENT
NATIONAL ENERGY BOARD
ATOMIC ENERGY OF CANADA LTD
ELDORADO NUCLEAR LTD
ATOMIC ENERGY CONTROL BOARD
ELDORADO AVIATION LTD
URANIUM CANADA LTD
MINISTER
HON. D.S. MACDONALD
PARLIAMENTARY SECRETARY
DEPUTY MINISTER
J. AUSTIN
ASST DEPUTY MINISTER (PLANNING & EVALUATION)
M. BUTLER
SENIOR ASSISTANT DEPUTY MINISTER
J.M. HARRISON
DIRECTOR PLANNING
DIRECTOR DEPARTMENTAL MANAGEMENT EVALUATION PROGRAM
DIRECTOR LEGAL SERVICES
C.T. MULLANE
DIRECTOR PUBLIC RELATIONS AND INFORMATION SERVICES
J.D. DONOGHUE
ASST DEPUTY MINISTER (MINERAL DEVELOPMENT)
J. P. DROLET
ASST DEPUTY MINISTER (SCIENCE & TECHNOLOGY)
C.H. SMITH
ASST DEPUTY MINISTER (ENERGY DEVELOPMENT)
G.M. MACNABB
DIRECTOR MINERAL RESOURCES BRANCH
W.K. BUCK
CHIEF EXPLOSIVES DIVISION
E.J. FRASER
DIRECTOR MINES BRANCH
J. CONVEY
DIRECTOR GEOLOGICAL SURVEY OF CANADA
Y.O. FORTIER
DIRECTOR SURVEYS & MAPPING BRANCH
S.G. GAMBLE
DIRECTOR EARTH PHYSICS
J.H. HODGSON
CO-ORDINATOR POLAR CONTINENTAL SHELF
G.D. HOBSON
DIRECTOR CANADA CENTRE FOR REMOTE SENSING
L.W. MORLEY
ENERGY ADVISERS
Oil & Gas:
Canada - R.B. Toombs
Canada/USA - W.A. Scotland
Internat. - R.P. Hooper
Electrical Energy:
E.W. Humphrys
Uranium & Nuclear Energy:
O.J.C. Runnalls
Coal - J.E. Morris
FINANCIAL & CORP. ANAL.
T.S. Tuschak
ENERGY POLICY COORD. & REV.
W.H. Hopper
DIRECTOR RESOURCE MGT. & CONSERV. BRANCH
D.G. CROSBY
SENIOR ADVISER FINANCE AND ADMINISTRATION
J.C. ALLEN
DIRECTOR COMPUTER SCIENCE CENTRE
S.E.G. TENCH
SENIOR PERSONNEL ADVISER
R.B. CODE

March 1972

Resource Inventory and Potential

MAPPING

Topographic Mapping

The Department of Energy, Mines and Resources, which is Canada's principal mapping agency, produces a great variety of maps and charts for many different purposes. Topographic maps are based on geodetic and topographic surveys, supported by air photography. Other maps feature Canada's geology, geophysical characteristics, land use, etc., and serve technological and scientific purposes.

Topographic coverage of Canada was increased considerably during 1971–72. Of the 418 National Topographic Series maps forwarded for reproduction, 136 were new and 282 were revisions.

The demand for photomaps continues to increase. A substantial contract was awarded for the production of 43 contoured photomaps of the Mackenzie River area at the scale of 1:50,000, together with a negative for the production of line maps.

The cartographic-services staff of the department compiled and/or drafted 553 maps. This included the drafting of 348 new and revised manuscripts for the National Topographic Series; cartographic services were also provided to other agencies and resulted in the production of 157 maps.

In the International Map of the World Series, 24 maps have been published and a further seven were in production. Work continued on the 1:125,000 scale map series, on the first-edition map of North America at 1:10,000,000, on various special-purpose maps, such as those showing Canada Manpower Centres and census areas, and on maps for the Representation Commissioner.

The Surveys and Mapping Branch made progress in automating its map compilation by acquiring new equipment and by improving its use and mastery of existing equipment.

By the end of the fiscal year, fifty per cent of the *National Atlas of Canada* had been printed in both English and French; completion is scheduled for 1973.

Topographical mapping was complemented by geodetic surveys. During the field year, 25 geodetic parties established vertical and horizontal control throughout Canada. First-order levelling was carried out in five provinces. High-precision levelling along the north shore of Lake Erie, which was done in the metric system, was a continuation of the International Great Lakes Datum re-evaluation.

Horizontal geodetic control was carried out by a number of field parties. Of note was the Aerodist network in northern Manitoba, northern Saskatchewan and the Northwest Territories, covering 91,000 square miles and adding 38 new control points to the system. (The Aerodist technique combines the use of electronic distance-measurement and aircraft.) In several areas horizontal control was done co-operatively with provincial agencies. The Geodetic Survey also made the first attempt to extend a first-order horizontal

control (high-precision control) by trilateration, i.e., the measuring of the sides of triangles rather than of the angles. The method proved highly satisfactory. Two helicopter-supported parties established control for 1:50,000 mapping: one covered 59,000 square miles in the District of Mackenzie north of Yellowknife, and the other provided vertical control over 127,000 square miles in northern Quebec and Labrador. Progress was made in automation and training, in the review of existing geodetic networks and in the improvement of survey technology.

Map distribution by the Surveys and Mapping Branch continued to increase at an average rate of five per cent, and over four million maps and air charts were distributed to civilian and military customers in 1971–72. Revenue from sales increased by $36,000, to a total of $577,572.

The increasing demand for maps is attributed to increasing interest in summer homes and land investment, vacation travel, resource development, and the use of maps in education.

Air Photography

Plans were completed during the fiscal year to move the reproduction centre of the National Air Photo Library into a new building scheduled to house also the Canada Centre for Remote Sensing. This would provide the reproduction centre with better accommodation, and would also ensure a rapid and effective flow of satellite data from the Canada Centre for Remote Sensing to the photo facilities once the Earth Resources Technology Satellite began its operations.

During the year the reproduction centre of the National Air Photo Library filled 11,238 customer orders for survey photography and remote-sensing imagery. This necessitated the production of more than one million photographic items, and represented an increase in customer requests of 36 per cent over the preceding year. Enlarged premises at the Ottawa headquarters of the library and new stereoscopic viewers and light tables will make it easier for customers to study items from the 3,660,000 air photos listed in the library catalogue.

For reasons of economy and efficiency the department completed plans for combining the Calgary branch of the National Air Photo Library with the publications unit of the Institute of Sedimentary and Petroleum Geology in that city.

The Interdepartmental Committee on Aerial Surveys, whose executive is housed in the department, coordinates the air-photo requirements of federal government departments. Private survey companies under government contract flew 61,951 line miles of photo coverage during the past year.

Geographical Names

The standardization of geographical names throughout the country is a prerequisite for reliable maps as well as for numerous other activities. During the fiscal year 1971–72 the secretariat of the Canadian Permanent Committee on Geographical Names investigated 16,339 names; of these 7,914 were new decisions. The secretariat also compiled or revised a number of territorial and provincial gazetteers, and carried out research on place names.

Geological and Geophysical Mapping

Although the layman, when confronted with the word "map," is most likely to think of topographic or road maps, the field is much broader and embraces the display of a wide range of scientific findings about the earth's crust in a map setting. This includes geological, geomagnetic, gravity, seismologic and other maps.

A systematic geological framework, developed to consistent standards, is the basis for estimating the potential for mineral and fuel resources in Canada. This framework is identified by the national bedrock reconnaissance. Mapping has been carried out by the Geological Survey since its inception in 1842, and reconnaissance maps at a minimum scale of one inch to eight miles are expected to be available for all of Canada by 1976.

Such mapping, in the field season of 1971, included Operation Torngat in Labrador–Quebec, which during the past three years has covered 65,000 square miles, and the near-completion of mapping of 15,000 square miles in the Yukon Territory. Reconnaissance mapping of the surficial deposits of Melville Island in the Arctic was started. This is the last major arctic island for which such information is not available, and the study is being undertaken as a basis for the territorial land-use regulations and petroleum exploration. More detailed reconnaissance mapping was done on the Canadian Shield, and along the British Columbia coast where the rock units are similar to those elsewhere

in the province that contain deposits of molybdenum and copper.

Other reconnaissance mapping was done in northern and central British Columbia, Ellesmere Island, Devon Island, Melville Peninsula, the Daly Bay area of the District of Keewatin, the Snow Lake area of Manitoba, and Harp Lake in the eastern Canadian Shield.

The greatly increased interest in the resource potential of Canada's extensive continental shelves—submarine extensions of the continent that vary from a few miles to hundreds of miles—has resulted in more extensive geological studies. The Geological Survey has offices in Vancouver, B.C., and Dartmouth, N.S. (Atlantic Geoscience Centre); both were engaged in marine geology during the year. On the west coast, offshore geological and geophysical surveys were made along traverses at right angles to the coast line for basin analysis, determination of fuel and mineral potential, delineation of the continental margin, and engineering and environmental considerations for seabed development on the shelf and slope. The staff at Dartmouth analyzed subsurface data from petroleum basins in eastern Canada and from the Atlantic continental shelf; they also carried out a geological survey of Hudson Bay with the aid of the submersible *Pisces III*.

Many geological mapping activities depend on information supplied by specialists in the various disciplines that are associated with geology. Paleontological research into the remains of ancient sea- and land-dwelling plants and animals is one of these. During the report period field studies were carried out in the arctic islands, Mackenzie Mountains, Mackenzie Delta, northern Yukon, northern Manitoba, southwestern Alberta, eastern British Columbia and Newfoundland. In addition, 190 reports were prepared on more than 2,400 collections of fossils; fossil spores and mosses were studied, and microfossils from well cuttings and surface outcrops were examined.

Laboratory specialists carried out 178 potassium-argon age determinations of rocks. The officer in charge of the geochronology laboratory spent the first half of the year assisting in the establishment of a similar laboratory at Laval University, Quebec.

Radiocarbon dating is used on material less than 30,000 years old. During the report period, 175 such determinations were made, mostly on geological material, but eleven determinations were made on archeological material submitted by the National Museum of Man.

The Geological Survey maintains at its Institute of Sedimentary and Petroleum Geology, Calgary, a repository of drill cores and samples from wells drilled in areas under federal jurisdiction, mainly the Northwest Territories, the Yukon Territory and the continental shelves. The repository is used by scientists and exploration geologists.

Geomagnetic charts are an important aid in understanding the structure of the earth's crust—the repository of all mineral resources accessible to man. They are also an essential aid in navigation. During the year the department published four magnetic charts of Canada at a scale of 1:10,000,000. A special magnetic chart of the Canadian Arctic was produced at the request of the Canadian Hydrographic Service. A complete set of magnetic charts of British Columbia at a scale of 1:2,000,000 has been compiled and was scheduled for publication in 1972. In addition, 329 aeromagnetic maps were issued by the Geological Survey as part of the federal-provincial aeromagnetic program.

Considerable field work on geomagnetism was done in various parts of Canada, particularly in the Canadian Shield. Study of paleomagnetism in rock may reveal the direction in which these rocks were oriented millions of years ago. This, in turn, may lead to theories on the widening of oceans and continental drift.

Staff of the Geomagnetism Division carried out various studies on geomagnetism and its relation to electrical currents flowing in the earth and the sea.

Like geomagnetism, gravity variations in the earth's crust help in the search for resources. Field surveys to extend national gravity mapping were continued in the Arctic, in British Columbia and in the eastern offshore region. In British Columbia, a detailed gravity survey of the Guichon batholith (a rock mass formed at considerable depth) done in co-operation with the British Columbia Department of Mines and the University of British Columbia suggests a relationship between minimum gravity values and porphyry-copper deposits.

An important aid in understanding the long-term behavior of the earth's crust and in mineral exploration is investigation into the variations of gravity. For example, gravity measurements make it possible to trace vertical movements in the earth's crust resulting from the melting of the vast ice masses that covered much of the northern hemisphere during the latest ice age. Facilities have been built up during the last few years for predic-

ting the loading effects of the ocean tide, which in turn helps in investigating coastal structure and regional variations in gravity data. Dalhousie University and the University of New Brunswick are co-operating in this program.

A gravimeter was recently operated on the ice of the Beaufort Sea to determine the feasibility of measuring the deep-ocean tide by this method.

Among other gravity studies, data on the density of sedimentary rocks were collected from oil companies operating in Alberta and Saskatchewan, to gain a better understanding of variations in the density of the sedimentary strata in the Prairies; gravity anomalies in the southern Canadian Cordillera were interpreted in terms of geological and crustal structure; the structural history of the Canadian Shield was studied; a series of new gravity maps was issued for the Sudbury area, which has a known economic potential; fossil meteorite craters were investigated; lunar rock samples made available by the United States were studied jointly by the Geological Survey of Canada and U.S. scientists.

The various gravity surveys have been tied into the Primary Gravity Network of Canada, which in turn is tied to the International Gravity Standardization Network 1971 (IGSN 1971).

The storage and retrieval of gravity data were recently revised and converted to the department's new computer. Requests from exploration companies for all forms of gravity data continued to increase during 1971.

The Seismology Division of the department completed a reconnaissance of lithospheric thickness in Canada with the use of surface waves, and an experiment designed to study the tectonic fabric and development of the Rocky Mountains with digital-recording long-period seismographs. Instrument assembly and design for this experiment went parallel with the development of essential new techniques for processing and analyzing data.

Other seismological studies concerned the structure of the crust and upper mantle, and one interesting series of papers produced a revised model of the physical make-up of the earth's core.

Mapping for resource and scientific purposes in the arctic islands has benefited greatly from the logistic and other support provided for many years by the department's Polar Continental Shelf Project group. The field surveys carried on or aided by this group began with an emphasis on the Queen Elizabeth Islands, but they will eventually cover all the Canadian sector of the Arctic continental shelf of North America, those parts of the Arctic Ocean that are of interest to Canada and which can be reached with available logistics, and those parts of the arctic islands and the mainland not studied by other branches of the department.

An interesting study under this head was a continuous bottom profiling in Mackenzie Bay and Beaufort Sea with seismic reflection and sidescan sonar, which indicates that a large ice-scour canyon, now almost completely filled in, once existed in Mackenzie Bay; the canyon shown on current bathymetric (deep-sea) hydrographic charts is what remains since the retreat of the last glacier. Gravity mapping was also carried out in the Beaufort Sea.

SEARCH FOR AND EVALUATION OF RESOURCES

Search for Resources

Many of the detailed studies by the Geological Survey of Canada contribute to the search for non-renewable mineral resources. Indeed, of the 99 parties that were in the field in 1971, some 20 were working toward this end; of course, many of the office and laboratory studies included in the 490 scientific projects worked on during the year served this purpose.

The geological staff intensified its analysis of northern and arctic petroleum basins. Because arctic Canada may well become one of the major oil regions of the world, and because this region is entirely under the jurisdiction of the federal government, the data needed as a base for policy decisions are most logically obtained by federal departments. The government is faced with the responsibility of both encouraging and controlling the surge of activity. Regulations must be based on a detailed knowledge of the sedimentary column. As the principal geological agency of the federal government, the responsibility for providing the required data falls on the Geological Survey.

After some years of being the Cinderella of the energy minerals, coal has again become an eagerly sought mineral. During the report period, samples were obtained by geologists from active mines and exploratory openings in the upper Elk River and Crowsnest areas

of southeastern British Columbia and the Sukunka River area in British Columbia as well as from the Blairmore, Mountain Park and Smoky River areas of Alberta. These samples will provide material for studies of coal quality and petrographic composition. Other samples were collected for research on ancient spores and pollen.

The Canadian Shield has proved to be a vast storehouse of mineral wealth in its southern, better-known reaches, and it is logical to assume that it should be equally rich in the north. Geologists have started an in-depth study of a 40,000-square-mile area north of Yellowknife where the gold mines will soon be exhausted. Part of this study consists of re-mapping, but a principal aspect is a geochemical survey of lake sediments and lake waters. A trial run done in 1971, fully justified the full-scale geochemcial survey planned for the season of 1972.

In order to test the applicability of geochemical techniques to permafrost terrain, detailed mapping was carried out in the nickel-rich Cape Smith–Wakeham Bay belt of northern Quebec and around a lead-zinc deposit on Little Cornwallis Island. It appears that trace elements are sufficiently dispersed throughout the sampled materials to make geochemical exploration feasible at a detailed and at a regional scale. Geochemistry is a relatively inexpensive exploration tool, and, even if not invariably reliable, it probably will have widespread use in assessing the mineral potential of our northern areas.

During the period covered by this report, funds available through the federal government's Special Employment Plan made possible a major project designed to evaluate further the mineral potential of northwestern Quebec and northeastern Ontario, an area where gold mining, long the economic mainstay, is in decline. Sampling of lake bottoms and surficial materials was carried out, and the results have been compiled in the form of maps for each of the 50 Quebec and Ontario townships involved.

Other field projects aimed at the discovery of mineral resources were: a study to relate dispersion patterns of loose surface materials to their source in the bedrock; a regional geochemical census of plutonic (formed at great depth) rocks in the eastern Yukon to aid exploration for metal ores; a project to aid the search for mercury, a possible "pathfinder" element in base-metals exploration; a stratigraphic, sedimentological and paleontological study in the north-central District of Mackenzie to aid in prospecting, especially for copper; a stratigraphic and metallogenetic study in the southern District of Keewatin outlining the potential for several types of ores.

One section of the Geological Survey collects and synthesizes information on the mineral resources of Canada in order to outline regions and geological environments likely to contain mineral deposits. During the past year, the staff of this section carried out studies on nickel, copper, zinc, silver and tin. As a result, several new criteria were developed for identifying areas with a potential for these metals. One interesting conclusion is that, contrary to commonly held theories, metamorphism is not necessarily detrimental to ore potential and may actually improve it. As large parts of the Canadian Shield have undergone high grade metamorphism, this conclusion could be of considerable importance.

Field work on mineral potential was also carried out in the central mineral belt of Newfoundland.

Evaluation of Fuels and Other Resources

The search for and discovery of mineral resources must be complemented by far-ranging analytical studies of their use and marketing, both in Canada and abroad. Such studies are essential for the formulation of fiscal and other government policies aimed at keeping Canada competitive in international markets while safeguarding the nation's resource potential.

Until the late 1960's almost all exploration for oil and gas was concentrated in the Prairies and the western Foothills. Now there is considerable interest in what may be described as Canada's frontier regions: the area north of 60 degrees latitude, including the arctic islands, and the continental shelf areas along with Hudson Bay. There is also increasing interest in the potential of the Athabasca oil sands in northern Alberta and other areas containing heavy oils. The oil-sands area, which may contain as much as 600 billion barrels of oil, is one of the richest fuel sources in the world. However, the oil is extremely difficult to extract, and this makes its economic situation uncertain.

World demand for oil will probably more than double in the next 15 years, which will put great pressure on all available resources and increase Canada's export opportunities, especially to the United States.

Whether such opportunities should be grasped is a matter of continuing debate. EMR is conducting an appraisal of Canada's oil and gas resources that will increase in accuracy as more geological and exploration data flow in.

Coal, which was not much in demand in recent years, has experienced a remarkable comeback, due to large measure to the growing needs of the metallurgical industry, especially that of Japan, and to fuel power stations at home. It has also become apparent that the world's supply of oil and gas will not be able to meet demand in the long term, and as the prices of these fuels rise prudent planning suggests greater use of our abundant coal reserves for steam raising in thermal power plants.

Throughout the 1960's, Canada's annual coal production was about 11 million tons. By 1971 it had risen to 19.4 million tons, and continuing growth in production can be expected, to an estimated 40 million tons per year in the late 70's and 60 million tons in the early 80's. Exports, mainly to Japan, have also risen, from 1¼ million tons in the 1960's to 7.7 million tons in 1971.

The department together with western provincial authorities has undertaken a comprehensive inventory of Canada's coal resources. A preliminary geological study related to this inventory has indicated that coal reserves in western Canada amount to about 118 billion tons, a tremendous reserve. However, these reserves are physical deposits which may not be economical with today's technology.

During the 1950's demand for uranium increased rapidly, mainly because of the manufacture of nuclear weapons in the United States and Britain. Once these demands ceased, Canadian uranium mines began to experience great marketing difficulties, and it was then that the federal government stepped in with its stockpiling program. These measures were designed not only to avoid serious social problems in the mining towns but also to meet the predicted demands for uranium in the future, particular to fuel nuclear reactors. This demand is now increasing at a rate of nearly 30 per cent annually.

About 75 per cent of Canada's electrical energy is derived from hydraulic resources. Although this proportion will decrease, new hydroelectric power plants will remain an important element for at least two decades, especially in such provinces as Newfoundland and Labrador, Quebec, Manitoba and British Columbia.

Future estimates of undeveloped hydroelectric resources will have to take better account of the economic realities of bringing them to production stage by the construction of power plants, dams, transmission lines, etc., as compared with the cost of building and operating plants fired by fossil or uranium fuels. Without such comparisons any estimates of hydroelectric capacity would be meaningless. Concern for the environment must be added to the economic restrictions. The department is making plans for an inventory of hydroelectric resources that will be comparable to the inventory of fuel resources and provide a better basis for economic and policy options.

Through its Resource Management and Conservation Branch, the department gains additional information on the oil and gas potential of the continental shelf off the east and west coasts of Canada and in Hudson Bay and Hudson Strait. Such information assists the department in regulating offshore exploration, which is now at a high peak, and it also contributes to the national inventory of Canada's oil and gas potential.

The department's Mineral Resources Branch collects and analyzes economic information on all of Canada's non-renewable resources, thus providing the federal government with a basis for policies governing taxation, aid to regional mineral development, import duties on foreign mineral commodities, negotiations with foreign governments on the flow of mineral commodities in world markets, and social effects of mineral development.

In recent years, much of the growth in Canadian mineral production has resulted from foreign demand, particularly from the United States and Japan. Is Canada's resource base sufficient to maintain its share of foreign markets and to supply the market at home? This is the question that motivates much of the economic and technical studies carried out in the department. One such study concerned the possible extension of the railway network of British Columbia toward the Yukon, taking account of the mineral and forestry potential along several proposed routes, and the development that might be stimulated. Another study, carried out in co-operation with the Manitoba Department of Mines, Resources and Environmental Management, produced an estimate of the undiscovered mineral resources of the Canadian Shield in Manitoba.

Still other such studies concerned the base-metal potential of the Timmins-Val d'Or "gold belt," the oil-and-gas potential of the Yukon and the arctic islands, and the abundance of major metals in Canada and their distribution.

The Mineral Resources Branch maintains an inventory of 14,000 Canadian mineral occurrences, giving the location, geology, history of ownership, development and other data. The inventory is open to the general public. Agreements have been concluded with several provinces for the exchange of mineral-occurrence information.

The evaluation of fuel resources embraces not only the collection and analysis of existing information but also laboratory and pilot-plant research on fuels. This applies particularly to Canadian coals and their suitability for metallurgical and other uses.

A peculiarity of coal is the difficulty of assessing its properties in the ground or at the mine. Only tests at a pilot-plant scale, e.g., approximating the conditions of actual coal-processing plants, yield reliable information. Samples must be large, which requires considerable effort on the part of the mining companies, especially where work is at the exploration stage. Because of this, the department has endeavored to co-operate with companies conducting exploration work (including established coal producers) in coal evaluation, so as to accumulate a general bank of information.

During the past year, the pilot plants of the department's Metals Reduction and Energy Centre were busy as usual, with coal samples flowing in from the Foothills belt of Alberta and from British Columbia.

Another line of research is based on drilling in Saskatchewan to determine the amount of lignite available for steam raising in thermal power plants. Here, again, the resource cannot be evaluated in the ground, and considerable research will have to be undertaken before reliable analytical results are obtained.

Work proceeded on improving laboratory methods for evaluating the coking quality of western Canadian coals.

The department continued its evaluation of crude oil and a computer program was developed to arrange the oils in ascending order of sulphur content for convenience in resources studies. A spinoff from this type of research has been an analytical procedure to identify the source of spilled oil in lake and sea water.

Mineralogical studies are being carried on to establish the means that could be used for beneficiating various Canadian ores, thus enhancing the nation's resource potential. Among such studies was an extensive survey of the silver-arsenide deposits of the Cobalt-Gowganda area of northern Ontario, which culminated in a recent issue of the *Canadian Mineralogist* devoted entirely to this topic. Also completed were studies of the tungsten-molybdenum-lead-bismuth deposits in the Mount Pleasant area of New Brunswick and of the base-metal deposits in the Red Lake area of northwestern Ontario. Current projects include a study of the porphyry copper-molybdenum deposits in the Highland Valley area of British Columbia and a survey of widely dispersed deposits of low-grade nickel ores in various provinces and territories.

An interesting new study concerns the platinum-mineral deposits from the Tulameen River area of British Columbia; this has resulted in the characterization of little-known platinum minerals and the discovery of two new ones. This work is particularly aimed at increasing our knowledge of Canadian platinum-bearing minerals to a level comparable with that already reached in the Union of South Africa and in the U.S.S.R., both of which exceed Canada in platinum output.

The studies devoted during recent years to the sulphide and related minerals, on which much of Canada's base-metal industry depends, continued throughout the year. A wide range of properties of these natural and related synthetic minerals has been studied with the objective of rendering their beneficiation easier and/or more profitable.

Other mineralogical studies concerned clays and shales from the Atlantic provinces, and their properties during ceramic processing. It was found that these materials contained sufficient kaolinite to make them suitable for the manufacture of structural-clay products. Studies were also made on the properties and usefulness of other non-metallic materials from Canadian deposits, such as silica from New Brunswick, granite, magnesia and limestone from Quebec, tremolite from Ontario, silica from Manitoba, clay-fly mixtures from Alberta, and travertine building stone from British Columbia.

Economic and Social Aspects

ECONOMIC PLANNING AND MARKET ANALYSIS

The growing need in Canada for all forms of energy and the expanding opportunities for sale of energy resources abroad have raised a number of important economic and financial questions. For example, the large capital investment required to develop and bring the various forms of energy to market may put stresses on Canadian financial institutions. Growing national consciousness concerning Canadian ownership and development of energy resources is a crucial factor in energy policy.

Direct investment in Canada's energy industries is already approaching $3.5 billion annually. These expenditures are expected to double by 1980. The implications of these increasing capital requirements must be assessed with great care, and the department is establishing a computerized information-retrieval system and a statistics data bank to analyze the financial moves within the energy industry.

The department will also analyze the implications of the various means available for Canadians to invest in energy companies. Related to this is research on the effect of taxation on company behavior, and the effect of various energy policies on employment.

Oil and Gas

In 1970 Canada attained self-sufficiency in oil, exporting as much oil to the United States from western Canada as she imported from overseas sources into eastern Canada, which area cannot economically be supplied from the Prairie wells. Since 1970 self-sufficiency has been solidified, as exports have increased. The National Oil Policy, which dates from 1961 and establishes the Ottawa Valley as the line dividing the markets for Canadian and imported oil, has been under pressure from petroleum refineries in Quebec and the Atlantic provinces to permit their moving into the lucrative southern Ontario market. This controversial problem has economic, social and strategic implications, that are being assessed by departmental experts. If oil were to be discovered off Canada's east coast, or in the eastern arctic islands, the entire supply pattern would change considerably. Research on the production and marketing of natural gas proceeds parallel with that on oil.

The urgency for such research is exemplified by production figures: in 1960 Canada had a daily consumption of 860,000 barrels of oil; in 1970 the consumption was 1.5 million barrels; in the year 2000 the daily consumption may approach 4 million barrels. In 1960 the country consumed one third of a trillion cubic feet of natural gas; in 1970, one trillion cubic feet; in 2000 consumption could be four trillion cubic feet.

Since all of Canada's exports of oil and gas go to the United States, the department carries out the same type of economic analysis in respect of these exports and related matters as it does for the markets within Canada itself.

Conversely, the oil situation in Canada is always influenced by international developments affecting this

important resource. For this reason, the department keeps track of all world developments in oil and gas. For example, the price increases placed on their oil and gas by Middle Eastern and African nations in 1971 and 1972 have increased the cost of energy in eastern Canada, and they have also raised the question of the reliability of foreign supply. Rising world prices tend to encourage exploitation of the huge resources locked in the Athabasca oil sands.

Other matters which the department has under advisement or in which its experts participate are the proposal to build several new deep-water ports on Canada's eastern seaboard for oil imports and the international consultations dealing with the oil market.

Coal, Uranium and Water Power

The department has initiated studies on which policy-makers may base long-term plans for Canada's coal resources. These studies embrace the state of the nation's reserves, and the distribution and marketing factors.

An assessment has been made of the estimated installation rate of nuclear reactors, the types that will be used and fuel they require. One of the questions that may be resolved with the aid of such studies is that of the further processing of uranium, i.e., the so-called enrichment. Since many of the world's reactors will require enriched uranium, which in the non-Communist world is produced in commercial quantities only in the United States, an extensive interdepartmental study was carried out on the feasibility and desirability of building an enrichment plant in Canada.

It was found that such a facility would require an electrical-power source of about two million kilowatts and a capital investment exceeding one billion dollars, exclusive of the power source. Since much of the know-how required for such a plant is in the hands of foreign governments, the Canadian government would have to negotiate for the release of the information and for its safeguarding in Canada. Also, the output from a uranium-enrichment plant would have to be largely exported, since present Canadian reactors are fuelled with natural uranium.

Assessment is also being made of the development in controlled thermonuclear (i.e., hydrogen) fusion, to determine the economic factors governing the use of that potential power source.

Electrical energy has a history of more rapid growth than the growth of energy output as a whole, and this trend will probably continue, with the development of more advanced processes for producing and using electrical energy. However, the construction of power plants—hydroelectric, thermal, or nuclear—often has detrimental consequences for the natural environment, and the choice of power plant will have to take this into account, along with general industrial and economic considerations.

Mineral Commodities

The department has undertaken a broad review of mineral production, trade and consumption in Canada, which takes into account related factors, such as energy, foreign ownership, foreign competition, etc. Federal-provincial consultation on commodity problems, such as those associated with sulphur and potash, also proved useful.

Further processing of minerals in Canada is under review. Generally, the further a mineral commodity is processed in the home country before being exported, the greater the benefit in wages and profits. This principle, however, is affected and sometimes negated by a number of factors.

The department found that further processing of some minerals to the smelting and refining stages has not kept pace with increases in mine production.

Somewhat special is the case of aluminum. Although Canada produces no aluminum ores, it has established a strong extraction industry on the basis of cheap electric power, advanced technology, and well-developed marketing skill. Aluminum has thus become one of Canada's most important export commodities. Since the construction of aluminum smelters is an effective means for regional industrial development, many governments in Europe have offered unusual incentives in the form of grants, low-cost loans and other measures to firms that will undertake to build and operate aluminum smelters in their territories.

The result has been world overcapacity in aluminum production, with a corresponding reduction in the economic advantages of the Canadian smelters. The department is exploring ways and means of reversing this trend, as far as Canada is concerned.

The Mineral Development Sector, which carries out such studies, has begun preparing for the consultations

within the General Agreement on Tariffs and Trade (GATT), scheduled to begin in 1973, and for arrangements affecting supply and demand in the wake of economic realignments, such as the expansion of the European Economic Community. Departmental experts helped to prepare Canadian representations to the International Sulphur Meetings; the OECD Aluminum Study Group; OECD Non-ferrous Metal Statistics Group; the OECD Iron and Steel Study Group; the OECD Coking Coal Study Group; the International Tin Council; the UN International Lead and Zinc Study Group; the UN Iron and Steel Committee meetings; the UNCTAD Iron Ore Meetings; UNCTAD Manganese meetings; the UNCTAD Tungsten meetings; the International Atomic Energy Agency; and the European Nuclear Energy Agency.

The department also organized and hosted a tour for mining and metallurgical experts from the People's Republic of China.

Certain mineral commodities received special attention from departmental analysts. These were sulphur, potash, aluminum, and copper.

An interdepartmental study group was set up to investigate means whereby a normal pattern could be maintained in copper distribution. Contractual arrangements on copper between Canada and Japan were also examined. Most of the copper ore produced in western Canada is exported to Japan in the form of concentrates, as it is Japanese industrial policy to import raw materials and to export finished products. This policy did have the effect of establishing a modern copper-mining industry in western Canada. However, Japanese smelters have recently endeavored to pass on certain new costs to Canadian copper exporters, costs arising from the devaluation of the Japanese currency, stricter pollution-control measures in Japan, and reduction in the imports contracted for. The department investigated the nature and the impact of these requests.

Both the federal and the British Columbia governments believe that copper smelting in that province is economically viable. The selection of a smelter site, however, is a lengthy and complex process, based on transportation costs, access to markets, ore supply, tax treatment in various countries, etc. Another complication is the air and water pollution a smelter is likely to cause. Smelting techniques and the cost and means of pollution abatement have also to be considered.

World oversupply in sulphur and the "involuntary" production in Alberta has resulted in the accumulation of unsaleable stockpiles. Federal-provincial discussions and international meetings are aimed at resolving this oversupply problem.

In Saskatchewan the provincial government has taken measures intended to regulate the production and marketing of potash, whose production in that province has far outstripped demand.

A number of studies concerned markets for Canadian minerals and strategies that might help to expand them, and the technical and commercial feasibility of proposed new mines and processing plants.

Growing public concern over the environmental effects of mineral development has directed the attention of departmental experts to the economic effects of such pressures. It is undeniable that greater safeguards for the conservation of the environment make mineral exploitation and processing more expensive. This, in turn, may lead to a weakening of Canada's competitive position in world mineral markets, especially in relation to other nations with less stringent environmental safeguards. It is the desire of economic and engineering experts to combine, as far as possible, better environmental safeguards with increasing productive efficiency.

Among the subjects studied this year were sulphur-dioxide emission and pollution, health hazards in the use of asbestos, and submissions to be made to the Stockholm Conference on the Environment.

Another field of study was systems analysis for use in the Canadian mineral industry.

The social and economic distress usually caused by the closure of mines in communities where these mines were the main source of income has prompted the department to search for ways of mitigating such effects. Mine closures may be due to absolute exhaustion of ore, technological change, or poor markets for the mine product. Better planning and co-operation between the various levels of government and the mines are most important.

During the period under review, the most significant event in the field of corporate taxation in Canada was

the passage of a revised federal income-tax act. The new act has far-ranging implications for Canada's mining industry, inasmuch as it reduces some of the tax exemptions for new mining ventures. The Mineral Resources Branch of the department participated in drafting the act and the proposed regulations, in so far as these concerned mining and petroleum production. One of the tasks of the branch during the review period was to ensure that the proposed new income-tax rules were properly understood by provincial governments and private industry.

The branch continued to advise other federal departments on specific taxation matters affecting some Canadian mines. It also provided foreign governments with information on Canadian mining laws.

REGIONAL AND SPECIAL PROGRAMS

Under this heading, the department reports chiefly on activities designed to benefit certain Canadian regions that are in need of economic development or that merit special research because of their peculiar geography. Also dealt with are foreign-aid projects.

Petroleum and Other Energy Sources

The Task Force on Northern Oil Development, chaired by the deputy minister of the department, was established by the federal government in December 1968 as an interdepartmental co-ordinating and advisory group on all matters relative to oil and gas development in the Canadian north.

Initial guidelines resulting from the work of the Task Force were issued in August 1970. Draft environmental and social guidelines were scheduled for release in mid-1972; these were based on three years of field and laboratory studies. The Task Force is also working on guidelines concerned with the financing, ownership and Canadian content of northern pipelines.

In 1968 the federal government and a number of companies formed Panarctic Oils Ltd. The government has maintained an interest of 45 per cent in the company and is determined to keep it in Canadian hands. The company is exploring for oil and gas in the arctic islands and has had encouraging showings. This work will be important in the determination of the oil and gas potential in the Arctic.

During the year the department helped the Cape Breton Development Corporation to conduct a technical-economic feasibility study of several choices open for the Number-20 Colliery of that corporation. The department co-operated with the Department of Mines of Nova Scotia and the Pictou County Research and Development Commission on a provincial plan for the orderly closure of the McBean Mine in Pictou County. The contribution of the department was financial and technological. The same type of aid was rendered to the New Brunswick government in its efforts to rationalize the province's coal mines.

The uranium industry also continued to require government assistance. Denison Mines, Canada's major uranium producer, and the federal government joined in stockpiling uranium in 1971 at a rate of two million pounds of uranium oxide per year. The agreement expires in 1974. Uranium Canada, a Crown corporation, was formed as an intermediary between Canada and Denison Mines, and the company is acting as sales agent for the stockpile. A tentative agreement was reached with Spanish utilities to purchase the joint stockpile over the next several years.

Federal-Provincial Co-operation

The department, through its Energy Sector, participated in the Columbia River Treaty Permanent Engineering Board, the recently established water boards for the two northern territories, the review board established under the Nelson River Transmission agreement with Manitoba, the study board examining the effects of the Lake Winnipeg-Churchill and Nelson River developments, and the Ontario Advisory Committee on Energy. Close liaison has been established with Quebec's James Bay Development Corporation, the James Bay Energy Corporation and Hydro Quebec.

The Energy Sector took part in a government-financed study of the socio-economic impact of the offshore exploration for oil and gas on the Atlantic provinces as well as the impact that might result from oil production in the offshore. The exploration now going on has already benefited Atlantic shipyards. The sector also continued its liaison with the Maritime utilities concerning the strengthening of electrical interconnections and the feasibility of power from the tides of the Bay of Fundy.

The federal government, through EMR and the Department of Regional Economic Expansion, has made

agreements with Manitoba, Quebec, New Brunswick, and Newfoundland and Labrador whereby it will help to finance mineral development in those provinces, some of whose regions are economically depressed.

In New Brunswick, work was undertaken in accordance with a 1970 agreement between the federal government and the New Brunswick Department of Natural Resources. This work has generated new information on the mineral potential of the province through geophysical and geological surveys. Test drilling in the Moncton-Saint John sedimentary basin indicated large deposits of salt and also of potash. Both are of potential economic significance. The salt may form a basis for an eventual chemical industry in that region, and the potash is close to the major market in the northeastern United States. These finds have attracted much interest in the mineral industry, and the province is now evaluating development proposals from a large number of companies. A second agreement for furthering mineral development was in the final stages of negotiation.

The Canada-Newfoundland agreement for mineral development will cost $2.7 million over four years. The money is being channelled through EMR and DREE.

In September 1971 the governments of Canada and Quebec completed renegotiation of a 1968 agreement for the Gaspé area, extending the original period from five to eight years and increasing the budget by $152 million to $411 million. Both mineral development and the transportation and social infrastructure are to be improved. Another agreement, for the expenditure of $20 million over five years, covers the northwestern part of the province and the Lake St. John area.

The Geological Survey of Canada has been responsible for the implementation of the federal-provincial aeromagnetic surveys. During 1971–72, two major contract surveys covering about 40,000 square miles were completed, one in Newfoundland and the other in central Baffin Island. About 115,000 square miles were mapped under contract in British Columbia, District of Mackenzie and in Quebec.

Assistance to Gold Mines

The Emergency Gold Mining Assistance Act (EGMA), which was passed in 1948, has provided financial assistance to gold mines suffering from the effects of rising production costs and an artificially fixed price for gold. This enabled the mines to stay in business and thus to provide a livelihood to the gold-mining communities, mostly in northern Ontario and Quebec. Even with this financial aid, many gold mines have ceased operating, and the number of lode gold mines receiving assistance under the act declined from 87 in 1948 to 28 in 1971.

In late 1971 a dramatic change occurred in the gold market that gave a new lease on life to the gold mines. The price of gold in open markets suddenly rose to $44 per ounce at the end of 1971 and to $48 per ounce in March 1972. This made it more profitable for Canadian gold mines to sell their output in the open market and thus to forego the EGMA aid, which was tied to the provision that the production be sold to the Canadian Mint. If the open-market price continues to be high, the prospects for the survival of Canadian gold mines are good, and new gold mines may be started.

Assistance under EGMA has been contingent on inspection of mines by engineers of EMR's Mineral Development Sector. Maximum assistance is $10.27 per ounce of gold produced. From 1948 to 1971, inclusive, payments totalled $301,270,629. During 1971 alone, payments amounted to approximately $11.8 million—down from $13.7 million the year before.

An amendment to EGMA enacted in February 1971 made it mandatory for mines receiving assistance to give notice of closure at least four months in advance, to use the services of the Department of Manpower and Immigration in hiring of new employees and in the placement of employees idled by mine closures. The amendment also extended the life of EGMA to June 30, 1973.

Foreign Aid

Resource development in developing foreign countries is one of the aims of Canadian foreign assistance dispensed under the auspices of the Canadian International Development Agency (CIDA). Of the $300 million allocated to foreign aid by CIDA in 1971-72, approximately five to six million dollars was destined to resource development. The Department of Energy, Mines and Resources plays a significant part in channelling this type of aid.

Practical training in many aspects of the earth sciences is given to some candidates from developing countries. These candidates may be supported either by CIDA or by an agency of the United Nations. Several EMR

experts are sent abroad each year as technical advisers. Also, capital assistance, primarily in mapping and geological surveying, is planned and supervised by EMR personnel.

Two technical-assistance projects were started during the year—a copper-mining project in India, and a lead-silver prospect in Burma. The department recommended that two mining experts be provided to India, and that a geologist, diamond-drilling supervisors and two diamond drills be provided to Burma. Assistance was rendered in the recruitment of qualified personnel.

Departmental experts from the Geological Survey of Canada supervised aeromagnetic survey contracts on behalf of CIDA in various West African countries and in Guyana.

Much time was spent in late 1971 in preparation for the second session of the United Nations Committee on Natural Resources, which is sponsored by the U.N. Economic and Social Council. The session was held in February and March 1972 at Nairobi, Kenya. The Canadian delegation was headed by J. P. Drolet, assistant deputy minister (mineral development) of EMR.

Technology and Environmental Concerns

TECHNOLOGY

A large share of the research carried out by the department is aimed at increasing the level of technological effectiveness in Canada. Because of EMR's mandate in the field of non-renewable resources, such research is concerned chiefly with mine safety, the concentration and beneficiation of ores, the processing of fuels to a marketable state, metallurgy, the methodology and instrumentation used in various geological, geophysical and topographic surveys, etc. Every year, Canadian companies active in the resource field benefit from technological advances produced by EMR research, and the work of the department itself progresses through continuous innovation.

Patterns in Fuel Technology

The department, through its Energy Development Sector, is co-operating with the Science Council of Canada in considering the kind of research that would contribute to the conservation and more effective use of energy sources.

Not all of Canada's coal deposits can be mined economically and safely with existing technology, especially where thick coal seams dip steeply. Techniques used for similar seams in other coal-producing nations are being examined to determine whether they can be applied in Canada. The transportation of coal, a bulk material of low unit value, has always been a problem in Canada, where coal fields are often far from industrial markets or export points. The department has been co-operating with the railways, coal producers and coal consumers in reviewing transport systems, including unit trains and pipelines.

The design and operating characteristics of Canadian nuclear reactors have also come under departmental scrutiny. The excellent performance of the first three Pickering reactors has rebutted many critics of the Canadian design, which uses natural rather than enriched uranium as reactor fuel. Analyses have indicated that it would be premature to embark on any substantial research to develop fast-breeder or thermonuclear reactors.

To keep Canada in the forefront on electrical technology, substantial capital support is being given to the Hydro Quebec Research Institute, whose research projects are reviewed by an advisory committee with departmental representation.

Stringent safeguards have been developed for offshore exploration for petroleum, aimed at preserving the ocean environment from contamination. The expanding exploration activities also encourage the companies concerned to develop new technology. The drilling units, among the largest in the world, now cost $25 million each to build and $40,000 per day to operate. The department, through its Resource Management and Conservation Branch, exercises considerable influence on the design of these units and of other exploration equipment.

Automation and Surveying and Instrumentation

The Surveys and Mapping Branch made a start in the development of a data bank of geodetic-control surveys. Electronic development was completed on three projects concerned with the automation of surveying procedures.

Several studies will have a profound impact on departmental mapping. A computer program purchased from the University of Stuttgart was tested for use in adjusting large photogrammetric blocks. This program can accommodate a wide range of ground-control configurations, with a minimum of control points. Operational procedures and specifications are being designed and documented to use this program in production.

A second program, which involves the completion of a photogrammetric adjustment method, contains many features peculiarly suited to the Canadian geography and is therefore potentially attractive to Canadian mapping companies.

Two months of geological surveys in various parts of the Canadian Shield were devoted to experimental/airborne gamma-ray spectrometry surveys. In addition to providing data useful to resource discovery, the results of this work will lead to improvements in equipment and techniques.

Geologists studied the electrical properties of rocks and sought to improve the instrumentation involved. Preparations were made for testing the use of seismic methods in defining the location, shape and size of sulphide orebodies. Other technological studies concerned airborne magnetometry and color photography as aids to geological mapping.

The Earth Physics Branch has equipped six of its magnetic observatories with automatic recording devices, eliminating the need for daily attention by a skilled operator. This system is now being tested.

An improved calibrator for meters measuring earth tides (movements of the earth's solid mass analogous to ocean tides) was built by the staff of the Gravity Division and is now being tested.

Metallurgical Technology

The Physical Metallurgy Division has developed great expertise in dealing with molten and solid metals, both alloyed and unalloyed. This research on melting, casting, and performance of metals has enlarged and improved Canadian technology in these fields.

One type concerns the behavior of molten metal in moulds. This is studied with X-ray fluoroscoping equipment, movie films, and fluidity tests. It is possible to produce alloys which, when exposed to certain temperatures and loading conditions, can be stretched by as much as 25 to 50 times their original size. Such alloys are said to be superplastic.

The department's metallurgists are studying the feasibility of producing zinc-aluminum alloy forgings by this method, which can produce very complex shapes by low loads. The main drawback is the slowness of the process.

The phenomenon of superplasticity in steel is also being studied, with the use of various thermomechanical treatments to obtain the best superplastic properties.

A very specialized project is the development of a new surgical needle. In microsurgery on small blood vessels it has been found that available needle-suture combinations are too large to avoid considerable tissue damage, which may lead to thrombosis. The physical metallurgists have made needles of significantly smaller diameter from unconventional metals and alloys of exceptionally high strength and flexural rigidity. Initial tests on laboratory animals have proved successful. Experimental needle-suture combinations have been prepared by electro-polishing and by laser welding for more extensive tests.

Work is continuing on the evaluation of the susceptibility of high-strength alloys to crack from environmental effects.

The addition of very small amounts of rare-earth metals, such as cerium, to structural steel can effect a great improvement in the rolling properties of steel. This, too, is being studied.

The development of titanium alloys containing aluminum has been retarded because when aluminum content is too high, the steel shows poor ductility and is susceptible to cracking. Research has shown that by substituting gallium for some of the aluminum an experimental alloy can be produced with considerable ductility and no loss of strength. These experiments have aroused considerable interest among metallurgical investigators generally.

Pipeline construction in Canada may benefit from current tests for defining the resistance of steels to sudden stress ("dynamic fracture toughness").

EMR's Physical Metallurgy Division acts as examining authority on behalf of the Canadian Government Specification Board for certification of personnel for non-destructive testing. Since the inception of these examinations eleven years ago, 2,300 persons have been examined, 22 per cent of them during the past year. Tests were held in eleven centres across Canada.

Petroleum Technology

As Canada's demand for petroleum products increases, there is a growing need for exploitation of lower-grade crudes. The work of the Fuels Research Centre has therefore focused on beneficiating low-grade petroleum, which has a high sulphur and a low hydrogen content. A method was found to increase the yield from Athabasca bitumen by two per cent—a significant amount in terms of annual production. Work was also done on improving catalysts used in petroleum refining.

Since natural gas is in ever shorter supply, an engineering study was made of other sources for the production of carbon black. Results are not yet complete.

The growing concern over the adequacy of Canada's petroleum resources in the face of expected future demands has prompted research into the incorporation of petroleum in coal as a means of stretching available petroleum resources. The difficulties in manufacturing, transporting and storing such slurries are numerous. It was found that acceptable flames could be produced with coal-in-oil mixtures, but that combustion rates of the various coal components varied widely. This requires further study.

Mine Design

Better design of mines, both underground and open pit, is aimed at improving safety and extraction rates.

Approximately 300 million tons of waste rock and 300 million tons of ore are being mined annually from open pits in Canada. If the rock slopes forming the walls of these large excavations could be designed with the same degree of accuracy as soil slopes, and if support systems could be developed comparable to those used for underground excavations, waste volumes could ultimately be reduced, resulting in substantial economic savings. Funds are being used to expand research in this area through outside contracts to universities, consultants and companies. The objectives of this project are to develop: design systems suitable for open-pit rock slopes, artificial support systems for open-pit rock slopes, and reclamation procedures for waste embankments.

A series of tasks is to be completed within the next three years, so that in the fourth year an engineering handbook on designing pit walls can be drafted for the use of staff engineers on mining properties. The task areas are as follows: (a) groundwater pre-mining survey, operations monitoring and controlling; (b) blasting effects and design; (c) structural surveying and analysis; (d) testing for field properties; (e) monitoring of effects of excavation, and (f) design analyses including both technological and economic data. The work in task areas (a) to (e) is being done on contract by universities and consultants with some assistance on instrumentation by Mines Branch staff; (f) will be done by Mines Branch staff.

Full-scale trials of artificial support for slopes are to be initiated in different rock types so that the effects of variations of geology and rock properties can be evaluated. Two contracts have been let to mining companies, with associated consultants, to conduct these trials.

The first phase of the reclamation work has been the production of *Tentative Design Guide for Mine Waste Embankments in Canada.* Work is continuing in co-operation with the Extraction Metallurgy Division on the effects of current operations on water quality, on alternate land use, and on the probability of public hazards. Vegetation studies are being done at Elliot Lake and, through the co-operation of the Department of Agriculture, at the Soil Research Institute, Ottawa.

By following the handbook on design produced by this project, waste volumes should be ultimately reduced by more than 25 million tons per year, representing a saving of more than $12 million annually. In addition to the monetary benefits, regions should benefit socially from the expanded production. Throughout the national economy other industries should benefit from the technological fallout, e.g., in the construction of highway and dam excavations.

Underground metalliferous and industrial mineral mines continue to be the backbone of mining in Canada. Research in these mines is concerned mainly with arti-

ficial support systems to improve the proportion of the resource that can be extracted. Civil-engineering techniques of cable bolting are being tested in connection with roof stability. Cut-and-fill is the most common mining method, and the stabilizing effect of back-fill is being assessed.

Work is proceeding on the development of advanced mining technology, which, while preserving the environment, will also lead to a greater utilization of mineral and energy reserves and to an improvement in Canadian mining techniques and management.

Another project is concerned with determining the best extraction ratio for salt mines. It was found that by leaving natural pillars of different design salt mines could obtain much higher extraction rates without impairing roof stability.

Ore Treatment

"Hydrometallurgy" is that branch of ore processing which uses liquids rather than heat to separate metals and gangue. Leaching is an important hydrometallurgical method.

One of the methods studied by the department in this field is percolation leaching of lump sulphide ores with bacterial solutions. Earlier work both in the laboratory and at the uranium mines had shown that such methods can be used on certain sulphide-bearing uranium ores in the mine itself, resulting in lower costs and less damage to the environment, because less material is brought to the surface. During the past year, preliminary work on copper-nickel sulphide ores has shown that the technique has possibilities for certain of these ores, though leach rates would be lower.

Acid pressure leaching of nickel-copper sulphide concentrates in a stirred reactor has also been studied, and has shown promising results. One of the benefits is the recovery of sulphur in the elemental form, which again reduces environmental damage.

Mathematical modelling, though widely used in industrial practice, has not yet found much application in metallurgy. The department is carrying out studies on ways of raising extraction efficiency with the use of generally applicable mathematical models.

The provision of technical evaluation, advice and background information on non-ferrous extraction metallurgy to private industry and other government departments has been an important function of the Extraction Metallurgy Division. This has included support of several co-operative EMR-industry groups formed for the exchange of information.

In its laboratories, the division is developing corrosion-resistant coatings for steel that will give a longer life to mill equipment, such as flotation cells and ball mills. Electroplating has produced chromium coatings with superior corrosion resistance. Other studies concerned new applications of X-ray emission spectroscopy, determination of organic reagents used in solvent extraction for metal recovery, and the automation of laboratory procedures.

To further the standards of analytical chemistry in Canada, the department is collaborating with the Canadian Mineral Analysts in the compilation of a *Canadian Assay Manual;* the first installment was scheduled to appear in mid-1972.

"Flotation" is the separation of the metal in pulverized ores from waste material by the use of solutions that will cause the metal particles to float above the waste. Flotation research is an important function of the Mineral Processing Division.

Among the various methods investigated were the concentration of metallic ions in flotation pulp, measurements of electric charges on flotation bubbles, filter cloths used in industrial plants and the electrochemistry of filtration, and development of a reagent to selectively float wolframite in tungsten ores that may lead to better recovery of wolframite.

The department has developed a process to selectively float antimony sulphides. Flotation of antimony ores is a recent development; former sources of antimony were lump ores from the Far East. Two Canadian mines now use flotation, but their process is not very efficient. A patent application for the EMR process is pending.

Continued research on recovering iron previously discarded in tailings has produced methods now being applied to the tailings from Carol Lake and to the "treat-rock" discarded mine waste at Schefferville. Departmental experts are co-operating with the company in the final phases of flotation research on the Schefferville ore in preparation for putting the new flotation plant in operation. Completion of these proj-

ects will materially increase the use of the orebodies concerned and thus conserve Canada's iron resources.

Many Canadian reserves of iron ore contain sulphides in such proportions as to prevent their exploitation, especially with present stringent anti-pollution regulations. Research has been completed on the flotation of pyrite from an iron-carbonate ore that will make possible the continued operation of a company's sintering plant; also, a flotation method has been developed for removing sulphides from iron ore produced by a potential iron mine. A copper concentrate is a valuable by-product.

Laboratory research in co-operation with private research has resulted in the development of treatment methods for a large complex sulphide-oxide orebody in New Brunswick with the recovery of lead, zinc, tin, tungsten, molybdenum, bismuth and fluorite. Pilot-plant studies have confirmed the metallurgical results, and feasibility studies are now being carried out by the company.

Studies on the development of technology for new techniques and processes for the beneficiation of Canadian industrial minerals were carried out on fluorite-barite and celestite from Nova Scotia; beryl spodumene and graphite from Quebec; ultrabasic rock, kaolin and tremolite from Ontario; spodumene from Manitoba; marl from Saskatchewan; magnesite from British Columbia; and scheelite from the Northwest Territories. Of particular interest has been work on the floatability of celestite in which the effectiveness of new taurates as collectors at various concentrations and low temperatures was investigated. Comparative grinding trials were carried out on 20 non-metallic minerals.

Much of the research in the Mines Branch is concerned with more fundamental studies into the structure of metal-bearing and other useful minerals. This includes the development of standards for the uniform assessment of minerals. In the analytical field, the department participates in the development of nationally and internationally acceptable methods of analysis for metallic constituents in ores, minerals, alloys, etc., on behalf of various standards associations. A range of standard reference ore minerals, typical of mineral deposits across Canada, is being developed. Statistical treatment of analytical results is being developed in co-operation with other agencies.

Another important field, whose results are of immediate interest to producers, is the on-stream analysis of ore slurries. A pilot plant has been developed for on-stream slurry analysis as an aid in process control in mills, with the use of X-ray fluorescence. A Canadian company has undertaken to develop an X-ray fluorescence unit based on this pilot plant. Other methods for characterizing slurries are also being studied, including the use of radio-isotopes for exciting the X-rays from the two or more elements to be determined.

Studies continued on means of producing new aggregates for construction and on the improvement of the quality of existing construction materials of mineral origin. Experimental concrete and cement mixes were subjected to various tests, including the effect of adverse environmental conditions on the test specimens.

Coal-Processing Technology

Canadian coal is staging a remarkable comeback after two decades of relative eclipse. However, modern ferrous metallurgy and combustion technology often require considerable processing of coal before use, which places a research burden on Canadian coal mines.

Substantial progress was made during the year in modern coking technology, especially in the field of form-coking processes. It has been found that recycling the coke breeze, which reduces the amount of low volatile coke in the oven charge, yields more coke. Two Canadian steel plants are now carrying out commercial trials of this process, and a third plant is considering experiments.

Research and development on coal washing continued at the Western Regional Laboratory in Edmonton. Consolidation of the coal-processing plant (with a capacity of three to eight tons per hour) progressed satisfactorily. The reconstitution plant for pipeline-sized coking coal, which used oil-agglomeration technology, was adapted to the dewatering of typical coal products and recovery of plant water. The coal-processing plant has become identified with the name "EMR Process," which designates the design and operation of its particular coal-washing circuit. A plant using the process is under construction at a mine in western Canada.

A two-year $511,000 program is under way to find economic ways of reducing the sulphur content in Cape

Breton coal. This research is being undertaken in aid of the Cape Breton Development Corporation which is seeking to produce coking coal at its new Lingan mine near Sydney, N.S. Information gained from the work at the Lingan pilot plant could also be applied to treatment of coal waste from mines at Springhill, N.S., and in New Brunswick.

Special attention is being paid to the so-called "combined-cycle" system of power generation which is now being developed extensively in the United States, Germany and elsewhere. In this system, which many experts believe will be the basis of a new type of thermal power plant, the fuel is turned into gas by air and steam pressure. The pressurized gas, after purification, is used first in gas turbines and the waste heat is then conducted to steam boilers which power steam turbines. The method has the advantages of lower capital costs and higher operating efficiency. Sulphur control is achieved more easily by this method than in other processes, so that air pollution is reduced.

Several types of Canadian coal may be suitable for this new combustion system. Also, coal-in-oil slurries might be used, which would encourage the movement of cheap strip coals from the Prairies to Ontario in slurry pipelines. Studies of these technological possibilities continue.

Development of Equipment and Instrumentation

Much of the work described in the foregoing sections would be impossible were it not for the development of specialized equipment and instrumentation in the technical services shops of the department itself. Often such equipment cannot be obtained on the market; also, available equipment requires adaptation, modification and installation before it can be put to use.

One of the most important tasks in 1971–72 was the equipping of the coal-research laboratories on Corkstown Road, west of Ottawa. Among the equipment designed and built by technical services staff was a coal-crushing station with vibratory sorter, a unit that splits up coal samples in such a way that several portions will be identical in every way; a "dry" coal quencher that uses water jackets instead of a stream of water; and a special door-lifting mechanism for the twelve-inch coke oven.

In conjunction with personnel of the Explosives Division, a door and a door lock for explosives magazines was designed. The drawings that were produced for this equipment have been incorporated in the EMR publication *Standard for Blasting—Explosives Magazines*. The new design meets more stringent safety standards. A number of models of the door lock were made for purposes of demonstration, and one has been given to each area inspector of explosives.

The staff built a machine for testing tear strength of materials from existing specifications.

Installation and distribution of electrical power circuits in the Mines Branch plants were also in the hands of technical service staff. A test facility for diesel engines was designed and installed under contract by the Department of Public Works.

REMOTE SENSING

The remote-sensing activities of the department are concerned with the scanning of Canada's land and water areas from aircraft and satellites and the development of the necessary technology.

Aerial survey and air photography have long played an important part in mapping Canada's territory and in helping to assess various resources, such as forest cover, agricultural crops, wildlife, etc. The development of sophisticated cameras and films—especially various types of infrared films and filters—as well as other types of sensors, and the possibility of placing such sensors in high-flying aircraft and in orbiting satellites has opened a new era in the mapping and evaluation of the Canadian environment.

Although remote-sensing techniques had been used for some time by various government and private agencies in Canada, the national effort in this field did not receive central co-ordination and planning until early 1971, with the establishment of the Canada Centre for Remote Sensing as a branch of EMR.

In May 1971 an agreement was signed between EMR and the U.S. National Aeronautics and Space Administration (NASA) whereby Canada would receive remote-sensing imagery from an orbiting satellite that was to be launched by the U.S. agency in 1972. At the same time, the Department of National Defence agreed to supply aircraft, crew and maintenance for airborne remote sensing under contract to EMR.

The cabinet approved a supplementary budget in July to increase the capacity of the Air Photo Production Unit and the National Air Photo Library, a budget for the remote-sensing program (airborne and satellite), and the establishment of the new Interagency Committee on Remote Sensing. In January 1972 that committee approved the terms of reference of the Canadian Advisory Committee on Remote Sensing, which consists of members from various levels of provincial and federal and private research establishments.

The Prince Albert Satellite Station (formerly known as the Prince Albert Radar Station) was completely refurbished to allow its use for the reception and recording of data from the Earth Resources Technology Satellite (ERTS), which was to be launched by (NASA) in July 1972. This work involved replacement of the antenna feed and tracking systems for the 85-foot-dish antenna, installation of new receivers and special recording equipment. A "quick-look" system producing instant photographs of the imagery flowing in was included in the system.

At the same time, the Ground Data Handling Centre was built up in Ottawa, containing the computers and other devices for transforming the tapes of ERTS imagery flown in from Prince Albert into corrected photographic film.

Airborne remote-sensing projects were flown for investigators in federal and provincial governments, universities and private industry. All these projects involve extensive ground-truth investigations, which are conducted by the principal investigators. Much of the data thus acquired will be used in evaluations of ERTS imagery.

Flying was carried out with one CF-100 and one C-47 aircraft; 28,000 sensor line-miles were logged. A Falcon aircraft, completely equipped for remote sensing, was purchased in January 1972. It will be serviced, maintained and operated by DND crews. A second DND-owned C-47 was obtained in the fall of 1971. A considerable number of man-hours were expended in the design of the most desirable configuration of this aircraft and the type of sensor package it will carry.

The Canada Department of Agriculture and the Forest Management Institute of the Department of the Environment have continued to make heavy demands on airborne sensing. The International Year on the Great Lakes created a demand for a number of preliminary investigative flights, necessitating a large portion of winter flying.

The sensor-development program, now in its second year, is being directed toward better ways of detecting air and water pollution, the physical properties of sea ice and improved methods of surveying Canada's natural resources. Competent sensor-development groups in industry, university and government were approached to undertake specific projects that were conceived from the wide range of requirements laid down by the user working groups of the Canadian Advisory Committee on Remote Sensing.

In air pollution, a laser ranging device know as a Lidar has been operated at York University to measure atmospheric constituents over the city of Toronto. Barringer Research Ltd. has tested a remote sensor for use in air-pollution monitoring over the Yellowknife region. Other air-pollution systems have been studied.

Water-pollution instrumentation includes a laser fluorosensor, developed by the University of Toronto Institute for Aerospace Studies, that was tested on the ground with the use of a trailer installation located at high vantage points. When the laser is pointed at the water surface pollutants such as oil slicks fluoresce. The fluorescent radiation is detected by a suitable sensor boresighted with the laser. Such an instrument can also be used to trace harmless fluorescent dyes introduced into streams and industrial-waste systems for tracking plumes and identifying polluters. Another system, developed by Spar Aerospace Products Ltd., uses an image-dissecting camera for tracking algae growths and other manifestations of pollution in the Great Lakes. It relies on the spectral signature and thus should find a wide range of uses in resource surveillance as well. Flight trials are planned for 1972–73.

An entirely new principle is being exploited for measuring the thickness of sea ice. Developed by members of the Department of Electrical Engineering, University of Toronto, the instrument uses the optical principle of holography in the microwave region to measure ice thickness and other physical characteristics. The Holographic Ice Survey System, known as the HISS radar, has been tested in a helicopter in the Toronto area, but will be tested in the Canadian Arctic in the winter of 1972–73.

An important event in the field of remote sensing was the First Canadian Symposium on Remote Sensing, held

in Ottawa in early February 1972. This symposium was attended by about 500 delegates from all parts of Canada who listened to over 60 scientific papers on all aspects of this burgeoning new branch of science.

ENVIRONMENTAL CONCERNS

While a concern for the preservation of the natural environment and the conservation of non-renewable resources permeates most of the activities of the department, certain research projects are dedicated exclusively to these principles. For example, the manner in which Canada's energy potential is being used will have a profound effect on the environment. Electrical energy is generally regarded as "clean," especially in comparison with coal and oil; but it must be remembered that electrical energy is not found in nature as a ready resource but must first be generated, either by harnessing water power or by the combustion of fuel. All fuel, including uranium, discharges heat into the environment, such as the lakes and rivers whose water is used for steam cooling, and this causes what is known as "thermal pollution." Aware of the problem, the department, in close conjunction with the electrical-power companies, is carrying out an assessment study of such dangers.

Again, the exploration for petroleum and natural gas which is now taking place off the east and west coasts of Canada carries with it the well-documented danger that the fragile marine environment may be polluted by oil spills and that the activity itself may disturb the ecological balance. To counter such dangers, the department's Resource Management and Conservation Branch, which exercises jurisdiction over offshore exploration, has laid down stringent safeguards under which exploration teams must operate.

Terrain Protection

Comprehensive studies of the terrain—and especially the soil—have only recently been recognized by industrial and urban planners as a prerequisite to responsible development. The need is particularly acute, as in Canada many soils either are of the alluvial type or are subject to severe frost effects, including permafrost.

The Terrain Sciences Division of the Geological Survey of Canada has embarked on an ambitious program of such studies, both in the inhabited and uninhabited parts of the country. The urban terrain was studied with the aid of borehole records from 27 cities. Data from 110,000 borehole records are now available for all major Canadian cities; these will be of great assistance in urban planning. This study, which was carried out almost entirely under contract, involved over 430 persons and 1,173 man-months.

In the Arctic, the Mackenzie Valley has attracted the concern of conservationists because of planned road and pipeline construction. To gain a better knowledge of that terrain, geologists are mapping 40 map-areas; during 1971 field work was completed on 26 of these. Field work was also carried out to determine the engineering-geological characteristics of earth materials and to evaluate factors affecting terrain performance. A field laboratory in engineering geology was set up at Fort Good Hope. Geologists also described and interpreted landforms in the Mackenzie Valley and the behavior of permafrost.

Construction of the new Montreal International Airport at Ste. Scholastique, Que., is requiring much geological information, and geologists have established a project to map, describe and explain the surficial deposits and landforms, to investigate the geodynamic processes and to determine the bedrock configuration beneath the area. These data will be valuable in planning for engineering construction, industrial development and land use, agriculture, and water supply.

The disastrous landslide at St. Jean Vianney, Que., in May 1971 prompted a request from the government of Quebec for engineering-geological assistance, and officers of the Geological Survey and the National Research Council participated in an on-site study as well as in an evaluation of proposed remedial measures.

Increasing urbanization in Canada will make effective urban land use of great importance. A prototype study initiated in 1970 in the Ottawa-Hull area (where field costs would be minimal and the program could be carried out by staff in conjunction with other duties) was continued in 1971. The purpose of this study is to develop methods of compiling, evaluating and presenting geological information for the areas to meet the needs of engineering and planning. This is being accomplished by preparing a comprehensive data base which will illustrate distribution, thickness and physical properties of surficial and bedrock materials and the magnitude and effect of active geological processes.

The program will allow six types of maps to be produced: bedrock topography, drift thickness, water-table elevation, distribution of surface material, and two types of proximal maps in which distribution of up to ten types of materials can be plotted by symbol. The importance of this type of information for regional planning in urban areas is obvious, especially for those charged with long-term planning.

Studies similar in aim but less comprehensive were carried out near Tuktoyaktuk, District of Mackenzie. Particular emphasis was given to the location of aggregate, and two areas of gravel suitable for construction uses were found. The data obtained during the study should prove valuable in planning future expansion of this far northern coastal settlement.

It has long been known that certain marine clays deposited along the St. Lawrence and Ottawa valleys during Champlain Sea time are unstable and prone to landslides. In mid-August a preliminary study, designed to identify some of the parameters significant to delimiting these deposits, was begun in co-operation with the Quebec Department of Natural Resources. Initial studies were made in the Gatineau River valley; these will eventually be extended to general landslide problems in eastern Canada.

Mapping of the surficial deposits of the Winnipeg area was completed. This study was designed to map, describe and explain the Quaternary deposits and landforms, to provide areal information and also background information applicable to soils and mapping, engineering and groundwater in this region, which includes one of Canada's major urban areas.

A study of the Quaternary geology of the Bow River valley was completed. The main object of this study is to produce a surficial map of the Calgary area that will complement subsurface data obtained from a drilling and well-logging program carried out in 1967 and 1968. The two sets of data will form a valuable basis for engineering-geology studies in the Calgary area.

A study of natural slope stability in the Fraser Canyon area of British Columbia was commenced during the report period. The area was selected on the basis of abundance of known slides and their danger to transportation routes, hydroelectric transmission lines and inhabited areas. Eighteen slides were mapped and the results obtained will permit a better assessment of remedial measures.

The Canadian standard seismic network, consisting of 23 observatories widely distributed throughout Canada and equipped with short- and long-period seismographs, continued in operation. The additional network, which gives better coverage of local earthquakes in earthquake-prone areas of Canada, was strengthened by the opening of an electronic regional station at Whitehorse, Y.T., in order to improve knowledge of the seismicity of the Mackenzie Valley and potential pipeline routes.

General and specific studies of Canadian seismicity continued. The country-wide results for 1966 were sent to press—about 400 Canadian earthquakes were detected, located and their focal parameters determined. The continuing study of Canadian seismicity was, however, further delayed by a concentrated effort on a study of the seismicity of potential pipeline routes to the western Arctic. Much technical information was made available to the interested consortia, and a start made on a major report summarizing all available information and calculations.

A number of very important papers were published in the continuing research and development program into the detection, location and identification of underground nuclear explosions. The division assisted External Affairs in the preparation of working papers for the Conference of the Committee on Disarmament and in their presentation. This work continued to attract favorable attention around the world and evoked editorial comment in scientific journals, political magazines and in hearings on disarmament and arms control in the United States Senate.

Other investigations concerned the seismological implications of the large-yield underground nuclear explosion of November 1971 in the Aleutian Islands; geothermal phenomena in various parts of Canada, especially the Arctic; permafrost behavior; and a co-operative program between Calgary and Herstmonceux, England, on so-called plate-tectonic motions, i.e., the extremely slow lateral shifting of large blocks of the earth's crust.

Safety and Pollution Abatement in Mining and Metallurgy

The Mines Branch, apart from helping Canadian industry to rationalize its plants and to improve its output in fuels and metals, is also taking a leading role in showing Canadian mining and metallurgical companies

ways and means of increasing the safety of their staff and reducing the pollution of air and water resulting from their production processes.

In Canada, as in most industrialized nations, the highly concentrated and mechanized extraction methods used in modern mining have increased the amount of respirable dust. Studies are therefore being conducted in the department into the physics of airborne dust in its measurement, including the classification of mine environments in terms of dust hazards and mine ventilation.

A comparison of dust-sampling instruments in Ontario mines was completed in 1971, as a co-operative venture among the department, the McIntyre Research Foundation and the Mines Accident Prevention Association. The samplers are worn by miners going about their daily work. Field work was completed in 1971 on an underground trial to clean up mine air by filtration. Various substances were tested for cost and efficiency as filters, and vermiculite was found to be a practical filtration medium because of its low cost, even though its efficiency is only moderate. A drastic decrease in lung diseases among miners is looked for from this research.

Spontaneous combustion has troubled coal mines for many years, particularly in mining the softer coals. Heating in waste areas and seam fires has occurred in western coal mines. Fires in coal mines are a great danger because of the potential ignition sources of methane and dust explosions, along with smoke, carbon monoxide, and roof falls. The department is endeavoring to develop an underground detector of early stages of spontaneous combustion and a continuous monitoring system linked to a computer that will alert mine management.

In pyrometallurgy—the extraction of metal by heat—considerable progress was made in suppressing fumes produced by electric ferro-alloy furnaces. This metallurgical method is widely used in Canada and has given Canadian producers a competitive advantage. However, it is important to overcome the rather serious pollution caused by these processes. A novel method of controlling the silica dust from the silicon furnaces was devised and tested at a small scale with such success that patent applications were prepared. Research on a larger scale is continuing.

In the processing of Alberta tar sands significant amounts of fly-ash are produced. The ash causes pollution but contains valuable carbon, nickel and vanadium. A process that would permit extraction of these materials and at the same time solve the pollution problem is a highly desirable research goal.

A pilot-plant experiment confirmed that the carbon can be separated from the fly-ash by flotation, with acceptably low losses of nickel and vanadium. The carbon fraction was, in fact, sufficiently pure to be of economic value. The residue contained most of the nickel and vanadium, but was highly siliceous.

Three approaches were tried for reducing the silicon content of the material—a magnetizing roast, a metallizing roast, and flotation. None yielded encouraging results. Two new approaches are now being investigated.

The first consists in flotation of the coke feed before it is exposed to the high flame temperature of the boilers, in an attempt to separate the various constituents.

The second approach consists in completely reducing the nickel, iron, vanadium and a little silicon from the ash material, leaving most of the silicon in a slag, which can be discarded. This procedure concentrates all the metallic constituents in a fraction which has approximately one tenth of the original ash weight. Preliminary experiments indicate that good recoveries are possible, and that the nickel and vanadium can be separated by a partial oxidation of the metal.

The resurgence of underground coal mining in western Canada is threatened by two dangers—gas outbursts, which at present limit mining depth to 1,000 feet; and roof instability, which limits extraction and productivity. To take full advantage of the expanded market for coal, western coal mines will have to be aided in the development of new mining methods along with safety measures. The department is investigating the structural conditions of several coal fields in conjunction with roof-control and gas-outburst studies. Detailed mapping and analysis of existing roof falls and drill cores will be carried out at one property in an attempt to predict zones of potential roof fall. On-the-spot measuring techniques are needed to understand the mechanisms of gas outbursts and to develop control measures. Preliminary studies are now being carried out.

Another danger faced by miners is created by unsafe diesel engines. To eliminate this danger, the staff of the

Canadian Explosive Atmospheres Laboratory has been working on the design and instrumentation of a testing facility for diesel engines. The laboratory certifies diesel engines with respect to the emission of toxic gas and safety from the ignition of explosions. The use of diesel-powered equipment in new highly mechanized coal mines is expanding, and the testing facility will be greatly appreciated when it comes into operation at the end of the year.

A different problem is being faced at Springhill, Nova Scotia, where a bank of coal waste is burning and causing air pollution. Departmental researchers, assisted by the Department of Mines of Nova Scotia, have analyzed the situation and concluded that the hill contains 1.7 million tons of waste; some of this is burned out, but other areas contain sufficient combustible material to sustain the fire, and the pollution, for years to come.

The fire could be put out and the land reclaimed by moving, cooling, compacting and sealing the waste. It may be possible to reduce the costs of such an operation by using the coal in the waste for the generation of electric power.

Abatement of Air and Water Pollution

Air pollution from the combustion of fossil fuels continues to plague Canada's urban and industrial centres. Research into ways and means of producing cleaner flames and cleaner smoke therefore receives much attention from departmental experts.

To study burner aerodynamics a research tunnel furnace was built and put into operation. This furnace permits detailed studies of the heat-release from flames, and a longitudinal slot permits the flames to be probed for aerodynamic measurements, chemical composition and particulate production. This research facility enabled a study to be made of a series of twelve burners on behalf of the Oil Heating Association of Canada for the improvement of domestic oil burners.

Two plume surveys, one at Great Canadian Oil Sands Limited, Fort McMurray, Alberta, and one at Boundary Dam Power Station, Estevan, Saskatchewan, were carried out. Data from these two studies are being reduced and collated. These surveys were conducted to obtain a clearer concept of the influence of the local factors of climate and topography on plume dispersion. This information is essential to define the limits which must be placed upon energy generation in a given area with existing technology.

The improvement of oil-spill detection requires the development of analytical methods that are capable of characterizing petroleum accurately even after it has been subjected to considerable weathering that tends to preferentially destroy the saturated compounds. During the year good progress was made in developing a "fingerprinting" method based upon a chromatographic separation according to boiling point. This system involves two detectors, one for the sulphur-containing compounds, and the other for the hydrocarbons. Highly characteristic "fingerprints" obtained on Canadian crude oils give a very promising indication that this approach will be successful.

The major effort in elimination of pollutants from fuels has been made in the development of hydrogenation processes for the removal of sulphur from heavy low-grade crude oils, such as that which occurs in the Athabasca tar sands, and residual oils since this class of fuel must eventually be used to sustain a considerable proportion of the economy. Good progress was made during the year in defining the conditions for more economical refining of Athabasca bitumen by hydrocracking.

In areas where sulphide-bearing ores are mined and processed, acidic waters are generated through the oxidation of metal sulphides and become a hazard to the environment. The oxidation is often catalyzed by the action of bacteria on the ore sulphides. A simple pollution-control measure is the neutralization of such acidic waters with lime; the application of such neutralization techniques, which also precipitate much of the dissolved salts, was studied for several mining situations. Where properly done, this technique is very effective, but where further purification of the waste water is required, ion exchange appeared to offer the most feasible route, technically and economically, and studies were carried out to evaluate the principal factors governing the application of this technology.

Studies on improving the technologies for removal of dilute sulphur dioxide from stack gases were continued, in particular those techniques using lime or magnesia.

A detailed investigation has been undertaken of atmospheric pollution caused by gaseous and particulate emissions from the stacks of small cold-blast cupolas such as are used throughout the country by the small

iron foundries. The initial stages of this investigation consisted of the collection of samples and the concurrent monitoring of cupola-operating practice at six small foundries. Reductions in dust production of over half the range could be achieved by changes in operating practice.

An important new line of research initiated by the department concerns the use of waste material produced in mining and metallurgy. If waste could be turned into useful by-products, another polluting factor would be eliminated or at least reduced.

Long-term studies were completed on the conversion of waste gypsum from Canadian fertilizer plants into useful gypsum products. Results showed that gypsum products having properties such as time-of-set, strength, and bond to gypsum wallboard paper as good as those from natural gypsum plasters, could be produced by using by-product phospho-gypsum. Bases added to neutralize the acid by-product plaster of paris tended to lower the strength of the plaster but it nevertheless met CSA specifications.

Preparation of an inventory of Canada's waste-mineral resources was started. The inventory will be used as a basis for the selection of research projects on mineral-waste utilization. In addition, a mineral-waste index of past work and references has been established.

During the fiscal year 1971–72 efforts in the Mineral Sciences Division on those projects concerned with environmental improvement have significantly increased by comparison with the previous year. Studies of the processes occurring during the weathering of tailings and slag piles are being conducted under carefully controlled conditions; the biological, physical, and chemical aspects of weathering in tailings ponds and piles are being investigated.

Other environmental projects seek to modify treatment processes of sulphide ores in such a way that they will not result in the emission of sulphur dioxide, a noxious gas.

ICE STUDIES

The behavior of ice masses in the Arctic affects not only the security and navigability of shipping lanes, but also the climate and the terrain. Ice studies are generally conducted under the auspices of the Polar Continental Shelf Project.

For the tenth successive year, a systematic aerial survey was carried out of the distribution, nature and movement of sea ice in the main channels of the Arctic Archipelago.

Studies of the mass balance and physical behavior of Arctic icecaps continue. The crystallography and internal structure of the Devon Island icecap are being studied to determine its history and the climate of the region during the recent geological past. A core containing a complete sample of precipitation, particulate fallout and other impurities over the past 2,000 years has been obtained.

Scientists from McGill University under contract continue to study the Meighen Island icecap, particularly its influence on and reaction to the local climate. Emphasis has been placed on the energy exchange between the atmosphere and the earth's surface of known uniform physical properties.

In the arctic islands, Polar Continental Shelf Project personnel have conducted measurements of temperatures in and beneath the permafrost layer. The PCSP has fostered frozen-sea research into the seasonal variations in water structure in relation to the growth and decay of the sea ice. The PCSP has also given considerable support to various other government departments in such projects as live capturing and tagging of ringed seals, collecting and identifying insects, counting polar bears and following their movements, and other research peculiar to the high Arctic. This included various geological and geophysical projects as well as the evaluation of electronic position-finding systems.

The Arctic Ice Dynamics Joint Experiment (AIDJEX) is a co-operative effort on the part of Canada and the United States aimed at understanding the interaction between the fields of motion of the atmosphere, the pack ice, and the sea water. This understanding is basic to forecasting ice conditions and to assessing variations in surface/atmosphere circulation. The main AIDJEX activities are scheduled for 1974–75, but preparations are well under way, and a major pilot study to test instruments and techniques to be used in the project was done in the Beaufort Sea.

Resource Administration and Regulation

In Canada's constitutional framework the regulation and administration of natural resources in the provinces rest with the provincial governments concerned. The federal government retains jurisdiction over those resources in federal lands within provinces—such as national parks—or in federally administered territories, i.e., the Yukon and Northwest Territories and the continental shelves off Canada's coasts.

Within the federal government, there is a division of jurisdiction. The Department of Indian and Northern Affairs regulates natural resources in the two northern territories and in the Arctic continental shelf; the Department of Energy, Mines and Resources regulates resources in federal lands in the provinces and in the offshore areas of Hudson Bay and Hudson Strait and the east and west coasts of Canada. The regulatory power is exercised by the Resource Management and Conservation Branch.

The present intense exploration in the offshore areas is concerned almost wholly with the search for petroleum and natural gas.

The branch designs, issues and administers various types of terminable offshore mineral grants, taking into account the unique conditions of the offshore environment. These grants, varying from non-exclusive licences through exclusive exploration permits to production leases, are issued and administered under the Canada Oil and Gas Land Regulations. An extensive revision of these regulations was completed, the first in over ten years, and the revised regulations were expected to be promulgated in the last part of 1972.

The branch issued 387 Canada Oil and Gas Permits covering 31.1 million acres during the fiscal year. The number of offshore permits administered as of March 31, 1972, was 5,648 covering 402.5 million acres as follows:

East Coast — 4,259 permits — 315,583,260 acres

West Coast — 237 permits— 16,272,694 acres

Hudson Bay and Hudson Strait—1,152 permits—70,592,807 acres

The first application received during this period was for the conversion of two offshore exploratory permits to ten oil and gas leases, covering 131,223 acres in the Gulf of St. Lawrence. Revenues from offshore permits amounted to $508,830, made up mostly of permit fees and work-deposit forfeitures.

Although prospects for mineral resources other than oil and gas are promising in the offshore, exploration for these resources is on a relatively small scale. This is no doubt due to the much greater difficulty of locating and extracting such ores and minerals in the offshore environment.

Federal oil and gas leases in the provinces numbered 252 at the end of the fiscal year, distributed among Alberta, Saskatchewan, Manitoba and Ontario. Revenues from federal mineral leases in the provinces amounted to $397,540, most of which were derived from oil and gas royalties.

The discovery of oil, gas and condensate on Sable Island by Mobil Oil Canada presented new challenges to the engineering and geological staff, not only in the regulation and supervision of the increasing exploratory activity resulting from the discovery, but also in the detailed evaluation of the structural and reservoir conditions and hydrocarbon distribution within the Sable Island prospect itself.

The petroleum industry spent $55 million exploring for oil and gas on permits administered by the branch: $17 million for geophysical and geological surveys and $38 million for exploratory drilling. Cumulative industry expenditures in Canada's offshore to the end of 1971 reached $200 million, consisting of $100 million for geophysical and geological surveys and $100 million for drilling.

The department approved 140 separate offshore exploratory programs during 1971 (including 21 exploratory drilling projects in the east coast offshore), all of which were monitored to ensure adherence to federal requirements designed to minimize the possibility of accidents causing pollution or the waste of resources, and to protect human safety and the living resources of the sea.

Senior officials of the department continued to represent Canada at meetings in Geneva and New York of the 91-member United Nations Committee on the Peaceful Uses of the Seabed and Ocean Floor beyond the Limits of National Jurisdiction. At issue here, among other matters, is the definition of the outer limit of national jurisdiction and the nature of the international regime and machinery required to manage the seabed resources of the area beyond. Much is at stake for Canada, and departmental officers are playing a very active role in the discussions and working groups of the committee.

The department also participated in negotiations with the United States, France and Denmark with respect to the delimitation of offshore boundaries of jurisdiction over seabed resources in the Gulf of Maine, St. Pierre Bank and Baffin Bay regions.

Services and Statutory Responsibilities

Legal Surveys in Federal Lands

Although provincial governments have jurisdiction over legal or land surveys in their territories, the federal government, through EMR's Legal Surveys Division, carries out and supervises such surveys in federal lands within provinces (i.e., national parks and Indian reserves) and in the northern territories. The division also undertakes certain other tasks, such as the demarcation of interprovincial boundaries and the certification of Dominion Land Surveyors.

During the year 22 field parties completed 146 separate survey projects: 76 on Indian reserves in all provinces except Newfoundland, Prince Edward Island and Nova Scotia, 3 projects in national parks, and 67 in the Yukon and Northwest Territories. To complete as many as possible of the projects required for federal government departments, 73 were done under contract.

Assistance was rendered to the Department of National Resources of New Brunswick in connection with its Atlantic Provinces Survey and Mapping Program preparatory to setting up an integrated survey area for Saint John and Kings Counties.

A major undertaking was the planning and preparation for the decentralization of the Field Survey Section, with nine regional offices to be established across Canada.

Technical instructions were issued for some 343 surveys in Crown Canada Lands.

Two federally appointed commissions, chaired by D. R. Slessor, the new Surveyor General of Canada Lands, worked on the survey and maintenance of provincial boundaries. The Manitoba-Saskatchewan Boundary Commission surveyed the remaining 30 miles of boundary, thus completing the actual field work. On the British Columbia-Yukon Territory boundary, 160 miles were resprayed with a defoliant, since the 1969 spraying of this area proved to be unsatisfactory.

The Board of Examiners for Dominion Land Surveyors met nine times. Of the 28 candidates who sat the 1972 annual examination at Ottawa, Edmonton, Calgary, Vancouver and St. John's, two passed the preliminaries, one the intermediate and eight the finals, the last qualifying for the Dominion Land Surveyor commission.

Aeronautical Charting

The federal government exercises exclusive jurisdiction and provides exclusive services in the field of aeronautical charting and the publication of pilot's handbooks. These show locations and approaches to airports along with the electronic aids to air navigation.

During the year, 52 different map series and flight-information publications were provided, and conversion of the World Aeronautical Charts at a scale of 1:1,000,000 to a new format was well in hand.

The division began a review of all charts for the so-called visual flight rules (VFR). Charts for southern

Canada will be reviewed every two years and those for northern Canada every four to five years.

New schedules for amendments to the *Canada Air Pilot* and the *General Pilot Handbook* were instituted, and the experimental operation of a new electronic air-traffic control at Moncton necessitated the production of special aeronautical charts, up-dated every four weeks.

A number of charts have been developed in conjunction with the evaluation of a Short Take-Off and Landing (STOL) service between Ottawa and Montreal. A *Toronto Terminal Radar Service Area Map* was produced to assist visual-flight-rule pilots through the controlled area. The preparation of a new publication covering the Northwest and Yukon Territories is under way.

International Boundary Commission

In 1925, Canada and the United States signed a treaty establishing a permanent International Boundary Commission, which was to maintain the international boundary properly marked out and cleared of tree growth. It was also to resurvey parts of the boundary, when and if this should become necessary.

The Canadian section of the commission is, for operational purposes, incorporated in the department's Surveys and Mapping Branch.

Canadian field parties operated in three areas during the year. On the Manitoba-Minnesota section, the boundary vista was recleared for 10 miles at the eastern end of the 49th parallel. Some 75 miles of the New Brunswick-Maine section was controlled by a chemical treatment and 20 miles of vista was recleared; 276 monuments were inspected and one was repaired.

On the Quebec-New Hampshire boundary 55 monuments were inspected along Halls Stream. Two reference monuments were relocated and three were repaired. On the Quebec-Vermont boundary a geodimeter traverse was run along the boundary and ties were made to the associated control triangulation; 96 monuments were inspected, 8 were repaired and two new marks set.

During the year, the Commission developed a lightweight inner tower to support the instrument when surveyors are making precise angular measurements from survey towers. A patent application has been filed on behalf of the Canadian Government.

Explosives Administration

The Explosives Division, a unit of the Mineral Development Sector, is responsible for regulating all factories that produce commercial blasting explosives, military explosives, blasting accessories, gunpowder, smokeless powders and percussion primers, ammunition, fireworks and other pyrotechnics, and for the quality and safety of their products. This responsibility extends also to the road transportation of these items and to their storage and importation.

Control is exercised by a system of licences, permits and sales records supported by inspections by members of the division and by the Royal Canadian Mounted Police. All licences and permits are issued from the Ottawa office.

A general quickening in construction and mining activity was reflected in an increased office and inspection workload with which the division was just able to cope. The number of factory licences continued to increase as expected, reaching a total of 55 by year end, mainly due to the expansion of on-site slurry or water-gel manufacturing facilities at additional open-pit mines. Two factories manufacturing sporting ammunition ceased operations. The number of licences issued for the storage of blasting explosives in support of construction projects, road building, seismic exploration, pipeline laying, erection of transmission towers, forestry and like operations increased to over 1,200.

A new hobby for youth—model rocketry—has been rapidly gaining popularity. By year end, 39 licences had been issued to hobby shops across Canada to permit the sale of model rocket engines to individuals licensed as firing supervisors by the Canadian Association of Rocketry, a division of the Youth Science Foundation of Canada. The small rocket engines used in this sport consist of a propellant explosive, and although relatively innocuous in themselves, even if involved in a fire, can accelerate to the speed of a bullet shortly after launch and can push a rocket to heights in excess of 2,000 feet. These properties make them a hazard to aircraft or to the public, if misused.

In the past few years, the increased use of explosives for criminal activities throughout Canada has created

a situation whereby the orderly marketing of explosives for legitimate and necessary purposes is being seriously hampered. The division mounted a two-pronged attack on this problem. First, amendments to the Explosives Act to provide for greater control over the purchase, possession and transportation of explosives were proposed. Bill C7, an Act to amend the Explosives Act, was introduced in the House of Commons on February 21, 1972. Secondly, in co-operation with explosives manufacturers and distributors, provincial mines departments and other departments and public agencies, and with the assistance of the Royal Canadian Mounted Police, new construction standards for blasting-explosives magazines were developed. These standards, which have been well received by vendors and users, require that magazines be bullet-resistant, fire-resistant, theft-resistant, weatherproof and well ventilated. A booklet entitled *Standards for Blasting-Explosives Magazines* was published and distribution started. Conversion of existing magazines or construction of new ones to these standards is under way, with a target date of December 1973 set for completion of the project.

Members of the Explosives Division promote safety programs and regularly meet with members of industry, federal and provincial government agencies, municipal authorities and other groups involved with the handling of explosives. The division also has available for distribution safety literature on the storage, handling and transportation of explosives.

Research Agreements

The several programs of grants in aid of research previously managed by different branches of the department were combined during 1971 into a common departmental program under the name "Research Agreements." Eligibility for participation in the new program was extended to Canadian research organizations other than universities. Whereas under the old system the support of university research was the chief criterion, under the new system relevance and contribution to the department's objectives were adopted as the chief criteria. All disciplines involved in the discharge of EMR's responsibilities were included. The intention was to bring many kinds of expertise to bear on the problems of national policy, to apply a multidisciplinary competence to the development of advice to government and information for the community at large.

The branches of EMR, with their disciplinary orientation, were responsible for assessing the proposals which related to their own activities and, in general, for maintaining contact with the investigators on substantive matters throughout the life of the agreement. Administrative matters were centralized in the Departmental Grants Committee with J. M. Harrison as chairman and T. E. Bolton as secretary.

No significant increase in the level of funding ($576,000) over previous grants in aid of research was provided for the EMR Research Agreements to be spent in 1972–73. The committee received 331 applications, requesting a total of $3,830,604; of these 92 Research Agreements were recommended by the branches—86 to university projects, 5 to provincial science councils, and 1 to the Royal Ontario Museum.

Administration and Support Services

Under this heading, the report describes the non-operating units of the department—those dealing with administration, finance, personnel, public information, etc.

Executive Offices

Top-management structure of the department was reorganized during the year. A Senior Assistant Deputy Minister and an Assistant Deputy Minister (Planning and Evaluation) were appointed, and authority was received for the establishment of an Assistant Deputy Minister (Administration).

The top executive officials of the department, with their respective responsibilities (where applicable), are indicated on the organization chart.

These officials, together with certain senior officers of the department, form a permanent Executive Committee, which helps to set departmental policies and priorities. A Management Committee, with wider membership, provides a link between the Executive Committee and the operating units. Plans were being made in 1971–72 for the establishment of a Departmental Secretariat, which would provide support services to the Executive and Management committees, provide liaison with Parliament, and fulfill certain other functions.

Personnel Services

On March 31, 1972, EMR had a full-time staff of 2,843, an increase of 141 from the preceding year. The department also employed approximately 2,100 casual employees, among them students and those on the winter-works program.

The Personnel Branch provided training within the department to approximately 15 per cent of the staff, chiefly in management.

The department's suggestion award plan achieved the highest overall standing in the Public Service of Canada, in terms of number and quality of suggestions per 100 employees.

Representatives of the Personnel Branch assisted in renegotiations of all but one of the 30 collective agreements covering EMR employees. Contingency plans were developed for breakdowns in labor relations, such as strikes. At year end, development of a formal framework for union-management consultations was well under way.

Although the number of classification requests increased slightly, personnel officers succeeded in reducing the average time needed to process submissions by more than 50 per cent over two years.

Finance and Administration

This branch includes Financial Services, Property Planning and Management, Administration Services (including Materiel Management and Technical Field Support Services) and Management Services. These units continued to provide the department with services in accounting, finance, program forecasts and estimates co-ordination, management of materiel, property plan-

ning and management, telecommunications, mail, central records, technical field support (materiel and equipment), and related areas.

During the last few years it had gradually become apparent that the staff of the department was outgrowing the Booth Street complex, and especially the modest administration building. A number of branches —such as Mineral Resources, Personnel, Public Relations and Information Services, the new Energy Sector —had to move wholly or partly to temporary quarters around Ottawa. To bring these units back together and to provide more suitable office space, a new office tower was planned for the Booth Street site and construction began during the year. The building is to have 21 floors and will cost approximately $10 million.

Outside of Ottawa, additions to existing buildings for the storage of drill cores were completed in Bedford and Calgary, and modifications were made to existing hangar space at Uplands Airport near Ottawa.

A major renovation was carried out in a building on Sheffield Road in Ottawa, for the Canada Centre for Remote Sensing and the Air Photo Production Unit.

Public Relations and Information Services

Services rendered include the publication of booklets, pamphlets, etc., and photos on the work of EMR, contact with Canadian and foreign news media, and editorial and publishing service to the scientific branches of the department.

Publicity arrangements were made for the 23rd Canadian Conference on Coal, the Chinese Mining Mission to Canada, the Remote Sensing Symposium in February 1972 and the Workshop on Gold-Mining Communities. The Canadian Institute of Mining and Metallurgy and the Canadian Institute of Surveying were assisted at their annual conventions in Ottawa and Quebec City, respectively.

Information programs were drawn up, with the cooperation of the participating departments and agencies, for ministerial news conferences on (1) expanded guidelines for the construction and operation of northern oil and gas pipelines and (2) Canada's remote-sensing program, which were held in June and July of 1972.

Advance publicity arrangements were made for three international scientific congresses to be held in Canada in July and August of 1972: the International Geological Congress, the International Photogrammetric Congress and the International Cartographic Congress.

Some 15,000 letters requesting information and publications were processed. A marked increase was noted in queries from the public and industry on oil and gas production, resource policies and mineral development. A number of inquiries concerned foreign ownership. Over 5,000 telephone inquiries were received from the press, public and industry.

Publications of a scientific or technical nature produced in 1971–72 include four issues of the *Canadian Metallurgical Quarterly*; Proceedings of the Sixth Rock Mechanics Symposium; Proceedings of the 22nd Canadian Conference on Coal; *Non-ferrous Metals Casting—History and Forecast*; numerous geological Bulletins, Memoirs and Papers, in English and French; and a wide range of earth-physics reports dealing with seismology, gravity and geomagnetism.

Computer Services

In October 1971 the Computer Science Centre installed a Control Data 6400 computer. This was done to satisfy the increasing computing workload of the Department of Energy, Mines and Resources and some sections of the Department of the Environment. At the same time the installation will effect cost reduction by centralization of computing on one large computer.

The CDC 6400 replaced a CDC 3100, which was transferred to the Canadian Centre for Inland Waters in Burlington, Ontario, and it is also processing most of the work previously contracted to computer utilities in the Ottawa area.

The new system provides seven terminal devices, located in the various departmental buildings in Ottawa, that are connected to the computer by telephone lines. Work may be submitted from any building, transmitted to the central computer, processed and the results transmitted back. This creates the effect of having a computer conveniently close to all users, and productivity is increased by eliminating the delays associated with the physical delivery of work to and from the computer.

Legal Services

The senior legal adviser and his staff of two solicitors are members of the Department of Justice assigned to EMR to render advice to its many components. The senior adviser is a member ex officio of the department's Executive Committee and for administrative purposes reports to the senior assistant deputy minister. The work of the office covers a wide range of activities, including the drafting of major contracts, advising on the legal implications of policy decisions, drafting of regulations and helping to draft new legislation.

Index

	PAGE
Aerodist	5
Aeromagnetic Surveys	7, 16
Air pollution:	
monitoring	24
plumes	28
Alberta tar sands	27
Algal growth	24
Arctic Ice Dynamics Joint Experiment (AIDJEX)	29
Athabasca oil sands	9
Barringer Research Ltd.	24
Beneficiating ores	11
B.C.-Yukon boundary	32
Burma, lead-silver	17
Canada Centre for Remote Sensing	23
Canadian Association of Rocketry	33
Canadian Permanent Committee on Geographical Names	6
Ceramic processing	11
China, People's Republic of (metallurgical exports)	14
Chinese Mining Mission to Canada	37
Clays and shales	11
Coal:	
assessing properties	11
metallurgical industry	10, 11
reserves	10, 13
search for	8
washing	22
Coal mining:	
techniques	18
transportation	18
underground	27
Continental shelf:	
geology	7
oil and gas potential	10
Copper, Canada and Japan	14
Coking technology	22
Denison Mines	15
Electrical energy	13
Emergency Gold Mining Assistance Act	16
Energy resources (sale of)	12
Environmental concerns	25
Equipment, development of	23
Explosives Division	33
Federal-provincial co-operation	15
Flotation	21
Foreign aid, resource development	16
Frontier regions (oil and gas)	9
General Agreement on Tariffs and Trade (GATT)	14
Geochemical surveys	9
Geological mapping	6
Geomagnetic charts	7
Geophysical mapping	6
Gold, price of	16
Gravity mapping	7
Ground Data Handling Centre	24
Hydroelectric power plants	10
Hydroelectric resources	10
Hydrometallurgy	21
Ice studies	29
India, copper mining	17
Industrial minerals, beneficiating	22
Interagency Committee on Remote Sensing	24
International Boundary Commission	33
International Gravity Standardization Network 1971	8
Institute of Sedimentary and Petroleum Geology	7
Kaolinite	11
Laser fluorosensor	24
Lidar	24
Lignite	11
Local earthquakes	26
Lunar rock samples	8
Manitoba-Saskatchewan boundary	32
Marine geology	7
McBean Mine, closure	15
Metamorphism	9
Mining:	
safety	27
underground detector	27
Mineral development:	16
environmental effects	14
Mineral occurrences	11
Mineral production	13
Montreal International Airport	25
NASA	23
National Air Photo Library	6
National Atlas of Canada	5
National Oil Policy	12
Non-destructive testing	20
Non-renewable mineral resources	8
Nuclear reactors	13
thermonuclear	18

	PAGE
Offshore:	
boundaries	31
exploration	10
mineral grants	30
oil and gas	15
Oil and gas exploration	9, 10
Oil and gas (world development)	13
Oil-spill detection	27
Operation TORNGAT	6
Ottawa-Hull area:	
landslides	25
marine clay	26
Paleomagnetism	7
Paleontological research:	
mapping	7
minerals	9
Panarctic Oils Ltd.	15
Permafrost terrain	9
Petroleum:	
basins	8
beneficiation	20
Physical Metallurgical Division	19
Pisces III	7
Polar Continental Shelf Project	8
Potash:	
Saskatchewan	14
New Brunswick	16
Power generation ("combined-cycle")	23
Primary Gravity Network of Canada	8
Prince Albert Satellite Station	24
"Quick-look" imagery	24
Radiocarbon dating	7
Regional Economic Expansion, Dept. of	15
Remote sensing	23
Research agreements	35
Rock slopes	20
Sable Island, oil and gas	31
Salt	16
Sea ice, thickness of	24
Seismic network	26
Seismological studies	8
Sidescan sonar	8
Slurry analysis	22
Spar Aerospace Products Ltd.	24
Special Employment Plan	9
STOL service	33
Sulphides, in iron ore	22
Sulphur (stockpiles)	14
Superplasticity	19
Surgical needle	19
Task Force on Northern Oil Development	15
Taxation:	
mineral resources	10
mining industry	14, 15
Terrain protection	25
"Thermal pollution"	25
Titanium alloys	19
Toronto Institute for Aerospace Studies	24
Underground nuclear explosions	26
Uranium:	
demand	10
enrichment	13
stockpiling	15
Water pollution	24
West Africa, aeromagnetic surveys	17