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# annual report 1972-73

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**Hon. Donald S. Macdonald, Minister**



Energy, Mines and  
Resources Canada

Énergie, Mines et  
Ressources Canada

# **annual report 1972-73**

**Hon. Donald S. Macdonald, Minister**

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## INTRODUCTION

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

The world oil crisis which was to develop as a result of the Middle East problem in late 1973 was recognized as a potential threat during the period covered by this report, and the energy specialists of the department were heavily involved in the collection and interpretation of energy data looking toward the elaboration of a new national energy policy. Evaluation of Canada's energy and resource potential also occupied much of the capacity of other branches, such as the Geological Survey, the Mineral Resources Branch, the Earth Physics Branch, the Mines Branch, etc., in addition to their continuing research and surveys.

Probably the most significant event in the field of science and technology was the launching of the Earth Resources Technology Satellite (ERTS) by the U.S. National Aeronautics and Space Administration in July 1972. Through an agreement with NASA, EMR's Canada Centre for Remote Sensing is able to receive and distribute imagery of Canadian territory transmitted by ERTS. The imagery, in four spectral bands, is transmitted to a receiving station at Prince Albert, Sask., and taped for further correction and processing in Ottawa. Photographs of the imagery are sold through the National Air Photo Library, a unit of the department's Surveys and Mapping Branch.

There is no transfer of funds involved in the NASA-EMR agreement, which has provided Canadian resource planners with a new, comprehensive, continuously updated overview of Canada's land and water areas. Many uses have already been made of ERTS imagery in various fields of research. One interesting experimental application was the transmission

of ERTS imagery of the Arctic, via satellite, to ships travelling through the Arctic sea lanes, giving the ship captain almost instant overviews of ice conditions over hundreds of miles.

The airborne remote-sensing arm of the newly established Canada Centre for Remote Sensing has also been building up its capabilities and has flown a large number of missions requested by users in many parts of Canada. It can call upon the services of four specially equipped aircraft for low- and high-level sensing missions.

Coal is a fuel whose reserves appear much greater than those of oil and gas, but they are widely scattered and of varying degrees of quality and accessibility. The department is developing a methodology for evaluating coal resources in terms of recovery and economics. The methodology is designed to be adaptable to changes in mining and combustion technology.

As part of a joint federal-provincial program to obtain a more accurate assessment of lignite resources in Saskatchewan, a drilling project was launched, in which more than 200 holes were drilled, and more than 2,000 samples were analyzed. The work will continue in 1973.

The department has been giving special attention to the Task Force on Northern Oil Development, which is chaired by the deputy minister. Pipeline guidelines based on the recommendations of the Task Force were established in 1970, and draft environmental and social guidelines were published in June 1972. To provide information and advice concerning the financing of a northern pipeline, which would involve expenditures of at least \$5 billion, the Minister of Energy, Mines and Resources established a National Advisory Committee on Northern Pipeline Financing. The committee is made up of senior representatives of the financial community in Canada.

The outlook for Canadian uranium mines brightened in 1972, with a sales agreement with several Spanish utilities for the delivery of approximately nine million pounds of uranium from 1974 through 1977, at a total value of



about \$60 million. Some six million pounds will come from the joint stockpile maintained by the federal government and Denison Mines, which was started in 1971; the other three million pounds will come from the general government stockpile. Both stockpiles were designed largely to maintain the Elliot Lake mining community.

The need to use and exploit the environment often leads to conflict, and rational management requires a broad knowledge base to which the studies of modern geological processes contribute. The Geological Survey has carried out a wide variety of studies under this general objective. Some of them deal with provision of use-hazard information on the behavior of earth and rock materials under specific conditions, especially in the Arctic regions where the extreme sensitivity of the terrain to man-made disturbance has become a matter of public concern.

Another area that is receiving ever more geological study is Canada's continental shelf, east, west and north. The shelf off eastern Canada has been the object of surficial and bedrock geological mapping and systematic geophysical surveys. In the Arctic, a unique co-operative venture between six oil companies and three EMR branches resulted in a seismic profile across the Sverdrup Basin, in which the attitude, nature and thickness of the various sedimentary strata overlying the basin were mapped.

A major geological project in 1972 was a regional geochemical reconnaissance by lake-sediment sampling of 36,000 square miles north-east of Yellowknife. This study, when its results were made available to the public, induced the staking of 200 claims.

Although map-making in EMR's Surveys and Mapping Branch has kept pace with technological advances in that field and the output is now much higher than ever before, experimentation is continuing on speeding up mapping through greater automation. A so-called "Automated Cartography Project" entered its production-development phase in 1972. A block of map sheets at a scale of 1:50,000 in the Yukon Territory was assigned for production by automated methods.

The economists of the Mineral Resources Branch continued to carry out research and to formulate recommendations concerning the degree of domestic processing and the use of minerals in relation to economic diversification or conservation of resources as appropriate to minerals.

The Mines Branch carried out further experiments in the hydrocracking of Alberta bitumen to study the effect of four operating variables on product yields, pitch conversion, and sulphur removal; the results helped to clarify problems associated with mechanical design and operating conditions that would improve liquid yields. Hydrogenation can convert up to 85 per cent of the bitumen to liquid fuel that is suitable for the manufacture of low-pour-point oils for arctic and aircraft use.

Other work done at the pilot-plant scale sought to achieve economical desulphurization of coal from the Lingan area in Nova Scotia, in order to produce metallurgical coal of coking grade for local steelmakers and possibly for export. A modular-type pilot plant was assembled and brought into operation using the EMR process based on compound water cyclones, and considerable progress was achieved.

The construction of northern pipelines raises problems such as the behavior of metals and alloys at very low temperatures. A comprehensive program continued on the evaluation and improvement of pipe steel that would provide structural rigidity of oil and gas pipelines and consequently ensure environmental protection.

Further improvements were made by the scientists of the Earth Physics Branch in the equipment for detecting and measuring natural and man-made earthquakes, such as nuclear explosions. Preliminary tests on tape-recorded data indicate that the automatic on-line digital processing system scheduled to begin operation at the Yellowknife seismic array in 1973-74 will achieve a very good detection level, thus contributing substantially to the world-wide monitoring of seismic events. The Canadian scientific effort in this field continues to play a leading role in dealing with problems in policing a ban on nuclear testing.

One of the most ambitious research projects ever launched in the Arctic is AIDJEX -- short for Arctic Ice Dynamics Joint Experiment -- carried out in co-operation between Canadian and United States agencies. The project is aimed at studying the dynamic behavior of sea ice, and the transfer of kinetic and thermal energy between the atmosphere and ocean through a complete or partial ice cover. Scientists hope that the information thus obtained will enable them to calculate and predict the movement of sea ice, climatic trends, and engineering factors needed for the design of fixed or

moving structures associated with resource development in or near the Arctic Ocean.

In 1972 Canada was host to the XXIV International Geological Congress, with an attendance of more than 5,000 at the meetings in Montreal. As the principal geoscience agency of the federal government, the department played a significant role in all aspects of the Congress and staff members, particularly of the Geological Survey, were active participants as authors of papers presented at the formal sessions, as members of organizing committees and as leaders of the field excursions which

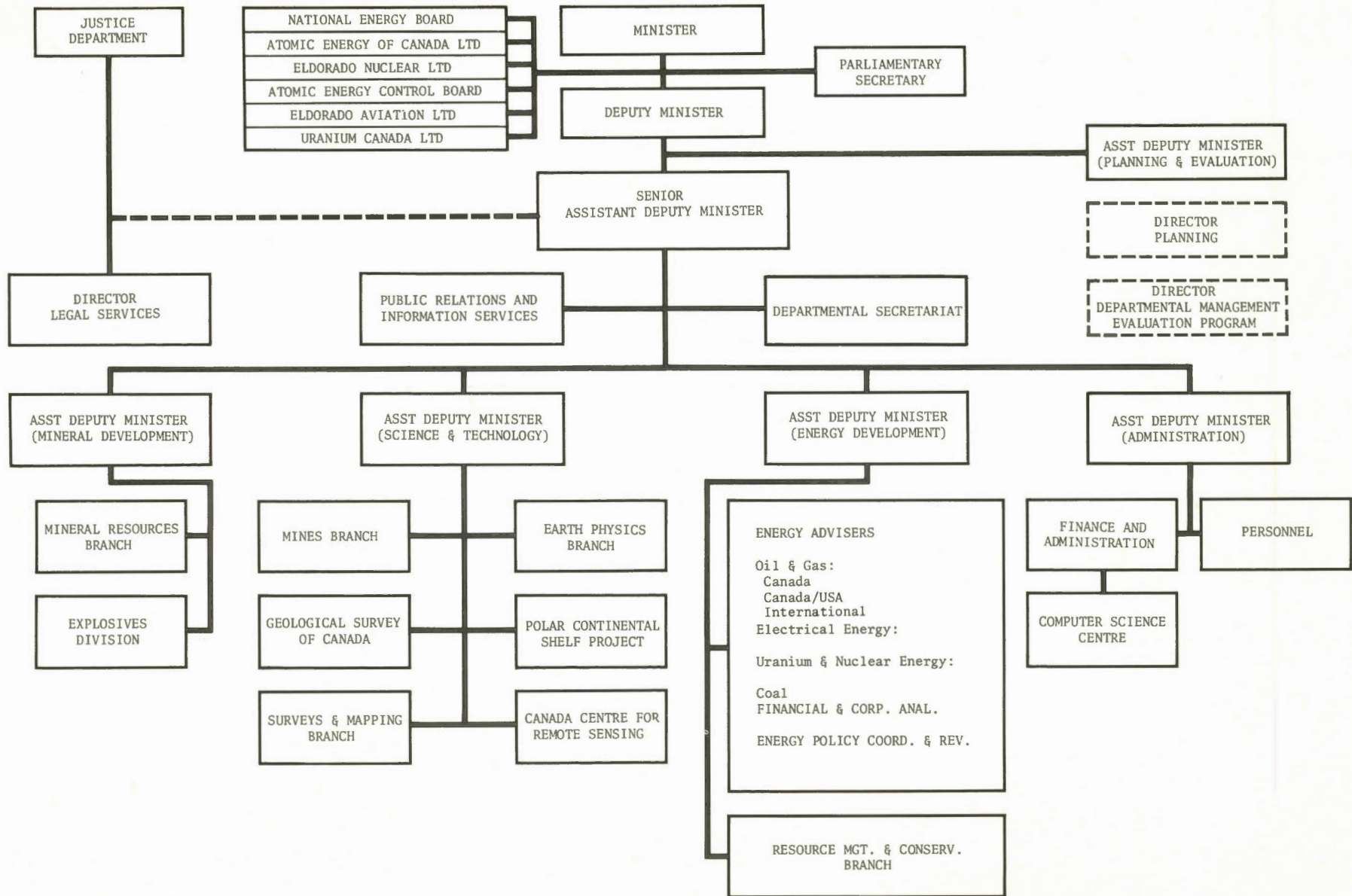
took geologists from many countries of the world to all parts of Canada, from east to west and to the high Arctic.

Canada also acted as host for the Fourth General Assembly and Sixth International Conference of the International Cartographic Association, and for the International Society of Photogrammetry Congress.

These are some of the highlights of the work of EMR during the fiscal year 1972-73. Other activities, in greater detail, are described in the pages that follow.



DEPARTMENT OF ENERGY, MINES AND RESOURCES



## RESOURCE INVENTORY AND POTENTIAL

### MAPPING

Control surveys. The Department of Energy, Mines and Resources is responsible for the establishment of national frameworks to serve the needs of mapping, charting, cadastral and boundary surveys, national security, geoscience research and related activities.

Field surveys were carried out in many parts of Canada, adding to and improving the national frameworks. With the help of the Department of Public Works, a first-order level line was started along the Mackenzie River from Fort Providence, NWT. This line will provide accurate vertical control for development projects along the Mackenzie River and the Mackenzie Corridor, and will be the first high-order level line to reach the Arctic Ocean.

An assessment was started of the accuracy of all geodetic horizontal control in Canada.

The Geodetic Data Centre averaged 15 visits or telephone requests for data per day, in addition to 1,200 written requests during the year.

Maps. The Department of Energy, Mines and Resources is the principal mapping agency in Canada. In fulfilling its role of taking the measure of Canada's land areas and publishing the results in the form of maps and statistical tables, it produces maps and charts of many types and for many different purposes. The task of mapping a nation so vast must be a continuing enterprise, for as long as economic expansion persists and new sources of wealth are discovered, it will be necessary to add to information in cartographic form. Such information must be available for the enlightenment, use and reference of all Canadians.

In 1972-73, 352 National Topographic Series maps were compiled to the scribing stage, comprising 49 new maps to be produced in full

color, 92 monochrome maps and 211 revision maps. In addition, 78 photomaps were forwarded for production.

There were 310 additional monochrome maps sent to contractors for the placing of "surround" information. These will be forwarded for production within the first three months of the fiscal year 1973-74.

Compilation of new and revised maps was reduced somewhat this year in order to prepare and assemble information for the Mapping Data Base of northern Canada. This Data Base project stems from the fact that the field surveying and aerial photography of Canada has reached the state where it is now possible to carry out, for vast areas of northern Canada, the initial stages of mapping (i.e., the measuring of the corner points of the aerial photos and the adjustment of these points to the ground survey grid). The actual drawing of 1:50,000 maps would not be done until a requirement for such mapping was established, but with the initial measuring completed (and stored in the Mapping Data Base) the maps could be drawn and printed very quickly. This concentration, during 1972-73, on the initial stages of a very large number of maps has had the effect of reducing the completion of maps below the normal annual production of the Topographical Survey Directorate. It is expected that this drop in production will last only one year.

Field work was completed on 262 maps by 24 parties operating in seven provinces and one territory.

The Topographic Mapping Division planned and inspected 1:50,000 and large-scale mapping contracts for various federal agencies amounting to approximately \$1,000,000 undertaken by private aerial-survey companies. One of the major projects was the aerial triangulation, numerical adjustment and 1:50,000-scale mapping of various parts of the Mackenzie River Corridor.

The department's draftsmen completed 303 new and



revised multicolor topographic maps and 164 monochrome prints. They also revised 15 index maps of the National Topographic Series. Printed during the year were 242 new and 190 revised multicolor topographic maps, 221 monochrome prints and 200 airphoto maps.

As during the previous winter, a cartographic unit was established in Vancouver, B.C., under the terms of the Federal Direct Employment Plan. The project ran from January to May 1973 and employed 45 draftsmen for most of the period.

The Surveys and Mapping Branch also prepared a large variety of special maps to accompany various publications and reports published by government agencies. Other maps dealt with such subjects as high-voltage lines and generating plants, radio and television coverage of Canada, areas served by Manpower centres, areas covered by permits for oil exploration, arctic shipping safety zones, coverage of Canada by the Earth Resources Technology Satellite, the Canadian highway network (for the Canadian Government Travel Bureau), etc.

Printing of maps surpassed previous records with an output of 42 million impressions, resulting in more than nine million copies of 2,850 maps and charts.

By the end of fiscal year 1972-73 the English and French editions of the National Atlas of Canada were within three months of their scheduled completion date. The first printing of the new Atlas will be distributed in loose sheets. Plans are being made for the second printing to be issued as a bound volume. As the Atlas entered its final phases, work was started on the next edition.

Approximately 3.5 million maps and charts were distributed. Certain changes in map and chart formats resulted in the reduction of paper quantities required in printing.

The most important outlet of the Canada Map Office is the network of 374 map dealers and 315 aeronautical-chart dealers. There are also 138 map depositories, where the public may obtain information on topographic map sheets.

Air photography. The National Air Photo Library, which has a stock of 3,726,000 contact prints in its reference file, received 13,353 requests for the reproduction of photography or information concerning available coverage. This compares with 9,569 requests received in 1971-72. Requisitions for photographic reproductions numbered 10,155.

The work of the National Air Photo Library

(NAPL) grew in volume and complexity with the increase in remote-sensing imagery -- airborne and satellite -- ordered and distributed from its offices. Close links have been set up with the Canada Centre for Remote Sensing.

The move of the reproduction centre of the National Air Photo Library from the Canadian Forces Base Ottawa (North) to more suitable quarters at 2464 Sheffield Road (shared with the Canada Centre for Remote Sensing) took place in April 1972. With the acquisition of a substantial amount of new equipment during the year, the centre is regarded as one of the most modern photographic facilities in the world.

The Earth Resources Technology Satellite (ERTS), which provides remote-sensing imagery of all Canada from an elevation of about 500 miles, was placed into orbit in July 1972; the reproduction of ERTS imagery was assigned to the centre. With this new duty, the annual production of ERTS, airborne sensing and air-survey photos came to over one million products.

The department is host to the Interdepartmental Committee on Air Surveys, which is responsible for contracting aerial photography flown for and on behalf of the federal government. Thirty such contracts were let, amounting to \$907,071. A total of 74,600 line-miles of photography was obtained in 1972, divided almost equally between propeller and jet aircraft. The Mackenzie Highway project accounted for all the non-jet air photography. Because of what appears to have been a malfunction in the cameras, a considerable part of the jet photography turned out to be unsuitable for mapping purposes.

The trend toward air photography for purposes other than mapping continued. Such photography is often ordered for assessing changes in biological and/or agricultural conditions.

Geographical names. The secretariat of the Canadian Permanent Committee on Geographical Names supervised the publication of the New Brunswick Gazetteer (second edition) in the Gazetteer of Canada series. It contains more than twice as many names as the first edition. Work continued on other gazetteers.

In May 1972, the chairman of the committee, J.-P. Drolet, and the executive secretary, G.F. Delaney, participated in the Second United Nations Conference on the Standardization of Geographical Names in London, England.

The history of geographical names in Canada and related subjects was researched. The staff continued to process a wide variety of toponymic submissions from government and private sources.



Geological mapping. Inventory mapping provides the data needed to establish the systematic geological framework that is the basis for estimating the potential for minerals and fuels in Canada. This framework is portrayed mainly by various maps that show three-dimensional data combined with the fourth dimension — time — and is identified by the National Bedrock Geological Reconnaissance (scale 1:500,000 or smaller) supplemented by upgrading surveys in areas where older reconnaissance work is not sufficiently detailed for today's needs.

Reconnaissance mapping for Operation Snag-Yukon was completed and preliminary results were published. Similarly, the final field phase of Operation Stewart (Yukon and western District of Mackenzie) was completed. Detailed stratigraphic studies were conducted to supplement the available data. The area is of economic interest as it contains tungsten, lead-zinc, and a coal deposit, the last having been discovered by members of the mapping team.

Inventory mapping of Yellowknife and Hearne Lake map-areas (1:250,000) was completed, and upgrading of additional map-areas to the north-east in this economically important area is expected to continue. Similar upgrading was started in several map-areas in the District of Keewatin originally mapped on a reconnaissance scale some 20 years ago during one of the first helicopter operations. Indications of sulphide mineralization were encountered but require further evaluation. Similar mapping was done in the Berens River area of Manitoba.

In addition to inventory mapping in bedrock areas, the mapping of surficial deposits was continued; indeed, in terms of personnel employed, this aspect probably was the more extensive. Such activities extended from terrain mapping in south-central British Columbia in co-operation with the provincial government, or mapping in the Winnipeg area, to studies of surficial geology and geomorphology in the Arctic Islands.

Until recently there has been little demand for terrain information from mountainous areas, but with the increasing pressure for information on all facets of the land it has become necessary to develop a scheme for classifying and mapping such deposits. A pilot study was carried out last summer in the Revelstoke area.

Many geological mapping activities depend on information supplied by a wide range of specialists who, because of their training, are able to make use of what appears to the un-specialized worker to be of slight importance.

During the report period, more than 2,000 lots of fossils were examined by paleontologists of the Geological Survey. In addition, paleontological studies were done in the field, such as the biostratigraphic studies in Newfoundland, studies of conodonts from arctic Canada or biostratigraphic work on northern Vancouver Island.

A knowledge of the magnetic properties of rocks and minerals can assist greatly in solving problems that arise in inventory mapping; during the report period, an extensive study of the paleomagnetism of the Lac Saint Jean, Sept Iles and Allard Lake anorthosites was started.

Laboratory specialists did more than 2,200 analyses in support of geochronological (age) studies of rocks and also did radio-carbon analyses of material less than 30,000 years old to assist in determining the age of their enclosing strata.

The geological framework of the eastern continental shelf and margin of Canada is known only in general outline. During the report period this area was the object of surficial and bedrock geological mapping and systematic geophysical surveys. Five regions were studied: a) Nova Scotia Shelf, Bay of Fundy and Southern Grand Bank; b) Gulf of St. Lawrence; c) North-east Newfoundland, Labrador Shelf and Sea; d) Baffin Bay and adjoining Sounds and e) Nova Scotia Grand Banks Continental Margin and the adjoining deep ocean floor. Similar submarine geological and geophysical surveys were made along traverses normal to the coast on the Pacific Continental Shelf for basin analyses, fuel and mineral potential, delineation of the continental margin for the purposes of establishing Canadian sovereignty, and engineering and environmental considerations for seabed development on the shelf and slope.

In support of geological mapping and other aspects of the scientific program, the Geological Survey published 48 new geological maps, 44 preliminary reports and 15 final reports; some of these reports were of considerable size, comprising hundreds of pages of printed text and many illustrations. In addition, continued public interest necessitated reprinting 21 reports and 12 geological maps. Open-file releases continued to provide an expeditious means of releasing interim results of Survey investigations to the public. Fifty-six open files were prepared, some of them consisting of many maps and sheets of data of immediate interest to those concerned with Canada's resource inventory and potential.

Geophysical mapping. Along with topographic,



special-purpose and geological maps, Earth Physics Branch scientists also produce data for maps showing magnetic, gravity and seismic patterns in and around Canada. Such maps are used in navigation -- sea and air -- and in exploration for minerals and petroleum.

In late 1972, a three-component airborne magnetic survey covered the Yukon Territory, the District of Mackenzie, Alberta, Saskatchewan and the western part of Manitoba. The distance flown was 60,000 nautical miles; survey lines were 20 miles apart, and altitude ranged from 8,000 to 16,000 feet.

Field parties made observations at 22 repeat stations in eastern Canada, as part of the annual updating of the ever-changing magnetic map of Canada.

The earth's magnetic field is seldom quiet. It responds to activity in the sun. Large disturbances, known as magnetic storms, are usually associated with sunspots and other visible eruptions on the solar surface. The changes in the strength and direction of the magnetic field are recorded continuously at 10 magnetic observatories extending from St. John's to Victoria and into the Arctic. One of the most intense magnetic storms ever recorded began on August 4, 1972, and lasted several days. It disrupted not only communication circuits, but even electric power-distributions systems, tripping circuit breakers repeatedly and burning out transformers.

Natural magnetic disturbances also have useful applications. They induce in the earth electric currents, which depend on properties of the rocks underground, their composition, temperature and structure. By recording these electric currents and the magnetic fields produced by them, scientists can study the earth's crust to depths of 50 miles or more, well beyond the range of classical geological methods.

During the spring of 1972, unmanned magnetic recording stations were operated on the ice of the Arctic Ocean north of Ellesmere Island. Analysis of the magnetic variations recorded indicates that the great anomaly of electric conductivity which sweeps under Ellesmere Island for 500 miles extends northward beneath the Arctic continental shelf for at least 120 miles. This discovery may have important consequences in the understanding of the geological history of the Arctic Islands.

A long-term investigation by paleomagnetic methods of the history of the Canadian Shield continued with field collections from Superior, Grenville and Archean terrains, in collaboration

with the Geological Survey of Canada, and Toronto and Carleton universities. A consistent picture extending back to 2.5 billion years ago is now emerging.

In the field of gravity mapping, surveys to extend the national gravity survey of Canada continued during the year in the Arctic, British Columbia, Quebec and the eastern offshore. In co-operation with the Polar Continental Shelf Project, field work was carried out on the sea ice in Mackenzie Bay and adjacent areas of the Beaufort Sea. As a result of this work, a new gravity map will be published in 1973, which will be of interest to companies carrying out oil exploration.

In Quebec an intensive survey in a 24,000-square-mile area in the Labrador trough was carried out with the co-operation of the Geological Survey and the Surveys and Mapping Branch. This survey was the first in a series to study in detail various regions of Canada that appear to offer good opportunities for crustal studies by gravity methods, for the ultimate benefit of mining.

Responding to growing interest in the Atlantic offshore, a geophysical investigation of the Nova Scotia continental shelf was started, combining gravity, magnetic and seismic methods. These studies will be extended to other suitable areas of Canada.

Gravity experts continued their study of lunar rock samples, particularly the effect of high-velocity meteorite impact. Space exploration was also in the focus when Apollo 17 astronauts were briefed on aspects of cratering at Sudbury as a preparation for their study of lunar craters.

The Seismology Division, using recently developed interpretation techniques, undertook a review of all previous work in the Rocky Mountains area which, combined with seismic methods, will result in a unified interpretation of this important region. Seismologists completed the interpretation of the crustal and upper-mantle structure from a refraction experiment carried out in the Shield areas of Quebec. They also made long-range refraction observations in the Sverdrup Basin in the Arctic, an experiment carried out jointly with the Geological Survey.

Mapping under the auspices of the Polar Continental Shelf Project. This project, which provides logistic and other support to a large variety of scientific research and technical surveys in the northern Arctic, again made a major contribution to greater knowledge of Canada's northernmost territories.



Quaternary geological mapping of Ellesmere and Melville Islands has proceeded at a favorable rate by the Geological Survey of Canada, with considerable support from the Polar Continental Shelf Project. The Beaufort Formation on Banks Island has been mapped; this formation was probably deposited prior to the development of the straits between the islands. Mapping of surficial deposits in the British and the Richardson Mountains upgrades previous work.

The potential usefulness of surface resistivity, selected borehole geophysical tools and seismic methods to detect, investigate and map surficial deposits in the permafrost environments was investigated.

A four-mile grid of gravity and bathymetric data was established at 982 stations in the Beaufort Sea, revealing gravity anomalies trending parallel to the coast or cutting the coast at a shallow angle. The northeastern sector of Victoria Island was covered by a gravity survey, revealing a relatively flat and featureless gravity field.

Continuous seismic-reflection profiling in the Mackenzie Delta, Eskimo Lakes, Liverpool Bay and continental shelf of the Beaufort Sea reveals existence of a discontinuous but very strong reflector which is believed to be the top of permafrost. This investigation is part of a continuing program to investigate the nature and areal extent of permafrost.

A unique co-operative program between six oil companies and three branches of EMR yielded valuable information pertinent to the sedimentary section and crust of the Sverdrup Basin. The attitude, nature and thickness of the various sedimentary strata overlying the basin have been mapped for one profile extending the length of the Basin.

## **SEARCH FOR AND EVALUATION OF RESOURCES**

Search for resources. Many of the detailed studies carried out by the Geological Survey of Canada are directed to the search for non-renewable mineral resources.

A major project in 1972 was a regional geochemical reconnaissance by lake-sediment sampling of 36,000 square miles northeast of Yellowknife. The results of the survey were made available to the public in mid-April 1973 in the form of 21 maps at a scale of 1:250,000. Part of the area was also covered by an airborne gamma-spectrometry survey. This study, when made available to the public, resulted in the staking of 200 claims. Similar staking in the Mont Laurier area of Quebec resulted from a shared-cost

airborne spectrometry survey carried out in 1971. Geochemical techniques were also applied in Newfoundland to outline areas of high potential in metallic mineral resources and thus to facilitate discovery by exploration companies. These studies were carried out for and in co-operation with the Newfoundland government.

Geochemical methods have proven very useful in mineral exploration, but different terrain conditions demand different techniques. The forested, non-permafrost part of the Shield, the area that contains the major part of our mineral wealth, has long defied the geochemist. During 1972, the Geological Survey continued a study into the use of organic gels as a sampling medium, and it is hoped that by 1973 it will be possible to present some conclusions that will be of assistance to those prospecting in the southern Canadian Shield.

Two major air-supported projects assisted in the evaluation of the potential of northern and arctic petroleum basins. Studies of the regional stratigraphy and structure of the Mesozoic rocks on Amund Ringnes, Ellef Ringnes and Cornwall islands were continued and the regional geological study of the Paleozoic rocks of western Devon Island was completed. A study of evaporite deposits in western Ellesmere Island was completed, as was a study of the stratigraphy and sedimentology of Paleozoic clastic rocks in northern Ellesmere Island.

One subdivision of the Geological Survey has as its objectives the determination of the character and distribution of mineral commodities in Canada, the understanding of the local and regional geological features conducive to the occurrence of specific types of mineral deposits and the application of data derived from such studies to provide qualitative and quantitative determinations of our mineral resources. During the report period, studies were done on copper, molybdenum, lead, zinc and the rare-earth elements. These involved field visits to many mining properties and mineral occurrences. Two maps (scale 1:500,000) indicating the copper and zinc potential of a 33,000-square-mile area in the Noranda-Val d'Or and Timmins-Kirkland Lake area were published. Three areas of high potential were outlined, none of which contained known deposits, but one south of Lake Abitibi has since been shown to contain a deposit (Magusi River) with an estimated potential of 3.74 million tons of 1.2% copper and 3.2% zinc — a result of great encouragement to those engaged in "Theoretical" predictions.

The Geological Survey, Mineral Resources



Branch and Mines Branch participated in a crash project with the code name Operation September to provide quantitative estimates of Canada's mineral endowment of copper, nickel, molybdenum, lead, zinc, uranium and iron. Although the department had successfully developed estimates for oil and gas, this new project required a different approach because of the many variables inherent in metal deposits. The task was completed within the time limits set and demonstrated the wide range of expertise available within the department.

Increased interest in the coal resources of Canada has been reflected in studies by the Geological Survey. Samples from the Upper Elk River, Crowsnest and Flathead coal areas of British Columbia and Alberta have been collected and studied. Staff members also participated in the joint federal-provincial coal-evaluation program in Saskatchewan which is designed to provide the geological framework needed to delineate areas of significant coal-seam development within the widespread Ravenscrag Formation.

The field aspect of a study of the mineral belt of central New Brunswick begun in 1971, which made use of existing mining-company geological maps, was completed.

Many of the studies carried out beyond our coasts are directed to an evaluation of potential resources. Geological Survey officers continued detailed and regional surface and subsurface studies in the Hudson Bay Basin and began subsurface stratigraphical investigations of the Mesozoic and Tertiary rocks of the Atlantic Continental Margin Basins. The results of the latter study indicate at least two areas containing sedimentary sequences capable of generating and retaining large volumes of hydrocarbons.

To assist agencies involved in resource development, geophysical data collected on cruises by the Bedford Institute prior to 1972 are being published as "natural resources charts" at a scale of 1:250,000.

Studies in the use of glacial till as a sampling medium for prospectors were continued and samples were collected in the Thetford Mines-Lac Mégantic region, an area containing ultramafic rocks that carry identifiable nickel and chromium values.

In support of the search for and evaluation of resources, the Geological Survey participates in energy-resource evaluations for the sedimentary basins of western and northern Canada. Studies were carried out in the fields of organic and inorganic geochemistry, clay

mineralogy, coal petrology and petroleum geology. The Geological Survey maintains at its Institute of Sedimentary and Petroleum Geology cores, samples and logs of northern wells and also a library of confidential and non-confidential company reports and maps covering geological and geophysical work done in the northern territories. This valuable collection is of great assistance in evaluation studies.

Several members of the Geological Survey took part in the department's Second Annual Evaluation of the Petroleum and Coal Resources of Canada. This provided, for the first time, a realistic appraisal of the nation's fossil-fuel resources based on strictly geological parameters derived in large measure from the results of the Survey's detailed analysis program of the sedimentary basins of Canada.

#### Evaluation of fuels and other resources.

Pursuant to an announcement by the Minister in September 1972 that the department would undertake a long-term assessment of Canada's oil and gas resources, the department's Energy Sector, the Geological Survey, and the Department of Indian Affairs and Northern Development have begun to collect a body of data and a preliminary analysis on these fuels. Continuing data-processing and analysis will permit annual updating and refinement of the appraisal of Canada's total oil and gas resource potential. As part of this program, an up-to-date inventory is being maintained by EMR of proven petroleum reserves and potential resources in the sea-covered areas of Canada. This inventory uses data from the petroleum industry submitted under the regulatory system administered by Indian Affairs and Northern Development and EMR, and from studies carried out by the department itself. Its purpose is mainly geological analysis and economic evaluation of potential hydrocarbon reservoirs in the frontier regions.

Canada's knowledge of its coal resources is limited to a general geological description and an assessment of the quantity of coal below ground, subject to minor recovery criteria. In such terms, the coal resources are large; but the recoverable amounts are much less, owing to difficult underground access. The department is developing the methodology for evaluating coal resources in terms of recovery and economics. The methodology is designed to remain unaffected by changes in mining and combustion technology.

In connection with a study being conducted by the Organization for Economic Co-operation and Development (OECD), members of the department have re-evaluated Canadian uranium resources and predicted demand for uranium to the year



2000. They found that reasonably assured resources of uranium, exploitable at not more than \$10 per pound of uranium oxide (U<sub>3</sub>O<sub>8</sub>), amount to 241,000 tons. Another 158,000 tons could be mined at \$10 to \$15 per ton. The experts believe that a further 530,000 tons is available at up to \$15 per pound.

At present, approximately 75 per cent of Canada's electrical energy is generated by hydroelectric stations. This is a substantial saving in fuels: at current levels of thermal-power efficiency, nearly 70 million tons of bituminous coal would be needed each year to produce the same electricity. This would nearly triple Canada's coal consumption.

The share of hydroelectric stations in the production of electric power is expected to decline. Estimates of future fuel needs for power production also require better knowledge of usable hydro resources. An assessment of these resources, bearing in mind economic and environmental constraints, is now being carried out by EMR, in conjunction with provincial organizations.

In recent years, it has been suggested that more ore is being used up by Canadian consumption and exports than is being found in Canada and that ore-discovery costs have greatly increased. Research within the Mineral Resources Branch has shown that, on the contrary, Canada has been adding to its net mineral reserves and that, although discovery costs have risen, the increase has not been as steep as is widely believed.

As part of a departmental study, estimates are being made of as yet undiscovered mineral deposits, on a regional basis, in terms of tonnage, grade, and ore types; this is done on the basis of geological indicators and experience. From these estimates, impression of future mineral production, capacity, employment and income are being evolved, both for known and as yet undiscovered mineral deposits. For planning purposes, various supply patterns are being simulated to meet forecast mineral requirement, in order to gain insight into the question of where, and at what rate, mineral capacity might best be developed from a national point of view.

A contribution was made to a study by the Ministry of Transport on the best route for constructing a railway extension in British Columbia toward the Yukon border. Estimates were supplied of the quantities of minerals that might be transported along such a railway extension, both from mineral deposits now known and from deposits that may be found and developed in the near future.

The objective of the National Mineral Inventory, a major component of EMR's data base, is to identify, describe and evaluate information on all known mineral occurrences in Canada. The inventory consists of a comprehensive summary of location, geology, history of ownership, development and results of development supplemented by map and literature references, on each occurrence. It has been estimated that some documentation exists on about 30,000 occurrences in Canada, and of this number more than half are now recorded in the inventory. The summaries are available to industry and the general public as well as government, and to facilitate reference to them they have been indexed and included in the Canadian Index to Geoscience Data, a publication of the Canadian Centre for Geoscience Data.

Tests and analyses. Departmental experts also carry out a broad range of tests and analyses, in field and laboratory, on the suitability of Canadian fuels, ores and other non-renewable resources for modern industrial processes. Such work is done chiefly in the Mines Branch.

The properties and location of Canadian coals and ways and means of preparing them for specific uses again claimed a major share of this work.

The mountain coals of Alberta and British Columbia represent more than 70 per cent of the geologically estimated coal reserves of western Canada. However, the assessment of the economically recoverable portion of that coal presents serious problems, as the coal seams are thick and/or inclined and accessible only through underground mining. Current underground methods do not work satisfactorily in such seams, and new methods need to be developed. By studying progress made in other nations, especially France, EMR engineers have begun to tackle this problem.

Gas outbursts and ground-control problems also limit the mining of some coal seams. Conditions causing such dangers and means of preventing them are being studied, with some positive results.

As part of a joint federal-provincial program to obtain a more accurate assessment of lignite resources in Saskatchewan, a drilling project was launched. More than 200 holes were drilled, totalling 100,000 feet, in the areas of Estevan, Willow Bunch, Wood Mountain and Cypress Hills. The work was completed during the 1972 field season. In the next season, the areas known to contain coal will be drilled more closely to obtain a more precise estimate of commercial quantities.



More than 2,000 coal samples were analyzed. Progress is being made in the data-processing of this project, though many improvements remain to be made.

A considerable advance was made in the study of the chemistry of coking coals as a means of resource evaluation.

The Mines Branch's coking laboratories at Ottawa maintained a high level of coking tests, evaluating coals being mined in British Columbia and Alberta, chiefly for export. The coking characteristics of each major coal deposit must be determined before its value can be calculated and a marketing agreement negotiated.

To help the coking industry of Canada, Algoma Steel Corporation donated a gas-fired movable-wall oven to the department. The oven is being installed in the EMR laboratory at Edmonton, Alberta, in space rented from the Research Council of Alberta. It is expected to become operational in mid-1973, and should give improved service in coking tests to western coal producers, with costs to be shared. Petrographic and other laboratory studies of coals, however, will continue in Ottawa, for the sake of continuity and coherence.

Mineralogical and analytical tests were carried out on a group of coal samples from the Lingan area of Nova Scotia to elucidate sulphur distribution in that high-sulphur coal.

The characterization of non-metallic ores continued during the year, particularly the long-term study of the composition and properties of ceramic clays and shales in Canada. A report on typical clays and shales of the Atlantic provinces is at the editorial stage. Ceramic properties of typical common clays and shales from the Prairies were determined and studies of their mineralogy were started. Tables of properties of many clays and shales evaluated in the past sixty years are being assembled by regions in English and French. These will be used in a comprehensive monograph of the properties and occurrence of Canadian clays in relation to their possible use in ceramics.

Other extensive evaluations were made on the properties and development of uses for asbestos fibre; on the properties and usefulness of clay fly ash mixtures from Edmonton for fire-brick; on chemically prepared magnesia from Quebec and magnesite from British Columbia for use in refractories; on a talcose rock from British Columbia for various commercial applications; two Canadian granites from Quebec, two marbles and one chalcedonic agate from Ontario and a travertine rock from British Columbia were assessed for their potential as building stone; an information circular was published entitled Canadian Minerals for Refractories; and many meetings were attended by a departmental representative to discuss new uses for Canada's large sulphur surplus and to establish a Canadian Sulphur Development Institute.

Studies, some completed and others in progress, have been conducted of the mineralogy of various areas of Canada to assess their ore deposits and means that could be used in beneficiating those ores that appear sufficiently attractive, economically, to be worth developing. Among the studies that were started in the fiscal year 1971-72 and have continued into 1972-73 are the large porphyry copper-molybdenum deposits in the Highland Valley and adjacent areas of British Columbia. This investigation is aimed at identifying the minerals and their relationships, thereby characterizing the features that would be of importance in beneficiation. A study of the platinum-bearing placer sands in the Tulameen River area of British Columbia seeks to characterize the platinum minerals present, to determine their mineralogical associations and to elucidate the mineralogy of the river sands. Ten platinum-group minerals have so far been identified, of which at least two are new minerals. An investigation has been started of the base-metal occurrences in the Sturgeon Lake area in the Kenora mining district of northwestern Ontario. This investigation is aimed at determining the mineral assemblages, their textural relationships, and their chemical characteristics. A study is also being made of the complex tin-bearing minerals found in the Mount Pleasant area of southwestern New Brunswick, and of the phase relationships that govern the natural assemblages of this series of minerals.



## ECONOMIC AND SOCIAL ASPECTS

### ECONOMIC PLANNING AND MARKET ANALYSIS

Growing domestic need for all forms of energy and the expanding opportunities for the export of any available surpluses to countries deficient in energy has raised a number of important political, technical, and financial questions. The enormous capital expenditures Canadian energy producers would have to make to satisfy expected domestic and foreign demand could strain Canada's financial capacity. These capital needs and the growing concern over Canadian ownership of energy resources, along with environmental and social factors have an important bearing on the development of a Canadian energy policy.

To provide the basis for such a policy, the federal government embarked on a series of special studies in 1971; these continued throughout 1972 and into 1973. The first product was to be an analysis of Canada's energy situation, scheduled for release in the summer of 1973.

Oil. Particular attention in the analysis of the petroleum situation in Canada is being paid to establishing deepwater ports in eastern Canada, and setting up related petroleum refineries. Eastern Canada has a number of excellent sites for deepwater ports, which is significant with the trend toward very large tankers for shipping crude oil. Such natural port sites are lacking on the eastern seaboard of the United States, and Canadian ports might therefore serve as transshipment points. Refineries are also being planned for Canadian port areas to serve North American markets.

Such proposals call for a reassessment of Canada's National Oil Policy, which so far reserves the area west of the Ottawa Valley for domestic petroleum.

Since oil and gas provide more than two thirds of Canada's energy, the department is studying a series of related matters, such as: the upward pressure on Canadian prices by higher prices in the United States; the desirability of a two-price system; security of supply from

foreign sources, together with alternative and emergency measures; the management of the international petroleum market; and federal-provincial relations in the field of oil production and marketing. The department also arranged exchange visits with oil and gas officials of the Soviet Union and China. The technical exchange with the Soviet Union was initiated in 1970, and that with China in the fall of 1972. The latter began with a visit of China's petroleum experts to Canada, and a return visit of Canadian specialists to China led by the Minister of Energy, Mines and Resources in the spring of 1973.

Coal. Studies of a similar nature are being conducted on Canada's coal supply. Since this matter is closely connected with mining, economic and political development in other countries, a series of studies was begun of coal developments in Australia, China, and the European Economic Community.

A comprehensive study was undertaken of increased employment in Canada through the mining and processing of metallurgical coal. Private companies and provincial governments contributed to the study and were provided with the results.

The economics of the coal market in comparison with those of other energy sources were studied, since any fluctuations in the latter may cause abrupt changes in the supply of coal and, in certain circumstances, coal shortages.

Uranium. Studies related to the feasibility of a uranium-enrichment plant which had been initiated in the previous fiscal year were continued. Although considerable effort is being made throughout the world to develop a centrifuge enrichment process, Canadian studies have been related to the gaseous diffusion process used in the United States. Much of the technology required for such a facility is in the hands of foreign governments. Therefore, if private industry in Canada were to embark on this endeavor, the government would need to be involved in the negotiations for the release of the data and for its subsequent safeguarding. The product from an enrichment facility would be destined primarily for export, in line with the objective of the further processing of uranium, since Canadian reactors are fueled with natural uranium.



Requirement and economics of heavy-water production were evaluated and discussed. Heavy water is an essential ingredient of the CANDU type of nuclear reactor used in Canadian nuclear power plants. Unless there is an adequate and assured supply at reasonable price, it will be impossible to pursue the Canadian nuclear power program envisaged by Ontario Hydro and other utilities.

Electrical energy. To safeguard and improve this traditionally valuable source of energy in Canada, the department is encouraging technological developments, interconnections between regions and, where appropriate, it is making financial contributions to projects with long-range benefit or significant economic risk.

While exports of electrical energy to the United States are modest, amounting to about 3 per cent of Canada's total generation in 1972, substantial benefits can be derived from cross-border exchanges. These, of course, must be subject to safeguards to prevent cost increases and supply shortages in Canada. Although no specific expansion of generating capacity has occurred to meet export requirements, construction schedules may be speeded up, and some money saved, if there are short-term opportunities for interprovincial or international power sales. Seasonal differences in demand patterns may also create opportunities in this market.

Economic studies. The broad economic studies of the department's Energy Sector included a forecast of Canada's energy demand to the year 2000, of relationships between energy development and use and employment, energy costs in the Canadian economy, possibilities of upgrading energy exports, Canada's position as a world energy source and user of energy, state participation in energy production, etc.

Progress was made during the year in setting up a data bank on energy, a computerized system for storage and retrieval of statistics. The data bank provides detailed financial and corporate information on the energy and associated industries not available elsewhere.

All these economic studies were to form the basis for the energy analysis slated for publication in 1973-74. They also helped the Energy Sector to discharge its functions of advising the government on energy policy and of keeping the Canadian public informed in this vital field.

Mineral commodities. The effect of the mineral industry on the economy of Canada -- how much employment it generates, what its influence is on foreign trade, what its

ramifications are for other industries, etc. -- has been little understood in the past. It is now a subject of intensive investigation.

The Mineral Resources Branch has become familiar with the very large medium-term econometric model of the Economic Council of Canada, referred to as the "Candide" model. With its forecasts were made and simulations run that will throw light on what the mineral industry may look like and what part we can expect it to play in the Canadian economy in 1980.

Longer-range work included the development of mineral-supply and -demand forecasts to the year 2000. This picture of the future, of mineral markets, international competition, and the share of world production and consumption that Canada may expect in 20 to 25 years helps in deciding what actions should be taken now. Lastly, tests were made of long-term world models. For example: "World Dynamics" is a method for making very long-range forecasts of social and economic systems, using the computer to keep track of all the interrelationships within these systems. The Mineral Resources Branch has monitored research developments in this field and conducted its own research owing to the importance attached to non-renewable resources. Work has been done on the "Limits to Growth" world computer model, and a smaller Canadian model was developed for the department at the Massachusetts Institute of Technology.

It was concluded that although the Club of Rome had brought before the public the spectre of overcrowding, pollution and resource shortage, its method of modelling was overly simplistic. It was further believed that the models were not useful at this time in Canadian government decision-making. Further studies are in process on the methods of World Dynamics, and a lengthy critique was scheduled to be published in 1973.

A delegate of the department participated in the deliberations of the Lead and Zinc Study Group, which seeks to stabilize international lead-zinc markets and to reduce barriers to trade.

A departmental mission, led by the deputy minister, visited Poland in order to acquaint itself with the production of metals and minerals in that country, and to seek information on the hydraulic mining of coal, which holds out important advantages to Canadian coal mines. The department, in co-operation with the Department of Industry, Trade and Commerce, sponsored a joint mission to China in November and December 1972.



The department provides an alternate delegate to the International Tin Council on an ad-hoc basis. Tin has been the most closely controlled metal in international trade.

During the fiscal year, arrangements were made for interested departments to participate in the preparations for the negotiations under the General Agreement on Tariffs and Trade (GATT), which were expected to begin in 1974. EMR named an assistant deputy minister to represent the department in an interdepartmental committee, and arranged for other personnel to begin work on the preparation of background data.

A world oversupply of potash continues to plague the industries based on this Saskatchewan resource. In order to plan for the future, the Mineral Resources Branch undertook a study of potash production, concentrating on provincial revenues and industry profits to 1980 and analyzing the effects of existing regulatory schemes and alternative measures.

A federal-provincial drilling program led to the discovery of a potash deposit in New Brunswick. EMR was called on to give advice on the development of the deposit in the light of difficult world market conditions.

A study is being carried out concerning the regional impact of a proposed copper smelter in the Clinton area of British Columbia, particularly with respect to jobs and purchase of locally made equipment. Two different smelting processes are being analyzed against this background.

Mining taxation. The department continued to provide advice to the Department of Finance on the taxation of the mining industry. Modifications were recommended of the amended Income Tax Act, which came into force in January 1972. Assistance was also given in revising regulations under the amended act.

Numerous requests were received from members of the mining industry for clarification of the Income Tax Act and Regulations, as well as for help to bring about amendments in the act. A review was made of the comparative effects of corporate income taxes in Canada and Australia on the mining industry of the two countries.

The Department of National Revenue is continuously advised on the administration of those parts of the Income Tax Act and Regulations bearing on the mining industry, such as the three-year exemption of new mines and the percentage depletion allowance. The

Department of Justice is assisted in court actions arising from the recommendations.

## 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. Foreign-aid projects are also reviewed.

Petroleum and other energy sources. Of the regional and special programs related to oil and gas, the department has been giving particular attention to the Task Force on Northern Oil Development. This interdepartmental committee, under the chairmanship of the Deputy Minister of Energy, Mines and Resources, was established by the federal government in December 1968, to give advice on all matters relative to northern oil and gas development and transportation. EMR's Energy Sector serves as co-ordinator for the work of the Task Force and its six subcommittees: environmental and social, economic impact, pipeline engineering, transport, marketing, and industrial supply. Pipeline guidelines in principle, based on recommendations of the Task Force, were established by the government in August, 1970. Draft environmental and social guidelines were published in June 1972. Consideration is now being given to guidelines concerned with financing, ownership and the Canadian content of northern pipelines. The Task Force environmental-social program is now entering its third year of a four-year \$20-million program. This program and other Task Force projects are designed to provide background information and baseline studies on all matters that will have to be appraised when an application to construct a northern pipeline is received by the government.

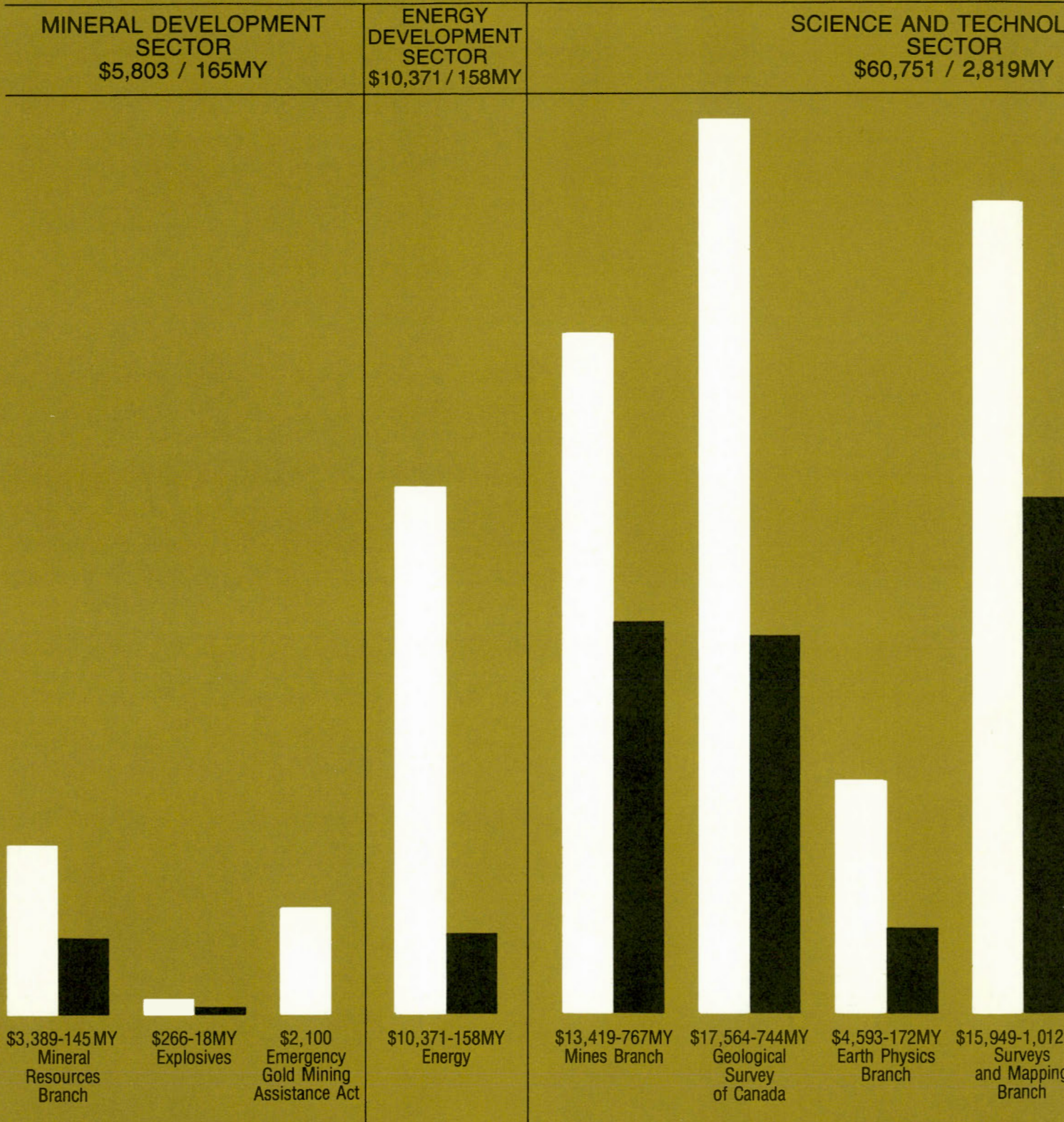
To provide information and advice concerning the financing of a northern pipeline, which would involve expenditures of at least \$5 billion, the Minister of Energy, Mines and Resources established a National Advisory Committee on Northern Pipeline Financing in 1972. This committee is made up of senior representatives of the financial community in Canada. Its findings will help to define guidelines for the financing and Canadian content of a northern pipeline.

Panarctic Oils Limited, a consortium in which the federal government has a 45-per-cent interest, was established in 1968 to carry out oil and gas exploration in the region of the Arctic Islands. The exploration has had very encouraging results. The extent of Panarctic's



# DEPARTMENT OF ENERGY

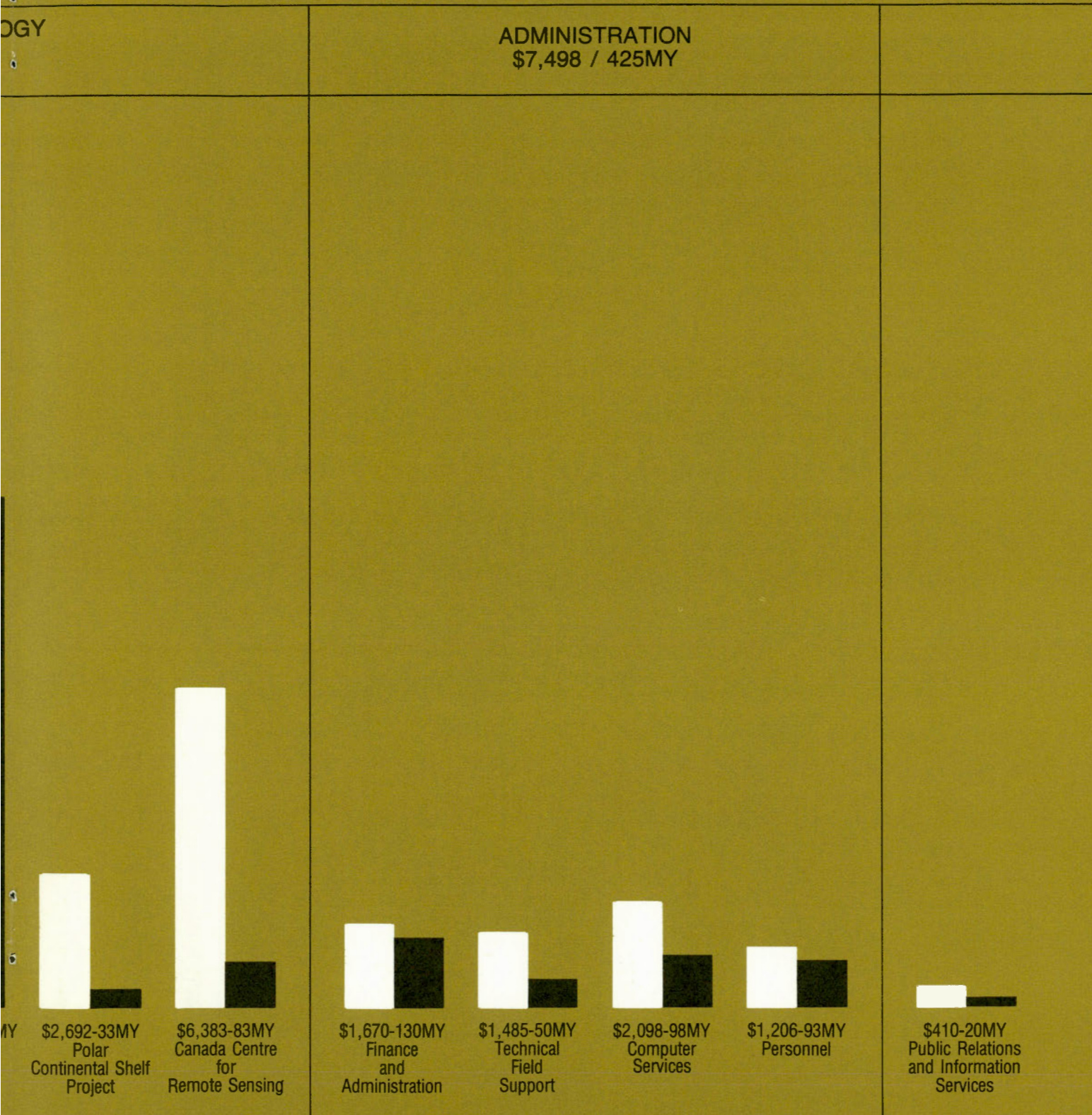
1972-73 ESTIMATES IN THOUSANDS OF DOLLARS AND MAN Y





# Y, MINES AND RESOURCES

YEARS / TOTAL FOR DEPARTMENT: \$84,423; 3,567 MAN YEARS (MY)





success in opening up the Arctic Islands gas and oil potential will determine in considerable part the future development of northern Canada. Initial appraisals are now under way on pipeline-route possibilities for Arctic Islands natural gas. The government's representation in the Panarctic consortium provides a means of encouraging the development of Canada's northern oil and gas resources and of northern Canada as an economically viable region. The government's future role in Panarctic is being assessed to determine how the company may best serve the national interest in opening up the resources of a region that is considered to be one of Canada's most important potential sources of hydrocarbons.

Policy recommendations and advice are provided on a number of offshore matters that have economic and social implications at the regional level. In the negotiations between the federal government and provincial governments, in particular those of the five eastern provinces, regarding offshore mineral rights, policy advice has related to the manner in which those rights should be made available for development, the manner in which they should be administered, and the allocation of offshore mineral-resource revenues. There has also been participation in studies especially concerned with the importance of ensuring that Canadian industry in general, and that of the coastal provinces in particular, will benefit as fully as possible from the exploration and development of our ocean resources, including energy resources.

The department continued to advise the Cape Breton Development Corporation, particularly on improving coal productivity and marketability. The Corporation has important regional responsibilities relative to the Nova Scotia coal industry.

The joint venture between the federal government and Denison Mines, begun in 1971, to stockpile uranium at a rate of two million pounds a year, continued throughout the fiscal year. This has permitted continuation of Denison's Elliot Lake operation at an economically viable level. In November 1972 a sales agreement was made with several Spanish utilities for the delivery of approximately nine million pounds of uranium from 1974 through 1977, at a total value of about \$60 million. Some six million pounds will come from the joint Canada-Denison stockpile and will exhaust that stockpile. The other three million pounds will come from the general government stockpile accumulated during the period 1963-70 to maintain production in the Elliot Lake area. The stockpile

programs were essential to maintain uranium mining until marketing prospects improve.

In the area of federal-provincial liaison and agreements, the Energy Sector is involved in a number of specific activities. The Nelson River Transmission Agreement between Canada and Manitoba, under which Atomic Energy of Canada Limited has built a high-voltage direct-current transmission line with terminal equipment rated at 1,080 megawatts, has reached the point where all the basic equipment requirements of Phase 1 have been placed on order. The Energy Sector provides the chairman for the Nelson River Agreement Review Committee. Since the Canada-Manitoba agreement contemplates its extension to cover additional converter terminal equipment up to the ultimate rating of 3,200 megawatts, discussions are in progress with Manitoba concerning the specific terms of a new agreement.

The department acts as co-ordinator in federal-provincial discussions relating to the James Bay regional development. Useful progress has been made in resolving a number of aspects relating to the environment, transport, communications, etc. The principal and most difficult problem of native people's rights remains unresolved and has been the subject of litigation before the Quebec Superior Court.

Interest in interprovincial electrical-transmission connections was focussed during the year on the Maritimes with discussions of a federal role in interconnection between Prince Edward Island and the mainland and in reinforcing the existing New Brunswick-Nova Scotia interconnections. These activities involve close co-ordination with the Department of Regional Economic Expansion.

Assistance was provided to the Province of Newfoundland in preparing the "energy section" of its economic development plan and also to Ontario's Task Force Hydro on matters concerned with rates and costing.

A review of the technical and economic aspects of Bay of Fundy tidal-power development is under way. This was studied in detail by the Atlantic Tidal Power Programming Board and reported on in 1969. A federal-provincial group is currently re-examining the 1969 conclusions which were that a Bay of Fundy tidal-power development would not be economically competitive with alternative sources of electrical energy.

In the international field the department has had a major role in the exchange of visits and technical information related to energy under the Canada-USSR Agreement for co-operation in



Industrial Technology. This has led to an improved understanding of areas of common interest. Better opportunities for economic co-operation in the oil, gas and electric-power fields which will be of benefit to both countries are being sought. A program of exchange visits on energy matters is also under way with the People's Republic of China.

Mineral development and exploration. The department seeks to further the use and processing of mineral resources in regions of the country that have lagged in economic development. Such development, where practical, can yield important economic and social benefits that diffuse throughout the region.

At the federal level, most of such development work is undertaken in conjunction with the Department of Regional Economic Expansion. Projects are being carried out in Newfoundland, Cape Breton Island, the mainland of Nova Scotia, New Brunswick, Gaspé, the Lac Saint Jean region of northwestern Quebec, and the gold-mining communities of northern Ontario.

The department's Mineral Resources Branch carried out a Mineral Area Planning Study (MAPS). It was designed to develop the framework for decisions on mineral resources in various areas, to examine the location of communities dependent on mineral resources, and how population, employment and income will change through time. MAPS has also analyzed the changing structure of the mineral industry: the proportion of commodities, the technology of mineral transportation, mineral processing. These factors significantly affect the regional expansion of Canada's mineral industry.

Railway construction in northwestern British Columbia continued in 1972-73, opening very favorable opportunities for mineral and forestry development. The department co-operated with the Ministry of Transport by upgrading its assessment of mineral potential and expected timing of development. The groundwork for a comprehensive regional development plan has been laid.

An extension of the New Brunswick co-operative agreement was prepared and implemented during the year. These activities have assisted in locating a significant potash and salt deposit in New Brunswick.

An amendment was enacted to the Emergency Gold Mining Assistance Act (EGMA), extending the life of the act to June 30, 1976, without change in the method of computing financial assistance.

The Geological Survey is responsible for the federal-provincial aeromagnetic surveys. Two contracts were completed during the year, one in British Columbia and one in northern Baffin Island. Another contract was initiated in Quebec (Ungava Peninsula). Good progress was made toward completion of four other existing contracts. More than 170,000 line miles were flown and 261 aeromagnetic maps were printed and published.

A unique and successful co-operative project involving industry and government was carried out in the Arctic Islands in the spring of 1972. Six oil companies participated, with the Geological Survey as operator, in a reconnaissance refraction-seismic profiling along a survey line between Melville Island and Amund Ringnes Island. In addition, a series of large explosions were detonated in support of deep crustal surveys by the Earth Physics Branch.

Two experimental high-sensitivity aeromagnetic surveys in the Kirkland Lake and Bathurst areas were shared with the provinces of Ontario and New Brunswick respectively, and a series of airborne gamma-spectrometer flights were made in collaboration with the Department of the Environment and various agencies of the province of Ontario to measure snow-water depth.

Foreign aid. The department provides technical advice and experts to developing nations through the Canadian International Development Agency. It also co-ordinates training courses for nationals of developing countries in disciplines related to EMR's mission.

In 1972-73, the Mineral Development Sector arranged 26 training programs and gave advice on technical assistance to copper mines in India and a lead-silver mining project in Burma. Geologists directed and co-ordinated various projects sponsored by CIDA. Aeromagnetic-radiometric airborne surveys were carried out in Niger, Cameroon, Upper Volta and Guyana. A geologist was seconded to the Omo River Project in Ethiopia and another was loaned to the government of Bolivia. A three-man geological survey team was sent to Brazil to advise on a proposal for the investigation of the Goias region. Advice on topographic surveys was given in Tanzania, Ghana, Kenya, and Guyana. Professional personnel from the department contributed to technical seminars in Indonesia and Brazil.

Arrangements were made for the Canadian representation to the third session of the United Nations Committee on Natural Resources, which was held in New Delhi, India, in February 1973.



# 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. EMR's responsibilities in the field of oil and gas include recommendations on the type of research that should be conducted to develop and conserve these two resources. Special attention is being paid to the heavy oils, including the Athabasca oil sands. Advancements in technology have an important bearing on the economics of oil extraction, which is particularly important in the Arctic and the offshore as well as in the Athabasca oil sands. The department is also co-operating with the Science Council of Canada in a review of such research.

The stringent requirements imposed on offshore exploration to ensure that it is carried out safely and does not pollute the environment have prompted the oil industry to develop new technology to meet government standards. This applies particularly in ice-infested waters such as those off northwest Newfoundland and Labrador, where drilling proposals by industry were under review during the year.

Not all of Canada's coals can be economically extracted with present mining techniques. Particularly difficult to mine are thick, steeply pitching seams, which present a danger to miners. The department is examining techniques used for such seams in older coal-producing nations to see whether they would be applicable in Canada.

Departmental experts have kept a continuing review of the performance of the Canadian-designed CANDU nuclear power plants and power plants of other countries. The excellent performance of the Pickering station has confirmed the suitability of the CANDU design for Canadian conditions. The specialists have concluded that it would be premature for Canada to embark on extensive research on reactors of the fast-breeder or thermonuclear type. They believe that the flexibility of the CANDU reactor and its ability to use thorium as well as uranium fuel mean that this type of reactor will continue to be an efficient and competitive energy source for several decades, even if the fast breeder is developed commercially elsewhere.

The Research Institute of Hydro Quebec (IREQ) has received loans and grants from the department to carry out research that would advance power-transmission technology throughout Canada. The institute became operational during the year, and most of the facilities provided for by the federal-provincial agreement are in place.

Contacts are maintained with the Canadian Electrical Association, especially in areas studied by the association's Research Committee and Environment Committee. These committees seek to find ways and means for industry and government to co-operate on research projects.

Automation in surveying and instrumentation. Although map-making in EMR's Surveys and Mapping Branch has kept pace with technological advances in that field and the output is now much higher than ever before, there is always room for the introduction of new labor-saving devices. The "Automated Cartography Project" entered its production-development phase in 1972. Time on the system was shared between production of 1:50,000 maps and further development. A block of 1:50,000 map sheets in the Yukon Territory was assigned for production by automated methods.

Additions to computer hardware, aimed at achieving a fully operational level in 1973, continued. With the assistance of Waterloo University, work began on cartography software.

Agreement was reached between the Surveys and



Mapping Branch and the Geological Survey of Canada for the establishment of a digitizing station in the Geological Survey to operate on-line with the Automated Cartography system.

Automation through the use of computers also took further strides in the research of the Earth Physics Branch. Instrumentation in the field of gravity research was improved. The Seismology Division commissioned for program development a mini-computer and a data-acquisition system which will provide on-line detection, location and identification of seismic events at the Yellowknife seismic array. The new system will be installed in a new laboratory at Yellowknife and will begin operation in 1973-74. (The array is capable of detecting underground nuclear explosions in other parts of the world.) Design work was completed and a start was made on the procurement of equipment for an Ottawa-based telephone-linked seismic system to permit rapid location of earthquake epicentres in eastern Canada.

Improvements in methodology and instrumentation were also made in the Geological Survey of Canada. High-resolution aeromagnetic surveys with a complex variety of instruments were carried out experimentally in the Kirkland Lake area and in New Brunswick. New methods of exploring the geochemistry of the sea and the geology of the sea bottom were tested.

Metallurgical technology. A number of investigations were again carried out in the field of physical metallurgy to test the performance of metals and alloys in Canadian environments. One of these concerned improvements in measuring the toughness of pipeline steel; another the improvement of welding technology; still another the development of non-polluting moulding mixtures for foundries. Criteria were drawn up for the reduction of brittle failure in cast-steel propeller blades for icebreakers. Experiments in improving the superplasticity of steels produced a steel which could be stretched to three times its original length in a single operation.

Hundreds of requests were received for information, assistance and advice on questions arising from the processing and use of metals and alloys, which were dealt with by telephone, letter, or tests. These requests originated with industrial companies, research institutes, and government departments.

The department's Physical Metallurgy Division acts as examining authority on behalf of the Canadian Government Specification Board for certification of personnel qualified to carry out nondestructive tests. During the past 12

months, 624 persons were examined at 27 test centres across Canada.

Hydrometallurgical processes, unlike conventional pyrometallurgical processes, allow metals to be recovered from sulphide ores without the discharge of noxious sulphur dioxide into the atmosphere. From an anti-pollution standpoint, hydrometallurgical processes are therefore preferred, and the department has been developing such a process that could be used on ore concentrates containing copper, nickel, cobalt and iron. The process had the advantage that it could be used at deposits smaller than that of Sudbury, for example, where conventional metal-producing complexes would be uneconomical. The sulphur is recovered in pure form, and may thus even have a market value. The process has a variety of possible applications, and some of the technology in it has already been used commercially.

New technology was introduced in the construction of a compression-testing machine that is capable, under stringent controls, of reducing a cylindrical metal specimen's height by 50 per cent. From such tests, accurate calculations can be made of the force needed to perform hot-metal forming.

Ore treatment. One of the techniques used by the Canadian mining industry to separate metal from other ore minerals is flotation, in which tiny metal particles are borne up in a froth and are skimmed off the gangue. Various sophisticated experiments are being carried on in the department's Mines Branch to improve flotation technology. Also under study is the floatability of non-metallic minerals, such as nepheline syenite, diopside, zircon, marl, graphite and special silicas.

Research continued on the chemistry of flotation pulps, in which copper and cyanide salts are used to modify the floatability of copper and other metal sulphides. A new flotation reagent was developed for the flotation concentration of scheelite, a tungsten mineral, and a patent was applied for.

The flotation process for antimony ores of New Brunswick was improved greatly by the discovery of new depressants for the iron and arsenic sulphides that interfered with antimony concentration. Using this new process, an idle antimony mine returned to production.

The production of high-purity iron-oxide concentrates suitable for direct production of steel by rolling and annealing was achieved on several samples of hematite concentrates. The process is being evaluated by an industrial firm.



The department continued to advise on and perform laboratory work for the development of a new fluorite-barite deposit at Lake Ainslie and the improvement of a new mine operation at Loch Lomond, both in Cape Breton, and for the concentration of celestite and the development of a processing plant for spodumene at Bernic Lake, Manitoba.

A method of recovering metallic silver from off-grade silver concentrates from silver mines at Cobalt, Ontario, consisting of grinding and screening, was found to be more efficient than the traditional method of melting or chemical extraction.

Experiments continued on the on-stream analysis of ore and coal slurries, which would greatly speed up processing.

Fuel technology. As in previous years, the work of the department's Fuels Research Centre has concentrated on beneficiating low-grade petroleum, i.e., the removal of sulphur, oxygen and nitrogen and the conversion of a large part of the asphalt fraction to oil. Significant advances were made in improving the mechanical aspects of the pilot plant. The yield of oil and gas to be expected from the Athabasca tar sands can now be predicted more accurately, and the environmental constraints of the refining process are better understood.

To help mining companies to design tall smoke stacks, which disperse noxious smoke more effectively, a study of smoke-plume dispersion was started in 1969 with the participation of private, provincial and federal agencies.

Various types of geographic regions have been selected for study. It has been found that experience accumulated in other countries cannot be confidently applied in Canadian conditions. During the past year, eight plume dispersion studies were completed and circulated to the participating agencies.

A test facility has been built in the department for assessing the pollution potential and the thermal efficiency of residential oil burners.

Studies were conducted in Ottawa on the quality of coking coal that is moved in slurry form in pipelines over long distances. Initial work was carried out on coal transported in water slurries, but a new proposal for developing a slurry system using oil is attracting considerable industrial interest.

Coke-testing facilities at the Ottawa laboratory have been improved through better ventilation, storage and handling, as well as the installation of new equipment. Coking research is being

carried out in close co-operation with Canada's steel companies.

Considerable progress has been made in the major pilot-plant investigation being carried out for the Cape Breton Development Corporation. It seeks to find the most economical method for desulphurizing coal from the new Lingan Mine in Nova Scotia, in order to produce a low-sulphur metallurgical-grade coal suitable for converting into coke.

At the Western Regional Laboratory in Edmonton, bench-scale research on flocculation has resulted in a patent application for a process developed by EMR.

Mining engineering. Judged by the number of underground mines (excluding coal mines) producing over 150,000 tons per year, Canada is by far the leading mining nation in the Western World, equalling the combined total of similar mines in the United States, Sweden and Australia. Much of the prestige of Canadian mining rests on this nation's method of underground mining. Research in underground mining seeks to improve existing methods and to develop new ones. The Mining Research Centre of the department has also pioneered the development, testing and use of instrumentation for monitoring rock movement and warning of dangerous conditions. Today, a growing number of mining companies, both large and small, use similar instrumentation and benefit from this research.

The only mining method, however, that promises any short-run defence against the converging pressures of foreign competition, lower domestic grades, and the growing costs of labor and environmental safeguards is the open-pit method. In Canada, over 70 per cent of mine production already comes from open-pit mines, requiring the movement of more than 300 million tons of ore and an equal amount of waste annually.

Open-pit mining costs can be lowered considerably if slope angles can be reduced safely. Consequently, EMR's Mines Branch has embarked on a far-reaching effort to achieve this aim, by enlisting, in addition to its own expertise, that of mining companies, universities and consultants. Much of the work is being done by contract. Full-scale trials of artificial supports for slopes are being made in different rock types.

Studies are being done on the effects of current mining on water quality, and on the probability of public hazards.

Systems engineering offers to the mining industry the advantage of safer, more efficient and competitive production. Research in this



field is designed to assist in the introduction of advanced techniques through co-operative projects with mining companies. Present projects concern the development of automatic control systems for mining machines such as raise borers, diamond drills and comminution operations.

A new service to mining and civil engineering companies has been provided in the Tunnelling Office of Canada, a part of the Mines Branch. The office has begun to distribute information on tunnelling, and preliminary discussions are being held on the formation of an International Tunnelling Society.

Conversion of non-metallic minerals. A considerable amount of work in the Mines Branch concerns the conversion of non-metallic minerals into useful products such as ceramics, construction materials, fillers and chemicals. The work also includes the development and modification of methods for determining thermal and dielectric properties of rocks, minerals and ceramics.

Studies on commercial clays and shales from Alberta, Ontario and Quebec were designed to develop the proper plasticity required by modern automatic processing machinery.

A new project was initiated in co-operation with the Department of Communications to develop improved ceramic dielectrics for use in microwave communication devices.

Long-term projects continued on the development of aggregates for concrete and on the improvement of construction materials of mineral origin. Studies are being made on the effect of extreme temperatures on the behavior of concretes made with different aggregates. To obtain information on severe winter conditions, field projects are undertaken in co-operation with the University of Ottawa. Experiments were carried out with micro fillers consisting of non-mineral wastes such as fly ash, calcined shale dust, siliceous precipitator dust and silica flour, which are used as thermal stabilizers. Initial results are encouraging and indicate that these wastes may become valuable constituents of concrete.

Studies were initiated on the feasibility of producing fine and coarse concrete aggregates from gneissic bedrock at the Jenpeg Dam site, Manitoba. Results are encouraging.

Analytical standards. During the year, the Mines Branch has become more active in work designed to establish standard methods of analysis in the mineralogical and metallurgical fields on a national and international basis,

and in the selection, preparation and certification of a range of standard reference materials for use in monitoring analytical procedures. In the development of standard analytical methods, the branch participates in the work of such organizations as the International Organization for Standardization, the American Society for Testing and Materials, the U.S. National Bureau of Standards, the National Institute for Metallurgy of South Africa and others. These methods, when developed, form the basis on which international commerce in mineral products is conducted. Standard analytical methods were developed for such materials as iron and steel, manganese, fluorspar, copper-lead-zinc ores, magnesium and aluminum alloys.

The Canadian Standard Reference Materials Project has been established during the past year to make available for sale a range of standard materials which include pure metals, alloys, minerals, rocks, radioactive sources, etc. The work involves the selection, fabrication, homogeneity testing after comminution, bottling, and certification for the desired elements on the basis of the analytical results provided by a large number of participating outside laboratories, after submission to rigid statistical analysis. The availability of these materials and the plans for the extension of the project to include additional materials have been brought to the attention of the Canadian mineralogical, mining and metallurgical companies.

Mine safety. The manufacture and use of explosives in mining have recently experienced great expansion and diversification, due mainly to the introduction of new types of explosives, such as ammonium nitrate-fuel oil and ammonium nitrate-water gel. This has had its effect on the testing work of the Canadian Explosives Research Laboratory.

Some of the new explosives have proven to be free of hazards, and it has become possible to permit their transportation with conventional safeguards. This has saved the mining industry millions of dollars.

The advent of newer blasting agents has required consideration of the release of noxious gases in underground mining. At the request of provincial mine ministers, the department is seeking to determine the nature of noxious gases produced by blasting with the aim of designing better mine-ventilation systems.

Canada is now third in the world in the production and use of explosives, and has an interest in the international standardization of classifications and markings. To this end, EMR



and the Ministry of Transport have applied for membership in the Dangerous Goods Committee of the Economic and Social Council of the United Nations, the focal point for the development of such international standards.

## REMOTE SENSING

Remote sensing by satellite. On July 23, 1972, the first of NASA's Earth Resources Technology Satellites, ERTS-1, was launched into a circular, near-polar orbit which provides complete global coverage once every 18 days from 81 degrees north to 81 degrees south. To read out Canadian data, an existing 85-foot parabolic dish antenna system at Prince Albert, Sask., was converted and equipped with appropriate tracking and recording facilities. Since three days after launch, imagery of Canada has been received almost continuously from the satellite's four-band multispectral scanner. A Ground Data Handling Centre which can process both ERTS and certain airborne remotely sensed data was established in Ottawa.

ERTS imagery is produced as both black and white and color composite images each encompassing an area 185 km by 185 km. There are usually four orbits and 60 to 65 scenes a day over Canada; the entire country can be covered in approximately 1,500 images. Users of ERTS imagery can order copies through a computer-based inventory and ordering system. In all, 308 standing orders were received in 1972-73, ranging in coverage requested from a small section of one province to the whole country. The reproduction and distribution of ERTS imagery is handled by the National Air Photo Library, whose Reproduction Centre is located in the same building as the Canada Centre for Remote Sensing.

In addition, ERTS-1 has the ability to re-transmit data which have been collected by remote data-collection platforms, and there are currently 14 of these in Canada, deployed by user agencies in various disciplines and being operated on an experimental basis.

Airborne remote sensing. In 1972-73, the Canada Centre for Remote Sensing expanded its activities in airborne remote sensing with the use of two more aircraft. The fleet is now composed of four: two DC-3's, a Falcon Fan-jet and one CF-100. Three of these were flying user-requested projects, and one of the DC-3's was reserved for project back-up and as an experimental test-bed for new systems. As in previous years, the Canadian Forces Airborne Sensing Unit performed all the actual flying and aircraft maintenance.

In all, 35,346 sensor line-miles were flown in 116 different projects. This, however, was only about 60 per cent of the planned mileage, due mainly to unusually poor flying weather and severe difficulties with equipment. By far the largest consumers of airborne remote sensing this year were agencies of the Department of the Environment and a number of Canadian universities.

Development began this year on a fully automatic Airborne Data Acquisition System (ADAS) for one of the aircraft. This is a computer-controlled system for centralizing and annotating all of the data gathered from a multitude of sensors aboard the aircraft, and will be used primarily for special programs where accuracy of integrated sensor systems is essential. The ADAS system will be integrated with an inertial-guidance-navigation system for the provision of real-time path-recovery information.

Applications of remote sensing. The Canada Centre for Remote Sensing is committed to developing remote sensing to its effective potential, and toward that end it began a major staffing program in the Applications Division. This has included environmental scientists for applications development, people with interpretive skills and a knowledge of remote-sensing techniques; and research scientists to work on methodology, with complementary skills in the use of physical and mathematical techniques to solve problems and provide numeric solutions by computer techniques.

By year's end, several state-of-the-art pieces of equipment had been acquired to aid these scientists in their work.

While the bulk of data interpretation rests with user agencies, the centre has identified a number of investigative projects which are technologically attractive, in as much as they promise high benefit-to-cost returns and offer an opportunity to develop some of those techniques of remote sensing which could have application to several different disciplines in the environmental and earth-resources fields. The projects will be undertaken as joint efforts with the user agencies concerned, and are expected to yield good demonstrations of the practical applications of remote sensing.

An example of the centre's experimental efforts which may well end in operational application is an investigation of a controlled oil spill in the Bahamas. The project, undertaken in co-operation with the Bahamian Government and the Canadian Department of the Environment, took place in February 1973, and the results



will be used as an aid to determining suitable locations for supertanker ports in the islands.

Another program initiated this year is a cooperative effort in aerial hydrography, undertaken in conjunction with the Marine Sciences Branch of the Department of the Environment. It involves water-depth determination using an aircraft, particularly in coastal and shallow waters where currently used water-based techniques are time-consuming, difficult, and at times extremely dangerous. One of the aircraft has been fitted out with an extremely accurate inertial navigation system to allow precise determination of aircraft position, and as imagery is gathered over the next 18 months it will be largely analyzed by the third participant, the University of New Brunswick.

Under the federal government's winter works program, the centre was able to temporarily expand its applications efforts through the establishment of regional winter works offices across the country. Each office was staffed by interpreters experienced in one or more of the major user disciplines who could assist users in their area in obtaining remote-sensing imagery and services to fill their requirements. These local offices, while not permanent, have provided an important educational function in these developmental stages of remote sensing in Canada.

Sensor development. Sensor development, now entering its fourth year, has reached the point where many of the projects are attracting funding from user agencies. Several sensors were field-tested this year, and two new projects initiated.

HISS, an entirely new principle for measuring the thickness of sea ice, is being developed by the Department of Electrical Engineering at the University of Toronto. This system, which uses the concept of microwave holography, was test-flown in the Canadian Arctic in May 1972. Promising results were produced from the initial data, and the completion of the rest of the system hardware is expected to reduce the time to operational status.

At York University, a laser ranging device (LIDAR) has been further improved and has been used extensively for measuring atmospheric constituents over Toronto. This work is now receiving funding support from the Atmospheric Environment Service, and a similar device for use on shipboard to profile water pollution is being funded at York by the Canada Centre for Inland Waters in Burlington.

Two other novel remote-sensing devices from York University were flight-tested during the past summer. One is a multiplex filter photo-

meter which proved successful in measuring chlorophyll concentration in lakes from the air. The other, an Image Intensifier Spectrometer, was flown in March, and successfully detected a test dye introduced into Lake Ontario in extremely low concentrations. Further development on both of these devices continues.

Also in the field of water-pollution studies is a laser fluorosensor at the University of Toronto's Institute for Aerospace Studies. The device was thoroughly field-tested during the summer, and demonstrated a very promising capability. It is being adapted at the centre to fly in the experimental DC-3 in the summer of 1973 to monitor oil pollution on water, and to measure water depth.

Barringer Research has built a carbon-monoxide detector which is expected to have application in, for example, the detection of incipient forest fires by monitoring the associated carbon monoxide.

In addition to the above, the Canada Centre for Remote Sensing has pursued the development through outside contractors of several other novel remote-sensing devices. These include advanced work in the field of infrared photography (McMaster University), and an image-dissection camera (SPAR Aerospace). The centre's sensor development program continues to contribute to the state of the art in remote sensing.

## ENVIRONMENTAL CONCERNS

In the energy field. Increasing attention is being given to the environmental factor in policy recommendations relative to oil and gas production, transportation, processing and use. The \$20-million budget of the Task Force on Northern Oil Development for research on northern pipelines is in large part directed to the determination of the ecological characteristics of the proposed route and to the design of construction and operation procedures that would protect the terrain and the wildlife and fish resources of the north.

Methods to reduce atmospheric pollution from automobile operation and industrial plants are under study to determine their effectiveness and costs to the economy. One of the most important challenges to be faced in controlling the environmental effects of oil-resource development will arise with the opening up of the Athabasca oil sands on a large scale. The production and use of oil and gas and their products possibly raise more environmental concerns than any other activity in the modern industrial economy; hence the need for a high



priority to environmental matters in oil and gas policy work.

Resource administration by EMR's Energy Sector includes ensuring minimum environmental risk to the marine environment, with full regard for the safety of human life and the living resources of the sea. Canada's safety requirements for offshore drilling are among the world's most stringent, and are backed up by a comprehensive program of enforcement based on regular inspection of operations. The Oil and Gas Production and Conservation Act provides full authority to shut down operations in the interests of safety or pollution prevention, to prohibit their resumption until adequate remedial steps have been taken, and indeed to take over management and control of an operation at the operator's cost if satisfactory steps are not being taken to remedy the situation.

Close working relations are maintained with the Department of the Environment to ensure adequate and timely agreement to expand knowledge and to develop standards relating to environmental effects of electrical-energy production.

The department is represented on the Lake Winnipeg, Churchill and Nelson Rivers Study Board and on the Yukon Water Board and the Northwest Territories Water Board established under the provision of the Northern Inland Waters Act, to license water use and maintain water quality in both Territories.

Geological studies. The need to use and exploit the environment often leads to conflict, and a rational management requires a broad knowledge base to which the studies of modern geological processes contribute. The Geological Survey has carried out a wide variety of studies under this general objective. Some of them deal with the provision of use-hazard information on the behavior of earth and rock materials under specific conditions, especially in the Arctic regions where the extreme sensitivity of the terrain to man-made disturbance has become a matter of public concern. Selected sites on Melville Island were chosen to study thaw depths and gullying under mechanical disturbance. Investigations were also made on Ellesmere Island on the effects of construction and vehicle operation. In more southerly regions with greater population pressure, investigations were concerned with pollution and land restoration of coal-mining areas in British Columbia, with landslips in the Ottawa-Hull region and with the future land use of the region surrounding the new Montreal International Airport.

In the Mackenzie Valley, a number of projects were carried out as part of the department's

contribution to the Environmental Social Program of the Task Force on Northern Oil Development. Some of these dealt with broad conceptual aspects and land classification especially related to terrain sensitivity; others involved studies of permafrost growth, erosion under permafrost conditions and such practical considerations as the instability of slopes and riverbanks which present an immediate threat to any nearby facilities such as roads, pipelines or structures.

Shallow seismic research was carried out in the Mackenzie River valley and delta areas for the investigation of the seismic properties of earth materials in the permafrost environment and in the detection of massive ice lensing at depth. Marine refraction profiling was conducted in the delta and the Beaufort Sea to map the occurrence of sub-seabottom permafrost.

The need for environmental concern is no longer limited to the land as we approach an era in which it is likely that extensive development will be undertaken in the coastal zone and the offshore environment. The impact must be predicted and any changes in the environment due to such development must be monitored, including the development of a capability to deal with contingencies such as oil spills, discharge of industrial effluents and the collapse of man-made structures. The Geological Survey, through its Atlantic Geoscience Centre, has already under way a number of projects such as those concerned with suspended sediments in the Bay of Fundy and the evaluation of industrial outfall, and with methods of silicate analysis of suspended and deposited sediments. Studies were also made on the distribution of various marine organisms, notably foraminifera, which provide sensitive indicators of changing conditions in the marine environment, man-induced or natural.

Safety and pollution abatement in mining and metallurgy. It is becoming increasingly apparent that if the fullest benefit is to be derived from rapid advances in mining technology achieved in recent years, research concerning health and safety must keep pace with the development of production. The department has undertaken research in several principal areas: dust and radiation, noise, dangerous gases such as methane, diesel exhausts and spontaneous combustion.

Progress has been made in determining dust levels and radioactive daughter products of radon in uranium mines. Initial studies were completed concerning the effect of noise in mining, methods of combatting its harmful effects, and Canadian and U.S. legislation to control it. Field work has started on gas emission in coal mines.



There is growing evidence that modern methods of mining coal increase the risk of spontaneous combustion, which could hinder the development of the coal industry in Canada. Results from studies conducted so far are preliminary.

The apparatus for testing diesel engines in the Canadian Explosive Atmospheres Laboratory has been completed. Four types of machines have been certified by this new service for use in coal mines in Alberta and British Columbia. The testing is paralleled by research on the technology of diesel-engine use under ground.

Both mining and metallurgical operations use large quantities of water, and in past years it was the general practice to draw the water from the lakes and rivers so abundant in Canada, and to return the water to the source after use. However, such water is often contaminated with various chemicals, and restrictions have recently been placed on its discharge.

The simplest means of preventing the discharge of contaminated water is recycling, but this is often not wholly practicable. The Mines Branch of the department is studying ways and means of extracting or neutralizing harmful chemicals contained in mine effluents.

Re-vegetation is generally recognized as the most practical means of stabilizing the surface of mine-waste dumps. Not only does it prevent erosion by wind and water, reducing the polluting effects of airborne dust and seepage, but it is also more pleasing to the eye than physical or chemical methods. Research is being conducted on the survival of plants on highly siliceous and acid mine tailings.

Other research aims at reducing air pollution in electric smelting and iron-making, and at the prevention of water pollution by coal fines, as at the coal-loading terminal in Vancouver.

Conversion of waste. Research is continuing into possibilities of converting waste material from mining and processing it into useful products.

For example, it was found that a mixture of asbestos tailings with sand gave a rock-wool insulation of good quality. Some other attempts to turn waste into commercially attractive materials proved interesting but inconclusive. A comprehensive program was started in 1972 for reducing mine and mill tailings and reducing environmental degradation. Results indicated that tailings from base-metal mines, because of high contents of impurities and/or

remote locations are of little interest, but other tailings, such as those from gold mines, have higher non-metallic contents and may serve as raw material for local production of such useful products as sand-lime brick.

Earthquake hazard. The Earth Physics Branch maintains and operates 22 standard seismograph stations in the Canadian Seismic Network. In addition, 11 regional stations were operated in co-operation with other agencies.

Preliminary locations and magnitudes of about 100 of the larger Canadian earthquakes were determined, and the final results for 1967 were sent to press -- about 400 Canadian earthquakes were detected, located and their focal parameters determined. The detailed study of earthquakes in western Canada during 1968 was completed. Studies were conducted in the field and in the extensive archives of the department for reports covering the seismicity of the potential pipeline corridors in the Yukon and Mackenzie Valley, and of the St. Lawrence Valley near Quebec City. Numerous requests for information were answered.

The fruitful co-operation with the United Kingdom, the United States, Sweden, Norway, and Japan in the field of nuclear detection and identification was continued by means of reciprocal visits and joint studies resulting in the publication of scientific papers. As well, individual and co-operative studies by Canadian scientists resulted in the publication of several important papers. Preliminary tests on tape-recorded data indicate that the automatic on-line digital processing system scheduled to commence operation at the Yellowknife array in 1973-74 will achieve a very good detection level, thus contributing substantially to the world-wide monitoring of seismic events. The Canadian scientific effort in these fields continues to play a leading role in the delineation of the problems (and their possible solutions) in the continuing search for a means of policing a nuclear-test ban.

## ICE STUDIES

The Arctic Ice Dynamics Joint Experiment (AIDJEX) is a co-operative, multi-discipline investigation of the dynamic behavior of ice, and of the transfer of kinetic and thermal energy between the atmosphere and the ocean through a complete or partial ice cover. The information to be obtained from it will help in forecasting the movement and variations in behavior of sea ice, in understanding climatic trends and in planning or designing structures and transport routes connected



with resource development in or near the Arctic Ocean. It is an international undertaking, with participating agencies from Canada, the United States and Japan.

Major AIDJEX field activities in 1972 consisted of a pilot study to develop instruments and techniques for air, water and ice measurements and to test certain scientific

assumptions in preparation for a major field season in 1975. The pilot study was supported by the department's Polar Continental Shelf Project in the Beaufort Sea.

The first edition of the Sea-Ice Atlas based on data collected from 1961 through 1968 will be published shortly.



## RESOURCE ADMINISTRATION AND REGULATION

The department is responsible for federal interests in mineral resources off Canada's east and west coasts and in the Hudson Bay and Hudson Strait regions, as well as those federally owned mineral rights within the provinces that become available for development.

During the year, two discoveries were announced as the result of exploratory drilling on the Scotian Shelf, in addition to the Sable Island discovery of 1971. The first of these finds, Primrose, 30 miles east of Sable Island, was a gas and oil discovery; the second, Thebaud, 6 miles southwest of Sable Island, involved gas and condensate. Interesting shows of gas were encountered in a third well on the Scotian Shelf, and shows of oil were found in two wells on the Grand Banks. The level of industry activity in the east coast offshore continued to increase, due partly to these favorable indications and partly to the pressures of the work commitments of the oil and gas exploration permits.

The department 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 exploration permits to exclusive production leases, are issued and administered under the Canada Oil and Gas Land Regulations. These regulations are currently under extensive review, and comprehensive revisions are expected to be announced in the near future.

Pending revision of the regulations, the issuance of Canada Oil and Gas Permits was suspended on March 21, 1972; no permits were issued during the fiscal year 1972-73. The number of offshore permits administered by EMR as of March 31, 1973, was 4,779, covering 345.3 million acres, in the following areas (per cent reduction of acreage during the year is shown in brackets):

East Coast--3914 permits--290,805,533 acres (-8%)  
West Coast--233 permits--16,043,850 acres (-1.5%)  
Hudson Bay - Hudson Strait--632 permits -  
38,467,969 acres (-45%)

The reduction in offshore holdings during the year is part of the normal evolution, of federal oil and gas permits, as favorable areas are consolidated. Total revenues received from offshore permits during 1972-73 amounted to \$680,769, up 25 per cent from the previous year.

The potential for offshore mineral resources other than oil and gas is also promising. However, in Canada as in other parts of the world offshore mining lags behind the offshore oil and gas industry both in the discovery of commercial offshore mineral deposits and in the technology of their recovery. No offshore claims were recorded during the fiscal year. In effect on March 31, 1973 were East coast 54, West coast 28, Hudson Bay 38 - a total of 120.

In the provinces, 57 oil and gas leases were issued as the result of two sales by public tender, bringing the total of federal oil and gas leases to 282, as follows: Alberta 160, Saskatchewan 102, Manitoba 17 and Ontario 3. As of March 31, 1973, distribution of productive oil and/or gas leases was: Alberta 35, Saskatchewan 22, Manitoba 9 and Ontario 1, making a total of 67. In addition, one potash lease is under production in Saskatchewan, and two leases for minerals other than oil and gas are held in Ontario. Revenues during 1972-73 from federal mineral leases in the provinces amounted to \$399,077, most of which was derived from oil and gas.

This work of the Resource Management and Conservation Branch comprises not only the regulation and supervision of increasing offshore exploratory activity, but also the detailed evaluation of the structural and reservoir conditions and hydrocarbon distribution within the various prospects themselves, as well as the economics and logistics of development and transportation systems. The thorough and continuing assessment of the potential of offshore hydrocarbon prospects forms a basis for federal policy on management of mineral rights, operational and environmental requirements, federal-provincial relations, and future plans for pipelines and storage facilities.



Some 150 separate offshore exploratory programs were undertaken by industry in the search for offshore oil and gas during 1972, including 21 drilling projects off the east coast. The petroleum industry spent some \$66 million exploring for oil and gas. Of this total, \$16 million was spent on geophysical and geological surveys and \$50 million for exploratory and assessment drilling. Direct expenditures by industry in Canada's offshore to the end of 1972 (excluding the high Arctic offshore) reached \$237 million: \$92 million for geophysical and geological surveys and \$145 million for drilling. Almost \$200 million of this was spent off the east coast.

Offshore programs are reviewed and supervised constantly to ensure adherence to federal requirements designed to minimize the possibility of accidents, prevent pollution of the marine environment, prevent waste of resources and avoid conflict with other users of the offshore.

To the end of March 1973, 78 wells had been drilled in the Canadian offshore.

Departmental officials attended meetings in Geneva and New York of the 90-member United Nations Committee on the Peaceful Uses of the Seabed and Ocean Floor beyond the Limits of National Jurisdiction. At issue, 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, both in the determination of the outer limits of national jurisdiction and in the efficacy of the regime and machinery to govern the international area beyond.

The department also participated during the year in negotiations with France and Denmark with respect to the delimitation of offshore boundaries of jurisdiction over seabed resources in the St. Pierre Bank and the Baffin Bay/Davis Strait regions, respectively.



## SERVICES AND STATUTORY RESPONSIBILITIES

Legal surveys in federal lands. Whereas provincial governments have jurisdiction over legal 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 Yukon and Northwest Territories. It also undertakes certain other tasks, such as the demarcation of interprovincial boundaries, the certification of Dominion Land Surveyors, and the control of oil and gas surveys made pursuant to the Canada Oil and Gas Land Regulations both in the northern territories and on Canada's continental shelves.

During the fiscal year, 19 field parties completed 89 separate survey projects: on Indian reserves in all provinces except Newfoundland and Prince Edward Island, and 6 in the Northwest Territories. To complete as many as possible of the projects required for federal government departments, 196 were done under contract.

Three federally appointed commissions, of which the Surveyor General of Canada Lands is a member, worked on the survey and maintenance of provincial boundaries. The Manitoba-Saskatchewan Boundary Commission continued to have work undertaken on the returns of the boundary survey. On the British Columbia-Yukon Territory boundary, the results of a previous spraying operation were inspected; it was found that, although satisfactory in part, the spray did not completely kill black spruce. The Saskatchewan-Northwest Territories boundary vista was completely cleared during the winter of 1972-73.

Aeronautical charts and publications. Discharging its obligations concerning the regulation, safety and development of Canadian civil and military aviation, the department produced 54 aeronautical chart series and flight-information publications in 1972-73 according to internationally accepted schedules and standards.

A new publication, VFR Supplement, was produced to provide the aeronautical community with summarized land aerodrome and associated chart data up to the latitude of 60° N. Information north of 60° will be

supplied by the Northern Supplement scheduled for publication next year. Both of these documents will have 84-day revision cycles.

Conversion of the World Aeronautical Chart series (scale 1:1,000,000) to the large-sheet back-to-back printing format was completed, while development of charts for short take-off and landing (STOL) flights between Montreal and Ottawa continues to accelerate, along with certain military aeronautical requirements.

International Boundary Commission. Under terms of a treaty signed in 1925 between Canada and the United States, a permanent commission was established with responsibility for the effective definition and marking of the boundary between the two countries. The commission was also responsible for the resurvey of any part of the boundary, if and when deemed 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 Quebec 45th-parallel boundary a geodimeter traverse was continued between boundary monuments to update existing survey data, with ties being made to the associated control triangulation. The boundary traverse determined new positions for 40 boundary monuments, with observations being made at 14 triangulation stations to provide control for 55 miles of traverse. In the course of this work 76 monuments were inspected and three repaired, one was relocated, and two control stations were re-established.

In the west, the Canadian section operated a vista-maintenance party along the British Columbia-Washington boundary. Thirty miles of 20-foot vista was cleared of undesirable growth, and 24 miles was treated with herbicides to deter further growth. A three-mile stretch of boundary vista was groomed by bulldozer and seeded with grass to assess grooming and mowing as an alternate approach to vista maintenance in settled areas. The commission field party, while operating along the 49th-parallel boundary, inspected 53 monuments and repaired 30. Later in the season operations were carried out along the British Columbia-Alaska boundary.



Four miles of 20-foot vista at the head of Portland Canal was cleared of heavy growth and six monuments and three triangulation stations were recovered in an assessment of the need for future work in that area.

Explosives administration. The Explosives Division is responsible for regulating all factories that produce commercial blasting explosives, military explosives, blasting accessories, gunpowder, smokeless powder and percussion primers, ammunition, fireworks and other pyrotechnics, and for the quality and safety of the products. This responsibility also extends 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 such licences and permits are issued from the Ottawa Office.

The number of factories licensed to manufacture explosives increased to 60 by March 31, 1973; some 370,000,000 pounds of commercial blasting explosives was produced. The production of fireworks, ammunition, blasting accessories and military explosives also increased over the same period. No existing factories ceased operations, and the number of licences issued for the storage of blasting

explosives increased to 1,300.

As a result of amended regulations under the Canada Explosives Act, all display fireworks must now be fired under the supervision of a qualified person. Accordingly, the division undertook to provide free courses to qualify candidates as "Fireworks Supervisors." The pilot course was held in Toronto on March 25, 1973, and similar courses will be conducted across Canada. Successful graduates receive a Fireworks Supervisor Card which is registered with the division.

Bill C-7, an act to amend the Explosives Act, which was introduced in the House of Commons in February 1972, was allowed to lapse at second reading. However, this Bill which will establish more effective control over the sale, purchase, possession and security of explosives will again be recommended by the division at a later date.

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



## RESEARCH AGREEMENTS

The underlying purpose of the department's Research Agreements is to fund extramural research and development projects that are directly related to the department's mission. Canadian research organizations that are not directly managed by the federal government and that undertake research in the natural, physical and social sciences and engineering are eligible to apply on behalf of individual investigators in their employ.

The intention is 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 the government and information for the community at large. The branches of EMR, with their disciplinary orientation, are responsible for assessing the proposals which relate to their own objectives and activities, and for monitoring the investigations throughout the life of the agreement.

For the second year of operation, the level of funding was increased by \$289,000 providing a total of \$865,000. The committee received 303 applications, requesting a total of \$3,604,249; 119 Research Agreements were recommended: 111 to university projects, 6 to provincial science councils, 1 to the Royal Ontario Museum, and 1 to industry.

Typical research projects included:

- the social impact of alternative energy-transportation modes in the Mackenzie River valley;
- federal-provincial management of oil and gas resources;
- government expenditures for declining industries;
- development of guidelines for safe and efficient mining of potash in Canada;
- chemistry of pyrite in ore tailings and coal;
- ferro-manganese exploitation of the ocean floor;
- mineral exploration research in western Canada;
- metallogeny of central Newfoundland;
- shoreline erosion on the Great Lakes;
- seismicity in the Quebec City region;
- a study of nationalization of a Canadian company, and the implications for Canadian mineral resources policy.









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