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Earth Physics Branch
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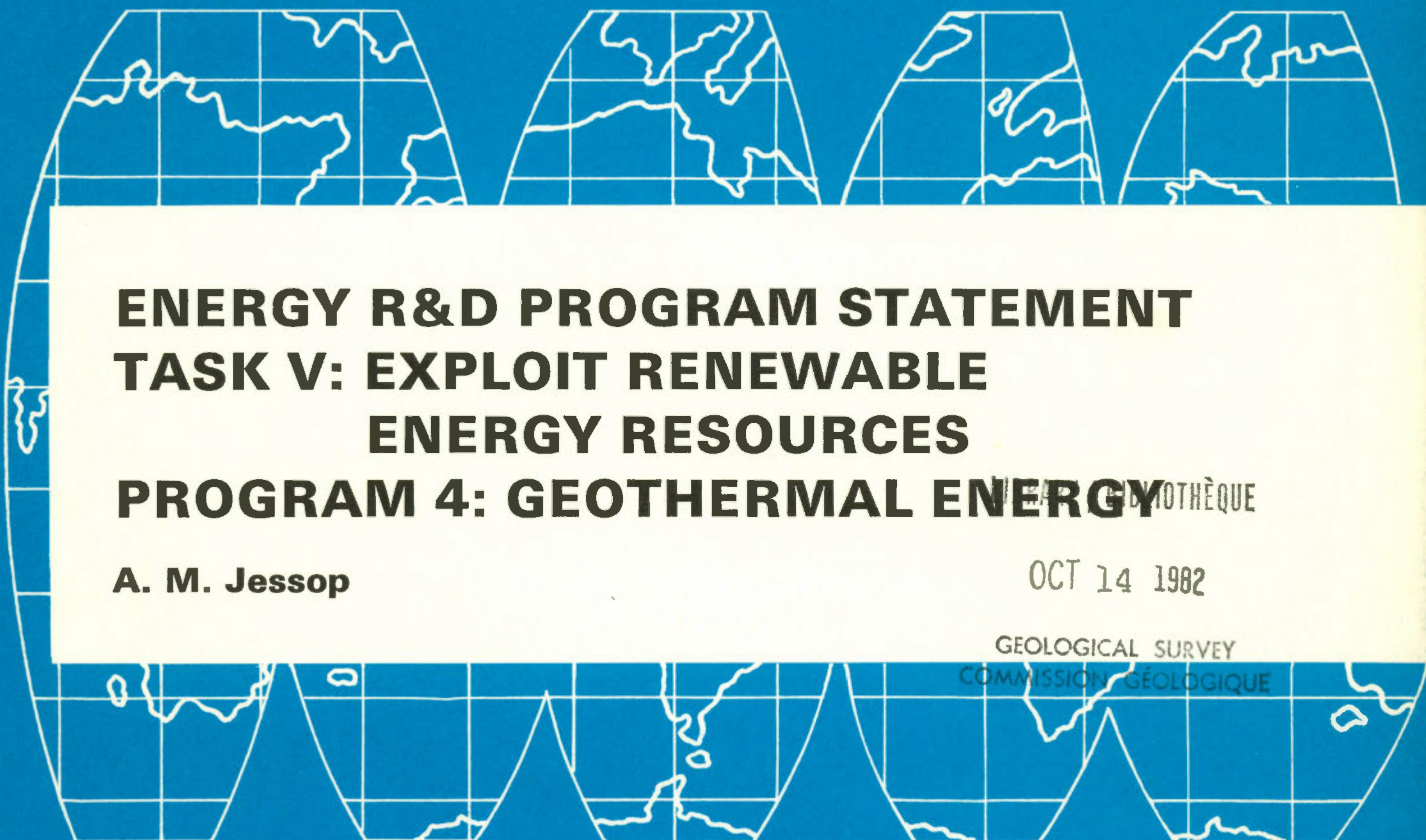
Geothermal Service of Canada



ENERGY R&D PROGRAM STATEMENT
TASK V: EXPLOIT RENEWABLE ENERGY RESOURCES
PROGRAM 4: GEOTHERMAL ENERGY

A. M. Jessop

Geothermal Series Number 4
Ottawa, Canada 1975

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Ottawa, 1975

PREFACE

The federal government's Energy Research and Development Program is divided among Six Tasks, including over 30 programs, directed towards providing the R&D necessary to ensure that Canada may have the capability to be self-reliant in energy supply (Appendix D). This document describes Program 4 - Geothermal Energy, of Task V - Exploit Renewable Resources. It was prepared for the Federal Task Force on Energy R&D, and contains the program outline recommended for implementation by the Government of Canada. The lead agency for this program is the Earth Physics Branch of the Department of Energy, Mines and Resources. The Department of Energy, Mines and Resources also serves as coordinator of the overall federal program. Copies of this document may be obtained from

Division of Seismology and Geothermal Studies,
Earth Physics Branch,
Department of Energy, Mines and Resources,
Ottawa, Ontario,
K1A OE4.

1. TASK V. EXPLOIT RENEWABLE ENERGY RESOURCES

2. PROGRAM 4 - GEOTHERMAL ENERGY

3. NEED FOR ACTION

We are ignorant of the geothermal potential in Canada. Since the western part of the country is part of the circumpacific belt of young mountains and recent volcanic activity, it is reasonable to expect that potential geothermal resources of volcanic origin are present in British Columbia and the Yukon. It is also probable that hot water in potentially useful quantities is present in deep sedimentary basins of the Great Plains and the northern regions of Canada. This is a new energy source in Canada and, since there is little current industrial activity, the federal and provincial governments should take a leading role in detecting and evaluating the potential, so that available energy can be used in the most efficient manner possible by industry or public utilities. It is conceivable that the electrical power needs of Vancouver could be supplied by geothermal resources, just as the needs of San Francisco are expected to be met by The Geysers field by 1980, and it is necessary to find out what resources are available and how they can be used.

4. NATIONAL OBJECTIVES

The national objective must be to develop any geothermal potential in Canada to supply space heating for all kinds of buildings, direct heat for industrial processing, or electrical power, to further the best interests of the nation. To achieve this, the first research effort should be led by the federal and provincial governments. Steps are now being taken (Dec. 1974) by B.C. Hydro to examine the potential at a geothermal site at Meager Creek north of Vancouver. When the existence and potential of geothermal resources can be demonstrated, and when economic factors are favourable, industry and public utilities will enter the development phase. A further requirement is legislation governing the exploration and development of the resources: for further information see Appendix A.

The federal objective is, therefore, to assess and demonstrate the potential.

5. PROPOSED NATIONAL R&D PROGRAM

A description of the five main categories of geothermal resources is found in Appendix B. The discovery and assessment of these resources will occur in the following four phases:

5.1 PHASE I.

Recognition of probable areas of geothermal resources. This phase will result in the selection of several areas of a few tens of thousands of square kilometres from the approximately 1.5 million square kilometres of the western mountain zone. This selection will be based primarily on heat flow, heat generation, geochemical measurements and volcanology, and will be carried out mainly by federal government agencies, probably with some contracts to universities.

5.2 PHASE II.

Identification of individual sites of geothermal potential. In this phase, sites of a few hundred square kilometres, showing strong indications of the existence of one of the forms of geothermal resource described in Appendix B will be identified. Techniques of geology, hydrology, geophysics and geothermics will be involved. Some of these are currently available from industrial survey companies, but others are available only in government or university departments. B.C. Hydro have already entered this phase at Meager Creek, and industrial developers may enter at this phase in future. The federal government should run a pilot study in order to promote geothermal energy, to study the Canadian geological characteristics, and to develop methods and technology. Coordination between federal and provincial governments will be necessary.

5.3 PHASE III.

Evaluation of potential resource site. In this phase the nature and magnitude of the resources at individual sites will be evaluated to determine the best use that can be made of them. This phase will normally be the responsibility of the prospective developers, which may be provincial or local public utility, or an industrial organisation, but a pilot study by the federal or provincial government, or both, may be required to demonstrate the viability of geothermal resources in Canada or to evaluate technique.

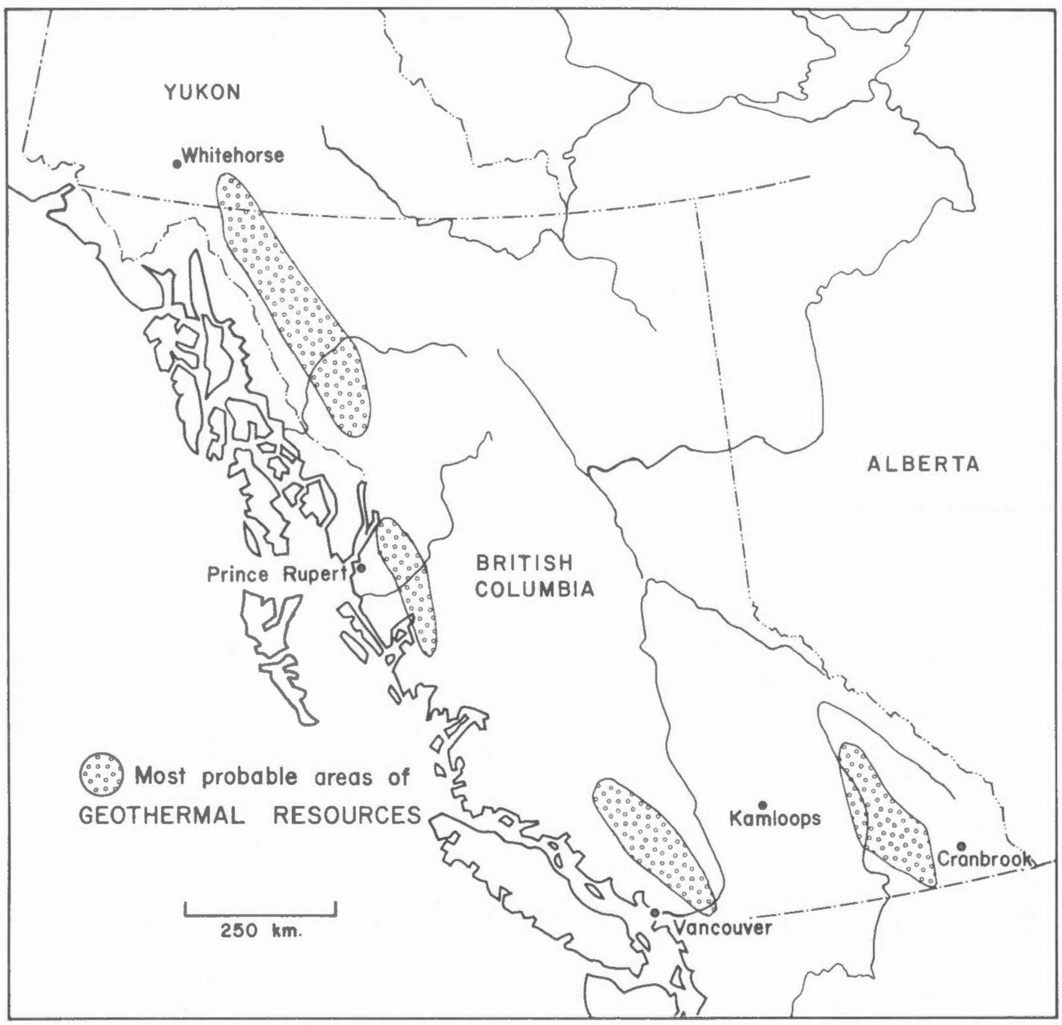
5.4 PHASE IV

Development of resources. It is important to note that a minority of geothermal resources are best suited to generation of electrical power, and that direct space heating or industrial processing are often the best use that can be made, depending on location. In this phase the developer, whether public utility or industrial, taps the resource and uses it or sells it to a user.

5.5 It is not intended that these phases should be regarded as rigid, mutually-exclusive steps. There will inevitably be some overlap. Time-scales will differ between locations. Surveys done or contracted by government agencies at first as a feasibility study will probably be done by the prospective developer as further sites are investigated and the feasibility of geothermal power development is proved.

5.6 Inevitably the major effort in the first five years will be in the Cordillera of British Columbia and the Yukon, but provision will be made for an investigation of existing temperature and porosity data in deep sedimentary basins. Areas where large sources of hot water (100°C - 150°C) may exist in sediments include the Great Plains, the Mackenzie Valley, the Arctic Islands, and offshore basins near Vancouver Island and Sable Island. The following map shows the parts of the Cordillera most likely to provide geothermal resources.

5.7 In the near-term, i.e., within 5 years, we can expect to identify at least some of our conventional geothermal resources, and possibly we can evaluate some of them thoroughly. In the mid-term, i.e., within 15 years, we can expect to begin to use some of the conventional resources, and we can identify some of the unconventional types. In the long-term, we can expect to derive benefit from hot dry-rock areas, and also the heat from normal areas should become accessible.



Areas of the Cordillera most likely to provide geothermal resources.

6. PROPOSED FEDERAL R&D PROGRAM

6.1 The federal and provincial government R&D programs need to go far enough through the processes of recognition, identification and evaluation that industrial or public utility agencies will be induced to carry on the work. Once this has been achieved, the federal effort can be retracted as the developing agencies take up the exploration process. It is unlikely that the federal government can ever withdraw from the basic research and data gathering that is essential to Phase I, and may extend into Phase II.

6.2 The federal R&D program should proceed in two parts: the continued regional surveys of Phase I, the recognition of probable resource areas, and a field study in which all possible exploration and assessment techniques will be evaluated in the Canadian context. The pilot study should also yield information about one or more sites, and should be undertaken either in direct cooperation with the provincial government or in such a way to avoid duplication of effort.

6.3 A continuing program of geothermal measurement has been proceeding on a small scale since 1962. This program was originally aimed at a scientific study of the crustal structure of all areas of Canada, but it has been redirected towards resource-associated research. It is on too small a scale to meet the needs of a resource-oriented program, but most of the techniques of the scientific work are applicable to the resource program. Appropriate geological and geochemical techniques are also in current use on a small scale. Work in Phase I should concentrate at first on the conventional geothermal reservoirs, but possible dry hot rock areas should receive increasing attention as the state of technology, developing outside Canada, indicates. In Phase I, techniques and studies required will be: geochemical analysis of spring waters, often the only surface indicator of reservoirs; volcanological studies to pinpoint probable hot spots; temperature data collection, to derive maximum benefit from existing data; and heat flow, heat generation measurements and magnetotelluric surveys, to examine the underground thermal regime. If airborne infrared surveys are to be of any help, it will be in Phase I, to examine areas where surface-derived knowledge of hot spring locations is not considered to be complete. Such areas will be very limited in extent.

6.4 The pilot study should be concentrated on one probable conventional resource area, and will involve, in Phase II, geological structure and reservoir hydrology, in order to determine the reservoir potential; drilling of shallow holes for temperature measurement, to detect high temperature gradients; electrical resistivity, to detect highly conductive reservoirs; extensive geochemical analysis of groundwater discharge; microearthquake studies, as a tool in the detection of high-pressure reservoirs; and electromagnetic surveys, if the resource is believed to be at shallow depth.

6.5 In Phase III, many of the same techniques will be required, but the attention will be focussed on a smaller area. Since this phase will normally be undertaken by prospective developers, federal government participation will probably be limited to evaluation of techniques.

6.6 In sedimentary basins the resource sites will cover larger areas, and Phase I and II will tend to merge into one operation. However, the required activities can be divided into the examination of the large amounts of data existing in oil company and provincial government files, and the active acquisition of new data to augment the existing material.

6.7 A list of projects and a workflow diagram are presented in Appendix C.

6.8 The Earth Physics Branch will continue to act as the lead agency for federal government activities in geothermal energy research. All activities related to research into geothermal resources will be coordinated by the Geothermal Service of the Earth Physics Branch. Activities in the different disciplines will be carried out or supervised by the relevant experts in the Earth Physics Branch, Geological Survey of Canada, and Department of the Environment. The Geothermal Service will maintain good communications between these agencies, coordinating their activities and reports.

6.9 Many technical services can be obtained by contract from universities or geophysical exploration companies. The universities that might be expected to take part include British Columbia, Toronto, Western Ontario and Dalhousie. Many competent exploration companies exist that are capable of the surveys mentioned.

Since this proposal is mainly a research program, and since this exploratory work must be done if geothermal resources are to be found and evaluated in Canada, greater or smaller budgets simply mean a faster or slower pace, rather than any change in the work to be done. The present proposal has been kept to a modest level in view of the relatively small amounts of energy likely to be produced in the next ten years. However, this is a research program designed to evaluate an unknown resource, and the energy supply and economic situation is changing rapidly at the present time. For these reasons national priorities should be kept under review.

7. EXISTING FEDERAL R&D PROGRAMS AND BUDGETS

There are bases for relevant technical activities within both Earth Physics Branch and the Geological Survey of Canada. At present the Earth Physics Branch is responsible for international liaison, interbranch coordination and field and laboratory research and data collection in all aspects of geothermics. The Geological Survey of Canada is responsible for hot spring inventory, geochemical analysis of spring waters and all volcanological studies. Other valuable expertise exists in the Division of Geomagnetism of the Earth Physics Branch, the Resource Geophysics and Geochemistry Division of the Geological Survey of Canada and the Department of the Environment.

8. EXISTING NON-FEDERAL FUNDING

8.1 The effort outside the federal government in Canada is restricted to B.C. Hydro, employing the services of Nevin, Sadlier-Brown, Goodbrand Ltd., a consulting company based in Vancouver, to carry out investigations in the neighbourhood of some hot springs. In the autumn of 1974 a program of electrical resistivity measurements and shallow drilling (1200 ft.) was in progress in the area of Meager Creek, near Pemberton, British Columbia. The target of this survey was the source of the water that flows from the Meager Creek hot springs, since the Geological Survey of Canada geochemical analysis suggests a high temperature source. The Earth Physics Branch was contributing its expertise in borehole temperature measurement and the loan of equipment.

8.2 The Meager Creek project belongs in Phase II, as described in Section 5. The choice of locations was based on the Phase I geochemical analysis, and the work utilizes current borehole measurement techniques, both being supplied by the federal government. Thus, existing research into geothermal energy is proceeding with the kind of cooperation and coordination that should be continued.

9. BENEFITS

9.1 If resources are found in Canada, the impact on energy supply before 1985 will be small compared with the total needs of the nation, but geothermal resources could be very important in certain areas. Benefits in space heating and industrial heat are probable, and will result in a reduction in the use and transportation of fuels and other forms of energy from elsewhere, particularly oil and gas. This could be of great advantage in remote parts of the western mountains where transportation is expensive.

9.2 It is possible that resources will be discovered that will permit the generation of significant electrical power. At first this will probably be in the Cordillera of British Columbia, and there will be no choice of locations. As the technology is developed for exploiting dry hot rock and the heat from normal areas, other parts of the country can be included, and freedom of choice of location of power plant and the overall contribution from geothermal resources will increase.

9.3 It is probable that hot water will be discovered in amounts sufficient for space heating or industrial applications. Heat of volcanic origin will be found in the Cordillera, but hot water may also be found in areas of deep sedimentary basins. Possible applications include pulp and paper manufacture, fish processing, market gardening under glass, horticulture, heavy water separation, and recreational facilities.

10. OTHER RELEVANT CRITERIA

10.1 Geothermal resources are good from an environmental point of view, except when the chemical impurities in the water make disposal difficult.

10.2 The existence of geothermal resources in Canada is a question of fact, which should be answered by the proposed research program. The probability of finding the existing resources depends on the scale of the effort and the skill of the researchers. A safe working assumption is that all except type 1 resources (steam reservoirs - see Appendix B) exist in Canada. The proposed program is designed to produce results in a time interval appropriate to developing technology and changing economic environment, but these factors are difficult to forecast.

11. OPPORTUNITIES FOR INTERNATIONAL COOPERATION

11.1 Since Canada is not one of the pioneers of conventional geothermal resources, it is important to develop and maintain good contact with more advanced countries. Countries that have valuable experiences are U.S.A., New Zealand, Italy, Iceland, Hungary and U.S.S.R. The first four are probably the most knowledgeable, and the U.S.A. has taken the lead in setting up a NATO-CCMS pilot study. Canada should make every effort to derive benefit from this venture, and to contribute when possible. The Institute of Geothermal Studies at Pisa, Italy, has an annual post-graduate training course.

11.2 The Canadian International Development Agency has been approached by the governments of two islands in the West Indies for assistance in the assessment of geothermal resources. CIDA has been considering the possibility of setting up a project with technical support from the Department of Energy, Mines and Resources and a preliminary fact-finding visit has been made to the area.

APPENDIX A

LEGISLATION GOVERNING EXPLORATION AND DEVELOPMENT OF GEOTHERMAL RESOURCES

The history of oil and gas development is an excellent example of the need for strong governmental regulation of resource exploitation by industrial agencies. At the moment there is virtually no legislation in Canada governing the use of geothermal resources, except for an Order-in-Council in British Columbia. Sound regulation concerning exploration, ownership, exploitation, environmental change and taxation is an essential requirement.

The absence of legislation is a deterrent to industrial action. The formulation of legislation after the beginning of exploration activity is viewed as a risk by industrial agencies, who do not like to begin a program without knowing what controls and tax structure will be applied.

A copy of the existing legislation follows.

HON. MINISTER OF MINES AND
PETROLEUM RESOURCES.

BILL

No. **77**] [1973
(Second Session)

Geothermal Resources Act

HER MAJESTY, by and with the advice and consent of the Legislative Assembly of the Province of British Columbia, enacts as follows:

Inter-pretation.

1. In this Act, unless the context otherwise requires,
"geothermal resource" means the natural underground reservoirs of heat that may be exploited, developed, or used for the production of heat energy, including, without limiting the generality of the foregoing, any minerals that may be obtained by means of a geothermal resource or by a natural or artificial injection of fluid, brine, gas, or steam in any form; but does not include petroleum resources, or water that is less than two hundred and fifty degrees Fahrenheit measured at its lowest location underground.

Crown property in geothermal resources.

2. Unless otherwise provided in any other Act, the right, title, and interest in all the geothermal resources in the Province is vested in and reserved to the Crown in right of the Province.

Printed by K. M. MacDonald, Printer to the Queen's Most Excellent Majesty
in right of the Province of British Columbia.
1973

APPENDIX B

THE NATURE OF GEOTHERMAL RESOURCES

Geothermal resources consist of five main types, each of which requires its own discovery, assessment and development techniques. As described here, types 1, 2 and 3 may be thought of as "conventional", in the sense that examples are already being exploited in several countries. Types 4 and 5 are "unconventional" in this sense. Type 4 is under active investigation in the U.S.A., while type 5 will be available only in the long-term.

1. Steam reservoirs. These are by far the best for the generation of electrical power. The steam is trapped in confined aquifers at high pressure and temperature, and can be tapped by drilling and fed directly to the turbines. This form of reservoir is extremely good from an environmental viewpoint, since it involves only a little land clearing and the erection of power stations and the associated feeder pipes. It is probably the best form of energy ever used from the point of view of disturbance of the environment. Although we are without factual evidence, it seems unlikely that any such reservoirs exist in Canada.

2. High temperature water reservoirs (200° - 250°C). These may be used for the generation of electrical power, but there is much wastage of heat. This form may have some environmental problems because of the large volumes of brine that must be disposed of, and the possible presence of other harmful impurities. It is quite possible that these reservoirs exist in Canada.

3. Low temperature water (80° - 200°C). These may be used for direct space heating, wood pulp processing, mineral extraction, food processing, agricultural and horticultural production, etc. There may be problems of brine disposal. The heat must be used close to the place where it is found and so the value of any reservoir depends on location. This type should be subdivided into two: (a) heat of volcanic origin, (b) reservoirs in deep sedimentary basins. Type (a) almost certainly exists in Canada, and type (b) seems very likely to be present.

4. Dry hot rock. In these features the heat is present, but the carrier is not. This type of resource seems very promising and there are probably some examples in Canada. Because of the absence of water to indicate their presence, these features are difficult to find. The development of these resources depends on the application of the technique of "hydrofracturing" in hot crystalline rocks, and the circulation of water through the resulting fissures. Since water would be recycled, environment problems will be small. Tests are now being made by the staff of USAEC-Los Alamos in hot areas associated with the Valles Caldera in New Mexico, and fracturing has been achieved in two wells.

5. Heat in normal areas. There is a vast amount of heat in the Earth's crust, but in normal areas it is necessary to go very deep to reach a high temperature. Gradients range from 10 to 30°C/km. The technology to use this heat does not yet exist, but it is conceivable that tunnelling devices could provide access to the great depths required.

APPENDIX C

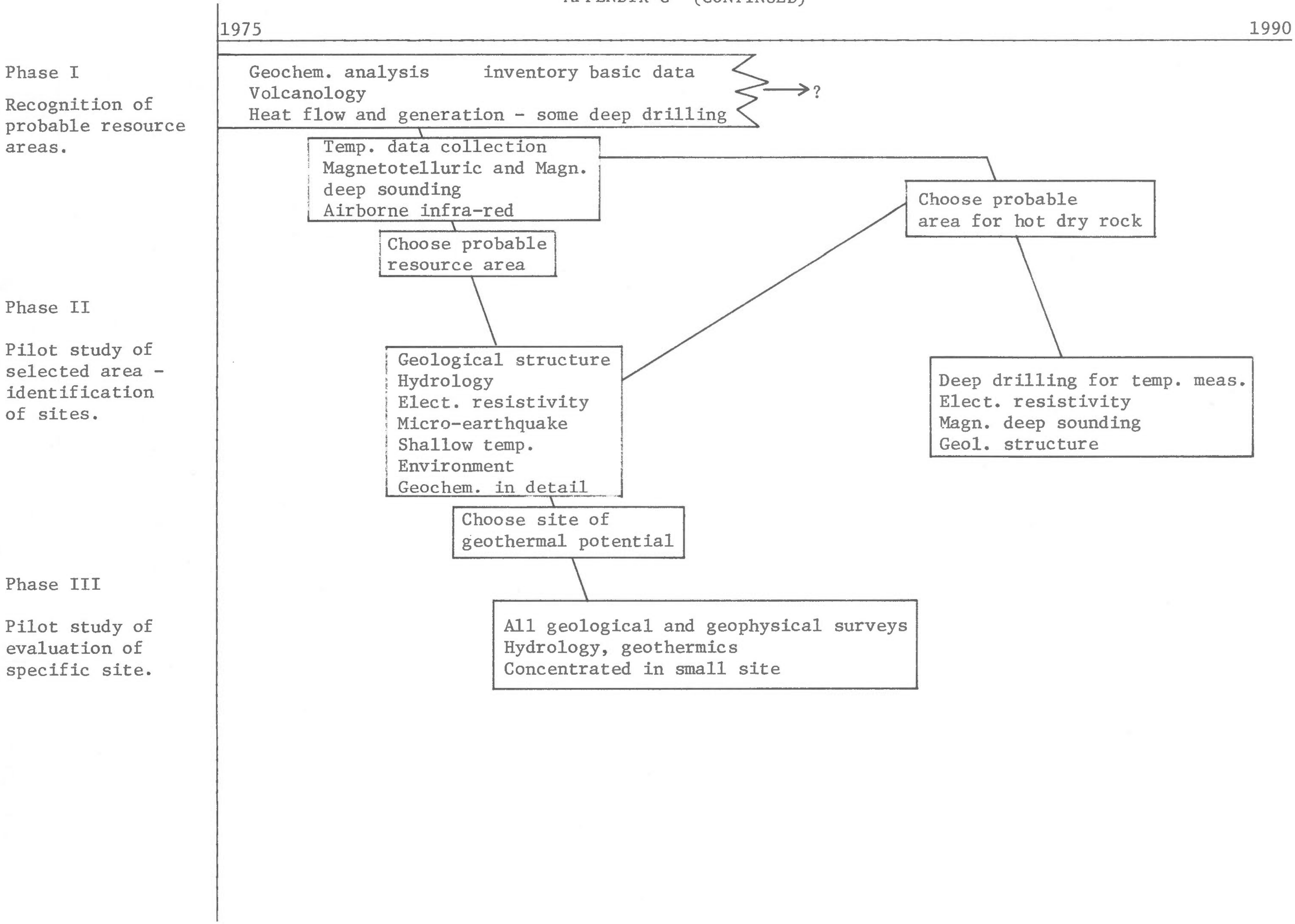
ENERGY R&D PROGRAM - PROGRAM SUMMARY

TASK V: EXPLOIT RENEWABLE ENERGY RESOURCES

PROGRAM 4: GEOTHERMAL ENERGY

			74/75	75/76	76/77	77/78	78/79	79/80	80/90
Coordination and international liaison	11-2 6-8, 11-1	EPB	—	—	—	—	—	—	—
Temperature and heat flow	5-1	EPB	—	—	—	—	—	—	—
Heat generation	5-1	EPB	—	—	—	—	—	—	—
Temperature data inventory	5-1, 5-6	EPB		—	—	—			
Shallow temperature surveys	5-2	EPB		—	—	—	—	—	—
Magnetic deep sounding and magnetotelluric surveys	5-1, 5-2	EPB		—	—	—	—	—	
Microearthquake studies	5-1, 5-2	EPB		—	—	—	—	—	
Geochemical analysis	5-1, 5-2	GSC	—	—	—	—	—	—	—
Volcanology	5-1	GSC	—	—	—	—	—	—	—
Geological structure	5-1, 5-2	GSC	—	—	—	—	—	—	—
Hydrological studies	5-2	DOE			—	—	—	—	—
Electrical resistivity	5-1, 5-2	GSC		—	—	—	—	—	—
Electromagnetic surveys	5-2	GSC				—	—		
Environmental studies	5-3	DOE							—

APPENDIX C (CONTINUED)



APPENDIX D

ORGANIZATION CHART FOR ENERGY RESEARCH AND DEVELOPMENT

TASK FORCE ON ERD

PANEL ON ENERGY R&D — OFFICE OF ENERGY R&D

Program	Lead Department
TASK I: R&D to Conserve Energy	
IA. Reduce Consumption and/or Increase Efficiency	EMR
IA.1 Transportation System	MOT
IA.2 Industrial Processes	ITC
IA.3 Efficiency of Energy Conversion & Storage	EMR
IA.4 Location & Urban Form	MSUA
IA.5 Commercial Buildings	NRC
IA.6 Municipal & Industrial Wastes	DOE
IA.7 Residences	NRC
IA.8 Food Supply System	CDA
IA.9 Life Styles	EMR
IB. Improved Data & Analysis of the Energy System	
IB.1 Role of Governments	EMR
IB.2 Information Generation & Analysis	EMR
IB.3 Implementing Energy Policies	EMR

TASK II: Increase Domestic Non-Renewable Energy Production	EMR
II.1 Oil and Gas	EMR
II.2 Oil Sands, Oil Shales & Heavy Oils	EMR
II.3 Coal	EMR
II.4 Uranium and Thorium	EMR

TASK III: Substitute Other Energy Sources for Oil & Gas	EMR
III.1 Coal to Generate Heat & Electricity	EMR
III.2 Gasification & Liquefaction of Coal	EMR
III.3 Methanol & Hydrogen Fuels	AECL
III.4 Nuclear Substitution for Oil & Gas	AECL

TASK IV: Develop Nuclear Capability	AECL
IV.1 CANDU System and Related Nuclear Safety	AECL
IV.2 Advanced CANDU System & Related Nuclear Safety	AECL
IV.3 Fusion	NRC
IV.4 Radioactive Waste Management	AECB
IV.5 Safeguards System	AECB

TASK V: Exploit Renewable Energy Resources	NRC
V.1 Hydraulic & Tidal Energy	EMR
V.2 Solar Energy	NRC
V.3 Wind Energy	NRC
V.4 Geothermal Energy	EMR
V.5 Biomass Energy	CDA

TASK VI: Improve Energy Transportaton & Transmission Systems	MOT
VI.1 Transportation of Energy Commodities	MOT
VI.2 Transmission & Distribution of Electricity	EMR