DEPARTMENT OF NATIONAL RESOURCES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1978/58

A CASE FOR RESEARCH AND DEVELOPMENT ON GEOTHERMAL ENERGY IN AUSTRALIA

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Abstract

We believe that the recent report by NEAC on proposals for 'A research and development program for energy' seriously underestimates Australia's geothermal resources and their uses. Consequently we believe that the 'watching brief' on R & D recommended by NEAC is inadequate.

We recommend an R & D program to (1) improve the assessment of Australia's geothermal resources (2) actively explore for geothermal sources (3) study and evaluate the possible uses of low-enthalpy geothermal sources (4) develop the technologies required to exploit these sources.

Introduction

This Record was prepared in response to the report by the National Energy Advisory Committee (NEAC) on proposals for 'A research and development program for energy.' The section on geothermal energy in that report states:

> "While geothermal energy is being seriously considered as an energy source in the United States and elsewhere, it is not promising for Australia. In terms of plate tectonics Australia is a stable land mass and does not meet the hydrothermal source requirements of a geothermal province i.e. youthful volcanism, crustal rifting and recent mountain building. However, there are some conduction-dominated geothermal sources in water bores in the Great Artesian Basin; a small proportion have water temperatures of 100°C. NEAC believes that Australia should keep a watching brief on both developments abroad and any new evidence arising from Australian geological surveys".

We believe that this statement seriously underestimates Australia's geothermal resources and their potential uses and we argue here for an increased effort on (1) geothermal exploration in Australia and (2) support for research and development projects designed to develop uses of low-enthalpy sources of heat.

Australian geothermal resources

Definitions and categories

Geothermal resources are classified (see Fig. 1) as identified resources where aquifers have been located and are known to contain hot water. The energy potential is considered to be demonstrated, when a continuous flow of heated water is currently available at the surface, and inferred, when information on flow is not available and extraction rates equal to the average in neighbouring aquifers must be assumed.

Geothermal resources are classified as undiscovered resources where aquifers have not yet been located in regions known to contain sources of heat. Resources of this type may be hypothetical, when high permeabilities can be expected in regions of diffuse heat, or speculative, when intense sources of heat are known in regions of hard rock with low permeability.

FIG. I

AUSTRALIA'S GEOTHERMAL RESOURCES

		IDENTIFIED		UNDISCOVERED	
		DEMONSTRATED	INFERRED	HYPOTHETICAL	SPECULATIVE
ECONOMIC					1×10^{17} J hot rock systems with artificial aquifers (1 km^3 of rock cooling from 500 to 200°C at 1 location)
SUBECONOMIC	PARAMARGINAL	4×10^2 MW (1) established on known hot water bores in GAB	4×10^2 MW (1) assuming hot water bores available in other basins at same rate as in GAB		1×10^{18} J hot rock systems with artificial aquifers as above but 5 locations
	SUBMARGINAL	1×10^3 MW based on known warm water bores in GAB	1×10^3 MW density of warm water bores in other basins assumed same as in GAB	1×10^{24} J total heat stored in basins highly diffuse	1×10^{26} J total heat stored in Aust. crust to depth of 10 km, highly diffuse

INCREASING ECONOMIC FEASIBILITY

INCREASING CERTAINTY

(1) If hot water is used only for generating electricity, the available energy is 20 MW.

(2) Assuming warm water can be used directly. Electricity generation impracticable.

(3) GAB - Great Artesian Basin

Sources of geothermal energy can be classified as either (1) hydrothermal or (2) conduction-dominated (which are renewable in the long term).

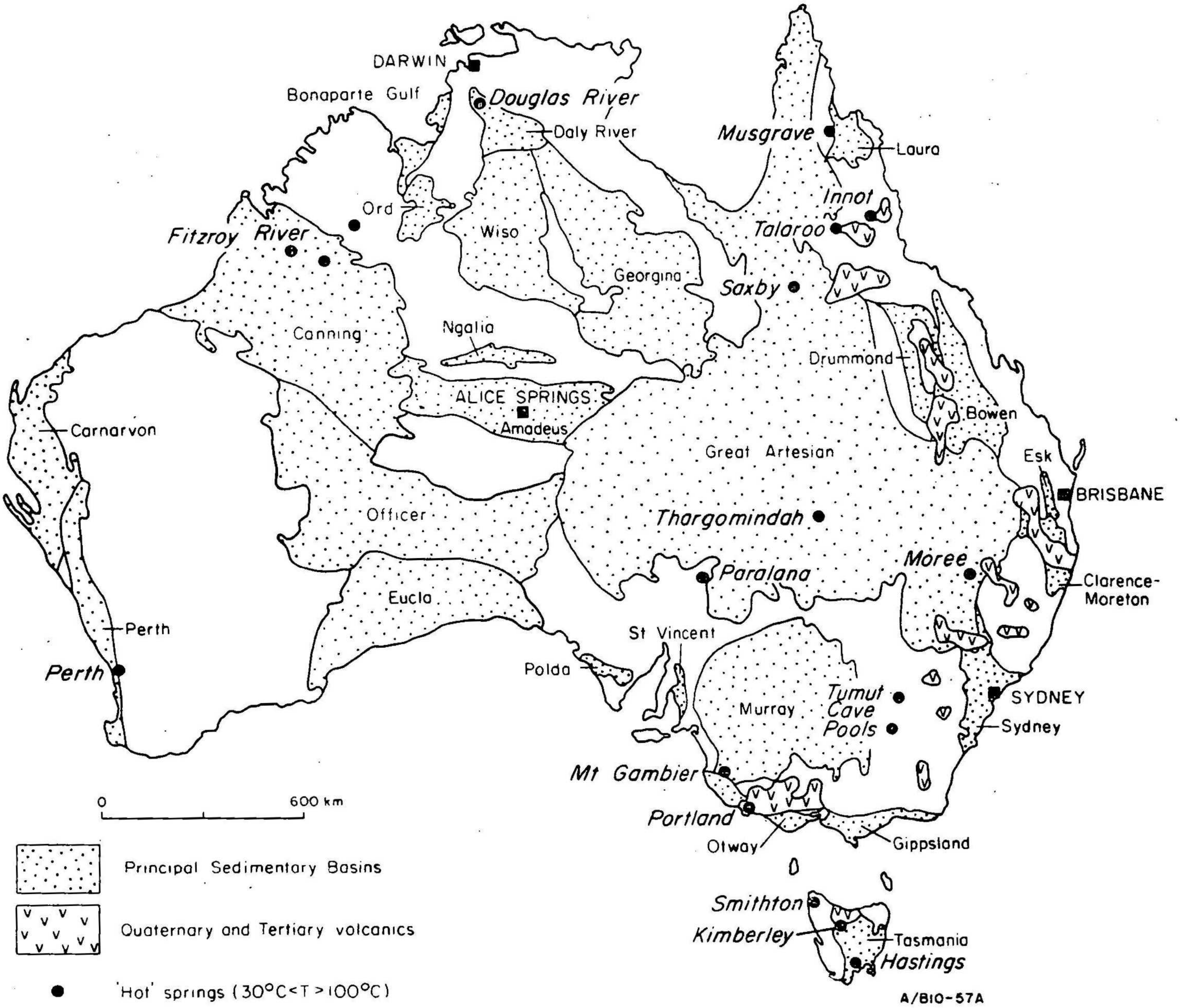
Hydrothermal sources have been found only in regions of recent volcanism and in well-defined earthquake zones; they are characterised by temperatures greater than 150°C at depths of less than 3 km. Steam, or a mixture of steam and water, is available at the well head and can be used directly to drive turbines for electricity generation. Sources of this type do not occur naturally in Australia; however, it may prove feasible to establish artificial systems in certain regions of hot dry rock.

Conduction-dominated sources are relatively common but have seldom been exploited. Water is commonly available in sedimentary basins at temperatures exceeding 100°C. Flash steam can be obtained, but only in small volumes, which are insufficient for generating electric power with steam turbines. Warm and hot waters are, however, required directly for many industrial and domestic processes including wood pulping, fish farming, horticulture, refrigeration, and space heating. Additionally, for isolated communities with a modest power requirement, electricity can be obtained by using heat exchangers. Vapour turbine systems have been developed for this purpose and in the USSR a 340-KW plant uses water at 81°C (Koenig, 1973). Commercial generators are available 'off the shelf' in U.S.A. with generating capacities of 10 KW for use with water at 85°C.

Known resources

Most of Australia's geothermal resources are of the conduction-dominated type associated with sedimentary basins (Cull, 1977). Sedimentary basins containing high-yield aquifers are found in all States (see Fig. 2), and they occupy more than half the area of the continent. The Great Artesian Basin alone covers 22 percent of the total land area. The energy contained in these basins exceeds 10^{24} J, and is replenished at a rate of 10^{9} W, in equilibrium with surface loss. Energy extraction rates must, however, depend upon the flow rate of bores. Furthermore, since artesian water is a valuable commodity for stock use, the number of geothermal wells in any region would have to be restricted so that

Fig. 2



Hot spring locations in Australia

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pressures are maintained. Geothermal energy can of course be extracted from existing water bores. In the Great Artesian Basin there are more than 1000 indexed water bores deeper than 300 m; of these, 226 penetrate to depths greater than 1000 m. Fifty-eight bores are classified as hot (water temperature greater than 65°C), with flow rates generally in excess of 10 L/s.

Estimates of geothermal energy currently available in the Great Artesian Basin (classified as Demonstrated Subeconomic Resources in Fig. 1) are made on the basis that only those bores classified as 'hot' are of potential economic interest. No consideration is given to bore location, plant costs, or wastage at the well head. These factors will vary according to the type of application and the energy extraction techniques. If, for instance, a vapour-driven turbine is used to produce electricity, no more than 300 kW could be obtained from each bore (assuming a water temperature of 80°C and a flow rate of 30 L/s). If the available geothermal energy is used solely for producing electricity, the present estimate of total generating capacity for all bores is about 20 MW.

Because geothermal gradients are generally greater than 30°C/km it is reasonable to assume that hot water can be obtained from any aquifer at depths greater than 1000 m. The spacing of hot water bores in the Great Artesian Basin should be representative of what is possible in other basins; consequently the initial estimate for Demonstrated Subeconomic Resources (Great Artesian Basin resources only) can be safely doubled by extrapolating to all of the other sedimentary basins in Australia (Inferred Subeconomic Resources).

Resources in other basins are not well known but in the Otway Basin near Portland, water is obtained from 1400 m at a temperature of 52°C with a flow rate of 70 L/s. This represents about 6 MW per bore of heat available for direct use.

<u>Adequacy of data and assessments</u>

Regional geothermal data have been obtained primarily by the Australian National University and the Bureau of Mineral Resources. Heat flow data on land have been determined at over 100 sites, and three provinces have been defined (Sass et al. 1976).

Comprehensive data on geothermal fluids in Australia are available only for the Great Artesian Basin (Horsfall & Polak, 1979). Detailed hydrological models have been proposed for the Great Artesian Basin and it is possible to make accurate estimates of the total heat available. In other sedimentary basins there are no detailed hydrological models, but the extrapolation of flow rates from the Great Artesian Basin to other basins is considered geologically reasonable. The energy assessments shown in Figure 1 are therefore unlikely to be seriously wrong.

Technological developments and limitations

Considerable quantities of heat can be obtained immediately from sedimentary basins. However, major geothermal power schemes are impracticable unless sources of intense heat can be located. Technologies now being tested in other countries may enable artificial aquifers to be established in hot dry rock (e.g. old volcanic systems), in which case estimates of available geothermal energy must be increased perhaps by a factor of 10 (Burnham & Stewart, 1973; Smith et al., 1975). Hybrid nuclear-geothermal systems have also been proposed; with them, the available energy is limited only by supply of suitable nuclear devices (Sandquist & Whan, 1973).

Geothermal fluids are frequently corrosive because of dissolved salts leached from host rocks. Therefore, in some instances the life of well-head plant may determine economic viability. Deposition of non-corrosive salts (scaling) may also be a problem. Service intervals may be unacceptably short or the production well may be self-sealing.

Disposal of waste fluid should present few problems. Most artesian water is pure enough to allow it to be simply discharged to existing rivers or to reservoirs for stock use.

Comments on known resources

In summary the geothermal resources in Australia, though small, are significant. Some can be exploited immediately, but others require further exploration and technological adaptation. Energy available from geothermal sources is comparable in application to solar energy and a Research and Development effort should be programmed.

NEAC accepts that solar energy may best be used for heating water, and categorises three areas of application: (a) swimming pools, up to 30°C; (b) domestic hot water supplies in the 60-80°C range; (c) industrial heating of water in the 90-120°C range. Geothermal resources can be used in all three fields, whether they be from high- or low-enthalpy sources.

We therefore believe that more than just a watching brief should be maintained in the R and D sector, and below we outline some of the steps which should be taken.

Research and Development Proposals

Geophysical assessment and exploration

We recommend a three-stage program with immediate aims of:

(1) Gather more temperature data from holes drilled for purposes other than heat flow investigation. This will enable rapid evaluation of the geothermal regime in Australia. At present the data are only sparsely distributed (see Fig. 3), and the regional pattern is ill-defined.

(2) Analyse data already available from oil wells and water bores to assess more accurately the geothermal resources of some of the more important basins. This would be a short-term 3-5 year project, and highly prospective basins like the Otway, Gippsland, Perth, and Sydney Basins would be studied first.

(3) Drill special purpose holes at selected sites to fill gaps in the regional heat flow pattern and to explore for zones of hot rock close regions of recent volcanism.

These three programs would not require great resources in manpower or money; (1) and (3) could be carried out by BMR and (2) either by BMR or by a university under contract.

Geothermal exploitation

Research and Development work is required on the exploitation

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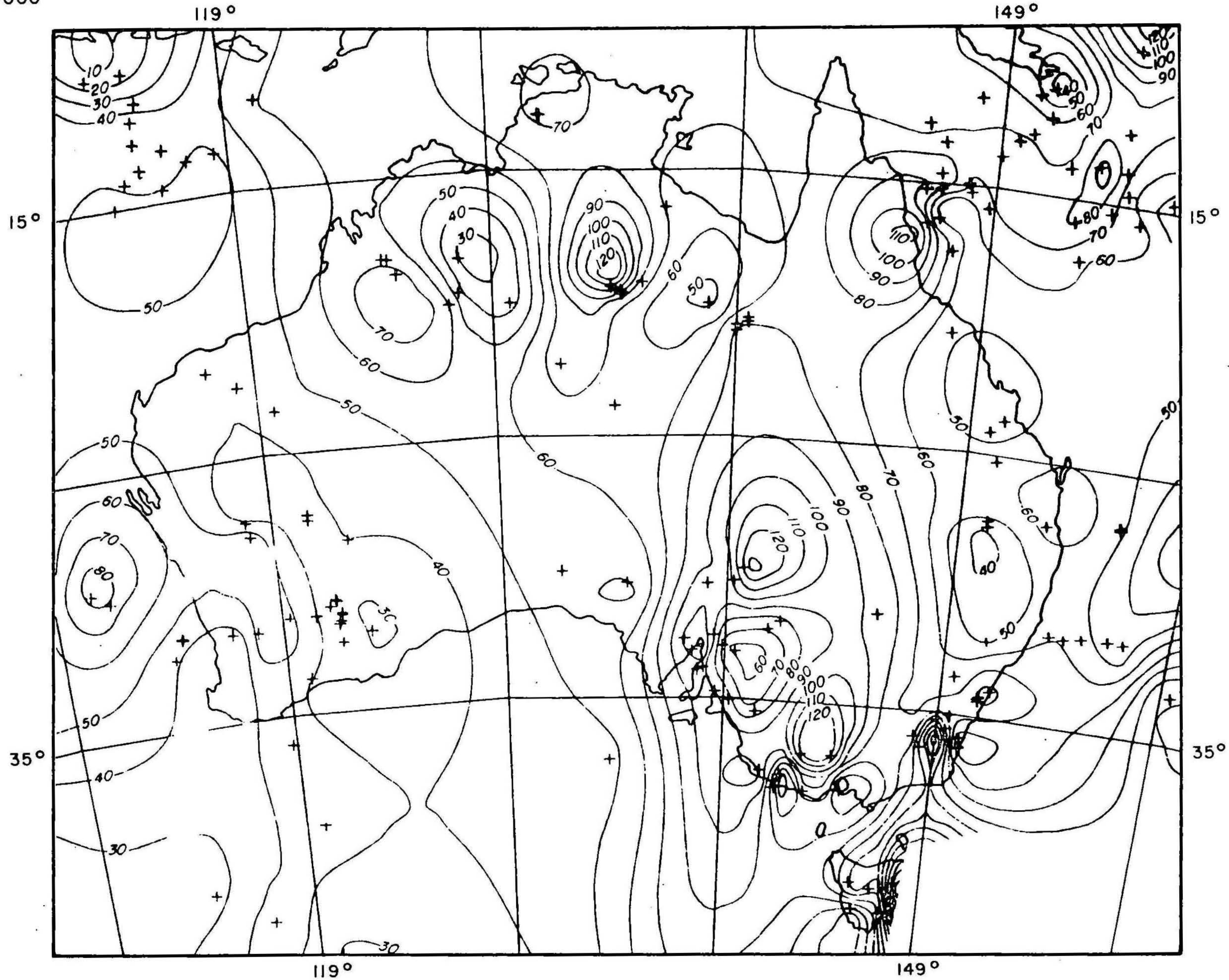

DISTRIBUTION OF DATA POINTS

Fig. 3

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of low-enthalpy geothermal resources. Overseas these sources have been used for horticulture, fish farming, and space heating. In Australia natural hot water is used for bathing and has already been used for the wood pulping industry at Traralgon in Victoria. A proposal has been made for geothermal space heating in a Portland hospital but this project has not been pursued.

It is therefore recommended that studies be carried out on the possible uses of low-enthalpy geothermal sources. At the same time studies should be undertaken on the technologies required to exploit these sources. These should lead to demonstration projects.

This work could be done either within CSIRO or by contract to a university or universities.

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