GEOTHERMAL ENERGY PROGRAMME IN INDIA

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ABSTRACT

There are about 340 known geothermal areas in India, each tapped by a hot/warm spring. The thermal areas are controlled by the basic structural and tectonic framework. Twelve well defined geothermal provinces are recognized. An order of magnitude geothermal resource potential in terms of stored heat for about one-third (113) of the known thermal spring areas, for which reliable though insufficient basic data exist, was estimated to be 49.9×10^{18} calories. If all these 113 systems are fully utilised in low to medium temperature nonelectric applications, at the places of their availability, they can substitute nearly 10,600 MW of electrical energy. The status of Indian geothermal activity relative to its application for electric and nonelectric applications is described in the paper.

INTRODUCTION

The global energy crisis has demonstrated that there is an urgent need to rapidly develop all possible alternative nonfossil fuel resources, to meet the ever increasing national demands for energy.

Geothermal energy, now recognized as an important and viable source of alternate energy, is presently being either developed or seriously examined by more than 80 countries with a view to establish and promote the geothermal industry.

From 1958 to 1973, the energy growth rate of geothermal power development was not very much more rapid than that for conventional power. In 1973, however, both the quintupling of the world oil crisis and the restriction of oil supplies dramatically changed the global energy scene and attention was diverted to the development of various new and renewable sources of energy including geothermal resources. Since then many advanced countries, like the USA, Italy, New Zealand, Japan and the USSR have been conducting research and development work in this area. This work includes assessment of resources, utilisation of geothermal resources and development of nonconventional hot rock and geopressured type thermal resources. The accelerated geothermal exploration and exploitation programmes have now been extended to such areas that were neglected earlier.

India is a large country and has diverse local conditions, availability of natural resources and needs. Considering the geotectonic evolution of the Indian land mass and its various segments there is a scope to develop and use geothermal energy sources. Concentrated early efforts aimed towards an overall assessment and development of geothermal energy resources of India are, therefore, necessary. This paper presents a perspective on the growth of geothermal energy in India.

SCOPE OF DEVELOPMENT OF GEOTHERMAL RESOURCES

A large volume of geological, geochronological, geotectonic, geochemical and geophysical data (including seismic,gravity, magnetic, heat flow and thermal gradient data) have been collected during the last 15 years by the Geological Survey of India (GSI), Oil and Natural Gas Commission (ONGC), and National Geophysical Research Institute (NGRI). Based on the present knowledge of geology, tectonics, the thermal field and the distribution of the known thermal waters of the Indian land mass, the main geothermal provinces of India are:

(a) Himalayan — Burmese — Andaman — Nicobar Arc Geothermal Province
(b) Narmada — Sone — Dauki Lineament Geothermal Province
(c) Konkan Geothermal Province
(d) Cambay Graben Geothermal Province
(e) Godavari Valley Geothermal Province

The major economically viable geothermal resources of India happen to be the hydrothermal type of medium to low grade. Geopressured geothermal resources of Cambay basin, if properly exploited, may also turn out to be economically feasible. Some of the users are listed below:

(i) geothermal power generation (limited);
(ii) space heating in Ladakh, Himachal Pradesh, Uttar Pradesh and other parts of Himalaya and Jummu and Kashmir Valley;

(iii) extraction of dissolved chemical/salt, etc. and refining some mineral deposits/borax, sulphur at sites and section at Puga in J&K;
(iv) greenhouse cultivation in Himachal Pradesh, Uttar Pradesh and other parts of Himalayan regions and J&K Valley
(v) fish (trout) cultivation (in Ladakh and many other parts of Himalaya);
(vi) pashmina (wool) industry (in Ladakh and many other parts of Himalaya)
(vii) extraction of medicines from plants;
(viii) paper pulp industry;
(ix) dehydration of fruits and vegetables, etc.
(x) cold storage;
(xi) tourism;
(xii) biotechnological/biochemical applications.

Practically in all states of India geothermal activity is noted on a prognostic basis. Barring certain parts of the shield zone most of the country possesses reasonable potential for development of geothermal energy.

PRELIMINARY ASSESSMENT OF GEOTHERMAL RESOURCES OF INDIA

Despite a common notion that India is not ideally located over the active belts (but for Narcondem Island) of the globe there are over 340 known thermal springs (Figure 1) listed so far, (Krishnaswamy and Ravi Shankar 1982) and groups under well defined geothermal provinces (Krishnaswamy, 1976; Gupta, Hari Narain and Gaur, 1976). An order of magnitude geothermal resource potential in terms of stored heat, for about one-third (113) of the known thermal spring areas, for which reliable, though insufficient basic data exist was estimated to be 49.9 x 10^{18} calories (Krishnaswamy and Ravi Shankar, 1982). Out of these geothermal systems 46 are of the high temperature type (over 150°C estimated deep reservoir temperature), 59 of the intermediate temperature type (between 90 and 150°C) and eight of the low temperature (less than 90°C) type. If all these 113 systems are fully developed for low to medium temperature nonelectrical applications, at the places of their availability, they can substitute nearly 10,600 MW of electrical energy (Ravi Shankar, 1985).

STATUS IN INDIA

Geothermal Potential

The data on geology collected by the national institutions form the basis for geothermal exploration since 1973. However, in-between studies of the thermal state of the Indian land mass and of the subsurface thermal conditions of Puga geothermal fields were carried out by NGRI, and some hot springs were studied by Jadavpur University. Subsequently an UNDP aided project was taken up by the Central Electricity Authority (CEA) and GSI. Under this programme and also under their own programmes, GSI, NGRI, ONGC and other institutions such as IIT, Kanpur and Kharagpur and Jadavpur University have been carrying out activities for the exploration and assessment of geothermal energy resources in the country.

Geothermal Potential of the Cambay-Kathna Geothermal Area

To find out the possibility of geothermal resources development in Cambay basin, the Cambay-Kathna field was taken up by ONGC on the basis of the higher geothermal gradients encountered in these areas. The generalized geothermal gradients are 38.72 ± 0.7°C/km and 41.85 ± 0.8°C/km in Kathna and Cambay fields respectively (Panda and Dutta, this volume). Five regions of high temperature gradient have been identified. The estimates indicate that the total assessable geothermal resource down to a depth of 2.5 km is on the order of 14.31 x 10^{11} kWh and the geothermal resource producible above 120°C is on the order of 581 MW years electrical.

HYDROCHEMICAL ANALYSIS OF CAMBAY BASIN

A preliminary geochemical analysis of geothermal fluids from thermal discharges at depths from wells in the Cambay-Kathna area has indicated that the temperature of hot water is 176°C and it mixes with about 70 percent water of meteoric origin, resulting in a final temperature of about 140°C in the geothermal reservoir.

There are four main hydrochemical provinces of thermo-mineral water in the area of Cambay basin. They are: (i) sodium bicarbonate water, (ii) calcium chloride water, (iii) magnesium chloride water and (iv) sodium sulphate water. There is a great reserve of sodium bicarbonate water throughout the basin. The calcium carbonate waters are mostly found along the eastern and western margin of the basin. The magnesium chloride water predominates along the northwestern margin of the basin, whereas the sodium sulphate water occurs along the eastern margin. The variation in Na/Ca ratio in the Cambay basin provides control to the drainage pattern. Low values of ratios, i.e. less than 40, appear to demarcate the boundry between the recharge and discharge areas.

GEOTHERMAL ENERGY UTILISATION

There are broadly two ways of utilising geothermal energy, (i) for electric power generation and (ii) for nonelectric utilisation. The geothermal resources having temperatures greater than 150°C are found economically suitable for electric power generation by conventional means and those with lower temperatures are good for nonelectrical uses. The present development to employ the binary cycle method, which uses freon liquid, isobutane, etc. as the secondary fluid and reasonably hot water (greater than 80°C) as the primary fluid through a heat exchanger to produce electricity, has widened the scope for exploitation of low enthalpy geothermal resources. The technical feasibility of such a process is proved worldwide but the economics needs careful investigation for particular field conditions.

A prefeasibility study to install a 3 MW conventional pilot power plant in Cambay field has been done by ONGC (Dutta and others, 1983). The study includes identification of wells, operating parameters and required initial investment. It is proposed to make use of some wells that

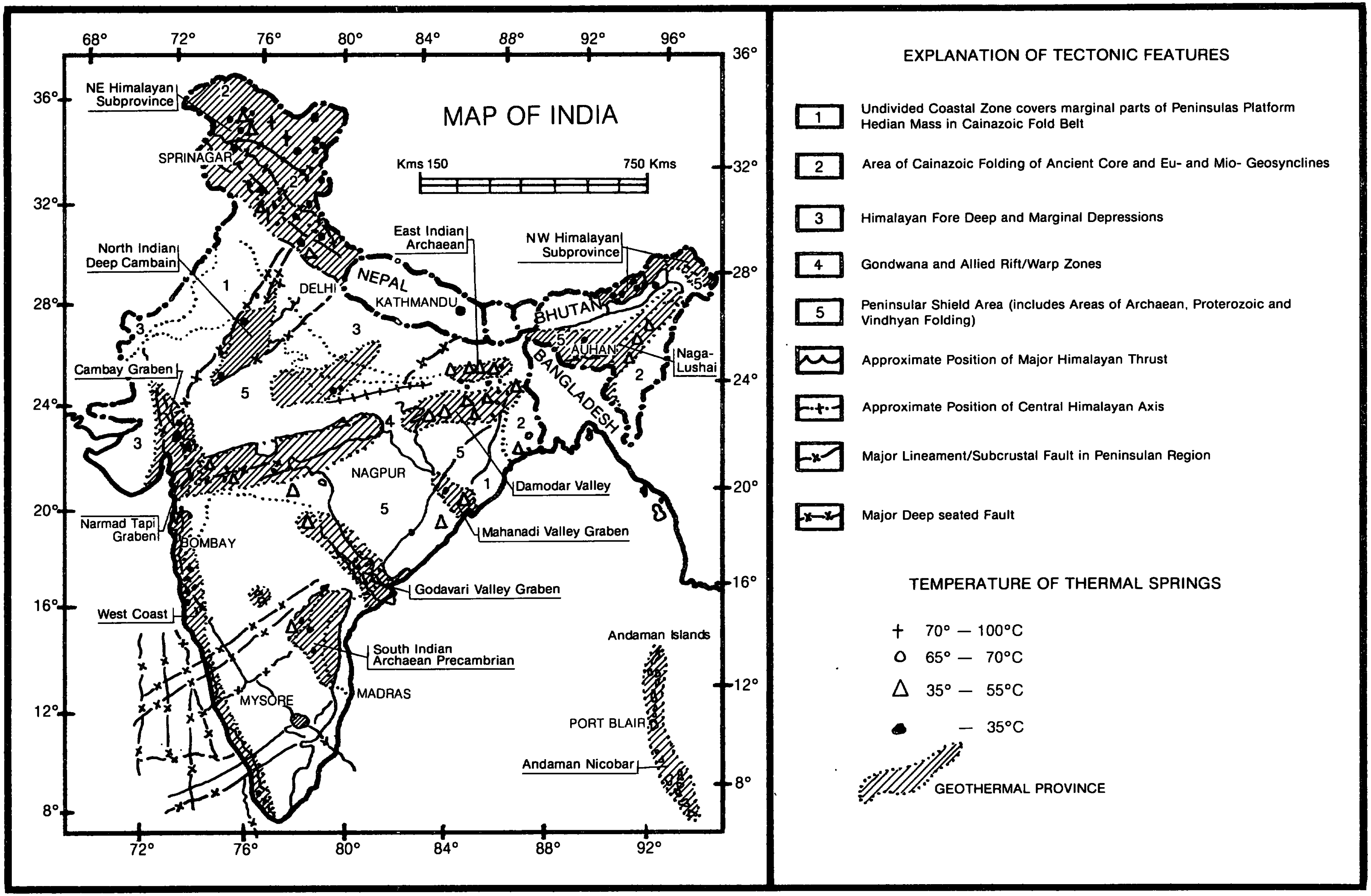

Figure 1. Map of India showing principal tectonic features, surface temperatures of thermal springs and geothermal provinces (Ravi Shankar, 1985)

are either out of service or abandoned. These wells are to be deepened to get the required fluid temperature.

From the data of completed and ongoing geothermal projects it will be seen that the Puga geothermal area is the most promising site for power generation with an estimated reservoir temperature of 226°C and an actual temperature of 135°C measured at shallow depth in a temperature gradient hole drilled in the area. The next promising area from the power generation point of view appears to be the Sarguja hot spring area with an estimated temperature of 160°C and an actual temperature of 109.6°C at the depth of 300 m, in intermediate depth holes drilled in the area. Under the R&D programme of the Department of Non-Conventional Energy Sources (DNES), National Aeronautical Laboratory and GSI have taken up a project for study of the design and development of a 5 kW binary cycle power experimental plant at Manikaran (Himachal Pradesh).

Geothermal energy in the form of natural thermal water has been used in India and elsewhere in a small way for bathing purposes and for tourism at places such as Sohna (Haryana), Manikaran and Bashist (Himachal Pradesh), Vajreshwari (Maharashtra), Bhim (Bihar), etc. since ancient times. The industrial use of geothermal energy in India has been demonstrated and applied for the extraction of borax from their deposits in Puga Valley geothermal area (J&K) by the Regional Research Laboratory, Jammu-Twai (RRL). Based on their work, J&K Minerals have set up a borax extraction plant of 5 tonnes per day capacity using geothermal fluid from the shallow bore holes for the purpose of extraction and refining of borax (Mehta and others, 1976). Experiments have also been conducted in Puga and Chumationg, a geothermal area (J&K), using geothermal energy for space heating and hot house cultivation. The experiment successfully demonstrated the use of geothermal energy for growing varieties of vegetables and flowers, which were never grown in the Himalayan region in the winter season. The experimental hot house at Chumationg heated by geothermal energy has been converted into an inspection hut.

At Manikaran (Himachal Pradesh) an experimental cold storage plant of 7.5 tonnes cooling capacity using geothermal water at 85°C (with an ammonia absorption system) has been installed by IIT, Delhi and GSI under the R&D programme of the DNES. The plant is expected to store the apples grown in the orchard of the valley. Space heating of tourist and a forest rest house at Kasaul (Himachal Pradesh) is underway as part of the CEA and GSI programme under UNDP.

Keeping in view the potential of geothermal energy, India is making a coordinated effort in the area of geothermal energy exploration and utilisation for nonelectrical and electrical applications.

The government has realised that even small increments of energy in a localised fashion can be instrumental in raising the life style of common man. Therefore, the Department of Non-Conventional Energy Sources has made a perspective plan to explore geothermal energy in a systematic fashion — looking at availability, production and utilisation.

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