INTERNATIONAL SUMMER SCHOOL
on Direct Application of Geothermal Energy
Under the auspice of the Division of Earth Sciences

GEOTHERMAL ENERGY POTENTIAL OF INDIA

Dr. S.K. Sharma, GRI,24 National Road, Dehradun 248001, India

ABSTRACT

The survey and studies conducted by Geological Survey of India led to the identification of about 340 geothermal hot springs in nine different geothermal fields in the country. Geothermal exploration carried out in India, so far, has generated valuable data through extensive scientific studies backed-up by drilling down to the at selected geothermal locations such as Puga, Manikaran, Tatapani, etc. concerning structural, geological, geo-chemical, hydrological and thermal parameter of geothermal systems. Initial estimates of promising geothermal ma-nifestation suggest power generation potential of about 10000 MW. In India the use of geothermal energy has been demonstrated for small scale power generation, in cold storage unit, in mushroom cultivation and poultry farming in Manikaran area of Himachal Pradesh and Laddakh region of Jammu & Kashmir. Keeping in view the potential and environmentally benign nature of geothermal power it is felt necessary to develop some of the geothermal sites in the country for power generation on commercial basis.

1 INTRODUCTION

Geothermal exploration carried out in India, so far, has generated valuable data through extensive surface, earth scientific studies backed-up by exploratory drilling down to the depths of about 500 meters at selected geothermal localities concerning structural, geological, geochemical, hydrological and thermal parameters of geothermal systems.

About 340 geothermal hot spring were identified by the Geological Survey of India (GSI), which are characterized by Tertiary and Quarternary orogenic activity in the Himalayas, Mesozoic and Tertiary blcok faulting activity in the shield areas, and moderately active seismicity and intense neotectonism. A total of about 10,000 MW could be generated from Himalaya, Naga Lushai, Andaman-Nicobar Islands, West Coast, Cambay Graben, Aravalli, Son-Narmada-Tapi, Godavari and Mahanadi, South Indian Cratonic geothermal provinces in India.

2 GEOTHERMAL POTENTIAL FOR POWER

The geothermal map of India fig. 1 shows a large number of thermal springs occur in the Himalayan Geothermal Province. Many of them show boiling point temperatures at the elevation of their respective occurrences. The thermal activity is strongest adjacent to Indus-Tsungbo Suture Zone in the north west Himalaya. Puga and Chhumathang areas are examples of this type of occurrence with temperature gradients exceeding 100^0 C/km and heat flow in excess of 200m W/sq.m. However, majority of the hot springs are located between the Main Central Thrust and the Central Himalayan Axis.

The hot springs of the Parbati valley, Satluj valley and Alaknanda valley are the typical example of such occurrences with $60^0 \pm 20^0$ C/km temperature gradient and 130 ± 30m W / sqm heat flow values. Lukewarm thermal springs with low temperatures (geochemically computed) generally occur along the outer margin of the Himlalayas. The foothill Himalayan belts exhibit low temperature gradients of $17^0 \pm 5^0$ C and low heat flow values of 41 ± 10m W/sqm.

In northeastern India, along the Naga-Lushai hill ranges bordering Mayanmar, thermal springs studied are similar in nature as observed in the foothills of northwestern Himalayas. The Andamam-Nicobar Islands represent Tertiary ranges with late Tertiary folding, faulting and Quaternary mud volcanism. Geothermal energy potential can be harnessed in this province.

The west Coast geothermal belt manifested by series of thermal springs along the west coast of Maharashtra, is one of the continuous belts (300km x 20km) in the country which has been systematically explored. The area exhibits high gravity, recent seismicity, Terttiary down faulting, temperature gradients of the order of $55^0 \pm 5^0$ C/km and heat flow values in the 130 ± 10m W / sqm range.

Cambay Graben Province is 200 km long and 50 km wide down faulted area with late Tertiary reactivation, plutonism and recent seismicity. Moderate temperature gradients of $40^0 \pm 15^0$ C/km and heat flow of 75 ± 18m W / sq.m, and the high bottom hole temperature rang of 100^0 to 145^0C have been recorded in the oil wells from the depth between 1.7 km and 1.9 km. Steam blow outs have been recorded in some of the oil wells from depths ranging from 1.5 km to 3.4 km.

Thermal wells are known to occur along the northeast-southwest ridge in parts of Rajasthan and Haryana. Most of the ridges are fault bound with evidences of neotectonic activity. The temperature gradients of $41^0 \pm 100^0$ C/km and heat flow of 100 ± 25m W / sq.m have been recorded in the Arravali Province.

On the other hand, Son-Narmada-Tapi lineament zone is a fault bound mega lineament belt in central part of the country, with a large number of hot spring manifestations. Temperature gradients in the 40^0 to 120^0 C/km range and heat flow values from 70 to 300m W/sq.m range have been recorded at several locations in the Son-Narmada-Tapi province.

Godavari and Mahandai valleys are fault bound grabens with post-Gondwana and possibly late Tertiary/Quaternary reactivations. Moderate temperature gradients of $39^0 \pm 10^0$ C/km and heat flow values of 80± 21m W / sq.m have been recorded in the Godavari Valley. Isolated warm springs are known to occur in Southern India. A systematic study and geothermal exploration is required in this province.

3 PROMINENT GEOTHERMAL POWER GENERATION SITES

The Tattapani Geothermal Field situated in Surguja district of Chattisgarh has several hot springs with moderate gas activity and silica deposits around the vents of these springs. The surface temperature of the hot springs varies from 50^0C to 98^0C and their cumulative discharge is about 60 litres per minute (A-Fig. 1).

Under the geothermal exploration programme for experimental utilization of heat from thermal fluids, as many as 26 boreholes were drilled for depths varying from 100 meters to 620 meters. Drilling of these boreholes was completed during April-December, 1993. GSI had reported that only five boreholes were planned as production wells which were producing hot water @ 24 tonnes per hour per bore hole at about 98^0C.

It would be essential to go for deeper drilling from 1500 meters to 3000 meters for obtaining adequate temperature/ pressure geothermal fluids and for commercial exploitation of the geothermal energy. Cost economic of a 5 MW capacity of geothermal power plant at Tattapani was worked out by National Thermal Power Corporation in August 1997 based on current price index.

Puga geothermal field is considered as one of the potential sites from the viewpoint of utilizing for power generation/heat applications provided there is application very close or at the geothermal site (B-Fig. 1). In the course of exploration of Puga geothermal field (by GSI) the following results were obtained:

(i) Shallow geothermal reservoir over a length of about 5 km with an average width of 500m and thickness ranging between 80 and 200m contain hot water steam mixture at around 140^0C

(ii) Geothermal discharge was of the order of 250 tonnes / hour from geothermal boreholes.

(iii) There is a possibility of a deep reservoir in that are where high temperature gradient of about 200^{0}C could be expected with deep geothermal exploration.

Groups of hot spring lying in Satluj and Spiti Valleys, falling in the region of Mandi, Simla, Kinnaur and Lahaul-Spiti districts of Himachal Pradesh, belong to four hydrothermal systems (C-Fig. 1). First three systems-those of the Satluj valley and genetically related, where as the Sumdo-Chuza system has a separate entity. The highest estimated base temperature range of 112^{0}C to 144^{0}C is indicated for Nathpa-Karchham sector. Tapri with high best temperature of upto 180^{0}C and Sumdo-Chuza with a best temperature of 84^{0}C hold promise from the view point of supplying large quantities of hot water.

The Beas Valley geothermal systems extends for about 45 km between Bashit in the North and Takoli in the South. Thermal manifestations in the form of isolated groups of geothermal hot springs have temperature ranging from 21^{0}C to 53^{0}C. Application of chemical geothermal indicates a maximum temperature of 120^0 ± 10^{0}C. application of chemical geothermal indicates a maximum temperature of 120^0 ± 10^{0}C. Low Enthalpy geothermal fluid available in the Beas Valley may be used for heating of space, greenhouse, for tourism promotion etc. With deep exploration, it may possible to generate electricity at some selected geothermal sites.

Thermal springs of Badrinath and Tapoban are located in the Alaknanda and Dhauliganga valleys respectively t elevations of 2000-3000m above MSL, in the Himalayan terrain. Silica geothermometer estimates reservoir temperature of Tapoban geothermal area to be 100^{0}C and for Badrinath geothermal area as 120^{0}C (D-Fig. 1)

The base temperature of most of the hot springs of Bihar ranges from less than 90^0 to 165^{0}C (E-Fig. 1). Hot springs with high fluid temperature could be used for power generation and also for non-electrical uses like agrarian and forestry products, sericulture, cold storage and tourism.

4 GEOTHERMAL POTENTIAL FOR POWER GENERATION

Preliminary estimates based on theoretical parameters suggest that from 113 geothermal systems explored so far by GSI and other agencies, a total of about 10,000 MW power could be generated. However, the figure is theoretical and tentative. The geothermal provinces in India are located in area of high heat flow and geothermal gradients varying from 70 to 500m W/m^3 and 60 to 230^{0}C respectively. Some of the geothermal sites contain valuable gas contents like helium and other hydrothermal deposits little silver and gold. However, all the geothermal sites in India belong to low to medium enthalpy reservoirs (95^0 to 190^{0}C) and then will require an Organic Rankine Cycle Based Binary Power plant of varying capacities to convert the geothermal energy into electric energy.

Such generation of electricity through geothermal resource is preferable due to its eco-friendly nature whereas much environmental hazards are associated with the coal and nuclear projects.

REFERENCE

Jago Rao, M.V. Rao, A.P. Et al. 1987. Results of Geophyssical Survey in the Tattapani Hot Spring Area, Distt. Surguja, Madhya Oradesh, *FSI Records*, Vol. 115, Part 6, pp 66-83.

Krishnaswami, V.S. and Ravi Shankar 1982. Scope of Development, Exploration and Preliminary Assessment of the Geothermal Resource Potentials of India, *Records of GSI*, Vol. III, Pt. 2.

Muffler, P. and Cataldi, R. 1978. Methods for Regional Assessment of Geothermal Resources, *Geothermics*, Vol. 7, pp. 53-89.

Ravishankar 1987. Satus of Geothermal Exploration in Maharashtra and Madhya Pradesh (C.R.), *GSI Records*, Vol. 115, part 6, pp 7-29.

Sarolkar, P.B., 1993. Subsurface Geological studies in Tattapani Geothermal Fields, M.P., *GSI Records,* Vol. 126, part 6, pp 36.

Thussu, j.L., Prasad, J.M. and Saxena, R.K. 1987. Geothermal Energy Resources Potential of Tattapani Hot Spring Belt, Distt. Surguja, M.P., *GSI Records* Vol. 115, Pt. 6, pp 30-55.