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Low Enthalpy Geothermal Resource Development At The Tattapani, India

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ABSTRACT

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 500m at selected geothermal localities concerning structural, geological, geochemical, hydrological and thermal parameters of geothermal systems. The geothermal provinces in India are located in area of high heat flow and geothermal gradients varying from 70 to 500m W/m3 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 thus, requiring an Organic Rankine Cycle Based Binary Power Plant of varying capacities to convert the geothermal energy into electric energy. The Tattapani Geothermal Field situated in Surguja district of Chattisgarh stands out among promising geothermal sites and 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^{0}C to 98^{0}C and their cumulative discharge is about 60 liters per minute. Under the geothermal exploration program for experimental utilization of heat from thermal fluids, as many as 26 boreholes were drilled for varying depths from 100m to 620m. Only five boreholes have been converted as production wells which have been producing hot water @ 24 tons per hour per bore hole at about 100^{0}C. An electric generation potential of 300KWe using Organic Rankine Cycle Based Binary Power plant been worked out based on the reservoir parameters (long duration flowing and static temperatures and pressures) and the current price index together with other direct heat applications, namely, tourism, balneology, canning and fish farming to develop the economics of an otherwise economically poor Tattapani area. The MT survey conducted in the region has indicated the possibilities of primary deeper reservoir ranging in depth from 1500m to 3000m where high temperature gradient of about 200^{0}C could expected for commercial exploitation. Though, at present the price of electricity is found to be slightly higher than the conventional one but such generation of electricity through geothermal resource is preferable due to its eco-friendly nature whereas much environmental hazards are associated with the coal or other conventional based projects.

1. INTRODUCTION

Geothermal energy is contained in underground reservoirs of steam/water and hot dry rocks. India's appetite for energy is increasing day by day. World Energy conference Survey of Energy Resources estimated in 1980 that proved recoverable reserves of fossil fuels to last 131 years at world consumption level of 1972. To avert the situation new energy sources are to be found and to reduce the growth rate of energy demand to zero, or even reverse it. 'Non-fuel' energy sources becoming important, gone are the days of cheap energy. Reduction in growth rate of population will go a long way to reduce the growth rate of energy demand. As per energy consumption scenario in India, the per capita energy consumption is low but the growth rate of energy consumption is high in India, being a developing country utilization of geothermal energy is one of the options. With energy demand multiplying, none of the reasonably accessible source can be allowed to go waste. The probable shape of things to come in future world energy supply will be ultimately limited to renewable sources alone. Gigantic efforts have already been made by Geological Survey of India (GSI) in the field of exploration of geothermal resources in India and the estimated energy in only one third of known thermal spring areas in the country is 10,000 MWe. If this energy is exploited for the benefit of society, development of backward, hilly & tribal areas can get a boost. but the status of utilization of geothermal energy in India at present is on symbolic level only as compared to the availability of the resources. Efforts are required to be directed for utilization of the resources, which have been identified for development, in backward, hilly and tribal regions in India, where maximum, benefit from geothermal resources can be derived as cost of energy sources through conventional means is also high there e.g. Puga - Chhumathang in Ladakh. (J&K), Tattapani in Surguja District (Chattisgarh) etc. Technology for utilization of geothermal energy for non-electric utilization of geothermal energy including space heating air conditioning agricultural usages; green house farming, horticulture, aquaculture, animal husbandry, industrial applications, chemical industry, extraction of mineral, food processing, pulp & paper manufacturing, balneology, tourism, bottled mineral water etc at such a scale is available in our country. The Geological Survey of India has identified about 340 geothermal hot springs throughout the country and a detailed Geothermal Atlas has been prepared which gives details about the potential geothermal energy sites in the country, Ravi Shankar and Guha S.K. (1992). The following ten geothermal provinces in the country have been recognized, which are characterized by the Tertiary and Quarternary orogenic activity in the Himalayas, Mesozoic and Tertiary block faulting and Epiorogenic activity in the shield areas, and moderately active seismicity and intense neotectonism. (I) Himalayan Geothermal Province : (II) Naga Lushai Geothermal Province : (III) Andaman-Nicobar Islands Province : (IV) West Coast Geothermal Province : (V) Cambay Graben Geothermal Province : (VI) Aravalli Province : (VII) Son- Narmada - Tapti Geothermal Province : (VIII) Godavri Geothermal Province : (IX) Mahanadi Geothermal Province and (X) South Indian Cratonic Province. The following Figure 1 shows these geothermal provinces of India giving regional heat flow patterns in mW/m 2. Solid bigger and smaller dots represent the high and low to normal heat flow sites respectively, while triangles indicate thermal springs. Out of these ten prominent sites, the Son- Narmada-Tapti lineament zone is a fault bound mega lineament belt in Central part of the country (VII), with a large number of hot springs manifestations. Temperature gradients in the 400 to 1200C/km range and heat flow values from 70 to 300 mW / m2 have been recorded at several locations in the Son- Narmada- Tapti province, Rao, J. and Rao M.V. (1987).

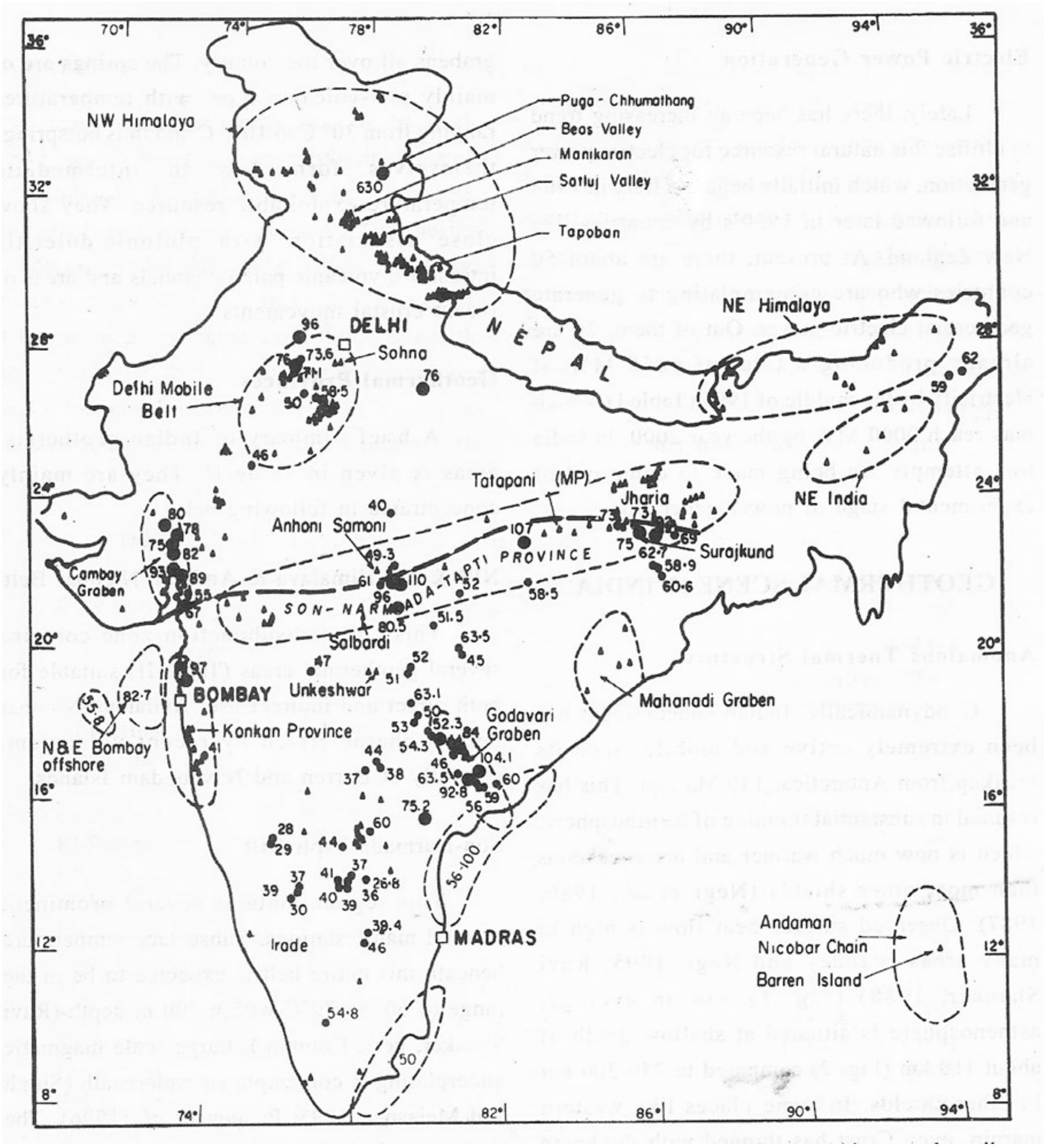

Figure 1: Geothermal provinces of India and regional heat flow patterns (after Ravi Shankar *et al.*, 1992)

1.1 Problem solution

Oil and gas have a head start on various other forms of energy. They are easily transported, easily converted and, in today's market still relatively available. But due to its exhaustible nature, more attention is now needed to develop alternative non-conventional energy sources in parallel to keep the energy requirements going. It is in this context that the geothermal resources stands out as a promising long term salvation due to its bounty in nature among various non-conventional energy sources in India. Nearly 10,000 MWe power generation potential has been estimated from the total geothermal resource base in India and it can be used for space heating and cooling, heating of green houses for cultivation, cooking etc. especially in the high altitude and the colder regions. Geothermal springs are also used for balenotherapy and the promotion of tourism in several countries of the world. Electricity can be generated from geothermal fluids where higher temperatures are available with the help of binary power plants based upon the Organic Rankine Cycle (ORC).

2. PROMINENT GEOTHERMAL POWER GENERATION SITE

The Tattapani geothermal field, situated in Surguja district of Chattisgarh, Figure 2, has several hot springs with moderate gas activity and silica deposits around their vents. An attempt has been made to evaluate the potential of the Tattapani geothermal field for commercial electricity generation.

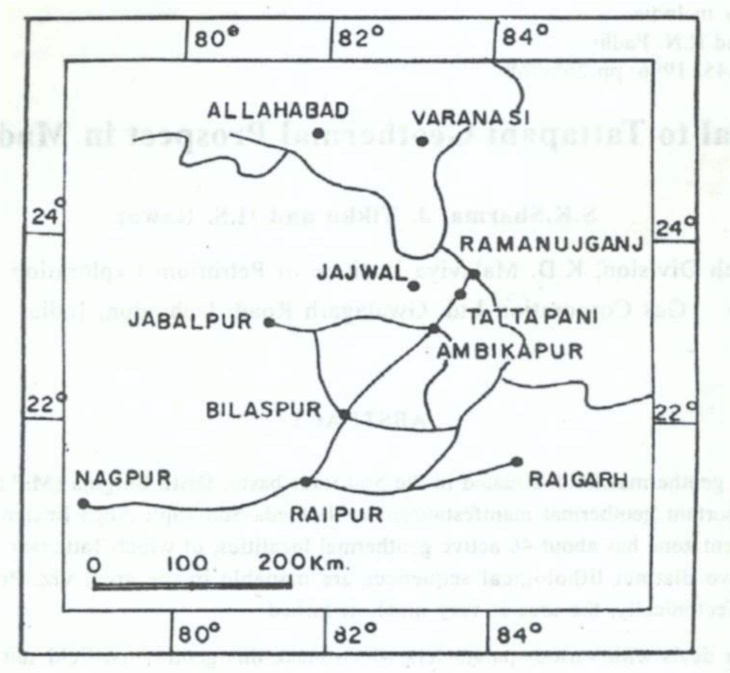

Figure 2: Location map of the Tattapani geothermal field

2.1 Geohydrological characteristics of the area

Geohydrological studies around the Tattapani thermal springs have delineated three sub basins, Figure 3. Basin I and II show flow of ground water towards the Kanhar river in an easterly direction. The gradient in Basin III area towards west feeding Sendur river.Botht he rivers flowing towards north ultimately feed the Son river. The groundwater in Gondwana occurs in confined conditions while the wells in Proterozoic rocks area tap groundwater under water table conditions. The depth of water level ranges from 6 to 10 m below ground level. Seasonal variations in the water table are quite high in basement rocks whereas the dug wells in Gondwana rocks show slight variations. Boreholes number GW/TAT/6, 23, 24, 25 and 26 show free flow of water at the well heads, Sharma and Tikku (1998).

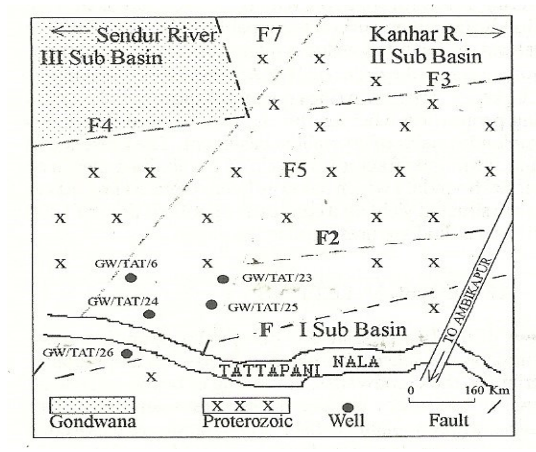

Figure 3: Geohydrological map of the area

The meteoric water, due to its deep circulation, collects heat and rises to the surface through the conduits provided by highly fractured fault zones. The Gondwana groundwater reservoir is a shallow aquifer zone responsible for recharge and cold water mixing at shallow levels.

2.2 Geology of the area

The geological setting of the area has rocks of Archean complex comprising coarse grey granite gneiss, fractured chlorite schist and bands of calcgranulite and pyroxene granulite and Gondwana Subgroup comprising siltstones and shales of Talchir Formation. Two distinct lithological sequences, one belonging to Proterozoic and other to Gondwana Supergroup are mapped in the area. In the reconnaissance and semi detailed investigation, including exploratory drilling, an anomalous area of about one square kilometer was establishes and the up flow zone identified. The geothermal activity is controlled by ENE – WSW trending attapani Fault and NE – SW trending cross faults, Figure 4.

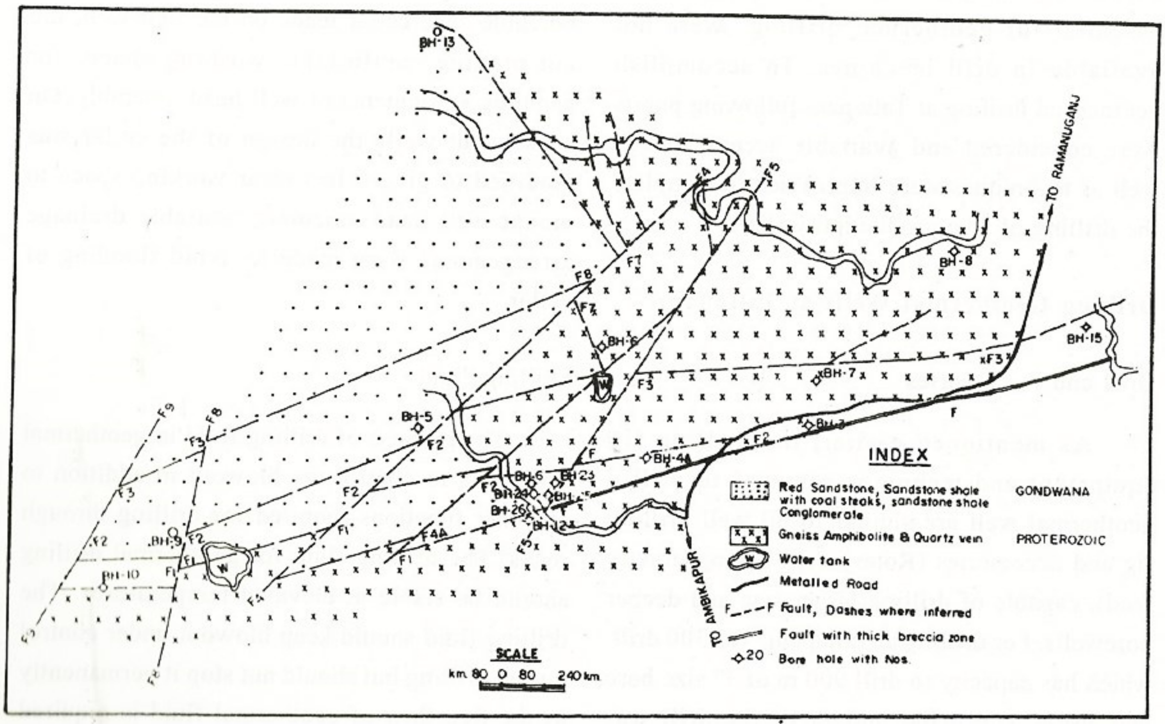

Figure 4: Detailed geological map of the Tattapani area

Tectonically, the area is very much disturbed. The area experiences geothermal gradients of over 5 – 6 times the normal value and heat flow has been inferred to be over 3 – 4 times the normal. Geochemically computed base temperature temperatures are of the order of 160^0 +/- 10^0 C.

2.3 Resource evaluation

The surface temperature of the hot springs varies from 50^0 to 98^0C and their cumulative discharge is about 60 liters per minute, Sarolkar P.B. (1987). Under the geothermal exploration program the GSI for experimental utilization of heat from thermal fluids, as many as 26 bore holes were drilled to depths varying from 100 to 620m, Thussu et al (1987). Drilling of these bore holes was completed in the period April - December, 1993. However, only five of the bore holes were found to be suitable for production as they were producing 60 liters of hot water per hour per bore hole at about 105^0C. With these parameters, a total of 300 KWe electric generation potential has been established based on the cumulative geofluid discharge of 1800 liters/ minute at 105^0C. This low to medium enthalpy reservoir will require the Organic Rankine Cycle based power plant to convert heat energy into electricity, Muffler, P and Cataldi, R (1978).

Deeper drilling was necessary in order to reach the actual reservoir where still higher temperature /pressure thermal fluids could be found. However, deeper drilling could not be carried out at the Tattapani geothermal field during the initial stage, mainly due to non availability of needed deep drilling equipment and other infrastructure facilities. Geothermal heat is extracted through geothermal production wells of diameters large enough to yield the highest possible rate of flow of geothermal fluid flow. It was considered essential to go for deeper drilling down to 1500 to 3000m to obtain geothermal fluids of adequate temperature / pressure for commercial exploitation.

Non-electric utilization of geothermal energy include space heating air conditioning agricultural usages; green house farming, horticulture, aquaculture, animal husbandry, industrial applications, chemical industry, extraction of mineral, food processing, pulp & paper manufacturing, balneology, tourism, bottled mineral water etc. In India direct application of geofluid include tourism (hot bath-balneology), mineral water and beginning has been made in space heating, green house farming, cold storage, poultry farming, mushroom cultivation, sulphur and borax extraction. Direct use of geothermal energy was to the tune of 12,000 MWth in the year 1991.

3. DISCUSSION AND CONCLUSIONS

The presence of pyrite, formation of stilbite and quartz in association with montmorillonite in the alteration mineral assemblages all suggest change in temperature, pressure, boiling zone and chemical composition of geothermal fluid s with passage of time in an area of about $9Km^{2.}$ This mineral assemblage is in equilibrium with temperature range of 100^0 C + 10^0 C which is actually recorded in the boreholes. An anomalous area of nearly $9Km^2$ were paleogeothemal manifestations could still be noticed at the Tattapani has now been reduced to an area of one square kilometer due to masking effect of most of the anomalous area /geothermal regime by the DeccanTrap activity thus explaining the inward retreat of geothermal boundary. The MT survey conducted in the region has indicated the possibilities of primary deeper reservoir ranging in depth from 1500m to 3000m where high temperature gradient of about 2000C could expected for commercial exploitation.

The area promises an electric generation potential of 300KWe besides several direct heat applications. 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. However, due to growing population and rapid pace of industrialization, the energy demand for India may increase fourfold by 2025. In this scenario and keeping in view the Agenda 21, a sustainable energy base emerges from the renewable sources of energy.

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