Assessment of Tatapani Geothermal Field, Balarampur District, Chhattisgarh State, India

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ABSTRACT

Tatapani is the most promising geothermal field located on Son-Narmada lineament in Central India. Two types of lithounits comprising Proterozoic basement rocks viz. granite gneiss, biotite gneiss, phyllite, and Lower Gondwana Group consisting of carboniferous clays, siltstone, sandstone and shale are exposed in this area. The tectonic contact between Proterozoic and Gondwana rocks is marked by the Tatapani fault trending ENE-WSW. Geological Survey of India has completed five borewells at the Tatapani Geothermal field which discharge hot water of > 100°C on surface. The silica geothermometer indicates an average reservoir temperature of around 157°C. The Na-K geothermometer indicates temperature in the range of 180°C to 200°C; hence, the deep reservoir temperature may be higher than 157°C as suggested by silica geothermometer. The hydrothermal alteration mineralogy supports the view that the reservoir temperature at deeper level may be in the range of 160°C to180°C or more. The production potential of 10.9 MWe binary cycle electricity production potential was estimated upto the depth of 1500m, for a period of 20 years, at the effluent temperature of 87°C.

Considering the improvement in power generation technology, it is attempted in this article to refine the assessment of resource potential of geothermal field at Tatapani. The fair assessment of potential at Tatapani may help in planning deeper exploration for establishing a geothermal power plant to generate energy commensurate with database created during the course of field and laboratory studies.

1. INTRODUCTION

Tatapani Geothermal field, Balrampur district, Chhattisgarh State, is a promising hot water reservoir in Central India, along the Son-Narmada lineament. Thermal manifestations in Tatapani consists of hot springs (50°C -97°C) in marshy ground, and hydro thermally altered clay zones covering an area of about 0.1 sq km (Ravishanker, 1987). Geological Survey of India carried out prospecting at Tatapani Geothermal Field (TGF) for proving potential of geothermal resource by geochemical and geophysical methods and exploration by drilling (Thussu and Prasad, 1987). Tatapani Geothermal field is located 95 km NNE of Ambikapur and is connected by all weather tar road from Bilaspur. Total 26 boreholes were drilled for exploration out of which borehole Tat/6, Tat/23, 24, 25 & Tat/26 proved to be successful borewells producing hot water of 100°C on surface @ 270 lpm to 425 lpm (Sarolkar P.B. and Mukhopadhyay D. K. 1996).

The boreholes Tat/23, 24, 25 and 26 were drilled as production wells with cumulative discharge from four bore wells of 1500 lpm. The feasibility of geothermal binary cycle power plant by utilizing this discharge was established in association with Oil and Natural Gas Commission (Pitale et al 1995).
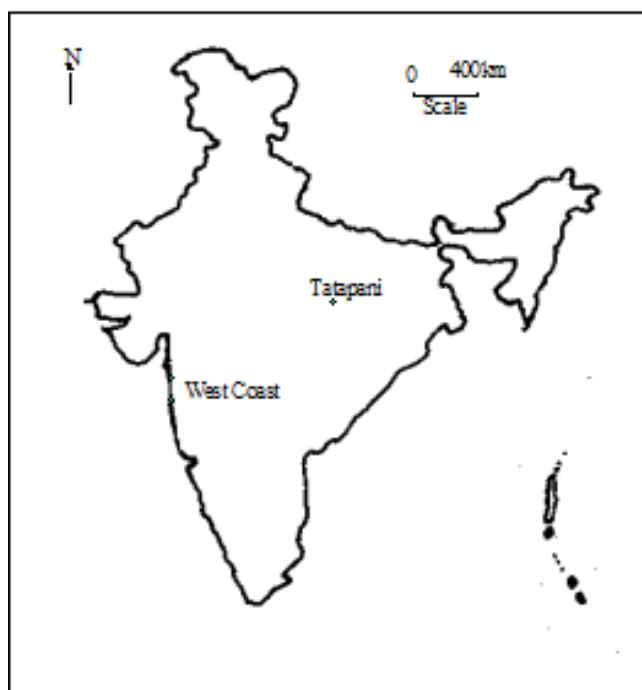

Figure 1: Index map of Tatapani.

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2. GEOLOGY

Archaean rocks comprising massive light grey gneisses, biotite-chlorite schist, biotite gneiss and few calc-granulite bands cover the area. Precambrian pink porphyrytic granite consisting of feldspar phenocrysts and stringers of biotite is exposed south of Tatapani. The pink granite is affected by shearing inducing gneissosity and crude alignment of biotite in the rock. The fault zone is marked by injections of quartz vein. The area north west of Tatapani is covered by rocks of Gondwana Supergroup, comprising green shale and laminated siltstone of Talchir Formation; thin bands of conglomerate comprising pebbles of biotite gneiss, chlorite schist, sandstone and quartz veins; and coarse feldspathic coal bearing Barakar sandstone. The rocks of Gondwana Supergroup show trend of N-S to N25°E- S25°W with low to moderate dips towards northwest.

3. RESERVOIR PARAMETERS

The above studies have postulated possibility of high temperature (160° to 190°C) reservoir at deeper level (table 1). AMT survey has suggested low resistivity zone at a depth of >300m to 600m which might correspond to deep aquifer.

Table1: Inferred reservoir temperatures.

Sl no.	Method of survey	Indicated temperature
1	Geochemical aqueous Geothermometers	160 °C to 200°C
2	Hydrothermal alteration	180°C to 250°C
3	Fluid inclusion study	140°C to 250°C

The present discharge is capable to sustain binary cycle power plant of 300 kWe. At Tatapani, the fact that the flow rate is high, that they emerge at near boiling point of water at atmospheric pressure but in association with a gas phase of clear meteoric signature, suggests the presence of a very well developed convective circuit (Misissale and others, 2000). The effluent water from binary plant could be utilized for direct uses viz. spa and tourism.

The estimated reservoir potential at Tatapani is 11 MWe with base temperature of 140°C covering an area of 2 sq km (ONGC 1993) to 18 MWe with base temperature of 112°C over an area of 7.2 sq km at the depth of 1500m (Pitale et al, 1995).

The thermal logging of boreholes indicates that the reservoir is mostly conical in shape with broad base at depth and tapering upwards towards surface. Based on the available thermal gradient data and the temperatures measured in the boreholes, it is surmised that at the depth of 2000m the temperatures may rise to around 200°C. But considering that the reservoir is in granite equal distribution of the temperature is not possible over the vertical depth hence average temperature of 150°C is taken for assessing the potential of the reservoir. The thermal logs and thermal gradient data on plotting in surfer software indicate surface area 8 sq km for the 150°C isotherm. The present potential is estimated based on this data and recovery factor of 0.33 from the fracture controlled granite. The potential is estimated for 500m thick zone at depth of 1500m to 2000 m from surface. The basic assumptions used for the calculation are given below:

1. Area at the depth of 2000m: 8 km^2 (Base temperature 150°C)
2. Reservoir thickness: 500m (depth 1500m to 2000m).
3. Porosity of rock : 0.10
4. Density of rock   : 2660 Kg/m3
5. Specific heat of rock: 0.19 Kcal/kg°C
6. Expected base temperature: 150°C
7. Temperature limit for Electricity generation by ORC system: 87°C
8. Recovery factor of reservoir: 33 %
9. Plant efficiency: 10%
10. Density of water : 916 gm/lt at 150°C
11. Life of plant : 20 years
12. Joules conversion factor: 4.18

The liquid potential based on these data: 5.05 MWe
The rock potential based on these data: 25.09 MWe
Total estimated power plant potential: 30 MWe

The potential Estimated for various porosity parameters is given in table below.

Table 2: Estimated power potential at 2000m depth.

Sr No.	Temperature	Assumed Porosity	Energy potential at 6%	Energy potential at 10%
1	150°C	0.1	18.1 MWe	30.1 MWe
2	150°C	0.05	17.4 MWe	29.0 MWe
3	150°C	0.02	17.0 MWe	28.3 MWe

The potential is estimated for the production zone of 500 m at the depth of 1500m to 2000m, with base temperature of 150°C. The power generation potential for the maximum temperature of 150°C and base temperature of 87°C varies from 17Mwe for compact rock of porosity 2% to 30 MWe at 10% porosity. This is a conservative estimate with assumption that the reservoir is rather

uniform and presently the power production will be from rather shallow depth using binary cycle method. The power potential will increase if the deep reservoir below depth of 2000m is exploited and higher temperatures are encountered at this depth. These data are encouraging to take up deep level exploration for geothermal resources at Tatapani.

4. CONCLUSION

The power potential of Tatapani geothermal field was estimated to be 11 MWe by ONGC and 18 MWe by GSI. The available data suggests that the reservoir temperature may be 160°C to 180° C. Considering these data, it is estimated that at the depth of 2000m and temperature of 150°C, Tatapani geothermal field may sustain production of 28 MWe to 30 Mwe depending on porosity varying from 2% to 10%, by binary cycle method at 10% plant efficiency. The power potential may vary from 17.0 MWe to 18.1 Mwe at 6% plant efficiency. There is need to explore the deeper reservoir to establish actual potential of the geothermal reservoir.

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