Proceedings World Geothermal Congress 2026, Calgary, Canada, June 8—11, 2026

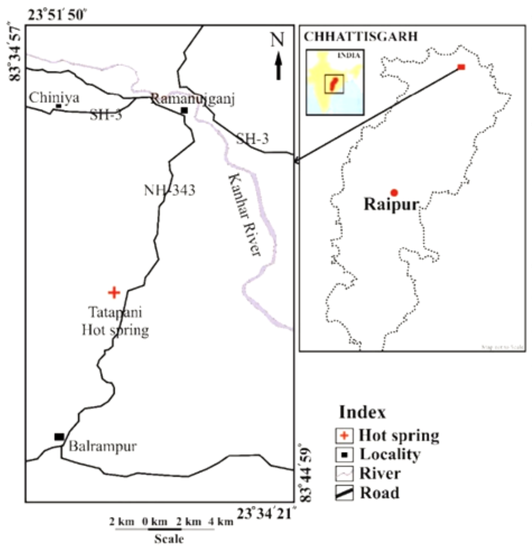
Geothermal Resource Potential in a Non-Orogenic Province, India – A Case Study for the Tatapani Geothermal Field

Priya Yadav[a1*], Gudni Axelsson[2], Archisman Dutta[3], Anurag Kumar Tiwari[4], Jaiprakash[5]

Ministry of New & Renewable Energy, New Delhi- 110003, India[1*], GRÓ-GTP, Geothermal Training Programme, Urdarhvarf 8 B (ÍSOR) 203 Kópavogur, Iceland[2], Geological Survey of India, Lucknow-226024, India[3], Department of Chemical Engineering, DR B R Ambedkar National Institute of Technology Jalandhar, Punjab-144008, India[4],National Institute of Solar energy, Gurugram, Haryana-122003, India[5]

***Corresponding author: priya.mnre@gov.in; priya@grogtp.is**

INTRODUCTION



- The Tatapani geothermal field is situated along the eastern margin of the Son-Narmada-Tapi (SONATA) lineament in Central India.
- It is structurally a fault-bounded systems, with anomalous thermal gradient of 81±36°C/km and heat flow of 219±87mW/m^2. Discharge temperatures reach upto 100°C in some boreholes.
- 26 boreholes were drilled by the Geological Survey of India at Tattapani, with five wells (max. 350m deep) discharging thermal fluids at a cumulative rate of ~1800l/min and temperatures reaching 112.5°C.

Figure 1: Regional geological map of study area

General Objective: Reappraisal of Geothermal Resource Potential in Tattapani, Central India

Specific Objective: Integration of 3G's (Geological, Geochemical, Geophysical), exploratory drilling and well logging data for improved volumetric assessment of geothermal resource of Tattapani.

METHODS

- **Geological:** Tatapani exposes rocks of the Chhotanagpur Granitic-Gneissic Complex and Gondwana Supergroup, with highly sheared, fractured basement and hydrothermal breccia along major faults; heat source may be coal, radiogenic, or magmatic.
- **Geophysical:** MT and other studies reveal a fault-controlled geothermal system with a conductive zone (1–10 Ω-m) at 3–10 km depth and an upper crustal conductor up to ~1 km.
- **Geochemical:** Thermal waters are Na-Cl type, circumneutral to alkaline (pH 6.8–9.7) with moderate TDS, showing partial equilibrium (Tres ~124–220°C), strong water–rock interaction, and long residence times (low tritium).

A Monte Carlo volumetric analysis was performed using conservative reservoir volume estimates to reduce resource risk, deriving output power based on volumes and other parameters derived from geological, geophysical, geochemical data and surface manifestation area. The assessment applied equations through VolumeMetric, using probabilistic input parameters such as system volume, porosity, thermal properties, reservoir temperature, recovery factor, rejection temperature, conversion efficiency, and production time.

RESULTS

Thermal Logging:

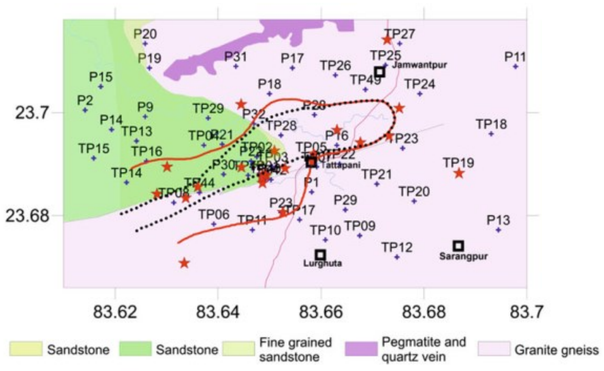
- Thermal logging is shown in **Figure 2**. GW-6 is the deepest borehole, if GW-17 is excluded which was drilled for coal exploration.
- Conductive temperature gradient measured is 100±20°C/km. GW-2 drilled on Tattapani fault recorded the highest thermal gradient of 87°C/100 m upto 78 m and then 104°C as bottom-hole temperature.
- Exploration established strong geothermal activity covering area of 8.825 sq.km., with average gradient of 81±36°C/km.

Hydrothermal Alteration:

- Quartz, chalcedony, amorphous silica, stilbite, montmorillonite, calcite, pyrite are present as main alteration minerals. Some amount of hematite, magnetite, and pyroxenes are also recovered from cores.
- Clay minerals are observed in all the core-samples.
- Mineral assemblages indicate equilibrium temperature of 130±10°C.

Nature of Thermal Reservoir:

- Intersection of Tattapani Fault and NE-SW trending cross faults localize thermal manifestations.
- Gondwana sediments host the shallow reservoir as evident from core drilling and regional geological studies.
- Granite (CGGC) hosts the deeper reservoir.
- Probably, heat source is underlined by radioactive decay of uranium, as good quantity of uranium oxides have been found in drill core samples.



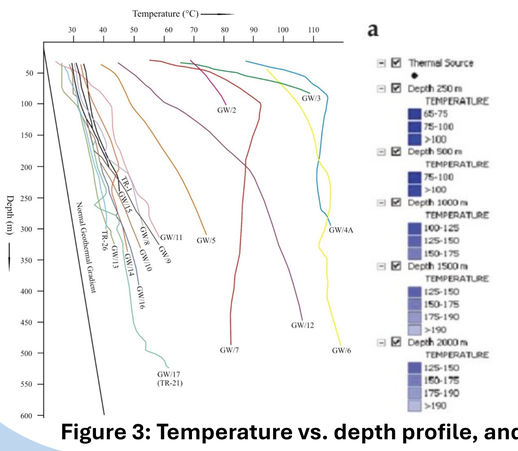


Figure 3: Temperature vs. depth profile, and depth-wise reservoir configuration

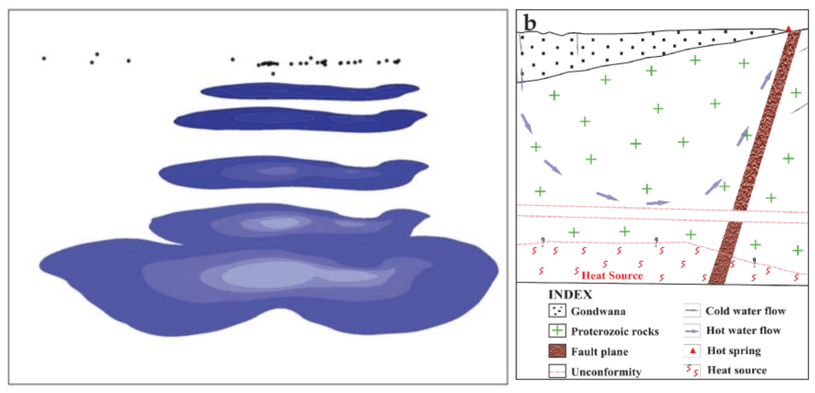


Figure 4: Tentative Model of Tattapani (GSI, 2022)

- The geothermal reservoir is ultimately represented as an elliptical conical frustum.
- It extends from depths of 1 km to 2 km, with the lengths of its major axis is estimated to be approximately 2.5 km at the top and 4.3 km at the base.
- The model is shown in **Figure 3** and **Figure 4**.

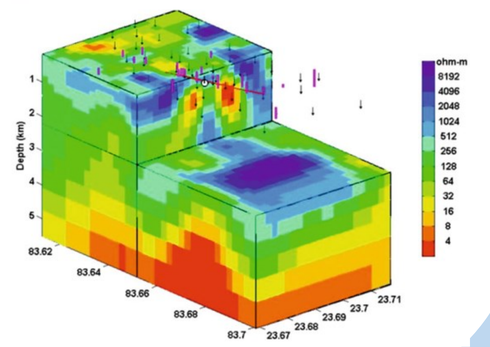


Figure 2: MT study in Tattapani (Patro, 2017)

DISCUSSION

- Using a reservoir area of 0.1–1 km^2, a depth of 1.5–2.5 km with the established *conical structure*, rock porosity of 1–5%, a 30°C cut-off temperature, 95% load factor, 11–13% efficiency, and reservoir temperatures of 180–250°C, the resource is evaluated over a 30-year period.
- Output sensitivity analyses indicate that the volumetric calculations were most influenced by factors like recovery factor, temperature, area and efficiency.
- The resource potential as estimated with P90, P50, and P10 values are 4.8, 9, and 14.2 MWe, respectively **(Figure 5).**
- The most likely value is 9.1 MWe, with the lowest and highest values of 1.1 MWe and 25.8 MWe, respectively.

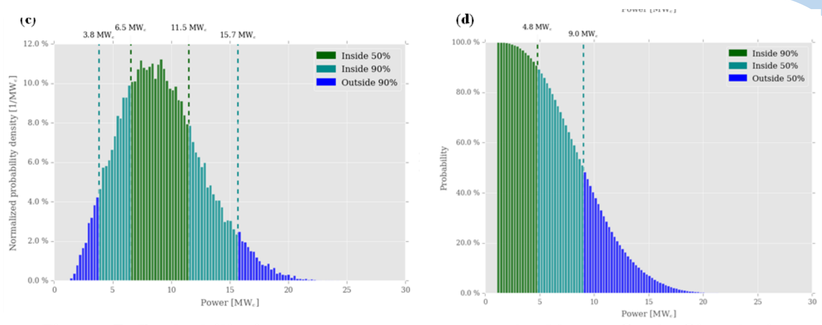


Figure 5: Probabilistic resource assessment by Monte Carlo Simulations

- Temperature modelling shows heat concentrated along the Tatapani fault is exceeding 120°C and indicating potential for binary power generation and direct-use applications.
- A conical, dome-shaped reservoir structure is inferred, with heat focused near fault intersections and extending to depths of about 1500 m.
- Earlier resource calculations by Sarolkar (2000) have estimated the resource value of 3.5 MWe at a proven temperature of 112ºC for ORC with no recharge or reinjection of residual fluids in reservoir.

CONCLUSION AND RECOMMENDATION

- The integration of 3G's analyses, volumetric assessment, and sensitivity evaluation offers a strong basis for future geothermal exploration and resource development.
- Volumetric assessment, though useful, has limitations in complex settings as it cannot capture the dynamic behaviour of fluid flow and heat transfer essential for long-term energy production.
- Uncertainties may arise from assumptions related to rock properties and thermal conditions. Further exploration should include detailed geological mapping, seismic surveys, and deeper drilling to better define subsurface structures.
- Given local ambient conditions and geothermal potential, direct-use applications such as binary power generation, geothermal cooling, balneology, and industrial heating are promising and sustainable.

Acknowledgements

I would like to express my sincere gratitude to the Ministry of New & Renewable Energy (MNRE) for supporting my interests in renewable energy, including geothermal energy. I also wish to acknowledge the Geological Survey of India for providing valuable data related to the Tatapani Geothermal Field. Additionally, I extend my heartfelt thanks to GRÓ GTP for granting me the invaluable opportunity to participate in the six-month advanced training program on geothermal energy.

REFERENCES

Axelsson, G.: Production capacity of geothermal systems. *Proceedings of the Workshop for Decision Makers on the Direct Heating Use of Geothermal Resources in Asia, 2008*, 14.

Bodvarsson, G.: Geothermal resource energetics, *Geothermics*, *3(3),* (1974), 83-92.

Chandrasekharam, D., and Antu, M.C.: Geochemistry of Tattapani thermal springs, Madhya Pradesh, India–field and experimental investigations, *Geothermics*, *24(4)*, (1995), 553-559.

Geological Survey of India (GSI): *Geothermal Atlas of India*, GSI Special Publication No. 125, (2022).

Patro, P.K.: Magnetotelluric studies for hydrocarbon and geothermal resources: Examples from the Asian region. *Surveys in Geophysics*, *38*(5), (2017), 1005-1041.