

Scientific Research Outcome Report

Prefeasibility study for 1MW Geothermal Power Generation in Gujarat, India

1. Faculty Name: Dr. B. K. Behera

2. Branch / Department: School of Petroleum Technology (SPT)

3. Researcher's Name along with designation: Dr. B. K. Behera, Professor, SPT, PDPU

4. Research Title: Prefeasibility study for 1MW Geothermal Power Generation in Gujarat, India

5. Major Goal of this Scientific Research Project: The aim of the study was to carry out investigation for geothermal provinces in Gujarat using various methods such as geological, geochemical and remote sensing Thermal Infra Red (TIR) data studies.

6. Major Activities

- Understanding the tectonic frame work of Gujarat
- Geochemical study of hot water springs across the state of Gujarat
- Remote sensing Techniques to identify potential geothermal locations
- Integration of all the data obtained from various methods and short-listing of potential geothermal locations for further investigation.

7. Specific Objectives & Research Hypothesis

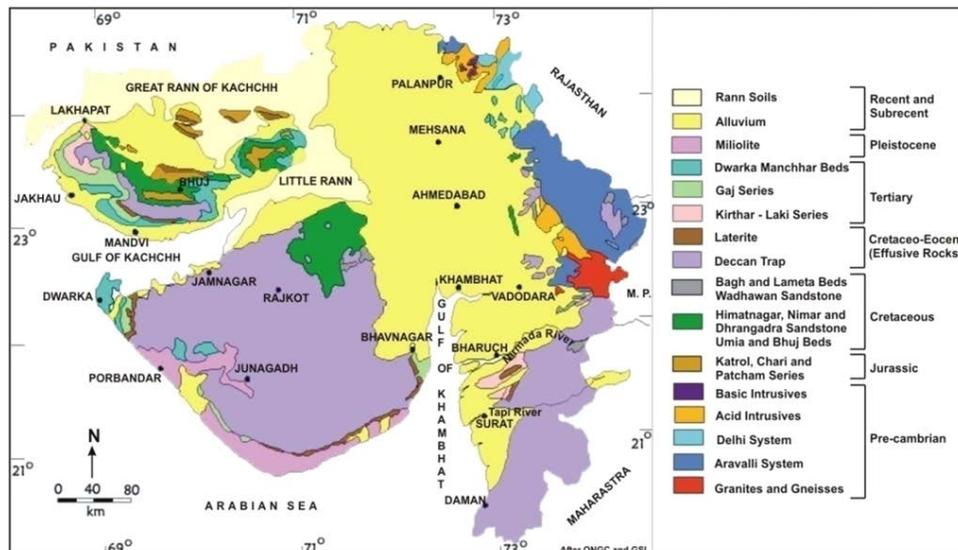
Geological Survey of India (GSI) had conducted surveys India to understand the geothermal potential. GSI had identified 17 thermal active thermal springs in Gujarat. The specific objective of this study was to identify geothermal prospects in Gujarat and converting plays into prospects for geothermal energy harnessing. The study group conducted pre-feasibility studies across various

sites across Gujarat, and shortlisted 6 potential sites viz., Unai, Dholera, Gandhar, Chabsar, Tuwa and Tulsishyam for conducting further studies.

8. Material and Methods along with necessary diagrams

• *Understanding the tectonic frame work of Gujarat*

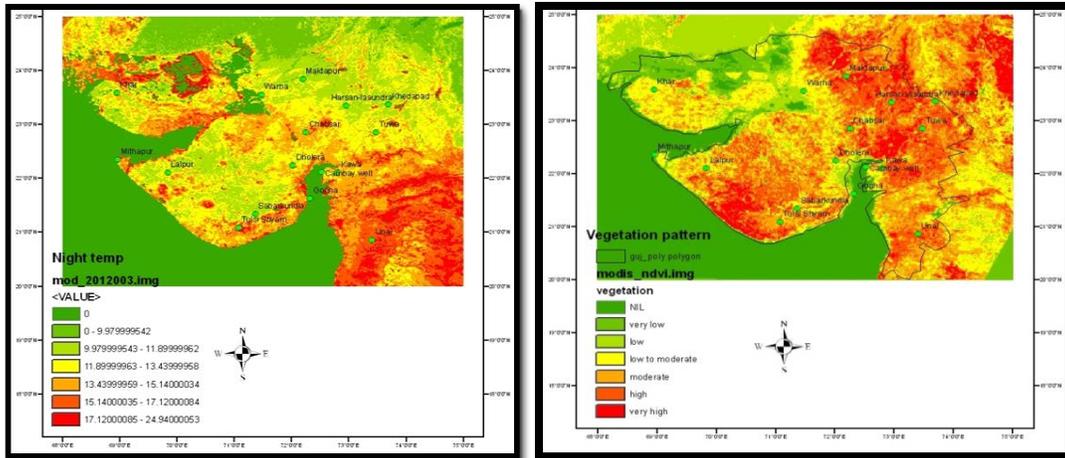
Gujarat state carries the distinction of diverse and unique combination of geological, geo-morphological and physiographic attributes as shown in Figure below. This westernmost region of Indian sub-continent has acquired its present state by combination of Tectono-climatic controls. The interplay of geologic, tectonic and climate have resulted into three physiographic domains in the region; i.e., Mainland Gujarat, Saurashtra Peninsula and Kachchh Peninsula.



Geological map of Gujarat (Source: Merh, 1995)

• *Remote Sensing Studies*

Remote sensing service was undertaken to locate the thermal manifestation over Gujarat in a short time. Visible and near infrared and hyper spectral imagery tools such as ASTER, MODIS, MASTER, AVIRIS have been successfully used in identifying geothermal indicators. The release of heat due to the cooling of the Earth and the heat produced by radioactivity appear to be primarily responsible for the heat flow observed at the surface of the Earth and the temperature distribution within it.



NDVI Image (left), LST Image (right)

Software like MRT, ENVI, ERDAS Imagine were used for the satellite data Processing. 16 day NDVI data were categorised into number of classes from no vegetation to high vegetation. Low to moderate vegetation with high LST regions were understood to have chance of geothermal potential. Comparing NDVI and LST we have interpreted the geothermally active area, i.e low NDVI with high LST are the feasible areas for further investigation (Fig). Chabsar, Gandhar and Dholera having low to moderate vegetation and high LST are considered for further investigation from remote sensing prospects.

- **Geochemical Analysis**

The main objective is to undertake the geo-chemical analysis of the water samples followed by the synthesis of the geochemical data in order to ascertain the nature of the source(s) of the thermal spring water and interpretation of various subsurface conditions and processes controlling the water chemistry.

- **Thermal Springs in Gujarat**

GSI has published a list of thermal springs in Gujarat. The team has visited all the listed locations, however not all the locations are active thermal springs. The dormancy of the springs can be attributed to many natural and man-made factors.

List of Geothermal spring sites in Gujarat

Sr. No	Location	Lat/Long	Sr.No	Location	Lat/Long
1	Chabsar	22°48' 72°16'	10	Mithapur	22°32' 74°01'
2	Cambay Wells	22°14' 72°41'	11	Unai*	20°51' 73°24'
3	Gogha	21°41' 72°16'	12	Tuwa*	22°51' 73°34'
4	Harsan	23°22' 73°05'	13	Tulsishyam*	21°08' 71°05'
5	Kawa	22°04' 72°47'	14	Savarkundla*	21°20' 71°19'
6	Khedapad	23°20' 73°56'	15	Lasundra*	22°55' 73°12'
7	Khar	23°33' 69°00'	16	Lalpur*	22°12' 69°48'
8	Maktapur	23°50' 72°22'	17	Dholera*	22°15' 72°12'
9	Warha	23°43' 71°43'	* Active Thermal Springs		

Sampling Methodology

- Sampling and Testing of water for pH, conductivity, odor, color and taste.
- Determining major chemical parameters like carbonate, hardness, major cations like, Ca⁺⁺, Mg⁺⁺, Na⁺ and K⁺ as well as major anions; CO₃⁻, HCO₃⁻, Cl, and SO₄⁻
- Determination of the trace elemental chemistry.

9. List of equipment, technical facilities/resources used from PDPU for the above mentioned research activity

- PDPU has provided space for housing research lab for the geothermal centre.
- PDPU library has been utilized for preparing the initial knowledge base

10. Significant Results/key outcomes/achievements/Benefits along with necessary pictures / diagrams / images

Based on the MODIS LST and hot spring locations, 6 locations namely, Tuwa, Dholera, Chabasar, Unai, Tulsishyam and Gandhar were selected for detail investigation. These locations were investigated for the subsurface thermal gradient to establish their utility from the point of view of harnessing the geothermal energy.

Tuwa and Tulshishyam: Hot springs at Tuwa and Tulshishyam were interpreted with LST and regional geology. They are located on deep faults in a hard rock terrain, which lacks any primary porosity. Primary porosity is void spaces in rock

during formation. However, it is negligible in hard rock due to their compactness but quite good in unconsolidated rocks.

Chabasar: This spring was not found during recent study and located very close to Ahmedabad City, so the LST difference may be due to mainly urban island rather than geothermal field.

Unai: This place is highly vegetated so remote sensing data is not reliable to come to any conclusion. However, based on the ground survey radiuses of 0.5km around Unai spring were marked as zone of availability of hot water. Many well in and around 0.5 km radius of Unai spring well reported to have high temperature during field work. This place is cross section of faults so may be taken for further study.

Dholera: Dholera thermal spring is located along the margin of Saurashtra Peninsula falling over the West Coast lineament and little west of the West Marginal fault of the Cambay Basin

Gandhar: This field is on un-consolidated sedimentary rock of quaternary age. This is located below Cambay well and also contact zone of sea with Cambay basin and falls on deep gravity fault running along mainland Gujarat.

11. Impact of the research outcomes or findings that address the intellectual merit and broader impacts of the research work

Based on the findings of this research, Government of Gujarat gave a mandate to PDPU to carry out further investigation at the 6 identified potential geothermal sites. This study gave way to the establishment of Centre of Excellence for Geothermal Energy for conducting exploration and exploitation of geothermal energy in Gujarat.

12. How the results have been shared/ disseminated:

Detailed pre-feasibility report has been prepared which can be accessed by the research community as well as industries interested in venturing into the area of geothermal energy

13. Give also name of other PDPU individuals involved in the research.

- Dr. Surendra Singh Kachhwaha, Professor, School of Technology
- Mr. Ranajit Banerjee
- Dr. Mahesh Thakur, Research Scientist, PDPU
- Mr. Gaurav Negi, M. Tech Student, PDPU

14. Which organizations have been involved as partners?

- UPES Dehradun

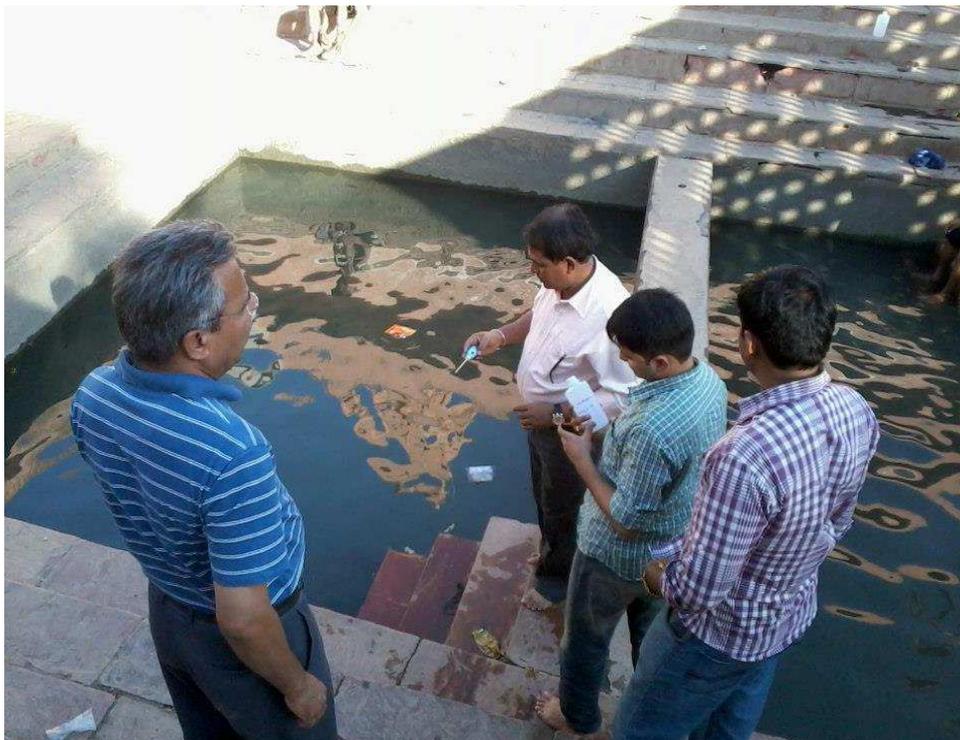
15. Have other collaborators been involved?

- Nil

16. Mention if any infrastructure got added out of research outcome to PDPU institutional resources

- Nil

17. Includes up to six images (images are optional)



Water Sampling and Temperature measurement at Tulsishyam



Students' Field Visit at Tulsishyam