

Scientific Research Outcome Report

Production of 1MW electrical energy using geothermal energy

CENTRE OF EXCELLENCE FOR GEOTHERMAL ENERGY (CEGE)

1. Faculty Name: Dr. Anirbid Sircar/Ms. Shreya Sahajpal

2. Branch / Department: Centre of Excellence for Geothermal Energy (CEGE) under SPT, PDPU

3. Researcher's Names along with designation:

- Dr. Anirbid Sircar, Head-CEGE and Director-SPT
- Ms. Shreya Sahajpal, Faculty-SPT and Coordinator, CEGE

4. Research Title: Production of 1MW electrical energy using geothermal energy

5. Major Goal of this Scientific Research Project:

Geothermal Energy is being harnessed and used for domestic as well as commercial purpose in many parts of the world, such as Indonesia, Mexico, Newzeland, Iceland, California. However, in India, the potential Geothermal Energy has not yet been tapped. Puga, Tatapani, Chamoli, and Bakreshwar have been looked upon as the potential geothermal reservoirs till date. However, according to geological surveys, Gujarat has a good potential as far as geothermal energy is concerned.

Researchers and scientists across the country have made several attempts to understand the geothermal potential in India. But no studies have been taken to the implementation stage. Researchers have conducted MT surveys at various sites, but the integrated studies have not been carried out.

The major objective of this project is to conduct research & development activities in the area of exploration and exploitation of geothermal energy. If harnessed properly, this energy can be utilized in domestic as well as commercial applications. CEGE has used techniques such as Geochemical studies, Magnetotelluric (MT) survey, and Gravity survey to identify the location of geothermal reserves in the study areas. The study areas

where CEGE has focussed its research in Gujarat are Unai, Dholera and Gandhar. Another objective of this research is to conduct resource estimation for all the three above mentioned sites, to understand the energy potential of the said areas. The uniqueness of this project is that in India, no study has been carried out for estimating the energy potential of any site. CEGE is conducting extensive research in the area of resource estimation. Monte Carlo Simulation is being used as the resource estimation tool.

CEGE has identified potential well locations in Unai and Dholera areas, where energy can be tapped after drilling the wells. CEGE has planned to drill parametric wells for understanding the process conditions. The parametric well will also help in validation of the subsurface picture depicted by MT. The success of parametric wells will give way to exploratory well drilling for tapping geothermal energy, which can be further used for domestic and commercial applications.

6. Major Activities:

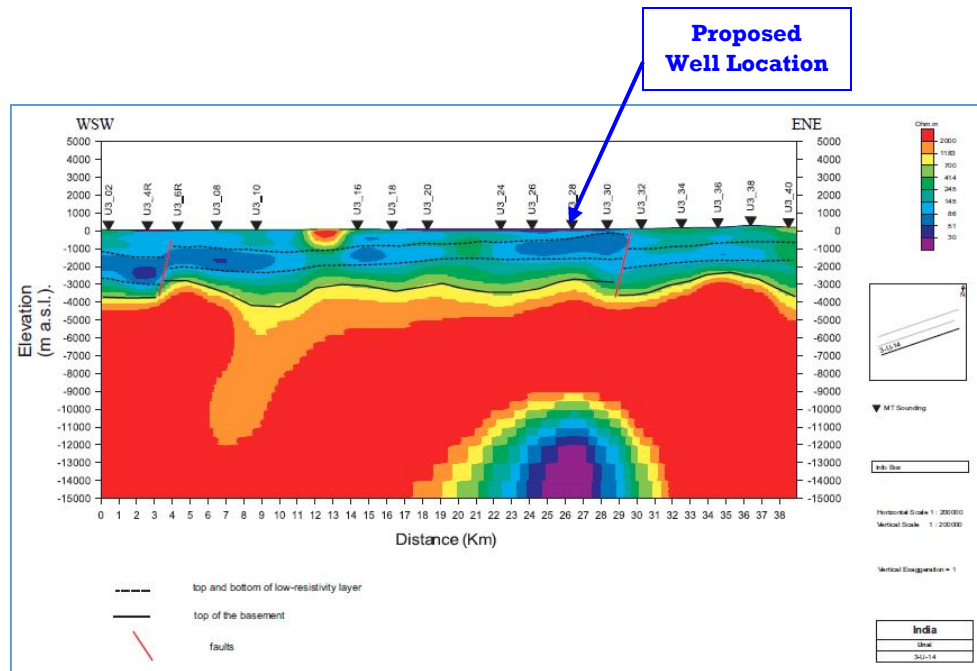
- Geochemical survey at the geothermal sites and performing physio-chemical analysis of water.
- Magneto-telluric (MT) survey over all the sites. Interpretation of MT data and integration of the same with other techniques.
- Gravity survey conducted at all the sites. Gravity data collected along the MT profiles and integrated the same with the MT results
- Analogue well data collected close to Dholera, to calculate the volume of the drillable prospect along with an understanding of porosity and heat capacity of the rock.
- The resource estimation carried out by CEGE based on the above data is an ongoing process and will be fine tuned based on the parametric well planned to be drilled.
- CEGE is in process of carrying out Environment Impact Assessment (EIA) Study to obtain Environment Clearance from Ministry of Environment and Forests (MoEF), Government of India.
- Investigation through 3D MT at Unai for better understanding of the subsurface
- Drilling of parametric and exploratory well at the prospective locations

7. Specific Objectives & Research Hypothesis

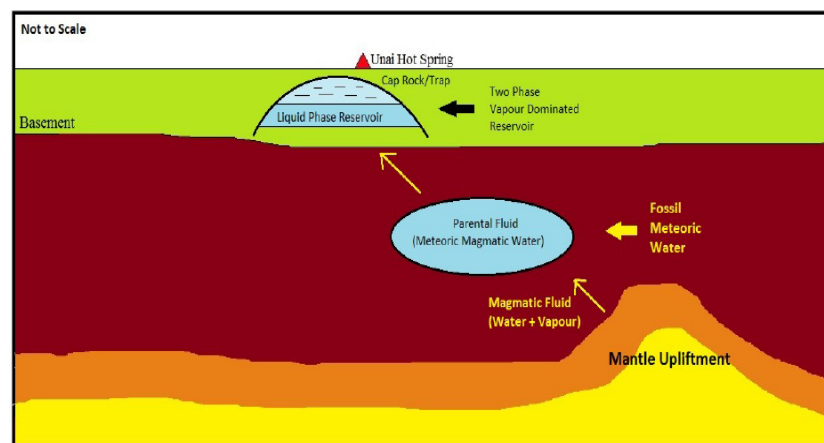
Oil and Gas exploration is an area where a huge amount of work has been carried out and a large database exists for researchers to carry out further analysis. However, even the big guns in oil and gas sector have never ventured into the arena of geothermal energy in Gujarat as, most of the potential sites have volcanic exposures on the surface. Thick basalts prohibit drilling of wells because of perceived uneconomical exploitation of hydrocarbon in these areas.

However, as the present study group started going into the depth of the study area, it was found that hot water can be found in shallow levels which can be directly used for domestic applications. Going further, CEGE has identified areas which are devoid of basalts or where inter-trapeans play an important role in holding geothermal water bodies.

While analyzing the subsurface picture at Unai and Dholera, CEGE has concluded that geothermal anomalies exist in both shallow and deeper levels. CEGE has developed a fluid flow model based on integrated studies, which depicts that the parental fluid ascends through the high permeable zones developed along the faults. High resistivity rocks exist at the deep sub-surface and geothermal source exists at deep and shallow regions. It is postulated that both are connected with fault system. The ascending hot fluid yields convective circulation systems beneath the cap rock. The fluid reaching shallower part may be of two phase or vapor dominated reservoir. This fluid can be a potential geothermal body which can be tapped by drilling of well at the identified location.



Resistivity cross-section based on 2D NLCG inversion



Proposed Fluid flow model of Unai

8. Material and Methods along with necessary diagrams

• Magnetotelluric Survey

The magnetotelluric (MT) method is a passive electromagnetic (EM) technique for which the electric and the magnetic fields are measured in orthogonal directions on the earth's surface. The MT method is passive in the sense that it utilizes naturally occurring geomagnetic variations as the power source. Field sources are equivalent current systems in the ionosphere (magnetotelluric (MT) frequency range - below 1 Hz)

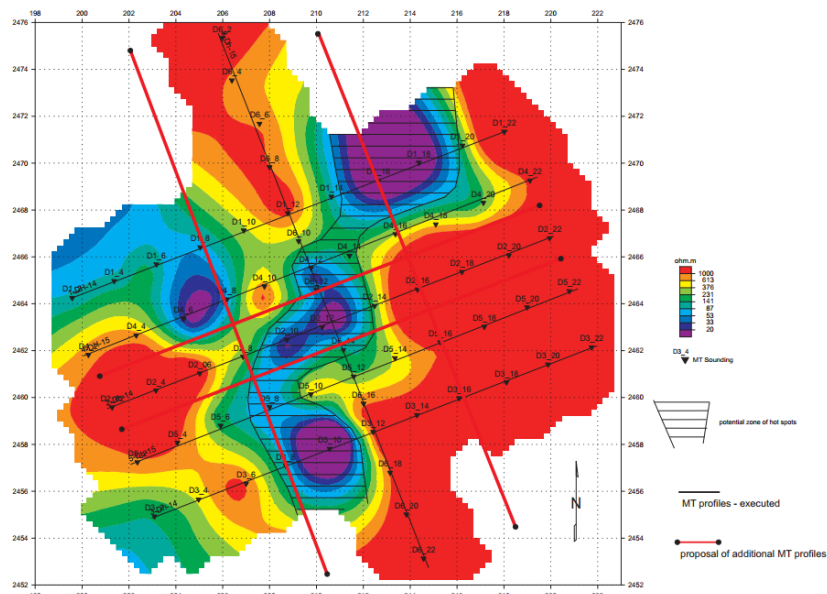


and lightning discharges in the earth-ionosphere cavity in equatorial zone (Audio-frequency Magnetotelluric frequency range – from 1 Hz to 10 kHz). The periodicity of the source as well as the resistivity distribution of the subsurface has influence on the depth of information retrieval. The depth of investigation ranges from a few tens of meters to hundreds of kilometers.

CEGE carried out MT survey at Unai, Dholera and Gandhar (66 MT soundings each). The main objective for performing MT was to understand the basement configuration and the geological structures above basement, delineation of possible traps/structures favorable for geothermal anomalous bodies in the areas and delineation of possible hot water bearing formations (zones) favorable to be a geothermal reservoir in the areas.



Unai: MT survey equipment



MT Profiles at Dholera (66 MT Soundings)

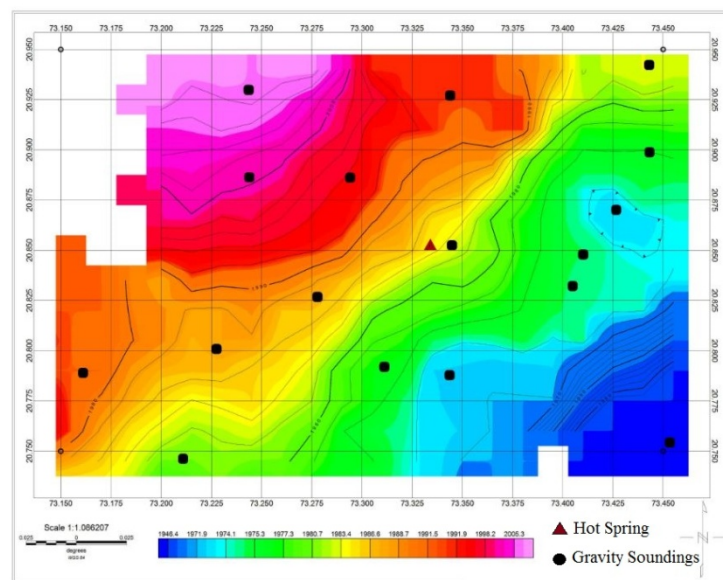
- *Gravity Survey/Gravimeter*

Gravity surveying can be used to detect dense bodies of rocks within host formations of less dense wall rocks. The sedimentary anomalies are identified using closed grid gravity data.

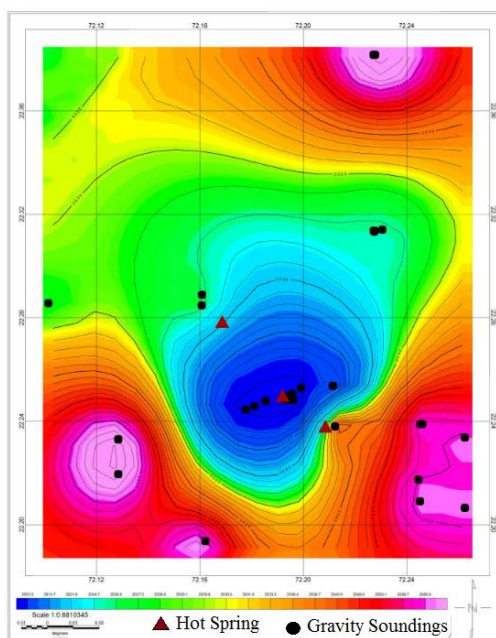
Gravity survey was performed at Unai and Dholera.



Gravity Data Acquisition at Dholera



Gravity Contour at Unai



Gravity Contour at Unai

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 along with necessary pictures / diagrams / images

After integration of the data obtained from various methods such as remote sensing, geochemical analysis and magnetotelluric survey Dholera and Unai have been identified as the potential geothermal locations for further investigation. 3D MT survey has been planned at Unai and Dholera has been selected for drilling a geothermal parametric well.

The success of the well will lead to commercial, academic and research benefits to the research community as well as to the state and the nation as well. This research is one of its kinds in India, and the successful completion of the same will put India in the energy basket of unconventional resources in the world.

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

The research outcome can be categorized under two broad headings.

- *Impact on the scientific community*

Efforts are on for the last 20 years for exploitation of geothermal energy. NGRI and other allied organizations have carried out lot of scientific work in the past but the results could not help in exploiting the geothermal resource in India because of ambiguous depiction of subsurface picture. CEGE has made attempts through various surveys and scientific studies which brought out the subsurface geobodies.

Plausible explanation of deep seated geothermal bodies and its relation to shallow bodies has been explained through visible faults. The present study will be the first of its kind to explain scientifically the surface manifestation of thermal springs. The centre has gone ahead and decided the first parametric well in India which will open a new chapter in the geothermal history. The surface and subsurface data to be collected will be of enormous value to the scientific community and it will be a leap forward in engineering research.

- *Impact on the academic community*

The gravity, magnetotelluric survey, software exposures have benefitted the students and research community to a great extent. The hands on experiences have enriched many students at a very early stage of their career and have made them industry ready for a field which will rule India in the near future.

12. How the results have been shared/ disseminated, you can list any of following:

M.Tech ongoing/PhD ongoing/Publications/International Conferences/Reports

M.Tech Ongoing

- An M.Tech project is ongoing on Exploration and Exploitation of Geothermal Energy

Publications

- Sircar, A. and Sahajpal, S., Geothermal Investigation in Cambay Basin, Gujarat, India, 2nd Annual International Conference on Earth and Environmental Sciences, June 2015, Athens, Greece. (Accepted for presentation. Full length paper to be communicated shortly)

- Sahajpal, S., Sircar, A., Singh, A., Negi, G., Vaidya, D., Shah, M., Dhale, S., (2015) Geothermal Exploration in Gujarat : A Case Study from Unai (Manuscript under preparation)
- Sahajpal, S., Shah, M., Sircar, A., Dhale, S., (2015), Geothermal Resource Estimation:A Case History from Dholera (Manuscript under preparation)
- Shah, M., Sahajpal, S., Sircar, A., (2015), Geothermal Resource Estimation Techniques using Monte Carlo Simulation (Manuscript under preparation)
- Sahajpal, S., Sircar, A., (2015), Geothermal Extraction Techniques: A review (Manuscript under preparation)

Reports

- 2D Magnetotelluric Survey for for geothermal exploration namely (no. of MT soundings) Unai(66), Gandhar(66) and Dholera(66)
- Study of Geothermal prospects in Gujarat through Remote sensing approach
- Physico-chemical Characterization of the Thermal Spring Waters Occurring in Gujarat, India
- Remote sensing approach for geothermal exploration in Gujarat, India

National/International Conference

- *International Geothermal Seminar*

CEGE organized an International Geothermal Seminar on Geothermal Energy Initiative & Development on 26th July, 2013. The seminar provided an opportunity for industries, academicians, researchers and geothermal experts from all parts of the world to contribute towards the development of geothermal energy. Experts shared their valuable views and experience on a wide range of topics related to successful implementation of geothermal power projects.

The seminar witnessed talks on interesting topics related to ‘Trends & Challenges in Geothermal Exploration’, ‘Sustainable Geothermal Utilization’ and ‘Analysis and Case Studies on Geothermal Systems’. The seminar was attended by industry representatives across India and abroad, academicians, government officials and students of PDPU.

- **UPCOMING EVENTS:** *International Conference on Geothermal Energy: Exploration and Exploitation* on 1st May, 2015. The key focus of the conference will

be bringing industry professionals, researchers, scientists, geothermal experts, policy makers, academicians and students onto a single platform in order to discuss the issues and challenges in exploration and exploitation of Geothermal Energy.

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

- Ms. Anjali Chaudhary, Research Associate, CEGE
- Mr. Dwijen Vaidya, Research Assistant, CEGE
- Ms. Shubhra Dhale, Research Assistant, CEGE
- Manan Shah (M. Tech Student, SPT, PDPU)

14. Which organizations have been involved as partners?

- Ministry of New and Renewable Energy, Government of India have agreed in principle to support this project. A project proposal on Geothermal extraction and possible conversion to electrical energy will be submitted to MNRE in next 45 days

15. Have other collaborators been involved?

- CEGE is in the process of signing an MoU with ONGC Energy Centre (OEC)

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

CEGE has procured various software for conducting analytical studies

- Winglink Software
- Grapher Surfer
- Gravimeter
- GPS
- Arc GIS
- Oasis Monatage
- Prosource
- Seismic Survey Equipment
- Risk (for Monte Carlo Simulation)
- Magnetometer (to be purchased)

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



Unai: CEGE research team



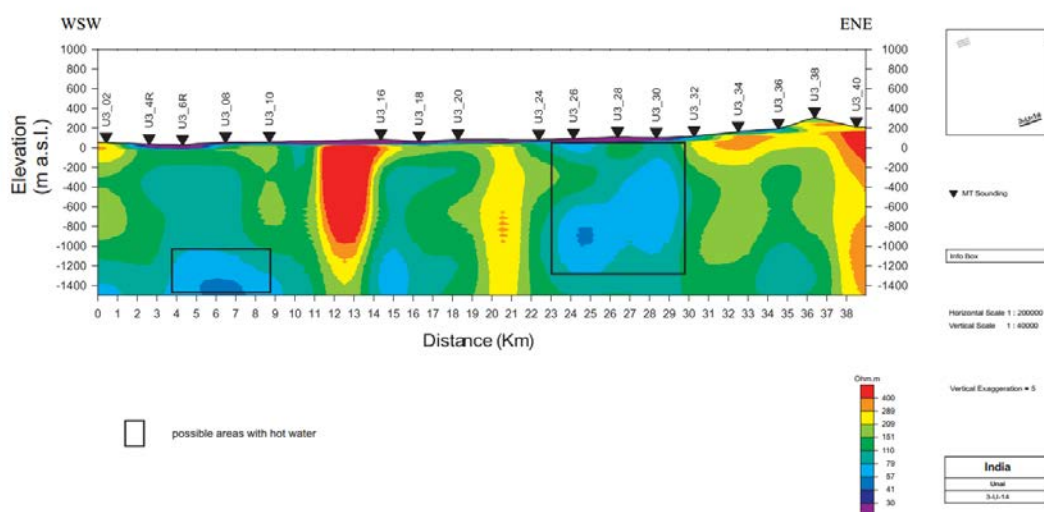
Unai: Researchers recording gravity values



Dholera: Utthan Hot Spring



*Dholera: Temperature measurement of
Flowing water from artificial bore well*



Unai: Resistivity cross-section depicting aquifer



Unai: MT Data Acquisition