TETRA TECH RPS ENERGY | TRAINING

N730: Geothermal Geology and Hydrology

Instructor(s): Kevin Gray

Format and Duration
Classroom - 5 Days

Summary

Understanding geothermal geology and hydrology is essential for the successful exploration, development, and management of geothermal resources. This course provides a detailed examination of the geological and hydrological processes that control geothermal energy systems.

Participants will learn about geological structures and heat sources that contribute to geothermal potential. Reservoir formation and permeability and the key controls on fluid movement and heat extraction. Hydrogeological modelling will be explained to enable an understanding groundwater flow in geothermal systems. The role of geochemistry and mineralogy in reservoir sustainability will be explored. The course will show the differences between hard rock and sedimentary geothermal systems and their implications for drilling and development. Geothermal resource exploration techniques – Geophysical, geochemical, and remote sensing methods.

By the end of the course, participants will be able to assess geothermal potential, evaluate reservoir characteristics, and apply geological and hydrological principles to optimize geothermal projects. This is a Foundation to Skilled level course designed for professionals involved in geothermal exploration, resource assessment, and hydrological modeling.

This course is delivered in partnership with Black Reiver Consulting Ltd.

Learning Outcomes

Participants will learn how to:

1. Understand the geological and hydrological processes that govern geothermal systems.
2. Differentiate between hard rock and sedimentary geothermal reservoirs and their unique characteristics.
3. Apply exploration techniques to assess geothermal potential.
4. Analyse hydrological and geochemical properties of geothermal fluids.
5. Develop conceptual models of geothermal systems for resource assessment.
6. Understand reservoir sustainability and how to manage fluid flow and heat extraction.

Training Method

This is a classroom course comprising a mixture of lectures, discussion, case studies, and practical exercises.

- Instructor led technical sessions covering real-world case studies.
- Step-by-step guidance on geothermal resource assessment.
- Hands on exercises and mapping activities.
- Hydrological modelling practice using industry standard tools.
- Comparative analysis of hard rock vs. sedimentary geothermal systems.

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Who Should Attend

This course is ideal for:

- Geologists & geophysicists involved in geothermal exploration.
- Reservoir engineers & hydrogeologists analyzing geothermal resources.
- Drilling engineers & project developers planning geothermal wells.
- Government & regulatory professionals assessing geothermal resource policies.
- Investors & environmental consultants evaluating geothermal projects.

Course Content

1. Introduction to Geothermal Geology & Reservoir Formation

- Fundamentals of Geothermal Energy & Heat Flow
- Understanding Geothermal Heat Sources
- Heat flow within the Earth – Conduction, convection, and advection.
- Radioactive decay and magmatic heat sources.
- Heat transfer mechanisms in the subsurface.

2. Geothermal Systems & Their Geological Settings

- Hydrothermal vs. Petrothermal systems – Key differences.
- Classification of geothermal resources (highenthalpy vs. lowenthalpy).
- Plate tectonics and geothermal activity – Rift zones, subduction zones, and hot spots.

3. Hard Rock vs. Sedimentary Geothermal Reservoirs

- Characteristics of Hard Rock Geothermal Systems
- Crystalline basement reservoirs – Fracture controlled permeability.
- Geothermal gradients in volcanic and metamorphic settings.
- Fluid movement in fractured igneous and metamorphic rocks.

4. Characteristics of Sedimentary Geothermal Systems

- Permeability in sandstone, limestone, and shale formations.
- Thermal storage potential of porous rock reservoirs.
- Basin scale geothermal systems and aquifer hosted geothermal reservoirs.

5. Comparing Hard Rock & Sedimentary Systems

- Drilling and well design challenges in different geological settings.
- Reservoir management and sustainability considerations.
- Case studies from volcanic, crystalline, and sedimentary geothermal fields.

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6. Structural Controls & Reservoir Permeability

- Geothermal Structural Geology
- Tectonic & Structural Controls on Geothermal Systems
- Normal, reverse, and strikes slip fault systems.
- Fracture permeability in geothermal reservoirs.
- The role of igneous intrusions in geothermal heat sources.

7. Understanding Geothermal Permeability & Fluid Flow

- Primary vs. secondary permeability in geothermal reservoirs.
- The role of faulting and fracturing in fluid movement.
- How permeability affects heat extraction efficiency.

8. Hydrogeology of Geothermal Systems

- Principles of Geothermal Hydrology
- Groundwater recharge and flow in geothermal systems.
- Influence of reservoir porosity and permeability on fluid circulation.
- Pressure and temperature gradients in geothermal fields.

9. Reservoir Fluid Flow & Thermal Transport

- Modelling fluid flow in porous and fractured geothermal reservoirs.
- Hydraulic conductivity and storage coefficients in geothermal aquifers.
- Heat loss mechanisms in geothermal systems.

10. Exploration Techniques & Geochemical Analysis

- Geothermal Resource Exploration
- Geophysical Methods for Geothermal Exploration
- Magnetotellurics (MT) and resistivity surveys.
- Seismic reflection and refraction for reservoir imaging.
- Gravity and magnetic surveys in geothermal fields.

11. Remote Sensing & GIS in Geothermal Exploration

- Satellite based thermal imaging for geothermal prospecting.
- Integrating remote sensing with field based exploration.
- Case studies of successful geothermal exploration using remote sensing.

12. Geochemistry & Fluid Analysis

- Chemistry of Geothermal Fluids

- Major ions and trace elements in geothermal brines.
- Water rock interaction and mineral scaling.
- Gas geochemistry – CO_2, H_2S, and noble gases.
- Reservoir Geochemistry for Sustainability
- Geochemical tracers for fluid flow tracking.
- Predicting reservoir depletion and mineral precipitation.
- Scaling and corrosion in geothermal production wells.

13. Conceptual Modelling & Well Design Considerations

- Building a Geothermal Conceptual Model
- Integrating Geological, Geophysical & Geochemical Data
- Using data to define geothermal reservoir boundaries.
- Developing 3D conceptual models of geothermal systems.
- Predicting Reservoir Performance & Heat Extraction
- Reservoir temperature and pressure modeling.
- Estimating longterm heat sustainability.

14. Geothermal Project Development & Risk Management

- Risk Assessment & Sustainable Resource Management
- Environmental & Social Considerations
- Land use and ecological impact of geothermal projects.
- Water usage and reinjection challenges.

15. Legal & Regulatory Frameworks

- Geothermal permitting and compliance regulations.
- International case studies of geothermal policy implementation.

This course provides participants with:

- A strong understanding of geothermal geological and hydrological principles.
- The ability to differentiate between hard rock and sedimentary geothermal systems.
- Knowledge of geophysical, geochemical, and hydrological exploration techniques.
- Skills in reservoir conceptual modelling and resource assessment.
- A practical foundation for developing sustainable geothermal projects.

Participants will leave equipped with the knowledge and tools needed to assess, develop, and manage geothermal resources effectively. This course can be tailored to regional geothermal conditions and project specific requirements.