Induced Seismicity in Geothermal Fields (G568)

Tutor(s)

Emmanuel Gaucher: Senior Research Geophysicist, Geothermal Energy and Reservoir Technology, Karlsruhe Institute of Technology.

Overview

This course covers fundamental and practical aspects associated with induced seismicity in deep geothermal fields. A refresher of the most relevant rock mechanics and seismological aspects will be followed by a review of the main observations and modelling approaches. Monitoring concepts for risk mitigation or reservoir imaging will also be presented.

Duration and Logistics

Classroom version: A 2-day course comprising a mix of lectures, case studies and exercises. The manual will be provided in digital format and participants will be required to bring a laptop or tablet computer to follow the lectures and exercises.

Virtual version: Four 3.5-hour interactive online sessions presented over 4 days. A digital manual will be distributed to participants before the course. This course will also contain practical exercises to reinforce key learnings. (In the virtual sessions, individual simplified questions will be asked; for a classroom version of the course, attendees will work in small groups.)

Level and Audience

Intermediate. The course is intended for geoscientists wishing to learn what seismicity in geothermal fields is, how it is induced and how we could mitigate it while using it for imaging purposes. Geoscientists from the oil and gas industry sensitive to hydrofrac operations can also join to understand differences.

Objectives

You will learn to:

1. Assess induced seismicity characteristics to gain critical information, such as location, magnitude and fault plane solutions.
2. Evaluate the pros and cons of the methods used to determine seismic information.
3. Design the main features of a seismic monitoring network for specific monitoring objectives within a given geological context.
4. Propose appropriate sensor deployment type(s), data management procedures and processing sequence.
5. Identify the main drivers for induced seismicity in a geothermal field.
6. Predict likely operations that could induce seismicity according to subsurface properties and structures, and identify the most critical ones.
7. Propose appropriate mitigation approaches taking account of the subsurface characteristics and operations proposed.

Course Content

1. Rock mechanics – why does the rock break? Why does a fault move?

Lectures

- The role of the stress field
- Rock and fault failure modes and failure criteria
- Slip and dilation tendency of faults. Is a fault likely to be reactivated?

Exercises

- Calculate slip-tendency on a fault.

2. Passive seismic

Lectures

- Seismogram content – what information is hidden in a seismogram? Source effect, geometrical spreading and receiver response
- Seismic source description – how can we use the seismogram to determine the characteristics of the seismic event, i.e. its location, origin time, energy and focal mechanism? What is the difference between magnitude and intensity?

Exercises

- Manually locate an earthquake.

3. Induced seismicity in deep geothermal fields – observations

Lectures

- In enhanced geothermal systems (EGS) and in hydrothermal systems
- Common features
- Correlation of seismicity with field operations

4. Induced seismicity in deep geothermal fields – modelling approaches

Lectures

- Statistical-based modelling
- Physics-based modelling
- Hybrid modelling

5. Induced seismicity monitoring

Lectures

- A few existing regulations
- ‘Traffic light system’ and ‘Adaptive traffic light system’ – towards a reservoir management system
- Seismic monitoring design – what influences the waveform observed at a seismic station?
- Network sensitivity, magnitude of completeness

Exercises

- Propose a seismic network and mitigation procedure for the monitoring of a virtual geothermal field.