Department of Physics and Materials Science

SEMINAR

Geothermal reservoir characterization and induced earthquakes at large distances from injection wells

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Abstract: Fluid injection operations in the central U.S. and Canada have been an excellent natural laboratory for the study of induced seismicity and earthquake triggering processes. Yet, anticipating and mitigating underlying seismic hazards remains challenging. Induced seismicity is commonly modeled as a pressure diffusion process within reservoirs and along pre-stressed faults. However, earthquakes at large distances and depths from injection wells are difficult to explain. I will present observations of induced earthquake sequences associated with field-wide injection in Oklahoma where we resolved triggering mechanisms at more than 40 km from disposal wells. At such distances elastic stress changes in the rock matrix surpass direct fluid pressure effects. Similar effects are observed for single well geothermal and wastewater injection sites where induced sequences extend to distance of up ~10 km.

In the second part of my talk, I will present results from a densely instrumented geothermal reservoir in Nevada. We document pressure changes and long-term surface subsidence of up to 1 cm/yr. We conduct novel tidal analysis and laboratory core testing to characterize elastic and flow properties at different scales. These tests highlight the importance of fault damage and hydrothermally altered zones in channeling fluid flow. Long-term deformation across the reservoir is associated with low-level seismicity which is punctuated by transient seismicity bursts during rapid maintenance shutdowns. The seismicity with magnitudes below ML1.5 is concentrated around one injection wells at 1.5 km depth. We construct a numerical model of abrupt seismicity rate changes and explain the observation by Coulomb stressing rate changes on optimally oriented faults. Taken together, these results demonstrate the importance of high-fidelity seismic monitoring and structural characterization for an improved understanding of seismic hazards and fluid flow.

Bio: Goebel is an observational seismologist studying seismicity and fault zone structures in energy reservoirs and around volcanoes. His research has demonstrated how injection induced elastic stresses can cause earthquakes at tens of kilometers from injection wells. His group is using lab observations, numerical models and seismic data to improve the understanding of earthquakes and fluid flow, see: http://www.ceri.memphis.edu/people/thgoebel/

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