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Pore-pressure mapping through Focal Mechanism Tomography at St. Gallen, Switzerland, geothermal field

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Sub-surface operations for energy production, such as geothermal energy, may originate various environmental risks. Science4CleanEnergy, S4CE, is a multi-disciplinary project (H2020-EU.3.3.2. - Low-cost, low-carbon energy supply) aimed at understanding the underlying physical mechanisms underpinning sub-surface geo-energy operations and to measure, control and mitigate their environmental risks. Among the different risks, of great relevance is the seismic risk due to the induced seismicity associated with field operations.
In general, induced events are expected in enhanced geothermal systems (EGS), where fluids are injected under high pressure into the rock to create reservoirs for fluids. However, also deep geothermal drilling operations aimed at increasing the permeability of the rocks by injecting fluids into the subsurface may induce earthquakes.
In the framework of the S4CE project, we investigate the role of pore fluid pressure in the generation of the seismicity induced during the deep geothermal drilling project close to the city of St. Gallen, Switzerland.
We analyse 346 earthquakes recorded from July 2013 to October 2013 with MLcor between -1.2 and 3.5 and depth up to 4.2 km that occurred during the different phases of the project. We estimate fault mechanisms based on first-motion polarities and, using a Focal Mechanism Tomography technique similar to that proposed by Terakawa et al. (2014), we estimate the 3D excess pore fluid pressure field.
We assume that fault strength is controlled by Coulomb failure criterion with a constant friction coefficient $\tau = \mu(\sigma - P)$, where τ and σ are the shear and normal stress on the fault plane, respectively and P is the pore fluid pressure. Under the hypothesis of uniform regional stress field, the FMT attributes the focal mechanism variations to fault strength heterogeneity due to pore fluid pressure acting on faults.
The analysis of the observed fault orientation relative to the regional stress field and the estimated fluid overpressure allows to comprehend if the induced events occurred on pre-existing faults or on unfavourably oriented fault triggered by pore pressure increase.
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