Seismicity time evolution and 3D/4D seismic tomography of Nesjavellir geothermal field (Iceland)

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Nesjavellir Geothermal Field is located in the Northern part of the Hengill central volcano in South West Iceland. The Hengill volcanic complex consists of three smaller volcanic systems feeding several geothermal fields with surface manifestations.

Geothermal energy is currently produced at two power plants, in Nesjavellir and in Hellisheidi. After an exploitation period started in 1947, the construction of Nesjaveillir power plant was completed in 1990. Nowadays it produces geothermal energy of up to 300 MW, which is 1,640 l/sec of hot water and up to 120 MW of electricity.

Part of the surplus geothermal water from the plant goes into the injection wells and in analogy with the nearby Hellisheidi power plant the re-injection of geothermal gases into basaltic formations is planned. To this aim several tests of fluids deep injection are being conducted to prepare the experimental re-injection of carbon dioxide and hydrogen sulphide.

In the framework of the H2020-Science4CleanEnergy project, S4CE, a multi-disciplinary project aimed at understanding the underlying physical mechanisms underpinning sub-surface geoenvironmental operations and to measure, control and mitigate their environmental risks, we investigate the seismicity evolution through the b-value and study the elastic properties of the propagation medium through the 3D/4D seismic tomography.

The seismicity recorded in the study area is due to different mechanisms. Indeed, while in Hengill the seismicity is originated by volcano-tectonic processes, small earthquake swarms between Hengill and Grensdalur volcano are due to the geothermal activity. Finally, the seismicity in proximity of Hellishedi and Nesjaveiiir power plant appears to be induced by re-injection of waste water from the geothermal production.

Seismic data are recorded by the Icelandic Meteorological Office (IMO) but also from Iceland GeoSurvey (ÍSOR) and by the COSEISMIQ project. The production data are from the OR energy company.

We used an iterative linearized delay-time inversion to estimate both the 3D P and S velocity
models and earthquake locations. The velocity model is parametrized by trilinear interpolation on a 3D grid. The inversion starts from the 1D velocity model, optimized for the area. Time variations of the medium seismic properties are observed in term of Vp, Vs and Vp/Vs ratio obtained by 4D tomography. The technique consists in applying the 3D tomography at consecutive epochs. Spatial and temporal characteristics of the re-located earthquakes are then analysed by using the ZMAP code to image the b-value in the investigate volume.

The images obtained for each epoch in terms of b-value, Vp and Vs velocities are then correlated with operational data.

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