Injection-induced surface deformation and seismicity at the Hellisheidi geothermal field, Iceland

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Abstract

Induced seismicity is often associated with fluid injection but only rarely linked to surface deformation. We observe 2 cm of surface deformation as well as a strong increase in seismicity during the initial phase of geothermal wastewater reinjection at the Hellisheidi geothermal power plant in south-west Iceland. Reinjection started in September 2011 with a flow rate of around 500 kg/s. Micro-seismicity increased immediately in the area north of the injection sites, with the largest seismic events in the sequence being two M4 earthquakes on 15 October 2011. Semi-continous GPS sites installed in October and November 2011 reveal a transient signal which indicates that most of the deformation occurred in the first months after the start of the injection. The surface deformation is evident in SAR interferograms as well, in the time interval between June 2011 to May 2012. We use an inverse modelling approach and simulate the geodetic data (InSAR and GPS) to find the most plausible cause of the deformation signal and investigate how surface deformation, seismicity and fluid injection may be connected to each other. We argue that fluid injection caused an increase in pore pressure which resulted in increased seismicity and fault slip. Both pore pressure increase and fault slip contribute to the surface deformation.

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