Induced earthquakes at the carbon sequestration site Carbfix2, Hellisheiði, Iceland

Vala Hjörleifsdóttir¹, Gunnar Gunnarsson¹, Sigríður Kristjánsdóttir², Bergur Sigfússon³, Halldór Geirsson⁴, Kristín Jónsdóttir⁵, Ingvi Gunnarsson⁶, and Kristján Ágústsson²

¹Reykjavík Energy, Reykjavík, Iceland (vala.hjorleifsdottir@or.is)
²Iceland Geosurvey (ISOR), Reykjavík, Iceland
³Carbfix, Reykjavík, Iceland
⁴University of Iceland (UoI), Reykjavík, Iceland
⁵Iceland Meteorological Office (IMO), Reykjavík, Iceland

The 303 MW Hellisheiði, Iceland geothermal power plant was commissioned in 2006 and in early September 2011, reinjection of geothermal fluid was initiated in the second reinjection site of the plant; Húsmúli. The site has 5 injection wells in operation, with depths of over 2000 m and a total of up to 500 l/s of fluid being reinjected into the site. Seismicity had previously been observed in the region, including both natural seismicity before power plant operations started (e.g. Foulger et al., 1988) and induced seismicity during drilling of the injection wells (Ágústsson et al., 2015). The reinjection caused severely increased level of seismicity within days, with two earthquakes of M 4.0 and M3.9 respectively, occurring a little over a month after the start of reinjection (Icelandic Meteorological Office catalog). The injection was also accompanied by uplift of approximately 2 cm (Juncu et al., 2018). Due to the increased level of seismicity, a committee was formed and several measures on how to control it were suggested – including starting reinjection gradually after it has been stopped (Bessason et al., 2012).

In 2014, as a part of the Carbfix2 project, the reinjection fluid in Húsmúli was combined with gas, and CO₂ and H₂S, previously being released into the atmosphere, is now captured and reinjected into the basaltic formation (Matter et al., 2016, Gunnarsson et al., 2018). It is estimated that the CO₂ and H₂S are crystalized into calcite and pyrite in under 2 years (Gunnarsson et al., 2018). This project has been very successful and is currently capturing and permanently storing an estimated 33% of the CO₂ and 75% of the H₂S extracted.

In this study we analyze seismicity data as reported by the Icelandic Meteorological Office Regional network, (1991-present) and the ON Power/ISOR local network (2016-present) and compare with operational parameters. We show 1) how the seismicity responds to changes in flow, pressure and temperature of the injected fluid, 2) how individual wells seem to respond differently, 3) how the mitigation measures taken by the operator have worked and 4) look for changes in seismicity due to the CO₂ sequestration.

This work has been funded by the European Union's Horizon 2020 research and innovation
Program projects Carbfix2 (grant agreement number 764760) and S4CE (grant agreement number 764810).