Fluid-rock reaction in N Iceland in connection with earthquakes

GABRIELLE J. STOCKMANN[1,2*], ALASDAIR SKELTON[2], MARGARETA ANDRÉN[2], ERIK STURKELL[3], NICOLE S. KELLER[1], RÍKEY KJARTANSDÓTTIR[1], TONCI BALIC-ZUNIC[4], HEIKE SIEGMUND[2], HREINN HJARTARSON[5]

[1]Institute of Earth Sciences, University of Iceland, 101 Reykjavík, Iceland (*gabrielle@hi.is)
[2]Department of Geological Sciences, Stockholm University, 106 91 Stockholm, Sweden
[3]Department of Earth Sciences, University of Gothenburg, 405 30 Gothenburg, Sweden
[4]Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark
[5]Landsvirkjun, Iceland

Groundwater monitoring in North Iceland near the municipality Hafralækur has been ongoing since September 2008 by sampling of water on a weekly basis from borehole, HA-01. The motivation for carrying out this monitoring is the borehole's proximity to the Húsavík-Flatey Fault (HFF), which runs across the Tjörnes peninsula. The HFF and the Grímsey Lineament represent the transform zone of northern Iceland, connecting the divergent plate spreading in the Northern Volcanic Zone to the Kolbeinsey oceanic spreading ridge north of Iceland. The Tjörnes transform zone has experienced several offshore M>5 earthquakes in the last decades, whereas no such magnitude earthquake has occurred on land since 1872. Therefore, crustal stress is building up and could potentially lead to M>6.5 earthquake in the future.

Two swarms of earthquakes which occurred north of Iceland in 2012 and 2013, with earthquakes of M>5, were associated with precursory hydrochemical changes in the groundwater of borehole HA-01 [1]. Changes in stable isotope ∂D were observed six months prior to the earthquakes, and changes in ion concentrations (Na and Si) two months before. These changes were ascribed to mixing of aquifers and changes in fluid-rock reactions, respectively [1,2]. Primary basaltic minerals are replaced by secondary minerals e.g. zeolites and clays, sometimes by pseudomorphic replacement. Of particular importance for this study is the zeolite mineral, analcime replacing labradorite and showing the ability to respond to crustal stress by preferential release of Na into groundwater [2], thus becoming an earthquake precursor.

[1] Skelton, A., et al. (2014), Changes in groundwater chemistry before two consecutive earthquakes in Iceland, Nat. Geosci., 7, 752–756.
[2] Andrén, M., et al. (2016), Coupling between mineral reactions, chemical changes in groundwater, and earthquakes in Iceland, J. Geophys. Res. Solid Earth, 121, 2315–2337, doi:10.1002/2015JB012614.