Hydrogeochemical changes coupled with earthquakes in Hafralaekur, northern Iceland

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Introduction

Earthquakes are common in Iceland along the two transform zones: the Tjörnes Fracture Zone (TF) and the South Iceland Seismic Zone (SISZ) (fig 1). These transform zones link Mid Atlantic Ridge ridge segments , north and south of Iceland: Kolbeinsey ridge in the north and Reykanes ridge in the south.

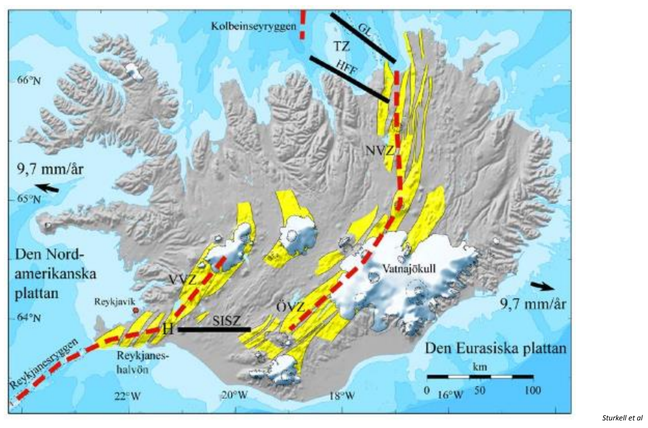

Figure 1. Tectonic map of Iceland showing the divergent plate boundary with dashed red lines and transform zones with black lines.

Methods

From Sep 2008 to June 2013, water samples were collected, on a weekly basis, from a 100 m deep borehole in Hafralaekur, 30 km south of Husavik, northern Iceland (fig 2 and 3).

Figure 2. In Hafralaekur samples are taken from an artesian well situated in Tjörnes Fracture Zone.

During this period there were two major earthquake swarms: one in September/ October 2012 and one in April 2013(fig 3). The water was analysed for δ^2H and $\delta^{18}O$ and cation concentrations using spectro-metric methods at Stockholm University.

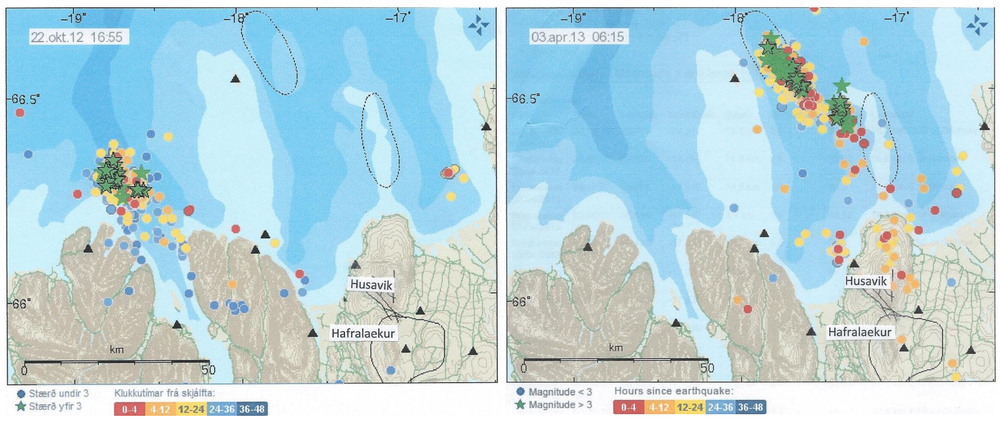

Figure 3. Earthquake swarms in Tjörnes Fracture Zone October 2012 and April 2013.

Results

The stable isotope data show a decrease in δ^2H four weeks before both earthquake swarms. Values for $\delta^{18}O$ decrease eight weeks before the earthquakes in September, but increase four weeks before the October and April swarms (fig 4).

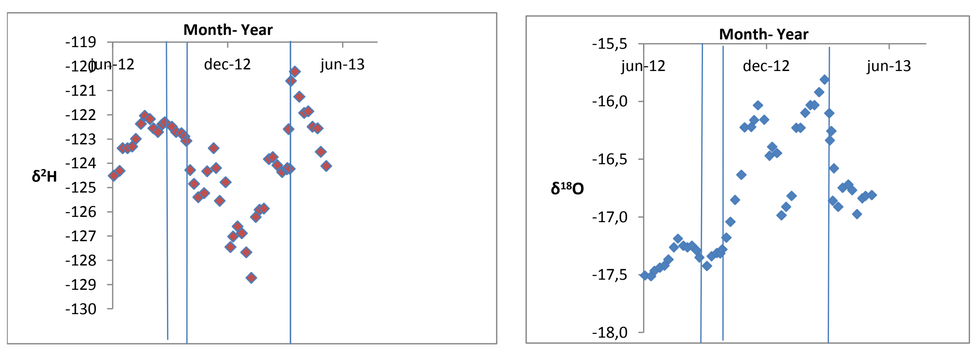

Figure 4. Changes in δ^2H and $\delta^{18}O$ in water from Hafralaekur June 2012- June 2013. Earthquake swarms are marked with vertical lines.

The concentrations of Na, Al, Ca and Si increase four to eight weeks before both earthquake swarms (fig 5).

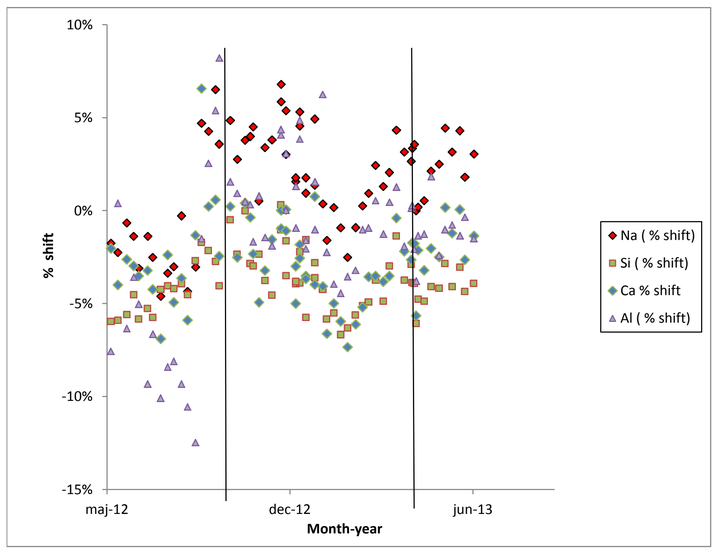

Figure 5. Changes in cation concentrations in water from Hafralaekur June 2012- June 2013.

Discussion

A decrease in δ^2H (and $\delta^{18}O$ in September) before the earthquake swarms indicates that the water in the borehole mixed with isotopically lighter (older) water before both earthquakes. The increase in $\delta^{18}O$ as well as in four cations ,four to eight weeks before the October and April swarms, could have been caused by water- rock interaction. The covariation in Na, Al, Ca and Si could be explained by dissolution of plagioclase.

Conclusion

Weekly analyses of δ^2H as well as $\delta^{18}O$ and cations like Na, Al, Ca and Si could be useful for earthquake prediction. If a decrease in δ^2H occurs with an increase in $\delta^{18}O$ and Na, Al, Ca and Si an earthquake could be expected in the region within one or two months.

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