

## Multiple sulfur isotope systematics of geothermal fluids in Iceland

JÓHANN GUNNARSSON ROBIN<sup>1</sup>, ANDRI STEFÁNSSON<sup>1</sup>,  
NICOLE KELLER<sup>1</sup> AND SUHEI ONO<sup>2</sup>

<sup>1</sup>Institute of Earth Sciences, University of Iceland, Sturlugata  
7, 101 Reykjavík, Iceland (jog13@hi.is)

<sup>2</sup>Department of Earth Atmospheric and Planetary Sciences,  
MIT, Cambridge, MA, USA

Multiple sulfur isotope systematics of geothermal fluids at Krafla NE Iceland were studied in order to determine the source and reactions of sulfur in the systems, as an example of a geothermal system hosted on a divergent plate boundary. Fluid temperatures ranged from 192 to 437°C with liquid water, vapor and superheated vapor being present in the reservoir. Dissolved sulfide ( $S^{II}$ ) and sulfate ( $S^{+VI}$ ) predominated in the water phase with trace concentrations of thiosulfate ( $S_2O_3^{2-}$ ) whereas sulfide ( $S^{II}$ ) was the only species observed in the vapor phase.

The reconstructed sulfur isotope ratios of the reservoir fluids based on samples collected at surface from two-phase and vapor only well discharges indicate that  $\delta^{34}S$  and  $\Delta^{33}S$  of sulfide in the reservoir fluid range from -1.5 to +1.1‰ and -0.001 to -0.017‰, respectively, whereas  $\delta^{34}S$  and  $\Delta^{33}S$  of sulfate are significantly different and range from +3.4 to +13.4‰ and 0.000 to -0.036‰, respectively. Depressurization boiling upon fluid ascent coupled with progressive fluid-rock interaction and sulfide mineral (pyrite) formation results in the liquid phase becoming progressively isotopically lighter with respect to both  $\delta^{34}S$  and  $\Delta^{33}S$ . In contrast,  $H_2S$  in the vapor phase and pyrite formed become isotopically heavier. The observed  $\Delta^{33}S$  and  $\delta^{34}S$  systematics for geothermal fluids at Krafla suggest that the source of sulfide in the reservoir fluids is the basaltic magma, either through degassing or upon dissolution of unaltered basalts. At high temperatures, insignificant  $SO_4$  is observed in the fluids but below ~230°C significant concentrations of  $SO_4$  are observed, the source inferred to be  $H_2S$  oxidation. Sulfate originating from the meteoric source water of the geothermal fluids is inferred to be negligible. The two key factors controlling the multiple sulfur isotope systematics of geothermal fluids are, (1) the isotopic composition of the source material and (2) the isotope fractionation associated with aqueous and vapor speciation and how these changes as a function of processes occurring in the system including boiling, oxidation and fluid-rock interaction.