Abstract


Introduction

The Reykjanes Peninsula is located on the landward extension of the mid-Atlantic Ridge, and is host to one of the more than 20 high-temperature geothermal areas (filled circles) in Iceland. This geothermal system is unique in that it is thought to be dominated almost entirely by seafloor, and consequently offers an excellent opportunity to study fluid-rock interactions in marine-dominated basalt hydrothermal systems similar to those of oceanic spreading ridges. However, the inconsistencies in the geochemistry of the fluids in the Reykjanes system indicate that the evolution of this system is more complex than simple basalt-seawater interaction models.

Studies done on Reykjanes geothermal fluids by Arnorsson (1978) indicate that fluid chemistry and salinity is comparable with seawater in contrast to other high-temperature fluids in Iceland which have a meteoric source (Krafla and Nesjavellir), or a mixed meteoric-sea water input (Svartsengi). However, hydrogen isotopic values of Reykjanes fluids are anomalously low for a seawater-derived fluid. Instead, the values suggest a fluid source with a δD value as low as -23.5‰. This is comparable to the isotopic composition of seawater, and consequently offers an excellent opportunity to study fluid-rock interactions in a geothermal system dominated regime, hydrogen contained in these relict minerals should diffusionally exchange with modern fluids in equilibrium with Reykjanes fluids. Epidotes from the Krafla and Nesjavellir systems predict fluids in close agreement with modern values. In contrast, the δD of fluids in equilibrium with Reykjanes and Svartsengi suggest a significant component of meteoric- or glacially-derived fluids not observed in the modern system.

Epidote-Stable Isotopes

δD values of geothermal epidote from wells RN-8, -9, -10 and -12 ranges from -60 to -59‰, -64 to -59‰, -64 to -79‰, and -63 to -81‰, respectively. δD in these wells are between -1.2 and 1.3‰, -3.0 and 0.2‰, -0.5 and 1.8‰, and finally between -0.1 and 2.3‰.

δD$_{\text{mineral}}$ shows a slight increase along a NW trend through the geothermal field, whereas δD$_{\text{fluid}}$ values generally decrease. This suggests a SE to NW migration of the geothermal upflow zone with time, which is consistent with measured down-hole temperatures and observed hydrothermal mineral zones.

Finally, each well has δD$_{\text{fluid}}$ values less than 0‰. These epidotes could not have formed only from seawater-derived fluids. Instead, the values suggest a fluid source with a meteoric component that has undergone variable amounts of isotope exchange with the surrounding host basalt.

Epidote-Fluid Isotope Fractionation

δD$_{\text{sys}}$ is determined for D and O using measured epidote isotope values (this study) and published fluid isotope values of deep wells (δD = -20.8‰, δD = -20.8‰, δD = -20.8‰). Results are plotted against temperatures approximated from the boiling point curve, and compared to the temperature-fractionation curves by Chacko et al. (1999) for D, and Zong and Matthews et al. (1981) for O. Hydrogen isotope fractionation between Reykjanes epidotes and geothermal fluid is lower than estimated equilibrium values. In contrast, oxygen fractionation correlates closely with published equilibrium curves.

These results are shown relative to other Icelandic geothermal systems by comparing fluids calculated to be in equilibrium with measured epidote to modern geothermal fluids. Epidotes from the Krafla and Nesjavellir systems predict fluids in close agreement with modern values. In contrast, the δD of fluids in equilibrium with Reykjanes and Svartsengi suggest a significant component of meteoric- or glacially-derived fluids not observed in the modern system.

References


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Fluid Origin and Evolution in the Reykjanes Geothermal System - A Stable Isotope Study of Hydrothermal Epidote

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