Isotopic insights into deep geothermal systems in the Snake river plain in southeastern Idaho

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The Eastern Snake River Plain (ESRP) in southeastern Idaho, USA is an area of high heat flow with significant potential geothermal resources. However, rapid groundwater flow in high permeability surficial basalts effectively masks thermal signatures of deep-seated geothermal systems in the ESRP. To identify potential signatures of hidden geothermal systems, we have measured chemical and isotopic compositions of geothermal samples from across the region.

For proof of principle, a series of samples from flowback waters collected following a 1-month geothermal stimulation experiment conducted at Newberry Volcano in the central Cascades in western Oregon were analyzed. The sulfate-water oxygen isotope geothermometer gave promising results with calculated temperatures of up to 230°C, similar to Na/K and multicomponent geothermometry giving temperatures of ~240-250°C. Oxygen isotopic compositions of the injected waters were shifted by about 1.5‰, suggesting significant water-rock interaction during the test and elevated helium R/R_a values indicate a strong magmatic signal at the site.

Isotopic compositions of more than 40 samples collected during 2014 from the ESRP have been analyzed. Several of these samples have the combination of elevated sulfate-water isotopic temperatures, shifted $\delta^{18}O$ waters and high helium R/R_a values that was observed in the Newberry samples, indicating the potential existence of higher temperature (>200°C) deep-seated geothermal reservoirs. Where possible, the δD and $\delta^{13}C$ of dissolved methane in these samples were also analyzed. Although concentrations were low (<15 nM), several had "magmatic" signatures. However, temperatures calculated using the inorganic carbon-methane carbon and water-methane hydrogen isotope geothermometer generally do not yield realistic temperatures suggesting that the best use for dissolved methane isotopes in the ESRP is as an indicator of abiotic methane versus microbial methane. These results indicate the potential utility of isotopic signatures to identify deep-seated geothermal systems.