Geochemistry of Breitenbush Hot Springs, Oregon, USA

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Spring, well and surface water samples were collected from Breitenbush Hot Springs in the Western Cascades of Oregon to determine the geothermal reservoir temperature and source(s) of geothermal water. A reservoir temperature of 137 ±2°C was determined using the Reservoir Temperature Estimator (RTEst) software package [1] constrained by a mineral assemblage of chalcedony, calcite, mordenite-K, and heulandite and Al concentrations derived from assumed equilibrium with K-feldspar. While the calculated reservoir temperature is significantly less than the 174 to 180°C values reported in previous geothermometric studies [e.g., 2,3], the modeled CO_2 fugacity (log(fCO2) = -0.06 ±0.07) and pH (6.04 ±0.06) are internally consistent, and estimated Al concentrations (9.6 ±0.5 ug/L) closely correspond to measured concentrations (8.9 ±4.6 ug/L Al). Other secondary minerals identified in samples from deep wells in the area can also be explained by equilibrium or supersaturated states obtained with this model. The estimated reservoir temperature is close to the maximum downhole temperature of 141°C measured in a deep well 3 km to the southeast and is consistent with reported fluid-inclusion data.

Stable hydrogen and oxygen isotope values of eight reservoir samples (δ^2H = -98.08 to -93.59 ‰; $\delta^{18}O$ = -12.91 to -11.81 ‰) yield a trendline which extrapolates to the values reported for "andesitic waters" [4]. A mixing model between this value and the intersection with the local meteoric water line gives a contribution of 4-7% magmatic water that is qualitatively consistent with reported $^3He/^4He$ and $\delta^{37}Cl$ data [5]. Comparisons of the isotopic values of the non-magmatic endmember with locally-derived isotope-elevation relationships result in recharge elevations of 1650 to > 2200 m, corresponding to the crest and upper slopes of the High Cascades ~20 km to the east. The resulting high recharge elevations and the presence of magmatic waters support a model of gravity-driven lateral flow from the Quaternary arc.

[1] Palmer, C.D. (2015) Idaho Natl Laboratory, INL/EXT-14-33959. [2] Ingebritsen *et al.* (1992), *JGR* **97**, 4599-4627. [3] Spycher et al. (2016) **41st** Geotherm Res. Eng. Wrkshp Proc, 1387-1395. [4] Giggenbach (1992) *EPSL* **113**, 495-510. [5] Ingebritsen et al.(1994), USGS Prof Pap **1044-L**.