Using Hydrothermal Water-Rock Reaction Models to Indicate Microbial Presence

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The aqueous chemistries of hot springs are controlled by water-rock interactions at depth. Secondarily, thermophilic microbes living in the hydrothermal system are expected to have increasing influence as spring temperatures decrease. The Rabbit Creek Area of Yellowstone National Park (YNP) hosts geochemically diverse hydrothermal springs (59.1°C to 92.2°C; field pH values 6.5 to 8.1) despite existing meters apart. The YNP drill core Y-5 was removed from the Rabbit Creek Area in 1967, providing insight to the subsurface composition [1] and making the Rabbit Creek Area an ideal case study for investigating the geologic and biologic controls on aqueous hydrothermal chemistries.

The program EQ3 was used to predict the aqueous chemical speciation of the hydrothermal springs using measured initial concentrations of dissolved major ions and trace elements from each spring. Local water-rock interactions were predicted using EQ3/6, through which we interacted local meteoric water with the summarized mineralogy of the altered rhyolitic tuff of drill core Y-5. The EQ3/6 model was cooled, depressuirzed, and calibrated to the aqueous chemistry of a proximal, near boiling spring with low extracted DNA yields of ~5 ng DNA/g of sediment. The calibrated EQ3/6 water-rock interaction model was further cooled to the temperature of each hydrothermal spring analyzed. The speciated aqueous chemistries of the springs from EQ3 were compared with the EQ3/6 predictions for each spring to determine the extent to which water-rock interactions control the aqueous hydrothermal chemistries.

The EQ3 chemical speciation for each spring was difficult to calibrate to field pH values, especially for springs less than 75°C, possibly indicating chemical disequilibrium in the springs due to microbes or otherwise. An outlier spring at ~74°C showed the most unexpected geochemistry, having the lowest concentrations of carbon and sulfur species but slightly elevated nitrogen species compared to the other springs. Speciated chemistries of springs with temperatures >70°C were generally similar to predictions from modeled water-rock interactions whereas cooler samples were not.

[1] White *et al.* (1975) *Geol. Surv. Prof. Paper* **892**. US Gov. Printing Office.