

## The geochemistry of the geothermal system in the Alvord Basin, Oregon

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### Introduction

The Alvord Basin is a north-northeast trending graben located in the northeastern Basin and Range Province, Harney County, Oregon, USA. Three main groupings of thermal springs occur in the valley: Borax Lake, Alvord, and Mickey Hot Springs. The primary source of recharge for the system is inferred to be meteoric water along the Steens Mountain-Pueblo Mountain fault block (Cummings et al., 1993).

The objective of this study is to characterize the major and trace elemental, and isotopic compositions of the thermal waters in the Alvord Basin to determine sources of water and dissolved constituents as well as the main processes of water-rock interaction.

### Results

Thermal waters in the Alvord Basin are sodium-bicarbonate-chloride-type with a significant proportion of sulfate. The waters are also unusually high in As (1-6 mg L<sup>-1</sup>) and B (10-27 mg L<sup>-1</sup>). Differences in chemical compositions are evident between waters of different spring groupings, however, waters from springs within each thermal area exhibit similar chemical characteristics, despite variations in emergence temperatures of up to 30 °C (Fairley et al., 2003). Chemical compositions have remained fairly consistent over time, with limited temporal variations. Determination of As speciation indicates that As(V) dominates in most springs, although, there is evidence that the water emerges with As(III) dominant, but the arsenic is rapidly oxidized to As(V), suggesting mediation by microbial activity. Oxygen and hydrogen isotope compositions are similar for waters in all three thermal areas and are consistent with meteoric water that has undergone O-isotopic exchange during water-rock interaction. Values of sulfate δ<sup>34</sup>S and bicarbonate δ<sup>13</sup>C show a very narrow range of variation both within and among the three thermal areas.

### References

- Cummins, M. L., St. John, A. M., and Sturchio, N. C., (1993), Proc. 15<sup>th</sup> New Zealand Geothermal Workshop, 119-124.  
Fairley, J., Heffner, J. & Hinds, J. (2003), Geophys. Res. Lett. 30, 1962.

## <sup>40</sup>Ar/<sup>39</sup>Ar-Kr-Xe systematics of quartz: Mt Isa, Australia

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Extension of the <sup>40</sup>Ar/<sup>39</sup>Ar methodology to include measurement of Kr and Xe allows the simultaneous determination of naturally occurring noble gas isotopes and the halogens (Cl, Br, I). The technique has been demonstrated as a powerful tool in understanding hydrothermal fluid origins in Phanerozoic ore deposits and is extended here to include quartz samples from three Proterozoic Cu deposits in the Mt Isa Inlier, northeast Australia.

The deposits selected (Mt Isa, Osborne and Eloise) include samples with complex fluid inclusion assemblages including two phase LV, V-dominated and multi-phase LVD types. Fluid inclusion hosted Cl degasses bimodally during stepwise heating. Variation in Br/Cl and <sup>40</sup>Ar/<sup>36</sup>Ar ratios measured during the first degassing peak (T <650°C) can be related to the different decrepitation temperatures of different fluid inclusion types. However, ~60% of the fluid inclusion gas is released from small undecrepitated fluid inclusions during a second degassing peak, triggered by a SiO<sub>2</sub> phase transition, at ~1200°C. Some fluid inclusions persist to temperatures of 1400°C.

At Mt Isa, Br/Cl values of 2-12×10<sup>-3</sup> and initial <sup>40</sup>Ar/<sup>36</sup>Ar values of up to 20,000 support the involvement of an ancient sedimentary formation water. At Osborne and Eloise, Br/Cl values of 0.6-1.5×10<sup>-3</sup> and initial <sup>40</sup>Ar/<sup>36</sup>Ar values of <2,000 suggest involvement of halite dissolution water in these iron-oxide-copper-gold deposits but cannot exclude a mantle/magmatic input for Osborne.

The significance of Ar-Ar quartz-fluid-inclusion ages is evaluated. An imprecise formation age determined directly from fluid inclusions in the Eloise sample is compatible with existing ~1530 Ma age results. Crushing the sample removed secondary fluid inclusions preferentially, leaving behind a greater proportion of primary fluid inclusions with more uniform initial <sup>40</sup>Ar/<sup>36</sup>Ar, that enabled an improved isochron.

In a Mt Isa sample, electron microscopy has confirmed the presence of sub-5µm captive mica within fluid inclusions. In this case, the captive-mica-quartz age relates to thermal cooling and does not constrain the time of mineralisation. Quartz is demonstrated to retain Ar over billions of years. However, where captive mica is present <sup>40</sup>Ar loss can occur from within the sub-reservoir into the surrounding fluid inclusion. In light of these findings some quartz ages may need to be reassessed.