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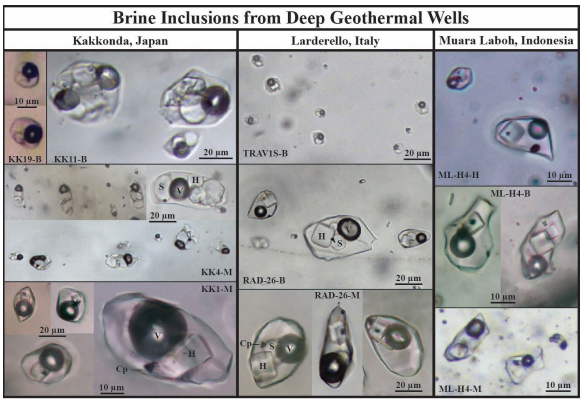

Fluid Inclusion Records of Critical Materials in Hypersaline Geothermal Fluids in Superhot Geothermal Reservoirs

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As exploration for geothermal power continually pushes into deeper Superhot or Supercritical geothermal reservoirs we will encounter fluids with increasingly complex chemistry and potentially corrosive properties. While fluids close to pure water already present complex challenges in this extreme environment, the potential for interacting with deep reservoirs of high-temperature magmatic-derived fluids creates and even higher level of complexity. Compared to groundwater systems, these magmatic fluids are often saline to hypersaline, sometimes exceeding greater than 50wt% dissolved salts and other components. These extreme solute loads and the highly corrosive nature of the fluids can present significant challenges for engineering materials for geothermal development and reservoir maintenance. However, the high dissolved load of critical materials (e.g. Li, Mn, Cu, Zn, Sb, Rb, W, Ag, etc.) and similarity to fluids present in hydrothermal ore deposits has raised questions about how these fluids might mirror ore formation processes in now extinct systems and whether they could represent a new critical material source in the future.

We will present data quantifying the chemistry of the relict hypersaline fluids trapped in quartz from 3 active deep geothermal systems; Kakkonda, Japan; Larderello, Italy; and Muara Laboh, Indonesia). Of the three systems, Kakkonda shows the most extensive infiltration of these hypersaline fluids within the source granite, trapped commonly in quartz veins and miarolitic cavities. In this conductive part of the Kakkonda system, it appears that the current fluids are a reasonable match to trapped fluids in terms of temperature (350ºC to 600ºC) and bulk composition (35wt% to 55wt%). We will show that in the past magmatic fluids were also expelled out of the granite and infiltrated the overlying meta-volcanics and meta-sediments, changing in composition and ultimately precipitating base metal sulfides. In the Larderello and Muara Laboh systems, the modern geothermal reservoir has instead extended down into the previously magmatic fluid dominated zones to varying degrees. Thus, we will use the available data from these systems to comment on the general evolution of geothermal systems from active magmatic degassing and saline-hypersaline fluid saturation to fully convective groundwater geothermal reservoirs and the implications for the transitional time in between.