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Trace element partitioning in siliceous sinters as a function of silica precipitation rates in El Tatio geothermal field

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The El Tatio geothermal field, located at 4200 m.a.s.l. in South America, is the largest geyser field in the southern hemisphere and the third largest in the world. Silica precipitation rates at El Tatio appear to be controlled by environmental conditions driving fast water-cooling, high evaporation, and microorganisms[1,2]. The precipitation dynamics can impact the incorporation of trace elements such as Ge and Al which can substitute Si atoms in the opal structure. The goals of this study are to understand the partitioning of Ge[3] and Al[4] in opal across a range of extreme environmental conditions, and the control of abiotic and bio-deposition in the silica precipitation rates in El Tatio. Thus, we sampled hydrothermal fluids, active sinter deposits, and set up in-situ fluid evaporation and opal precipitation experiments.

In El Tatio, silica concentrations in the chloride-rich hydrothermal fluids range between 90-160 mg/L, and most of the samples are undersaturated in opal at the boiling temperatures (~85ºC). The evaporation experiments showed that the silica concentrations decrease over time, suggesting silica precipitation. Ge/Si ratios increase and Al/Si ratios decrease due to the removal of silica. The precipitation experiments indicate that silica precipitation rates range between 0.1–1.7 $kg/year/m^2$. Silica precipitation rates increase with fluid cooling at distance from the vent[2]. Thus, Ge/Si ratios are high when precipitation rates are slow (high fluid Tº) and low as precipitation rates speed up (low fluid Tº). Al/Si ratios follow a similar partitioning mechanism, decrease with high precipitation rates and therefore low temperatures. These results are consistent with low trace element incorporation with rising silica precipitation rates[3] due to the fast cooling of hydrothermal fluids. Our results underscore the effect of rapid amorphous silica precipitation on discriminating trace elements as observed in silica precipitation experiments[3], and emphasize the role of the fluid temperature and precipitation rates as controls of trace element partitioning in sinter deposits.

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