

REE mobility in the hyperacid brine of Kawah Ijen crater lake (Java, Indonesia) during the precipitation of sulfate minerals

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Six water samples were collected at Kawah Ijen hyperacid crater lake to investigate the Rare Earth Elements (REE; lanthanides plus yttrium) fractionation during the spontaneous precipitation of minerals in the laboratory. Temperature (~33°C), pH (~-0.27), TDS (~105 g/kg) and chemical composition are quite homogenous between samples.

σ REE concentrations dissolved in the Kawah Ijen crater lake are higher than the typical values of common natural waters and range from 5.9 to 6.5 mg/kg (Inguaggiato et al., 2020). An experiment in the laboratory was run; the samples were stored (25°C) waiting for the precipitation of minerals oversaturated to study the REE fractionation and compare these results with those previously obtained in Poás hyperacid crater lake. XRD analysis of minerals spontaneously precipitated identified gypsum. Electron microprobe analysis allowed identifying minor amounts of other minerals on gypsum crystals. The bulk chemical composition of the minerals and the crystal habit allowed proposing Sr-Ba sulfate, jarosite, Al-sulfate as minerals precipitated. σ REE concentrations in minerals precipitated (mainly gypsum), are higher (59.5 to 78.6 mg/kg) than REE dissolved in lake water. REE patterns of solids precipitated normalized to the average local rock (andesite) show Light REE (LREE) enrichment compared with Heavy REE (HREE), similar to the REE patterns found in the mineral precipitated (mainly gypsum) running the same experiment using the water of Poás volcano (Costa Rica; Inguaggiato et al., 2018). The distribution coefficient of REE, $K_D = [REE]_s / [REE]_{aq}$, allow us to calculate the REE fractionation during minerals precipitation. The $[REE]_s$ is the concentration of a REE_i in the solid precipitated and

$[REE]_{aq}$ is the concentration of a REE_i in water after the precipitation of minerals. LREE K_D values are higher with respect to HREE and range from 18.4 to 0.7. The K_D calculated for Kawah Ijen samples have patterns and values similar to those calculated between the gypsum and the lake water of Poás. The similarities between REE fractionation at Kawah Ijen and Poás lakes during gypsum precipitation, allow us to generalize this process in similar natural environments.

Inguaggiato et al. (2020), *Sci. Total Environ.*

Inguaggiato et al. (2018), *Gondwana Res.*