

## Rare Earth Elements behavior at Poás hyperacid crater lake (Costa Rica) during a cycle of frequent phreatic eruptions (2008-2016)

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Variations in major elements and physico-chemical parameters at active crater lakes have been used in the past decades to identify precursors of volcanic activity changes. In this study the variations of Rare Earth Elements (REE) were investigated at the hyperacid crater lake Laguna Caliente of Poás volcano (Costa Rica) to 1) scrutinize if they can be related to the major changes of phreatic activity during 2008-2016 (more than 700 phreatic eruptions occurred), major elements and physico-chemical parameters, and to 2) identify the geochemical processes that cause the variation of REE over time (Pappaterra et al., 2022).

Our results show that the total concentration of REE ( $\sigma$ REE) varies from 950 to 2,773  $\mu\text{g L}^{-1}$ .  $\sigma$ REE, TDS and the major elements concentrations rise when the phreatic activity is higher, except Ca that has an opposite behavior. High  $\sigma$ REE concentrations and TDS values are consistent with an enhanced leaching process due to the decrease of pH.  $(\text{La}/\text{Pr})_{\text{N-local rock}}$  and  $(\text{LREE}/\text{HREE})_{\text{N-local rock}}$  ratios range from 0.93 to 1.35 and from 0.71 to 0.95, respectively, and their variations are related to the main changes of the phreatic activity.  $(\text{La}/\text{Pr})_{\text{N-local rock}}$  ratio increases when phreatic activity increases,  $(\text{LREE}/\text{HREE})_{\text{N-local rock}}$  ratio decreases when phreatic activity increases.

The results obtained comparing major elements with  $(\text{La}/\text{Pr})_{\text{N-local rock}}$  and  $(\text{LREE}/\text{HREE})_{\text{N-local rock}}$  variations show that Ca is the only element that behaves in the opposite way compared to the other major elements, decreasing when  $(\text{La}/\text{Pr})_{\text{N-local rock}}$  increases and decreasing when  $(\text{LREE}/\text{HREE})_{\text{N-local rock}}$  decreases. The estimation of Ca loss and mass balance calculations corroborate that gypsum/anhydrite precipitation can be responsible of REE

variations over time. The processes that mainly affect the REE variations in the lake are the different degrees of leaching of the local rock (andesite) and gypsum/anhydrite precipitation. Previous studies identified that gypsum precipitated from hyperacid crater lake waters incorporates REE, especially LREE in higher amount than HREE (Inguaggiato et al., 2020 and references therein).

These results suggest that REE behavior is sensitive to changes in phreatic activity and could provide additional information on fluid-mineral dynamics.

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

Pappaterra et al. (2022), *Front. Earth Sci.*