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Understanding Zinc isotopic signatures in volcanic lakes

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Volcanic lakes are surface water reservoirs that provide insights on the processes occurring into the underlying hydrothermal-magmatic system of volcanoes. Volatilization releases high temperature gases from magma which are subsequently incorporated into the hydrothermal system. One way to investigate the input of magmatic volatiles in the hydrothermal envelope is thus to understand these processes by monitoring the chemical changes in key reservoir that are volcanic lakes. As a moderately volatile element [1], Zn can fractionate during magmatic outgassing, making it a potential isotope system tracer for magmatic contributions in volcanic lakes. However, its cycle in volcanic lakes still needs to be understood.

In this study, we have analyzed $\delta^{66}Zn$ for 4 volcanic lakes. These lakes vary in acidity from neutral to hyperacidic. The extremely low pH (from 0.1 to 1) of Kawah Ijen (Indonesia) and Santa Ana (San Salvador) demonstrate a clear magmatic input. Taal (Philippines, pH≈3) and Kelud (Indonesia, pH≈6) volcanic lakes are more dominated by hydrothermal inputs.

The hyperacidic lakes show minimal isotopic variation, with $\delta^{66}Zn$ values similar to the basalt-andesitic host rock (0.25‰). In contrast, we observe large variations in $\delta^{66}Zn$ for the Taal (-0.55‰ to 0.4‰) and Kelud (-0.1‰ to 0.25‰) sites.

To understand trace element abundances in the volcanic lakes, we calculated enrichment factors ($EF_X=(X/Mg)_{lake}/(X/Mg)_{Rock}$). Volatile elements such as Sb, Bi, Se, Tl are typically highly enriched in lake waters compared to their concentration in magmas. In this study, EF shows that the Zn concentrations for Taal and Kelud volcanic lakes are depleted, indicating that Zn could precipitate as sulfides for Taal or Zn enriched calcite for Kelud in the hydrothermal system, prior to lake discharge. Kawah Ijen and Santa Ana Zn show EF values near 1, suggesting the Zn source is the host rock dissolution, in agreement with their $\delta^{66}Zn$.

Those finding would imply that isotopic compositions of volcanic lakes should be interpreted with caution in terms of magmatic input.

[1] Lodders (2003), *ApJ 591*, 1220-1247