Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7041

Understanding Zinc and Strontium isotopic signatures in volcanic lakes

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Volcanic lakes are surface water reservoirs that provide insights of the processes occurring into the underlying hydrothermal-magmatic system of volcanoes. High temperature gases are released by volatilization from the magma and incorporated into the hydrothermal system. A way to trace this magmatic input is then by measuring compositional changes into the volcanic lake. Zinc, being volatile, can fractionate isotopically during volatilization and hence be a good marker to trace the magmatic contribution in volcanic lakes.

We have investigated $\delta^{66}Zn$ and $^{87}Sr/^{86}Sr$ for 4 volcanic lakes ranging from hyperacidic to neutral waters. Two of them, Kawah Ijen (Indonesia), and Santa Ana (San Salvador), have a clear magmatic input with a pH ranging from 0.1 to 1. Taal (Philippines) and Kelud (Indonesia) are more dominated by hydrothermal input with pH of 3 and 6 respectively.

We observe a large variation in $\delta^{66}Zn$ for the Taal and Kelud volcanic systems (respectively from -0.55‰ to 0.4‰ and -0.1‰ to 0.25‰). On the other hand, Kawah Ijen and Santa Ana volcanic lakes isotopic values are similar to the basalt-andesitic host rock (0.25‰). To understand the abundances of trace elements in the volcanic lake, the enrichment factors ($EF_X = (X/Mg)_{lake}/(X/Mg)_{Ref}$) were calculated. Volatile elements like Sb, Bi, Se, Tl are usually highly enriched in lake waters compared to their magma concentration. In this study case, EF shows that Zn concentration for Taal and Kelud volcanic lakes is depleted indicating that Zn could precipitate as sulfides in the hydrothermal system. On the contrary Kawah Ijen and Santa Ana Zn values show an EF around 1 suggesting that Zn is coming from the host rock dissolution, in agreement with their $\delta^{66}Zn$.

$^{87}Sr/^{86}Sr$ isotopic preliminary data for Kawah Ijen, Santa Ana and Taal volcanic lakes show a small isotopic shift from the magmatic value that could be explained by the precipitation of gypsum and/or barite. The variation of $^{87}Sr/^{86}Sr$ for Taal volcanic lake could also been interpreted by a mixing of fluids between two different hydrothermal reservoirs. Those finding would imply that isotopic compositions of volcanic lakes should be interpreted with caution in terms of magmatic input.