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Lead isotope constraints on the origin of andesite and dacite magmas at Tungurahua volcano (Ecuador)

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Understanding the occurrence of large explosive eruptions involving silica-rich magmas at mostly andesitic volcanoes is crucial for volcanic hazard assessment

Here we focus on the well-known active Tungurahua volcano (Ecuador), specifically its eruptive sequence for the last 3000 years BP, which are characterized by VEI 3 explosive events involving mostly homogeneous andesitic compositions (56-59 wt.% SiO_2). However, some large eruptions (VEI $\geq$ 4) involving andesitic and dacitic magmas (up to 66 wt.% SiO_2) also occur at 3000 BP, 1250 BP and 1886 AD. An additional outburst of siliceous magmas occurred during the last eruptive eruption of this volcano in 2006 [1]. Volcanic products at Tungurahua are described as been generated by a binary mixing between a silica-rich and a silica-poor end-member, but the origin of these components was not discussed [2].

Major, trace elements and Sr-Nd-Pb isotopes were used to investigate the genesis of the andesites and dacites. Andesites are heterogeneous in terms of Pb isotopes ($^{206}Pb/^{204}Pb$: 18.189-19.154, $^{207}Pb/^{204}Pb$:15.658-15.696, $^{208}Pb/^{204}Pb$: 38.752-38.918, $^{207}Pb/^{206}Pb$: 0.8240-0.8275) but homogeneous in terms of major-trace element. Dacite are characterized by homogenous and low $^{207}Pb/^{206}Pb$ (0.8235$\pm$0.0001), very low Nb/U (1.97 to 4.49) and Ce/Pb (2.52-2.99) and high Th/La ratios (0.24 to 0.49). Triangular distribution of data in major element or trace element ratio vs. Pb isotopes plots suggests that at least three components control geochemical variability at Tungurahua. We interpret andesite compositions as reflecting mainly a deep mixture of two mantle components, with small addition of crustal material. We suggest that dacite results from a mixing between various andesite compositions and a larger amount of a contaminant derived from the volcanic basement of the Tungurahua made of late Cretaceous to Palaeogene oceanic plateau basalts and volcano-sedimentary rocks volcanic.

Since andesite and dacite occur during the same eruption, we suggest that crustal contaminated magmas are stored into the crust and are sporadically sampled by andesite magmas ascending from greater depths.. As a result, the amount of assimilated crust (and thus the amount of silica-rich magma) may be used as a proxy of the magnitude of the eruption.

[1] Samaniego et al. JVGR (2011)

[2] Schiano, P., et al. Contrib. Mineral. Petrol. 160(2010) 297-312.