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Insights in Ecuadorian magma sources: from whole-rock geographical trends to single mineral isotope compositions

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Ecuadorian magmas result from processing through a thick crust a heterogeneous range of primitive melts. This results in a complex geochemical signal at the surface, where source and processes footprints are intricate. We propose here to compare two approaches at different scales. The first one aims to understand the general trends in Ecuadorian magmatism looking at the geochemistry of whole-rocks at the scale of the arc to decipher continental crust and slab component imprints. The second approach is based on the idea that whole-rock compositions represent rough averages of all processes taking place from source to eruption, but that those processes could be sorted out studying different minerals present in the rocks.

For the first approach, 71 samples were analysed for major and trace elements as well as Sr, Nd and Pb isotopes to complete the existing geochemical dataset. This study confirms the already identified across-arc geochemical trends described in the literature that reflect the decrease in mantle melting and the slab dehydration away from the trench. Along-arc geochemical trends were identified for the first time, especially marked in the front arc which encompasses 99% and 71% of the total variation in $^{206}Pb/^{204}Pb$ and $^{87}Sr/^{86}Sr$ ratios of Quaternary Ecuadorian volcanics. These trends suggest (1) more extensive crustal contamination of magma in the southern part (up to 14%); and (2) a changing nature of metasomatism in the subarc mantle wedge with the aqueous fluid/siliceous slab melt ratio decreasing away from 0.5°S. Subduction of a younger and warmer oceanic crust in the Northern part of the arc might promote slab melting. Conversely, the subduction of a colder oceanic crust south of the Grijalva Fracture Zone and higher crustal assimilation lead to the reduction of slab contribution in magmas erupted in the southern part of the arc.

The second approach focuses on one volcanic edifice, the Guagua Pichincha. 42 minerals (amphibole, plagioclase, pyroxene) were picked from two dacite samples and analysed for major and trace elements, and Pb isotopes. Early crystallized, high-Al amphiboles with Al_2O_3>=9.8 wt.% and Eu/Eu*>0.7 have the lowest and most heterogeneous $^{206}Pb/^{204}Pb$ (18.816-18.999), whereas plagioclases have the highest and most homogeneous $^{206}Pb/^{204}Pb$ (19.003-19.023). Low-Al amphiboles and pyroxenes display intermediate compositions and variability (18.934-19.007). The large isotopic disequilibrium between mineral phases and whole-rocks show that a rock sample is a complex mix of minerals and melts recording different parts of the magmatic system. Trace element and isotopic data show that primitive melts feeding the young Guagua Pichincha are heterogeneous. These melts seem to be contaminated by the Western Cordillera basement comprised by accreted ocean terrains on their way to surface. Minerals are precious insights of magmas' history as mass balance calculation reveals that in the case of these 2 dacites, the whole-rock Pb isotope composition is completely buffered by the matrix composition.

Combining these two scales allows us to better understand the scale of mantle heterogeneity under the Ecuadorian arc and the significance of whole-rock compositions in arc magmas.