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Searching for end-member magma compositions at the Andean Central Volcanic Zone (CVZ, 18°S) using multivariate statistic procedure (Polytopic Vector Analysis) and olivine compositions

M. Banaszak and G. Wörner
University of Göttingen, Geoscience Center, Geochemistry Department, Göttingen, Germany (mbanasz@gwdg.de)

The composition of primary mantle input into the crustal magma systems is poorly constrained in the Andean central Volcanic zone (CVZ) due to an absence of erupted basaltic lavas (<52 wt% SiO_2). Nearly all erupted magmas have been, to varying degrees, modified by complex petrogenetic processes during their passage through nearly 70 km of crust. Consequently, the most mafic magmas found in Holocene volcanic centres in the CVZ are rare basaltic andesite lavas (~52-54 wt% SiO_2 and ~4-9 wt% MgO), which constitute a set of "baseline" compositions.

Such baseline andesitic components affect the magma systems of Taapaca and Parinacota volcanoes both located at 18˚S in the CVZ. These compositions are surprisingly variable in major and trace element contents, LILE/HFSE (Sr/Y: 20-160) and REE patterns (Sm/Yb: 2-12) given that their magmatic regimes are quite distinct: Taapaca is a dome complex consisting of hybrid monotonous dacites hosting basaltic andesite enclaves and Parinacota is a compositionally complex stratocone comprising basaltic andesite to rhyolite magmas. Taapaca dacite, however, fall on the same compositional trend formed by the range of Parinacota lavas. Thus, these volcanoes represent two distinct differentiation regimes, manifested by isotopic evidence and this suggests that the distinct geochemical signatures are related to different styles of differentiation and assimilation in the lower crust, i.e. in the MASH zones at different depths.

Searching for magmatic end-member compositions in the mixed Taapaca magmas, comprising evidently more than two end-members, we applied a multivariate statistic procedure, a Polytopic Vector Analysis (PVA), designed for mixtures in geological environments where pure end-members themselves (can or) cannot be directly sampled. PVA is a mathematical method that allows simultaneous application of the complete major and trace element datasets and determination of the number of magmatic end-members, their compositions, and their proportions in the hybrid magmas.

The PVA procedure allows us to resolve two distinct compositions from the various (more or less LILE-enriched) basaltic andesites observed as lavas or enclaves: 1) a near primary magma (~47 wt% SiO_2, ~6.5 wt% MgO, >1600 ppm Sr) rich in Ni, Cr, LILE, Ti, P, Zr and 2) an andesitic magma apparently derived from it that is significantly modified and represents the evolved component (~56 wt% SiO_2, ~4 wt% MgO, <570 ppm Sr) in the basaltic andesites.

Olivine compositions found in the high- and low-LILE basaltic andesite lavas at Parinacota show a common composition in their cores (Fo_{78-81}, 1291-2533 ppm Ni). Rim compositions develop into two distinct trends that can be linked to the basaltic and andesitic end-members identified by PVA (Fo_{74-79}, 61-1324 ppm Ni and Fo_{68-77}, 662-1971 ppm Ni, respectively). The PVA analysis also allows estimating the isotopic composition of $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ for the modelled basalt end-members. This composition ($^{87}Sr/^{86}S$=070517-70523; $^{143}Nd/^{144}Nd$=0512489-0.512502) falls between typical mantle values and the CVZ isotopic baseline values and represents the most "mantle-like" value identified in CVZ magmas.