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Carbonate assimilation of ultrabasic magma: The Pleistocene Cupaello kamafugitic volcano (central Italy)

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The Pleistocene Intra-Apennine Province (IAP) in central Italy contains several small volume eruptive centres, characterized by basic-ultrabasic lithologies, often characterized also by ultracalcic and ultrapotassic compositions. They are emplaced above the thick carbonate and evaporite sedimentary sequence of the Apennine Chain. The small monogenetic volcano of Cupaello (~640 ka) offers the chance to investigate exotic volcanic rocks such as ultracalcic kamafugites, known in literature as coppaelite. This volcano also offers the opportunity to study the interaction of ultrabasic melts with sedimentary carbonates (Maiolica Formation). Indeed, assimilation of local carbonate-rich sediments has been already documented as a likely process at least in the neighbouring IAP volcanoes of San Venanzo [1] and Polino [2] volcanoes. On the other hand, alternative views considers the CaO-rich (CaO up to 38.8 wt%) and SiO_2-poor (SiO_2 down to 14.2 wt%) composition of some Cupaello pyroclastic rocks a reflection of a carbonatitic component in their mantle source [3].

Cupaello lavas are ultrabasic (silica = 42.6-44.1 wt%) and ultrapotassic (K_2O = 5.2-7.6 wt%; K_2O/Na_2O = 18.0-33.9) rocks, characterized by euhedral to subhedral phenocrysts of clinopyroxene and phlogopite set in a hypohyaline-hypocrystalline groundmass made of melilite, kalsilite, phlogopite, olivine, calcite and glass. Perovskite, opaques, wollastonite, monticellite and apatite represent the accessory phases.

The trace element signatures of Cupaello kamafugites, such as high LILE (e.g., Rb = 482-673 ppm), high LILE/HFSE ratios (Ba/Nb = 71-82), negative Eu anomalies (Eu/Eu* = 0.68-0.72), as well as the presence of negative anomalies for Nb, Ta, P and Ti coupled with peaks for Pb in primitive mantle-normalized diagrams are compatible with the derivation from a subduction-modified source [4]. Isotopic ratios confirm this hypothesis, with the presence of strongly radiogenic $^{87}Sr/^{86}Sr$ (0.71123-0.71125), unradiogenic $^{143}Nd/^{144}Nd$ (0.51200-0.51207) and $^{206}Pb/^{204}Pb$ isotopic ratios buffered to 18.76.

The negative correlation of major oxides and trace elements with CaO, pointing toward an end-member represented by the Apennines limestone lithologies, offers an alternative hypothesis to the widely accepted presence of a carbonatitic component. The very small volume of emplaced magma, as well as the thick carbonate succession to be pierced to reach the surface renders unavoidable strong crustal assimilation by the original magma. The high Fo (89.5-90.2) in Cupaello

olivine, as well as the thin border of monticellite around the rare olivine could be explained by assimilation of limestone wall rock, as demonstrated experimentally [5]. The CaO-richest (CaO up to 38.8 wt%) and SiO_2-poorest (SiO_2 down to 14.2 wt%) compositions are found in pyroclastic/epiclastic deposits (no longer available for sampling). We believe that these whole-rock compositions reflect the presence of abundant, almost completely sterile, secondary calcite.

Bibliography

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