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Unravelling the petrogenesis of lamproitic magmas by means of textural and chemical analysis of mica

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A complex history of mantle-crust interaction is evident in contrasted populations of phlogopite-biotite in lamproites from the Socovos, La Aljorra and Zeneta outcrops of the Neogene Volcanic Province of SE Spain.

The volcanic rocks have compositions that vary from alkaline, typical of lamproites (high MgO, TiO_2, K2O, Cr, Ba, Sr and Zr), to sub-alkaline, minettes. Samples from Socovos are the most alkaline, with normative Ol+Cpx+Opx and modal -phenocrystic- Ol+Cpx, whereas samples from La Aljorra and Zeneta are Qtz+Opx normative and have Ol+Cpx+Opx phenocrysts.

Xenocrystic quartz and plagioclase and metapelitic/metagranitic xenoliths are present in some of the samples denoting interaction with crustal material during ascent and emplacement. This contamination process influenced the textural and chemical development of the coexisting trioctahedral micas. Textures and mineral chemistry allow identification of four types of micas: mantle xenocrysts (locally deformed), early crystallized phenocrysts, late crystallized grains (phenocrysts, overgrowths and microphenocrysts) and crustal xenocrysts.

The mantle xenocrysts show the lowest Ti and Fe and the highest Mg and Cr contents. They are Al-poor (ca. 2 atoms per 24 O, OH, F, Cl; apfu) and [IV](Si+Al) deficient, hence they have a tetra-ferri-phlogpopite component (i.e. [IV]Fe3+). Interestingly, they show oscillatory zoning in Cr (range 0.2 - 0.02 atoms pfu), which is likely a result of mantle metasomatism in the source because many of the oscillatory structure are locally deformed (as are the olivine xenocrysts, also indicating mantle conditions). The early and late phenocrysts have somewhat lower Al contents, and show a trend of slightly increasing Al coupled with Ti- and Fe-enrichment and Cr-depletion. This results in the micas evolving towards less [IV](Si+Al) deficient, though [IV](Si+Al) saturation is not reached. This may suggest that crustal contamination and/or magma mixing did not play a major role in the evolution of the magma during mica crystallization.

At Zeneta (and locally at Socovos), however, the rocks bear clear evidence of a crustal component, they contain xenocrysts of biotite s.s. with inclusions of hercynite, apatite, zircon, monazite and ilmenite. These crystals are Fe- and Al-rich, [IV](Si+Al) saturated, Cr- and Ti-poor, and have intermediate Ti contents. They are commonly corroded, though some are zoned with relictic cores, and notably rims, richer in Ti and Mg and poorer in Fe and Al so trending towards (but not reaching) the most evolved compositions of the late crystallized phenocrysts. This is consistent with growth of new biotite from a hybrid/contaminated lamproitic magma.

Combining regional, petrological, geochronlogical and geophysical arguments with the results of the mica study allows us to relate the process of crustal hybridization/contamination of lamproitic magma with partial melting of the base of the Betic crust at 9 Ma. The melting may have resulted from either post-collisional collapse or basaltic underplating. Mineral-scale studies clearly have wide-reaching implications for interpreting complex geodynamic problems.