



Decoding multi-stage processes in mantle xenoliths from microtextural and chemical evidences

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Mantle-derived xenoliths rapidly brought to the surface by alkaline magmas commonly exhibit reaction features valuable for elucidating magmatic and metasomatic processes that occur in the mantle, or during the transport to the surface, or post-entrainment processes.

In this contribution, we focus on a suite of fresh anhydrous and hydrous amphibole-bearing spinel lherzolites from Devès in the Southern Domain of the French Massif Central. We present three different cases: (1) reaction zones developed around primary pyroxenes, amphibole and spinel; (2) the presence of carbonate as veins and vesicles in composite carbonate-silicate pockets from well-developed reaction zones; (3) the presence of secondary orthopyroxene in veins cross-cutting or rimming primary olivine.

Case 1

* The presence of low Ti (0.5 wt.% TiO_2), Cr- and Mg-rich (1.2 wt.% Cr_2O_3 , mg# = 88) pargasite coronae around relict spinel testifies for mantle modal metasomatism by a melt of alkali basalt composition.

* Reactional textures around amphibole consist of secondary clinopyroxene, olivine, spinel, \pm plagioclase, formerly volatile-filled bubbles, and small (10 μm) patches of fresh colourless glass. A single decompression process is not sufficient for explaining the amphibole breakdown and the secondary phase composition, but additional components (alkalis) brought by a percolating agent are required.

* In anhydrous samples, similar secondary assemblages are observed at the contact between primary spinel and orthopyroxene. The presence of former amphibole is ruled out by the Al-rich composition of secondary spinels. The secondary assemblage is likely to result from reaction between the primary phases and the same percolating agent as above.

Case 2

* Some carbonate veins cut spongy large clinopyroxene crystals resulting from a former metasomatic event by an infiltrating (alkali?) melt as in case (1).

* The carbonate fills globular vesicles in reaction zones that contain secondary clinopyroxene, olivine, spinel, \pm quenched plagioclase and small glass patches or rims. The secondary clinopyroxene and olivine indent or are included in the carbonate crystals. The carbonate is a low Mg (MgO <1 wt.%) calcite poor in alkalis and REE. Although apparent immiscibility features, the tie-line glass-carbonate does not intersect experimentally determined immiscibility and, thus, the carbonate represents crystal cumulates. The co-precipitation of carbonate and associated secondary minerals occurs near the base of the crust (as inferred from secondary silicate-liquid pairs estimates) and results from a magmatic fractionation of an alkali/carbonate mantle-derived melt.

Case 3

* The secondary orthopyroxene is characterized by a lower content in Al_2O_3 (<2.5 wt.% compared to 2.9-4.4 wt.% in primary orthopyroxene, depending on the sample. It also contains less Cr_2O_3 and TiO_2 (<0.2 wt.%) and has similar mg# (90-91). It includes small (<1 μm) rounded Cl-apatite (2.5 wt.% Cl). Small (2 μm) pores are observed throughout the veins and at the contact with the primary phases. Secondary orthopyroxene formed in the mantle (1.5 GPa, 1150°C) from a metasomatic volatile-rich hydrous silicate melt.