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Magmatic and metasomatic processes in the mantle evidenced by the behavior of Ti in amphibole from lherzolite xenoliths (French Massif Central).

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Amphibole has been widely recognized in mantle xenoliths brought to the surface by alkaline magmas and is responsible for chemical modifications (e.g. enrichment in K, Ti, and Fe) of the mantle prior to xenolith entrainment. We present here evidences for multi-stages melt (and fluid) rock - interactions based on a detailed investigation of the amphibole composition (with focus on the Ti behavior) in spinel lherzolites from the French Massif Central. The nodules are fresh, encased in a thin basaltic rind in sharp contact with the peridotite, without any invasion of the host basaltic melt along fractures. They are olivine-rich (60-72 vol%) lherzolite with variable (7-26 vol%) orthopyroxene, (1-18 vol%) clinopyroxene and (1-5 vol%) spinel, and contain (2-20 vol%) amphibole and minor mica [1]. Pargasite occurs as disseminated crystals generally developed at the expense of spinel ± clinopyroxene, and may also fill cross-cutting veinlets, and form continuous or discontinuous bands with variably abundant relict spinels. Some samples (SD23, SD27, LN8) are surrounded by a selvage (up to 5 mm thick) of Ti-pargasite and kaersutite with sharp contact with the peridotite.

In the selvage: Far from the selvage/peridotite contact, amphibole is cumulative and accompanied with rare phlogopite crystals, absent nearer to the contact. Amphibole from the outer part is a Cr-free Al-rich kaersutite, and its composition mostly varies in the inner reactional part with a decrease in Ti and Al, while mg* increases (e.g. SD27) towards the contact. The outer part of the selvage is the remnant of a dyke, while in the inner part amphibole has reacted with the peridotite, for example in sample SD10, the reactional part is well-developed and isolated peridotite remnants are embedded in pervasive selvage-like.

In the peridotite: Amphibole composition varies progressively as a function of increasing distance from the selvage. Although the amplitude of these variations depends on the samples, the general trend is an increase in mg*, Cr and Al while Ti decreases. Particularly, Ti decreases sharply at the selvage-peridotite contact for a similar mg* in all samples. Disseminated amphibole far from the selvage-peridotite contact is a Cr-rich pargasite.

The compositional variations of the amphibole reflect different processes of amphibole formation, and can be evidenced by the behavior of Ti. The different Ti-Al correlations observed in amphibole from selvage (positive) and peridotite (negative) are linked to distinct crystal-chemical mechanisms for Ti incorporation in the octahedral sites of the amphibole structure. Expressing the variations in amphibole composition with a set of exchange-vectors, we propose two preponderant Ti-incorporation mechanisms: 1) $(\mathrm{Ti}^{4+}\ {}^{6}\mathrm{Al}_{2}^{3+})\ (\mathrm{M}_{-1}^{2+}\ \mathrm{Si}_{-2}^{4+})$ for amphibole in the selvage and 2) $(\mathrm{Ti}^{4+}\ \mathrm{M}^{2+})\ ({}^{6}\mathrm{Al}_{-2}^{3+})$ for disseminated amphibole in the peridotite. Mechanism (1) is likely to result from the crystallization of a percolating silicate melt in the mantle, whereas mechanism (2) results from hydration of the peridotite reacting with a percolating fluid emanating from the silicate melt.

[1] Wagner and Deloule, 2007, Geochim. Cosmochim. Acta, 71, 4279-4296;