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Formation of amphibole lamellae in mantle pyroxene by fluid-mediated metasomatism: A focal plane array FTIR study from the Carpathian-Pannonian region

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Abstract

Amphiboles in the upper mantle (most frequently pargasitic in composition) have recently gained attention due to their role in the water budget and potential control on the rheology and physical discontinuity of layers of the mantle. Although nominally anhydrous minerals are often analyzed with Fourier transform infrared (FTIR) spectroscopy, amphiboles, especially in natural samples, are only rarely the focus of such studies because of their complex structure and variable composition. In mantle xenoliths, amphibole occurs not only interstitially or forming veins, but also as lamellae within orthopyroxene and/or clinopyroxene grains. The genesis of such lamellae is often ambiguous, as they could either be metasomatic products, or form by exsolution without an external H_2O source upon decreasing P-T conditions and consequent destabilization of hydrous point defects in the host pyroxene. To constrain the origin of amphibole lamellae in pyroxenes, we studied mantle xenoliths from the Carpathian-Pannonian region (CPR) by applying hyperspectral imaging using an FTIR equipped with focal plane array (FPA) detector. Amphibole lamellae are absent in xenoliths of the central part of the CPR, but appear in those from the marginal localities that represent a well-hydrated supra-subduction mantle environment. Some of the lamella-hosting pyroxene grains are in contact with interstitial amphibole, suggesting that the formation of the lamellae is related to the amphibole-producing metasomatism; however, others have no adjacent amphibole. To determine the origin of the amphibole lamellae in pyroxenes without neighboring amphibole, hyperspectral images were used to give an estimation of their volume proportion (0.8–5.1 vol%) in the pyroxenes. Using these volume proportions, we calculated that a bulk water content of ~330–670 (orthopyroxene) and ~740–1430 (clinopyroxene) wt. ppm is needed to be contained in the host grain to be able to facilitate subsolidus exsolution of the observed amount of amphibole lamellae. These water contents are, however, too high for mantle pyroxenes, even for an aqueous-fluid saturated upper mantle. This suggests that the formation of amphibole lamellae is related to a metasomatic event with fluid input from an external water source (e.g., melt/fluid inclusion or metasomatic agent on the grain boundary).

Keywords: Amphibole lamellae, upper mantle xenolith, Fourier transform infrared spectroscopy, fluid metasomatism, hyperspectral imaging, mantle water content