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The fate of metaclinopyroxenite during serpentinite subduction

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Subduction of the partially hydrated section of the lithosphere is widely accepted as the major water carrier to sub-arc depths. Geodynamic models and geochemical mass balances assume that this section is comprised almost exclusively by the maximum hydrated counterpart of harzburgite, i.e. antigorite-serpentinite. The common wisdom gained through the study of oceanic and continental lithospheric sequences indicates, however, that this assumption is an oversimplification and that the widespread occurrence of other lithologies, such as clinopyroxenites, should not be disregarded. It is obvious, however, that the role of these non-conventional lithologies in the subduction factory will also depend on their ability to record hydration and dehydration reactions.

Here we report the textural and mineral assemblage evolution of clinopyroxene-tremolite bearing serpentinite, metaclinopyroxenite bodies and associated diopside-chlorite schists interlayered in serpentinites from the Cerro del Almirez (Betic Cordillera, Spain), the only place known where the high-pressure antigorite dehydration front is preserved (Trommsdorff et al., 1998; Padrón-Navarta et al., 2011). Cpx-Tr serpentinite bodies are unevenly distributed at the decametric scale in the serpentinite sequence and occurs as isoclinally foliated layers. Tremolite in these rocks was formed by the reaction:

antigorite + diopside = tremolite + olivine + fluid [1]

These rocks have been traditionally interpreted as strongly dismembered clinopyroxenite layers finely intermixed at the cm-scale with serpentinite. The following observations regarding the relationship between metaclinopyroxenite bodies and diopside-chlorite schists are, however, against this hypothesis. Detailed observations in almost undeformed coarse grained (cm-sized) metaclinopyroxenite bodies show that incipient transformation of mantle clinopyroxene occurs along former exsolution lamellae by the reaction:

clinopyroxene + fluid = diopside + chlorite [2]

Further deformation along these weak zones eventually results in the development of diopside-chlorite schists. The systematic lack of chlorite in Cpx-Tr serpentinite strongly suggests that these lithologies do not necessary represent an intermixing of antigorite-serpeninite with clinopyroxenite layers. Instead, they might be derived from more lherzolitic protoliths, where the Al-content in the mantle clinopyroxenes, and released during progressive metamorphism, was accommodated by antigorite (which can reach up to 3.5 wt. % $Al2O_3$). Although rare, diopside-chlorite schists should then be considered as an important host for Ti and REE. Futhermore, the stability of this assemblage beyond the antigorite breakdown conditions has further implications for the deeper recycling of these elements in subduction zones.

Padrón-Navarta, J.A., López Sánchez-Vizcaíno, V., Garrido, C.J., Gómez-Pugnaire, M.T., 2011. Metamorphic record of high-pressure dehydration of antigorite serpentinite to chlorite harzburgite in a subduction setting (Cerro del Almirez, Nevado–Filábride Complex, Southern Spain). J Petrology 52, 2047-2078.

Trommsdorff, V., López Sánchez-Vizcaíno, V.L., Gómez-Pugnaire, M.T., Müntener, O, 1998. High pressure breakdown of antigorite to spinifex-textured olivine and orthopyroxene, SE Spain. Contrib Mineral Petr 132, 139-148.