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Reaction-induced rheological weakening in the supra-subduction mantle: an example from garnet pyroxenites of Ulten zone (Eastern Alps, N Italy)

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Pyroxenites are common compositional heterogeneities in the upper mantle and represent key lithologies in mantle deformation processes, as the local presence of pyroxene-rich compositions can weaken the mantle strength. Pyroxenites occur ubiquitously as variably deformed layers in most of oceanic and orogenic peridotite massifs, and thus can be used as a proxy to investigate the rheological behavior of the mantle in different geodynamic settings, including subduction zones.
In the Ulten Zone (Tonale nappe, Eastern Alps, N Italy), numerous peridotite bodies occur within high-grade crustal rocks. Peridotites show a transition from coarse protogranular spinel lherzolites to finer-grained amphibole + garnet peridotites (Obata and Morten, 1987). Pyroxenites veins and dikes, transposed along the peridotite foliation, show a similar evolution from coarse garnet-free websterites to finer-grained garnet clinopyroxenites (Morten and Obata, 1983). This evolution has been interpreted to reflect cooling and pressure increase of pyroxenites and host peridotites from spinel- (1200 °C, 1.3-1.6 GPa) to garnet-facies conditions (850 °C and 2.7 GPa) within the mantle corner flow (Nimis and Morten, 2000). This results in the consequent formation of garnet at the expense of spinel. In particular, garnet initially formed as coronas around spinel and as exsolution lamellae in high-T pyroxenes, and later as neoblasts along the foliation of pyroxenites and host peridotites.
Microstructures and crystallographic orientation data indicate that the transition from spinel- to garnet-facies conditions occurred in a deformation regime. Pyroxene porphyroclasts in garnet clinopyroxenites show well-developed crystallographic preferred orientation, high frequency of low-angle misorientations, and non-random distribution of the low-angle misorientation axes. These features indicate that pyroxene porphyroclasts primarily deformed by grain size insensitive (GSI) creep. Core-and-mantle microstructures in pyroxene porphyroclasts also suggest that GSI creep was aided by subgrain rotation (SGR) during recrystallization, leading the formation of

smaller, neoblastic, and strain-free pyroxene grains around porphyroclasts. These recrystallized grains have been interpreted to deform by grain boundary sliding, i.e. a grain size sensitive (GSS) creep mechanism, as indicated by the occurrence of quadruple junctions between straight grain boundaries. Our rheological models also suggest that GSS creep of neoblastic pyroxenes occurred at differential stress of 40 MPa and strain rates of 10^{-18}-10^{-15} s^{-1}.

The transition from GSI creep in the porphyroclasts to GSS creep in the neoblasts was accompanied not only by a reduction of the grain size of pyroxenes, but also by the crystallization of garnet along the pyroxenite foliation which facilitated pinning by second phase in the recrystallized matrix. This stabilized the fine-grained microtexture produced by the GSS creep process, and finally contributed to the rheological weakening of pyroxenites.

Pyroxenites of Ulten Zone thus offer a unique opportunity to investigate the effects of mantle weakening on the processes that control the material exchange between crust and mantle at subduction zones.

Morten, L., & Obata, M. (1983). Bulletin de Minéralogie, 106(6), 775-780.
Nimis, P. & Morten, L. (2000). Journal of Geodynamics, 30(1-2), 93-115
Obata, M., & Morten, L. (1987). Journal of Petrology, 28(3), 599-623.