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Plastic deformation and development of antigorite crystal preferred orientation in serpentinite

José Alberto Padrón-Navarta (1), Andréa Tommasi (2), Carlos J. Garrido (3), Vicente López Sánchez-Vizcaíno (4), María Teresa Gómez-Pugnaire (1,3)

(1) Universidad de Granada, Mineralogía y Petrología, Granada, Spain (padron@ugr.es), (2) Géosciences Montpellier, Univ. Montpellier 2 & CNRS, 34095 Montpellier, France , (3) Instituto Andaluz de Ciencias de la Tierra, Granada, CSIC-UGR, Fac. Ciencias 18002 Granada, Spain , (4) Dep. Mineralogía y Petrología, UGR, Fac. Ciencias, 18002 Granada, Spain

Serpentinite microstructures are an invaluable tool to decipher deformation mechanisms over a considerable range of pressure and temperature conditions in several tectonic settings involving hydrated lithospheric mantle, such as the mantle wedge tip and the slab-mantle wedge interface in subduction zones. Serpentines have significantly lower strength than anhydrous mantle minerals and a highly anisotropic behaviour. Moreover, because of their large stability field, serpentine, especially antigorite, the stable variety at high pressure and high temperature, can potentially record a large part of the deformational history. Recent published works show however disagreement concerning the dominant deformation mechanisms and fabrics developed in naturally deformed antigorite serpentinite and HP-HT deformation experiments. This suggests that serpentinite microstructures are dependent on PT conditions during deformation but this has not been investigated in detail so far. Here we present a detailed microstructural study of naturally deformed HP-HT antigorite serpentinite from Cerro del Almirez ultramafic massif (Betic Cordillera, SE Spain) [1,2], together with numerical modelling of crystal-preferred orientation (CPO).

We measured the serpentinite fabric by using high-resolution EBSD mapping (1 micron measurement steps) over representative areas from several samples in two orthogonal sections (XZ and XY sections). Antigorite both sections shows a distinct and coherent CPO, characterized by a strong alignment of (001) poles normal to the foliation plane and a weaker, but clear, parallelism between [100] axis and macroscopic lineation defined by magnetite stretching. Antigorite subgrains are resolved in high resolution EBSD maps and are most commonly oriented in two sets: (1) parallel to (001) planes, showing sharp or gradual change in orientation (∼10º) with [010] as the main misorientation axis and (2) parallel to (100) showing smaller (<10º) rotations around [010] rotation axis. Low angle rotations along the [100] axis are also occasionally observed. Misorientation analysis of subgrains for the whole thin section indicates that low angle misorientation occurs dominantly by rotation around [010], most probably indicating activation of the (001)[100] slip system. In Ca-rich serpentinite, tremolite is syn- to post-kinematic with respect to the foliation thus constraining the maximum temperature conditions during deformation to ∼600-650ºC. Equilibrium-based CPO modelling indicates that simple shear cannot account for the observed fabric and that a small amount of compression (transpression) is required in order to reproduce the observed strong (001) maxima normal to the foliation plane and the distribution of [100] and [010] within the foliation plane. These results are important to predict in the future the development of seismic anisotropy in response to large scale plastic flow in the hydrated mantle wedge and slab-mantle wedge interface.

[1] Trommsdorff, López Sánchez-Vizcaíno, Gómez-Pugnaire & Müntener (1998), Contrib Mineral Petr 132 139-148.
[2] Padrón-Navarta, Hermann, Garrido, López Sánchez-Vizcaíno, Gómez-Pugnaire (2010), Contrib Mineral Petr 159, 25-42.