Deformation and anisotropy of antigorite

Charis Horn, Pierre Bouilhol, and Philip Skemer

Hydrous silicates such as antigorite have highly anisotropic seismic and rheological properties. It is thought that these minerals may influence several geologic phenomena of subduction zones, including shear localization, intermediate-depth earthquakes, and shear-wave splitting. To understand the feedbacks between serpentinization, deformation, and seismic anisotropy, we analysed microstructures from a suite of antigorite-bearing samples from the Kohistan paleo-island arc in Pakistan. Weakly deformed samples display evidence for crystallographically-controlled growth of antigorite after olivine. Two distinct relationships were found:

1. (010)ant//(100)ol with [100]ant//[001]ol and

2. (010)ant//(100)ol with [100]ant//[010]ol

However, this topotactic replacement produces a bulk texture with only modest seismic anisotropy. In contrast, highly deformed samples, in which the serpentine was sheared to produce a strong lattice-preferred orientation (LPO), were found to possess extremely strong bulk anisotropy (P-wave and S-wave anisotropy up to ~25% and 31%, respectively).

Moreover, these microstructures would be capable of generating strong trench-parallel shear wave splitting when the sheared interface is dipping, or otherwise oriented at a high angle to an incident shear wave. Given the apparent rheological weakness of antigorite, we hypothesise that progressive deformation will localise in areas with higher modal percentages of antigorite, thus overprinting any original topotactic signature in the rocks. These regions of highly deformed antigorite then have the capability to substantially affect seismic wave patterns in a subduction zone. Mylonitic antigorite in a dipping structure could explain some of the complex patterns of shear wave wave splitting in subduction zones. ■

For more information, please see: Horn, C., Bouilhol, P., Skemer, P. (2020) Serpentinization, deformation, and seismic anisotropy in the subduction mantle wedge, Geochem, Geophys, doi: 10.1029/2020GC008950

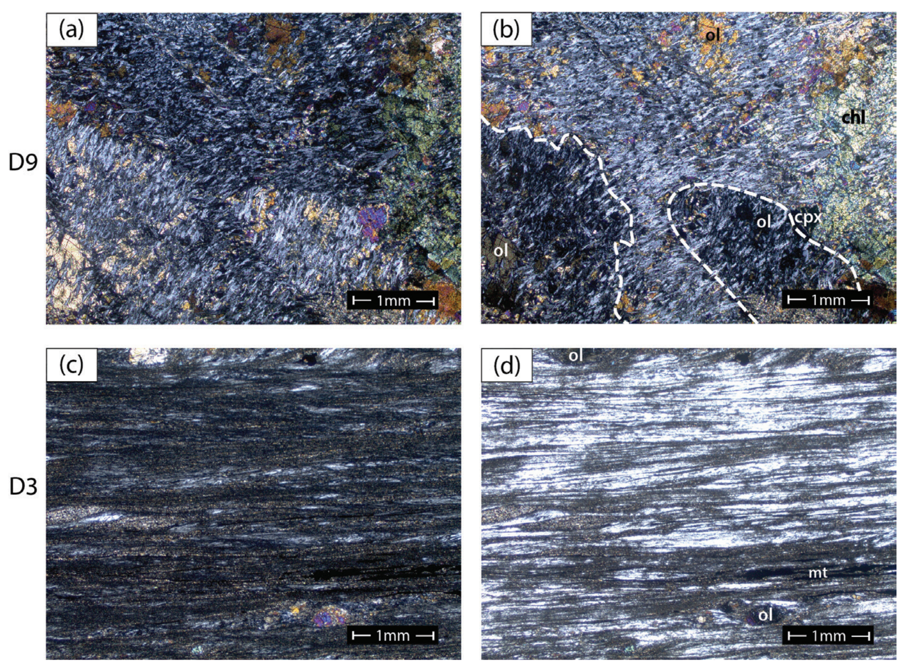

Figure 1. Photomicrograph of samples D9 (protomylonite) and D3 (mylonite) in crossed-polarized light. (a&b) and (c&d) display the same fields of view but with the polarizers rotated by 45°. Low birefringence (grey to white) grains are antigorite, and higher birefringence (orange, pink, and purple) grains are olivine. (a,b) In the relatively undeformed protomylonite "haloes" of antigorite with similar orientations surround relict olivine (marked as white dashed lines), suggesting there is a topotactic relationship between the olivine and antigorite grains that formed during hydration. (c,d) Mylonites exhibit a strong degree of crystallographic alignment between antigorite grains, which can be seen in the similar extinction angles visible across the entire thin-section. These mylonites are inferred to be the product of progressive deformation of a more weakly deformed protolith.