Experimental Investigation on the Deformation and Dehydration Faulting of Antigorite in Subduction Zones

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It has been well documented that antigorite is one of the most important hydrous minerals for understanding trench-parallel seismic anisiotropies and the genesis of intermediate-depth earthquakes in subduction zones. However, the deformation and dehydration faulting of antigorite have not been well characterized in the laboratory. Here we report results of shear deformation experiments on antigorite within its stability field and axial compression dehydration experiments on antigorite beyond its stability field. Within its stability field, the shear deformation experimental results show that antigorite can develop various strong fabrics with the (001) planes parallel to foliation and the [010] axes parallel to lineation that can cause large shear wave delay. Antigorite is much weaker than olivine and dominates the seismic anisotropies in serpentinized peridotite. These results suggest that antigorite can cause trench-parallel shear wave polarization only when the dip angle of a subducting slab is greater than 60°. Beyond its stability field, the axial compression experimental results suggest that dehydration of hydrous minerals can generate new faults in homogeneous rocks (regular earthquakes) and small tremors (slow earthquakes) along pre-existing fault caused by regular earthquakes in subduction zones. The regular earthquakes are single events characterized by relatively large stress drops and short durations. The slow earthquakes are multiple stick-slip events characterized by much smaller stress drops and longer durations. There is a narrow temperature range for faulting in serpentinite. Fluid-filled mode I cracks in olivine or pyroxene-rich zones are crucial for the self-organization and generation of mode II shearing in serpentinite. These results are well consistent with the characterizations of trench-parallel seismic anisiotropies and the distribution of earthquakes in subduction zones.