Deformation of olivine during phase transformation to wadsleyite

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The strength of subducting slabs in the transition zone is critical in controlling the style of mantle convection. However, rheological properties of a subducted slab are elusive: low temperatures of a slab would make it strong, but in many regions there is evidence of intense deformation of slabs in the transition zone. One potential cause of intense deformation of subducting slabs is grain size reduction during phase transformation of olivine to its higher-pressure polymorphs (wadsleyite and ringwoodite). However, there have been no experimental studies to quantify the influence of grain-size evolution.

In addition to grain size reduction, distribution of small grains during phase transformation governs the degree of weakening during phase transformation (for e.g. load bearing framework vs. inter-connected layered framework). We conducted laboratory studies on the size and spatial distribution of new grains of wadsleyite after the transformation from olivine. Our results under static conditions (in a multi anvil at Yale University) show that an interconnected microstructure develops during the initial stage of phase transformation and that the grain size of the interconnected phase (wadsleyite) depends on the temperature at which the phase transformation occurs (smaller grains at lower temperatures). Development of an interconnected microstructure may lead to strain localization in the weaker phase, i.e. the fine-grained interconnected network accommodates most of the strain and therefore weakening of the entire composite. We will test this model through synchrotron in-situ deformation experiments where an olivine aggregate will be deformed during slow pressure increase from deep upper mantle pressure (~10 GPa) to transition zone pressure (~15 GPa) at a given temperature simulating the deformation of a slab penetrating into the transition zone. We will use the Rotational Drickamer Apparatus (RDA) at a synchrotron facility (Argonne National Lab, 6-BM-B beamline, white beam and x-ray radiography) and characterize the stress acting on olivine and wadsleyite during such simulation. We ran pilot test experiments at Yale to calibrate the load-T-t of phase transformation using RDA. We plan to present our preliminary results.