Experimental observation of antigorite dehydration triggered by shear stress at subduction zone pressure and temperature conditions

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Role of serpentinites

Subducted serpentinites (>13 wt. % H2O) release fluids through a series of dehydration reactions [1, e.g.):

- brucite + antigorite = olivine + fluid
- antigorite = olivine + pyroxene + fluid

Natural observations (e.g. metaserpentinites in Erko Tobbio, ET) indicate that the fluids are released at specific locations within the rock, cf. EGU23-3130 (GD4.2). Self-organisation of fluid pockets into a vein network is essential for an efficient fluid flow [2]. The transition from isolated fluid pockets into a connected network could result from embrittlement, reactive fluid flow or a combination, and might be affected by mineral preferred orientation and/or external stress fields (Fig. 1).

Experimental approach

We performed high-PT experiments in a Griggs apparatus, both hydrostatic and axial compression. The experiments were designed to analyse the effect of foliation and stress on the fluid release and vein formation. We used an isotropic (Linnaajärvi, NOR) and anisotropic (Zermatt, CH) antigorite-serpentinite (Fig. 2).

Run conditions:
- 1.5 GPa confining pressure
- 620 - 650 °C
- hydrostatic or axial compression (strain rate: 10^{-6} s^{-1})
- 0 - 8 % strain

Just enough to observe the very onset of dehydration and vein formation.

Experimental products

Secondary phases form along grain boundaries and occasionally form planar features (Fig. 3 left).

Interfaces represent rheological contrasts. Fractures and shear planes form (Fig. 3 middle - right).

Secondary phases are crystalline, no melt formed. Minerals are olivine (Ol) + pyroxene + phyllosilicate (ps) (Fig. 4)

Network formation

The veins form two conjugate sets within the capsules (Fig. 5). The preferred orientation of the veins is more pronounced in the anisotropic experiments and slightly depends on the orientation of the serpentine foliation (Fig. 6).

Implications

- Local stress accumulation can trigger dehydration through changes in internal energy (distortion of crystal lattice, dislocation density increase)
- Dehydration occurs along planar features caused by stress and forms veins
- Dehydration veins cause rheology contrasts along which fracturing can occur
- Foliation enhances vein formation through changes in stress field

References