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

Lisa Eberhard[1], Oliver Plümper[1], Holger Stünitz[2,3]

[1]Department of Earth Sciences, Utrecht University, Netherland (l.eberhard@uu.nl)
[2]Department of Geology, Tromsø University, Norway
[3]Institut des Sciences de la Terre d'Orléans (ISTO), Université d'Orléans, France

EGU23-3360

Role of serpentinites

Subducted serpentinites (>13 wt. % H_2O) 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 Erro 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).*

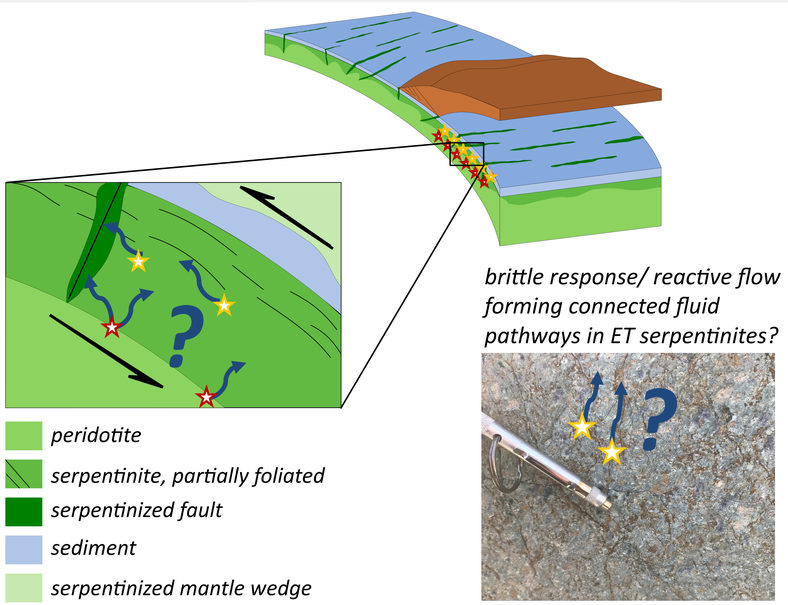


Fig. 1: Fluid release in subducted serpentinites occurs in specific locations and eventually forms a connected network, as in the ET metaserpentinites. Sketch after [3], not to scale.

Central questions

- **WHERE** are fluids released?
- **HOW** do fluid flow networks form through self-organisation?
- **WHAT** are controlling parameters for self-organisation?

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 (Linnajavri, NOR) and anisotropic (Zermatt, CH) antigorite-serpentinite (*Fig. 2).*

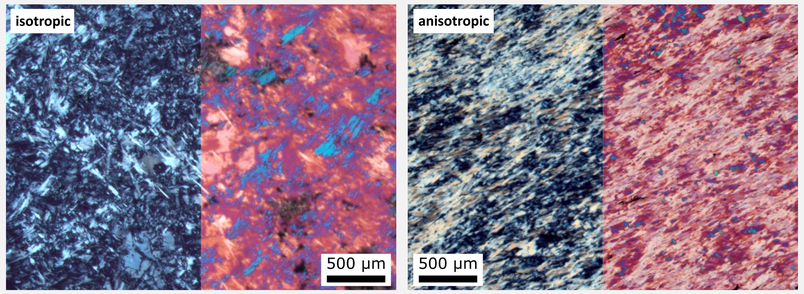


Fig. 2: Fully serpentinized starting material was used for high-PT experiments. Images show micro-textures in plane- and cross-polarized light.

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

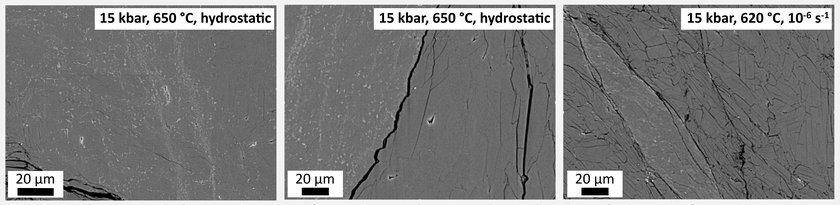


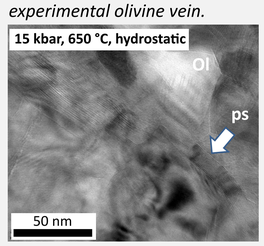
Fig. 3: Backscattered electron images of experimental run products showing olivine vein formation.

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)*

Fig. 4: TEM image of an experimental olivine vein.



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*).

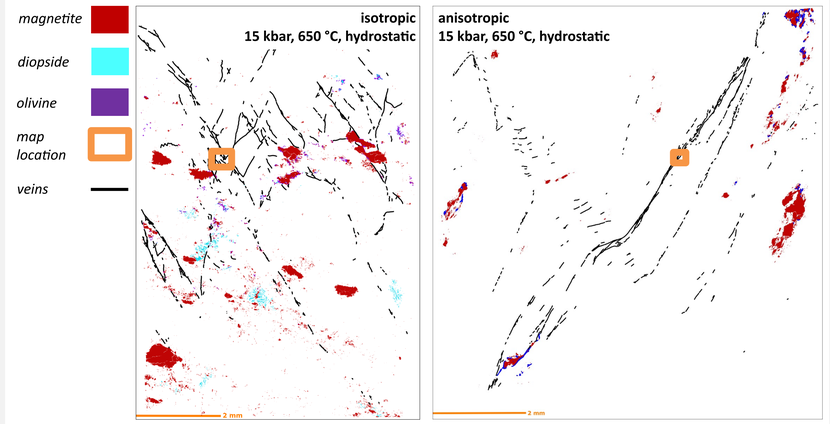


Fig. 5: Sketch of run products in an isotropic (left) and anisotropic (right) experiment, showing the distribution of veins. Also shown are minor phases, which seem to not influence the vein formation.

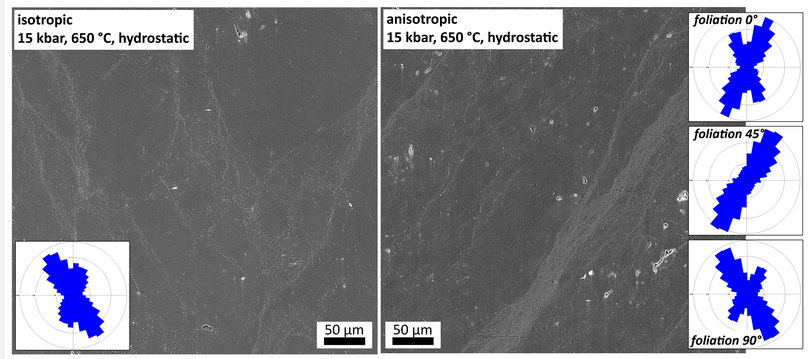


Fig. 6: Backscattered electron images of olivine veins in an isotropic (left) and anisotropic (right) experiment. Rose plots show orientation of veins additionally for experiments with different orientation of the serpentine foliation (orientation relative to compression axis).

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 occure
- Foliation enhances vein formation through changes in stress field

References

[1] Ferrand TP (2019) Seismicity and mineral destabilizations in the subducting mantle up to 6 GPa, 200 km depth. Lithos 334-335:205-230.
[2] Plümper O, John T, Podladchikov YY, Vrijmoed JC, Scambelluri M (2017) Fluid escape from subduction zones controlled by channel-forming reactive porosity. Nature Geoscience 10:150-156.
[3] Kita S, Ferrand TP (2018) Physical mechanisms of oceanic mantle earthquakes: Comparison of natural and experimental events. Scientific Reports 8:17049

Sharing not permitted