Permeability of serpentinites at high PT: towards fluid flow determination in subduction zones

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The process of dehydration in subduction zones is important for (i) element recycling, (ii) hydration of the mantle wedge, as well as (iii) melting processes related to arc volcanism. Additionally, the release of fluids is also proposed to be related to the origin of deep earthquakes. The transport of fluids from the slab into the mantle requires a sufficiently high permeability. Due to shear deformation in subduction zones a strong foliation will be developed by preferred orientation of serpentinite minerals, which might influence the permeability. Measurements of permeability up to 100 MPa indeed showed that the foliation yields a strong anisotropy in serpentinites. The permeability parallel to the foliation is one order of magnitude higher than in the perpendicular direction.

Here we present a method to estimate the fluid flux in serpentinites at mantle conditions combining laboratory experiments, X-ray CT scans and numerical modelling. For this purpose, we performed HP-multi-anvil experiments at temperatures of 500 °C to 700 °C and pressure up to 2.5 GPa. As starting material we used a natural antigorite sample showing a strong foliation. A cylindrical drill core is placed into an MgO sleeve. The MgO is hydrated to brucite at the PT conditions at which serpentine is still stable, i.e. serpentine partially dehydrates and brucite is formed as the released fluid moves into the MgO sleeve. After the experiment the location and proportion of brucite formed allows the preferred fluid flux to be determined. The formation of 5 times less volume per unit area of brucite in the direction perpendicular to the foliation indeed indicates a preferred fluid flow parallel to the preferred orientation.

In a second step we employ CT scans to obtain data on the pore space of the samples. Finally, using numerical methods, we determine both the porosity as well as the permeability of the recovered samples. Combined, these methods can be used to obtain a model of fluid flow in subduction zones.