Serpentinite-fluid interaction in subduction zones

H. PILORGÉ[12]*, B. REYNARD[12], G. MONTAGNAC[12], H. CARDON[12] AND S. LE FLOCH[1]

[1]Université Claude Bernard Lyon1, CNRS, 2 rue Raphaël Dubois, 69622 Villeurbanne Cedex, France (*correspondence: helene.pilorge@ens-lyon.fr)

[2]Ecole Normale Supérieure de Lyon, CNRS, 69007 Lyon, France

Subduction zones are places of intense fluid circulation revealed at depths greater than 30 km by the observation of high conductivity zones, non-volcanic tremors, and volcanism. The mantle overlying the subducted slab is made of antigorite, the high temperature and high-pressure variety of serpentine. Seismic studies confirm the presence of significant amounts of serpentine and fluids in these zones. Thus fluids circulate upwards in a serpentinite layer along the slab. The aim of this study is to better constrain the fluid-rock interactions, the permeability and related transport properties of antigorite serpentinite, by conducting diffusion and dissolution-precipitation experiments at subduction zones conditions.

An assemblage consisting of an antigorite serpentinite core, and of antigorite powders mixed with $NiCl_2$ and deuterated water (D_2O) were placed in a Belt press under P = 3 GPa, T = 315-540°C during 12 to 38 hours. We obtained diffusion profiles of deuterium parallel to the layered structure and calculated diffusion coefficients: $D = 10^{-14}$ to 10^{-15} $m^2.s^{-1}$ at 540±20°C using Raman mapping of isotopic exchange between antigorite and deuterated water. Diffusion coefficients perpendicular to the layered structure are two orders of magnitude lower, which confirms that the diffusion is more efficient parallel to the layers. Below 500°C, complementary experiments in diamond anvil cell show that solid-state hydrogen diffusion is negligible in experiments. Thus, D incorporation in serpentine is mostly associated with precipitation and recrystallization at the lowest investigated temperatures.

SEM imaging and EDX analyses revealed Ni-rich antigorite recrystallizations in mineral platelets, from which apparent growth rates of 5.10^{-12} $m.s^{-1}$ at 540±20°C and 6.10^{-13} $m.s^{-1}$ at 315±20°C were inferred, confirming the observation of recrystallization by Raman spectroscopy. Recrystallization kinetics will influence precipitation-solution mechanisms, porosity cementation, and possibly rheology, if slower than diffusion in the aqueous fluid. Recrystallizations grow mostly sub-perpendicular to the main stress direction and are associated with porosities that modify the rock permeability. They may influence the transition between pressure-solution creep and brittle failure, thereby changing the deep faults or subduction zone strength.