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Water-mineral interactions, rock permeabilities and deformation in subduction zones.

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Fluid-rock interactions are central to numerous processes on Earth and in the solar system. They may have a major role on Earth plate tectonics and on its initiation. For instance, subduction zones are known as sites of intense fluid circulations. If fluid circulation in subduction zones is known from a variety of observations (high electrical conductivity zones, non-volcanic tremors and slow slip events, hydrothermal vents and mud volcanoes), mechanisms of fluid-rock interactions are still poorly constrain. For example, permeabilities of rocks under subduction high-pressure are unknown, fluid pathways, i.e. channelized or not, are still debated. One difficulty with fluid-rock interaction study is to identify them in rocks where fluid is not present anymore. One way to encompass this difficulty is to use hydrogen-isotope variations in rocks and minerals, as they provide a powerful method of documenting fluid-rock interactions in the Earth's crust, and also in experimental systems at the P-T conditions of subduction (1-3 GPa, 300-700°C).

In order to investigate in details fluid-rock interactions in subduction zone conditions, we reacted different high-pressure hydrous minerals with liquid D2O in a Belt apparatus in the range 1.5 to 3 GPa and from 315 to 650°C. Experimental samples were characterized both by Raman micro-spectrometry and SEM imaging in order to reveal fluid-rock interactions and fluid pathways, active at high-pressure. By combining both analytical techniques, we can build on rock permeability. Our experiments show that antigorite-rich serpentinites are highly permeable and reactive with aqueous fluids whereas chloritites are almost impermeable and poorly reactive. Blueschists (glaucophane + epidote) have intermediate behavior. Those differences may be partly explained by different mechanical behavior. During experiments, antigorite grains are fractured, whereas chlorite grains are kinked. Open micro-cracks and fractures in antigorite grains create or maintain rock porosity. In the opposite, kinking in chlorite efficiently reduces porosity. We discuss potential implications of our experimental observations to subduction zones with an emphasis on fluid flows and fluid-rock interactions.