High resolution characterization of porosity and permeability evolution during serpentinization

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Field samples of mafic and ultramafic materials are nearly always hydrothermally altered in some way. The hydration process requires, however, that surface-derived, water-rich fluids penetrate into and permeate throughout the intially completely impermeable rock matrix during the relatively brief time that the rock spends at pressures and temperatures conducive to the alteration reactions. Although flow paths and permeability will be generated through tectonic processes such as detachment faulting, it appears likely that a significant amount of the porosity and permeability are generated at the nano- to micrometer scale as a result of local overpressuring related to serpentinization reactions. To explore this process, we have conducted synchrotron x-ray computed tomography (XRCT, 0.75 μm pixel size) and (Ultra) Small Angle Neutron Scattering ((U)SANS, ~10 nm – ~10 μm effective resolution) on two serpentinized troctolite samples. The first sample, from IODP 1309D drill core, was chosen to illustrate the evolution of porosity generation and distribution with increasing alteration percentage. Preliminary analysis indicates that, as serpentinization reactions proceed, nano-scale pores are generated at the expense of those at the micrometer scale. The second sample, from Bardon Peak in the Duluth Complex of northern Minnesota, was chosen to illustrate the evolution of porosity as fluids penetrate into the side walls of tectonically produced fractures. Preliminary analysis of these samples indicates that, although the core of the fracture appears visually to be completely filled with alteration products, it maintains a significant amount of micrometer-scale pores that likely allow continued fluid fluxes. The sustained fluid flux, in turn, allows continued penetration into and alteration of the fracture walls. Together, the XRCT and (U)SANS data provide an important and unexplored view of the evolution of porosity and permeability during serpentinization of mafic and ultramafic material.