American Mineralogist, Volume 101, pages 2645–2654, 2016

CHEMISTRY AND MINERALOGY OF EARTH'S MANTLE

Electron diffraction determination of 11.5 Å and HySo structures: Candidate water carriers to the Upper Mantle

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Abstract

The dehydration reactions of minerals in subduction zones strongly control geological processes, such as arc volcanism, earthquakes, serpentinization, or geochemical transport of incompatible elements. In aluminum-bearing systems, chlorite is considered the most important hydrous phase at the top of the subducting plate, and significant amount of water is released after its decomposition. However, the dehydration mechanism is not fully understood, and additional hydrates are stabilized by the presence of Al beyond the stability field of chlorite. We applied here a cutting-edge analytical approach to characterize the experimental rocks synthesized at the high pressures and temperatures matching with deep subduction conditions in the upper mantle. Fast electron diffraction tomography and high-resolution synchrotron X-ray diffraction allowed the identification and the successful structure solution of two new hydrous phases formed as dehydration product of chlorite. The 11.5 Å phase, $Mg_6Al(OH)_7(SiO_4)_2$, is a hydrous layer structure. It presents incomplete tetrahedral sheets and face-sharing magnesium and aluminum octahedra. The structure has a higher Mg/Si ratio compared to chlorite, and a significantly higher density (ρ_0 = 2.93 g/cm^3) and bulk modulus [K_0 = 108.3(8) GPa], and it incorporates 13 wt% of water. The HySo phase, $Mg_3Al(OH)_3(Si_2O_7)$, is a dense layered sorosilicate, [ρ_0 = 3.13 g/cm^3 and K_0 = 120.6(6) GPa] with an average water content of 8.5 wt%. These phases indicate that water release process is highly complex, and may proceed with multistep dehydration, involving these layer structures whose features well match the high-shear zones present at the slab-mantle wedge interface.

Keywords: Subduction, MASH system, electron diffraction tomography