An experimental approach of asteroidal water-rock interactions: mineral formation in a Fe,Si-rich system under anoxygenic conditions

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Water-rock interactions observed in carbonaceous chondrites bear similarities to terrestrial serpentinization[1], with, however, specificities that need to be addressed experimentally for the environmental conditions that prevailed on their asteroidal parent bodies to be understood. Mixed valent Fe-rich serpentines are common, but their mechanisms of formation and the Fe oxidation processes under the presumably low T and anoxygenic conditions of asteroids are still poorly understood. We performed syntheses of serpentines with different starting compositions as well as alteration experiments of reduced minerals (olivine and metal). Anoxygenic conditions were maintained throughout, and the influence of the addition of $MgAl_2O_4$ -a minor yet ubiquitous component of chondrites- on Fe oxidation was tested. The experimental products and their Fe valence state were studied down to the nanometer scale using TEM, EELS and STXM-XANES at the Fe $L_{2,3}$ edges. A complex partitioning of Fe among hydroxide and silicate phases is observed, and two main conclusions can be drawn. First, results from both hydrothermal alteration and synthesis suggest the efficiency of spinel in catalysing the oxidation of aqueous Fe^{2+} by water at low T (60°C), similarly to previous experiments in Fe-poor systems[2]. Such processes produce hydrogen that may then have played an important role in the evolution of the parent bodies of chondrites (redox state, abiotic organosynthesis[3,4]). Second, at high Fe/Si and Fe^{3+}/Fe_{tot} ratios we observed the crystallization of Fe-rich serpentine close to the cronstedtite end-member at room temperature. Such a rapid formation of cronstedtite is in good agreement with the association of this mineral to the early stages of aqueous alteration in CM chondrites[6,1]. Implications on terrestrial processes will also be discussed.

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