Crystal chemistry of Fe-serpentines in chondrites: A nanoscale study

A. ELMALEH[1*], F. BOURDELLE[2], F. CASTE[1], K. BENZERARA[1], H. LEROUX[3] AND B. DEVOUARD[4]

[1]IMPMC, Sorbonne Univ., UPMC, CNRS, MNHN, IRD
[2]LGGgE, Univ. Lille 1
[3]UMET, Univ. Lille 1, CNRS
[4]CEREGE, Aix-Marseille Univ., CNRS
(*Correspondence: Agnes.Elmaleh@impmc.upmc.fr)

In this study, we focus on the parameters controlling the formation of serpentines in chondrites, based on a nanoscale investigation of their crystal chemistry. Carbonaceous chondrites are fragments of undifferentiated small bodies formed in the outer solar system. Extensive water-rock interactions took place at early stages of their formation. In CM chondrites, such as Murray, they resulted in a special case of serpentinization, which produced Fe^{2+},Fe^{3+} - rich serpentines. The mechanisms controlling Fe oxidation and the compositional variations (Fe, Mg, Al contents) of serpentines are poorly understood. To address these questions, nanoscale investigations are required given the small size of the crystallites. Here we used TEM and STEM-EDS combined with STXM-XANES at the Fe $L_{2,3}$-edges. We measured the angular dependence of XANES in reference single crystals of Fe-rich serpentines, so that orientation effects could be taken into account in meteorites, by combining XANES and electron diffraction. We focused on an altered primary component of the Murray chondrite. We show that strong redox, chemical and structural disequilibria characterize the alteration assemblages, and a multi stages fluid circulation history is documented. From this study, we propose mechanisms that may have played a role in the early formation of (Fe^{2+},Fe^{3+})-rich serpentines documented in CM chondrites, as well as in their transformation with on-going alteration towards Fe-poorer compositions inferred from previous petrologic, mineralogical and magnetic studies.