# Serpentinization in carbonaceous chondrites: a nanoscale mineralogical study

A. ELMALEH[1,*], F. BOURDELLE[2], N. MENGUY[1], K. BENZERARA[1], H. LEROUX[3], F. CASTE[1], AND M. FIALIN[4]

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

Here we report a mineralogical study of alteration assemblages in CM chondrites based on SEM, EMPA, TEM and STXM coupled with XANES at the Fe $L_{2,3}$-edges. CI and CM carbonaceous chondrites are among the most primitive rocks of the solar system, but they have experienced pervasive water-rock interactions after ice that accreted with rocky materials have melted. In CM chondrites, a case of serpentinization is observed, as the main alteration products are $Fe^{2+}$,$Fe^{3+}$,Al- and Mg-bearing serpentines. A limited number of major primary components is observed in chondrites (chondrules, containing mainly ferromagnesian minerals and Fe,Ni-alloys, refractory inclusions, containing mostly oxides of refractory elements, as well as dispersed Fe,Ni-alloys and Fe-sulfides), but their products of alteration, and the relationships between the hydrated matrix and these components are poorly understood. Difficulties in understanding the mineral replacement reactions stem from the small scale of the secondary crystallites and from the fact that the preservation of primary features is low. We focused on altered primary components of various CM chondrites in which remnants of the initial minerals or assemblages can be identified. In particular, we investigated a chondrule where grains and grain boundaries have been almost completely pseudomorphosed (Cold Bokkeveld chondrite), and where unaltered remnants of forsterite and Fe,Ni-alloys can still be observed. We will compare crystal-chemistry data obtained on serpentine assemblages 1) replacing a refractory inclusion, 2) replacing Mg-rich ferromagnesian grains in a chondrule, and 2) found in an aggregate in the matrix. First, we will discuss the similarities observed in the compositions of serpentines found in various environments. Second, in several serpentine assemblages we observed an inverse relationship between the amount of Fe and the $Fe^{3+}/\Sigma Fe$ ratio, which suggests that the mobility of $Fe^{2+}$ played a role in the decrease of the amount of Fe in serpentines as alteration proceeds, inferred from previous studies of CM chondrites.