TEM observations of Ivuna matrix in connection with its 3D structure

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CI chondrites are chemically the most primitive material in the solar system. They underwent extremely strong aqueous alteration. We have focused on 3D structure of the matrix of Ivuna meteorite (CI) to understand aqueous alteration processes and its original structure if possible. After detailed observation of a polished thin section using SEM/EDS, a cubic-shaped sample ~20 μm in size was picked up from the matrix using FIB and its 3D structure was obtained using nano-tomography with the spartial resolution of ~100 nm [1]. 3D structure of a part of the same sample was also obtained with higher resolution by FIB serial sectioning and SEM observation. Irregularly-ellipsoidal objects a few μm in size, which are composed of porous aggregates of Mg-rich phyllosilicates rimmed by less-porous Fe-rich phyllosilicates, were found in the matrix and called phyllosilicate composite (PC). In the present study, we made detailed TEM observation on the Ivuna matrix including PCs.

An ultra-thin section was picked up from the CT sample using FIB (FEI Helios NanoLab G3) and observed with (S)TEM/EDS (JEOL JEM-2100F). Two types of phyllosilicate aggregates were recognized throughout the matrix including PCs. One is composed of bundles of coarse phyllosilicates (~100 nm) with abundant pores while the other is an aggregate of fine phyllosilicates (~10 nm) including tiny ferrihydrite aggregates (Fe-rich in bulk composition) with less-abundant pores. Both types of phyllosilicates have ~7 Å and ~12 Å layers indicating serpentine and smectite, respectively. The former and latter types correspond to the coarse and fine phyllosilicates in the matrix of the Orgueil meteorite [2], respectively. In contrast to Orgueil matrix, where the fine phyllosilicates are dominant with clusts of the coarse phyllosilicates, coarse phyllosilicates are dominant in the Ivuna matrix. The core and rim of a PC are composed of the coarse and fine phyllosilicates, respectively. If the fine phyllosilicates resulted from alteration of the coarse phyllosilicagtes as proposed by [2], the present results indicate a smaller degree of aqueous alteration of the Ivuna matrix than the Orgueil matrix. The rim of PCs should be formed by this later aqueous alteration and PCs should reflect original texture before the alteration.

[1] Kitayama et al., 2017, *JpGU*, PPS10-10. [2] Tomeoka and Buseck, 1988, *GCA*, 52: 1627-1640