Mineral-organic matter relationships in primitive CO3 chondrites

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CO3 carbonaceous chondrites contain up to ~1 wt% carbon which is predominantly within the matrix and present as a wide variety of organic materials including soluble molecules and kerogen-like insoluble organic matter (IOM). Most studies of organic matter (OM) in chondrites focus on residues extracted through acid digestion of the sample, which leads to a loss of spatial information and potential damage to the OM. The loss of spatial information limits our understanding of the relationship between the mineralogy and organic materials in carbonaceous chondrites. In this study we have used *in situ* transmission electron microscopy (TEM), scanning transmission X-ray microscopy (STXM) and X-ray absorption near edge structure (XANES) spectroscopy to explore the spatial relationships between mineralogy and organic matter in the matrix of the primitive CO3 carbonaceous chondrites DOM 08006 (3.0), NWA 7892 (3.05) and MIL 090010 (3.1).

The matrix in DOM 08006 consists of an amorphous groundmass embedded with ~0.1 μm silicate, sulphide, metal and phyllosilicate grains. While DOM 08006 appears fairly featureless, NWA 7892 and MIL 090010 are "fluffy" in nature. C K-edge XANES spectra from these three samples show the presence of diffusely distributed C-rich regions with characteristic functional group chemistries. The spectra are all characterized by the presence of aromatic C, ketone and carboxyl species, with traces of carbonate possibly present in some areas. The relative intensities of these features and the presence of other C species vary depending on their location within the sample. N K-edge spectra showed no absorption features sufficient for assigning functional groups. It is likely that the OM is present in the form of inter-grain carbonaceous material as well as distinct carbonaceous sub-grains, with the functional chemistry of these forms influenced by the mineralogical environment. The grain-scale variation is much greater than that seen in bulk acid extracted IOM.