Transmission electron microscopy of iron metal in Almahata Sitta ureilite

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Almahata Sitta (AS) is a polymict breccia mainly composed of various ureilite lithologies with lesser chondritic lithologies [1]. Fe metal is a common accessory phase in ureilites, but our earlier studies on Fe metals in one of AS fragments (#44) revealed unique features never seen in other ureilites [2,3]. In this abstract we report detailed transmission electron microscopy (TEM) on these metal grains to better understand the thermal history of ureilites.

We prepared FIB sections of AS#44 by JEOL JIB-4000 from the PTS that was well characterized by SEM-EBSD in our earlier studies [2,3]. The sections were then observed by STEM (JEOL JEM-2100F).

One of the FIB sections shows a submicron-sized intergrown texture composed of Fe metal (kamacite), Fe carbide (cohenite), Fe phosphide (schreibersite), and Fe sulfide (troilite). Probably, this eutectic-looking texture was formed by shock re-melting of pre-existing metal + graphite + phosphates (phosphide?) + sulfides with various amounts.

The other FIB section is mostly composed of homogeneous Fe metal (93 wt% Fe, 5 wt% Ni, and 2 wt% Si), but BF-STEM images exhibited the presence of elongated lathy grains (~2 μm long) embedded in an interstitial matrix. The SAED patterns from these lath grains could be indexed by α-Fe (*bcc*) while interstitial areas are γ-Fe (*fcc*). The elongated α-Fe grains show tweed-like structures suggesting martensite transformation. Such a texture can be formed by rapid cooling from high temperature where γ-Fe was stable. Subsequently α-Fe crystallized, but γ-Fe remained in the interstitial matrix due to quenching from high temperature. Presence of C may have enhanced its stability. This scenario is consistent with very rapid cooling history of ureilites suggested by silicate mineralogy.

[1] Zolensky *et al.* (2010) *MAPS*, **45**, 1618-1637. [2] Goodrich *et al.* (2010) *MAPS,* **45**, A66. [3] Mikouchi *et al.* (2011) *MAPS*, **46**, Suppl.,5409.

Structure of Amorphous Ferric Arsenate from EXAFS Spectroscopy and Total X-ray Scattering

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Amorphous ferric arsenate (‘AFA’, $FeAsO_4 \times nH_2O$) is a secondary As precipitate frequently encountered in acid mine-waste environments. Its structure has been proposed to resemble that of scorodite ($FeAsO_4 \times 2H_2O$) in which isolated FeO_6 octahedra share corners with four adjacent arsenate (AsO_4) tetrahedra in a three-dimensional framework (framework model). Conversely, AFA was postulated to consist of single chains of corner-sharing FeO_6 octahedra being bridged by arsenate (chain model). In order to test the accuracy of both structural models, we synthesized AFAs and analyzed their structure by As and Fe *K*-edge extended X-ray absorption fine structure (EXAFS) spectroscopy and total X-ray scattering. We found that both As and Fe *K*-edge EXAFS spectra were most compatible with isolated FeO_6 octahedra being bridged by AsO_4 tetrahedra ($R_{\text{Fe-As}} = 3.33 \pm 0.01$ Å). Wavelet-transform analyses of the Fe *K*-edge EXAFS spectra of AFA complemented by shell fitting confirmed Fe atoms at an average distance of 5.3 Å, consistent with crystallographic data of scorodite and in disagreement with the chain model. Reduced pair distribution functions, $G(r)$, provided unequivocal evidence for the absence of single corner-sharing FeO_6 linkages in AFA. Analyses of radial distribution functions, $R(r)$, additionally indicated that in AFA each As atom has on average about four nearest Fe neighbors, in accordance with the framework model. In summary, our findings imply that scorodite formation from AFA in mining environments proceeds via growth of small clusters with a scorodite-type local structure.

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