Transmission electron microscopy of iron metal in Almahata Sitta ureilite

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Almahata Sitta (AS) is a polymict breccia mainly composed of variable ureilite lithologies with small amounts of chondritic lithologies [1]. Fe metal is a common accessory phase in ureilites, but our earlier study on Fe metals in one of AS fragments (#44) revealed a unique mineralogy 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 study [2]. The sections were then observed by STEM (JEOL JEM-2100F).

One of the FIB sections shows a submicron-sized symplectic intergrown texture composed of Fe metal (kamacite), Fe carbide (cohenite), Fe phosphide (schreibersite), and Fe sulfide (troilite). Each phase has an identical SAED pattern in spite of its complex texture, suggesting co-crystallization of all phases. This is probably caused by shock re-melting of pre-existing metal + graphite to form a eutectic-looking texture. 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 the 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. 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] Mikouchi *et al.* (2011) *MAPS*, **46**, Suppl.,5409. [3] Goodrich *et al*. (2010) *MAPS*, **45**, A66.