HAXONITE FROM 25143 ITOKAWA AND ITS IMPLICATIONS FOR METAMORPHIC PARENT BODY FLUIDS.

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Introduction: In 2003 the Japan Aerospace Exploration Agency (JAXA) launched the Hayabusa spacecraft to rendezvous with the S-type near-Earth asteroid 25143 Itokawa. In 2005 the probe landed on the asteroid and collected regolith samples which were successfully returned to Earth in 2010. After NASA's Apollo missions to the Moon this was only the second time that samples were collected on the surface of an extraterrestrial body and brought back to Earth.

We received two samples of the typically <100 µm sized regolith particles collected. The particle RA-QD02-0115 had a size of 65 µm x 50 µm and was dominantly composed of olivine with abundant inclusions of Fe,Ni metal, troilite, chromite and merrillite. We sliced the particle into eight subsamples via the focused ion beam (FIB) method and extensively studied four of these samples by analytical transmission electron microscopy (TEM).

Results: The mineral chemistry of olivine yielded a fayalite content of 29.8±1.1 mol% and a molar Fe/Mn ratio of 57±2, both consistent with an equilibrated LL-type chondritic material, which was previously reported for other particles [1]. FIB slicing revealed abundant, mostly sub-µm sized voids within the particle.

The metal inclusions are often polyphase and consist predominantly of tetrataenite which is intergrown with taenite and kamacite, the latter being Co-rich (up to 6 at%). For the first time, we were able to detect the carbide haxonite, ideally $Fe_{23}C_6$, in samples returned from 25143 Itokawa. Haxonite occurs as grains of up to 0.5 µm size and is associated with the metallic phases. The interface between haxonite and tetrataenite/taenite is semi-coherent and the cubic (base-)lattices share the same crystallographic orientations.

Discussion: Haxonite has been described from unequilibrated type 3 ordinary chondrites, commonly in association with magnetite (carbide-magnetite assemblages, CMAs). These assemblages are interpreted to have formed from C-H-O-bearing, oxidizing fluids [2]. The high FeO content of olivine in RA-QD02-0115 and no detectable CaO suggest a petrologic type >3. The abundance of voids indicates the presence of a fluid during thermal metamorphism, but the absence of magnetite implies different conditions relative to type 3 CMAs. Using *ab initio* estimates of the Gibbs energy functions of Fe carbides [3], we explore the possible range of fluid compositions.

References: [1] Nakamura T. et al. 2011. *Science* 333:1113–1116. [2] Krot A. N. et al. 1997. *Geochimica et Cosmochimica Acta* 61:219–237. [3] Djurovic D. et al. 2011. *CALPHAD* 35:479–491.

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