FORMATION OF NEEDLES AND WHISKERS DURING OXIDATION OF THE GIBEON IVA IRON METEORITE.

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Introduction: We extended our prior study [1] of Gibeon iron meteorite metal oxidation to higher temperatures and higher oxygen fugacities. During this work we observed formation of Fe oxide blades, needles, and whiskers, which are described below.

Experimental Methods: Gibeon meteorite metal filings and foils were heated in dry air at several temperatures between 728 K and 1173 K. All samples were weighed before and after reaction to determine extent of oxidation. The samples were further examined by optical microscopy, x-ray diffraction, electron microprobe analysis, and scanning electron microscopy to characterize the oxide products.

Results and Discussion: All reacted samples consist of a duplex oxide layer overlaying unreacted metal. The oxide layer consists of an outer layer of hematite and an inner layer of magnetite spinel.

The oxidized samples in the present study display features similar to those of oxidized iron-nickel synthetic alloys [2-4]. For example, no wüstite has been detected in any of our oxidation products, and magnetite spinel is always the oxide in contact with the metal. Nickel is greatly enriched in the metal (up to 65 wt %) near the oxide-metal interface, and is present in significant amounts in the magnetite layer, forming a $Ni_xFe_{3-x}O_4$ spinel ($0 < x \leq 0.8$). Cobalt shows a similar pattern of enrichment in the metal (up to 2 wt %) and is also present in the spinel.

The kinetics most closely follow diffusion-controlled, parabolic kinetics. The nickel enrichment serves to reduce the oxidation rate [1] and to suppress the formation of wüstite [2,5].

Upon examination of the oxide layer, blades, needles, and whiskers of various morphologies were discovered. A scanning electron micrograph of some of these structures is in Figure 1. The needles are reddish in color and have typical diameters of <1 µm to a few µm and lengths up to ~50 µm. They appear to grow from the surface directly out of the outer hematite layer, and consist of α-Fe_2O_3. Earlier studies of similar structures formed on iron [6,7] suggest a screw dislocation mechanism of formation.

We will use our results and literature data to discuss constraints on formation conditions of the blades, needles, and whiskers and possible implications for nebular chemistry.

References:
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Figure 1. Secondary electron image of external oxide surface of sample heated at 973 K for 660 hours. The image frame is 61.9 • m across.