FORMATION OF NEEDLES AND WHISKERS DURING OXIDATION OF THE GIBEON IVA IRON
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Introduction: We extended our prior study [1] of Gibeon iron meteorite metal oxidation to higher tem-
peratures and higher oxygen fugacities. During this work we observed formation of Fe oxide blades, nee-
dles, and whiskers, which are described below.

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

Results and Discussion: All reacted samples con-
sist 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 syn-
thetic alloys [2-4]. For example, no wüstite has been
detected in any of our oxidation products, and magnet-
ite spinel is always the oxide in contact with the metal.
Nickel is greatly enriched in the metal (up to 65 wt %)
early the oxide-metal interface, and is present in sig-
ificant amounts in the magnetite layer, forming a
Ni\(_{x}\)Fe\(_{1-x}\)O\(_{4}\) spinel (0 < x ≤ 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, nee-
dles, and whiskers of various morphologies were dis-
covered. 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\(_{2}\)O\(_{3}\). 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 dis-
cuss constraints on formation conditions of the blades,
needles, and whiskers and possible implications for
nebular chemistry.

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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.