MAGNETITE WHISKERS AND PLATELETS IN THE ALH84001 MARTIAN METEORITE: EVIDENCE OF VAPOR PHASE GROWTH. John P. Bradley[1], Ralph P. Harvey[2], and Harry Y. McSween, Jr.[3], [1]MVA Inc., 5500/200 Oakbrook Parkway, Norcross, GA 30093; [2]Department of Geological Sciences, Case Western Reserve Univ., Cleveland, OH 44106; [3]Department of Geological Sciences, Univ. of Tennessee, Knoxville, TN 37996.

Carbonate globules in the ALH84001 meteorite have previously been suggested to contain evidence for martian life [1]. Brightfield and darkfield TEM images of these carbonates reveal nanometer-sized magnetite crystals with distinctive morphologies and internal dislocations implicating growth from a high-temperature vapor phase [2], consistent with previous suggestions that the carbonates formed at high temperatures [3, 4] The magnetite whiskers and platelets are apparently the nanofossils described by [1]

Magnetite "whiskers" (filamentary rods and ribbons) and "platelets" are mixed with more equant magnetite crystals. The crystals are ubiquitous throughout the globules, including the magnetite- and sulfide-rich rims. Rods and ribbons up to 150 nm in length with aspect ratios of 5–10 are elongated along [111] and [100] directions. Rods have rounded and ovoid cross sections, whereas ribbons are blade-like with sawtoothed edges. Some rods contain microstructural defects indicating spiral growth about screw dislocations (Fig. 1). Burgers vectors calculated from SAED patterns indicate offsets of ~1 unit cell across the screw dislocations [2]. Some ribbons appear to be defect-free, whereas others contain multiple dislocations. Platelets are tabular with outlines that can be square, rounded, or irregular.

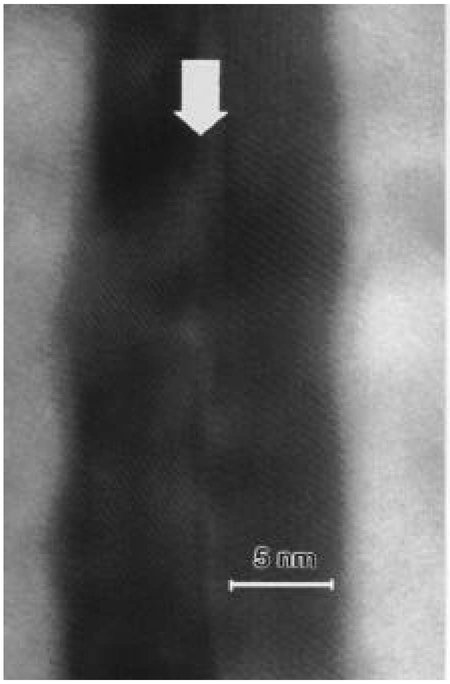
Whiskers and platelets both with and without dislocations are typical of minerals condensed directly from vapors or supercritical fluids. Whisker and platelet morphologies are not a requirement for vapor phase growth, but their presence at any abundance is a key fingerprint of this process [5,6]. Natural whiskers are usually found mixed with a variety of morphologies which include platelets and equant crystals. They have been reported in volcanic fumeroles and hydrothermal deposits [5], within vugs in lunar breccias [6], and in IDPs [7].

Much of the nanophase magnetite in ALH84001 may have condensed during episodes of vapor or fluid injection, although other magnetite appears to have formed *in-situ* by (thermal?) oxidation of Fe sulfides. The variety of magnetite morphologies and microstructures in the carbonates is in accordance with other observations of vapor phase condensates [5,6]. Particularly instructive is an experiment conducted by inserting a tube into an active fumarole [5], in which tiny magnetite whiskers condensed at the high-temperature (£800^{O}C) end. This observation is consistent with condensation temperature calculations (>500^{O}C) for magnetite in fumarole gases [8].

The high temperatures suggested for formation of these minerals are inconsistent with biominerals. Terrestrial biogenic magnetites are single-domain crystals, less elongated than the whiskers, and occur as chains held together by lipid membranes. The sizes and morphologies of the whiskers and platelets resemble those of "elongated and ovoid forms" in ALH84001 previously described as nanofossils [1], and we have observed no other nanoparticles with similar shapes. Some magnetite whiskers appear to have twisted growth forms, as observed in other vapor-deposited minerals. We also observe fields of oriented whiskers (Fig. 2), which are similar to published SEM images of nanofossils. Although the sizes and single-domain structures of some equant magnetites in ALH84001 may be similar to biogenic magnetite, their intimate association with whiskers argues that they too are simply vapor phase condensates.

References: [1] McKay D. S. et al. (1996) *Science* 273, 924. [2] Bradley J. P. et al. (1996) *GCA* 60, in press [3] Mittlefehldt D. W. (1994) *Meteoritics* 29, 214. [4] Harvey R. P. and McSween H. Y. (1996) *Nature* 382, 49. [5] Symonds R. (1993) *Geochem. J.* 26, 337. [6] McKay, D. S. et al. (1972) LPSC 3rd, 739. [7] Bradley J. P. et al. (1983) *Nature* 301, 473. [8] Quisefit J. P. et al. (1989) *GCA* 53, 2591.

EVIDENCE OF VAPOR PHASE GROWTH. J. P. Bradley[1], R. P. Harvey[2], and H. Y. McSween, Jr



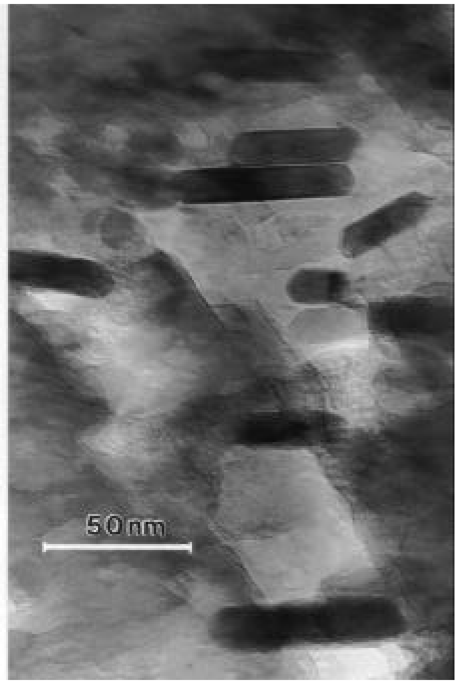


Fig. l. (left): High-resolution lattice-fringe image a magnetite whisker containing axial screw dislocation. Arrow indicates position of screw axis. Note the change in orientation of lattice fringes across the screw dislocation and banded surface relief (most pronounced along left edge of whisker).

Fig. 2. (right): Brightfield image of a “school” of oriented magnetite whiskers (part of a group of ~20) resembling an often-published SEM image of “nanofossils”.