Crystal structural modifications in U-rich, oscillatory-zoned hematite

C.L. CIOBANU[1,*], A.SLATTERY[1], M.VERDUGO-IHL[1], L. COURTNEY-DAVIES[1], N.J. COOK[1], K.EHRIG[2]

[1] The University of Adelaide, SA 5005, Australia (*correspondence: cristiana.ciobanu@adelaide.edu.au; ashley.slattery@adelaide.edu.au; max.verdugoihl@adelaide.edu.au; liam.courtney-davies@adelaide.edu.au; nigel.cook@adelaide.edu.au)

[2] BHP Olympic Dam, Adelaide SA 5000, Australia (Kathy.J.Ehrig@bhpbilliton.com)

Hematite, (α-Fe_2O_3; rhombohedral) is the most common phase among the five Fe_2O_3 polymorphs [1]. Hematite from U-rich deposits is shown to incorporate this element up to several wt.% UO_3 [2,3]. This is commonly associated with a more complex signature comprising radiogenic Pb, W, Sn, and Mo and expressed in crystals with pronounced oscillatory zoning. TEM study of FIB-prepared foils extracted from high-U grains has shown crystal structural modifications interpreted as vacancy-induced supertructures [2].

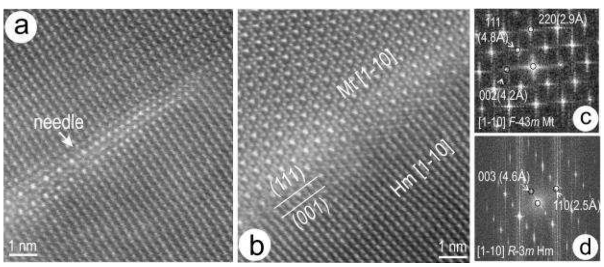

Fig. 1. HAADF-STEM images of atom-wide (a) and tens of nm-wide (b) magnetite (Mt) needles in U-rich hematite. (c, d) FFTs obtained from hematite (Hm) and Mt in (a) and (b), respectively. Images obtained at 200 kV (Titan Themis; Adelaide Microscopy).

HAADF-STEM imaging shows modification of the crystal lattice from [1-10] rhombohedral to [1-10] cubic across domains nm- to tens of nm wide (Fig. 1). TEM-STEM mapping shows these domains are Fe-richer and O-poorer relative to matrix hematite, suggesting these represent nm-scale needles of magnetite (Fe_3O_4) instead of cubic (β-, γ-) Fe_2O_3 polymorphs. Such needles are not found in high-W (up to several wt% WO_3) or low-U (up to thousands of ppm U) hematite. Results suggest that such magnetite needles occur at the upper U solubility limit in the U-bearing hematite lattice. This is most significant for understanding reliability of such grains for high-precision U-Pb dating.

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