THE MINERALOGY OF THE EL ALI IAB IRON: CONDITIONS OF FORMATION

Christopher D.K. Herd[1], Andrew J. Locock[1], Radhika Saini[1], and Chi Ma[2]. [1]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E3, Canada. Email: herd@ualberta.ca [2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125.

Introduction: The El Ali meteorite is a 15.2 ton iron meteorite from Somalia, originally known by camel herders and others in the region as "Nightfall" [1]. Further insights into the history of this significant meteorite are provided in [2, 3]. The meteorite belongs to the IAB Complex as defined by [4] – a group that spans a diversity of bulk compositions and that is typified by silicate or other inclusions. IAB irons may have formed by melting due to impact heating on a porous chondritic body [4].

Detailed study of phosphate inclusions in El Ali revealed the occurrence of at least three new minerals. Analysis by EPMA (University of Alberta) and by SEM-EBSD (Caltech) on specimen MET11814/2-1/EP1 of the University of Alberta Meteorite Collection revealed the occurrence, and enabled the description of: elaliite ($Fe^{2+}{}_8Fe^{3+}(PO_4)O_8$, IMA 2022-087), elkinstantonite ($Fe_4(PO_4)_2O$, IMA 2022-088) [5], and olsenite ($KFe_4(PO_4)_3$, IMA 2022-100) [6]. Details of elaliite and elkinstantonite can be found in [7]; olsenite is described in [8]. Here, we discuss the origin of these minerals and the implications of their occurrence for the petrogenesis of the El Ali meteorite.

Occurrence: Elaliite, elkinstantonite and olsenite occur along with wüstite, troilite, sarcopside and Ca-bearing graftonite within inclusions in El Ali. Most inclusions are ~100 µm across, although larger, mm-scale inclusions have the greatest mineralogical diversity (Figure 1). In larger inclusions, elaliite typically occurs as ~10 x 50 µm euhedral elongate laths at the interfaces of troilite±wüstite and graftonite-rich areas (Fig. 1). Graftonite-rich areas also contain <5 µm grains of Si-bearing sarcopside, elaliite and troilite. In smaller (<200 µm) inclusions, elaliite occurs with troilite set in a matrix of sarcopside/graftonite [7]; this is also the typical setting for olsenite [8]. Elkinstantonite has thus far only been found in smaller inclusions, as subhedral grains associated with troilite+wüstite symplectites, troilite, and elaliite. Minor terrestrial alteration extends along fractures and grain boundaries; this is consistent with the specimen being taken from the exterior of the meteorite. The identification of magnetite [7] is currently being reassessed.

Implications: The mineralogy of El Ali reflects a diversity of iron valence states, from Fe^0 (Fe-Ni metal), to Fe^{2+}-dominant minerals (troilite, wüstite, graftonite/sarcopside, olsenite and elkinstantonite) to mixed Fe^{2+}-Fe^{3+} elaliite. These reflect varying relative proportions of Fe, S, P, K, Ca, and O in a low-oxygen fugacity system.

The textures and mineralogy of the large inclusions suggest the crystallization of two immiscible phases in the Fe-S-O system during cooling, represented by troilite and wüstite symplectites on the inclusion margins (Fig. 1). This was followed by crystallization of an O-rich (S-poor) melt – represented by the inclusion interiors, dominated by graftonite, and containing elaliite and Si-bearing sarcopside. The presence of Si in the sarcopside may suggest coupled substitution of Si^{4+} for P^{5+}, enabling Fe^{3+} for Fe^{2+}; in this way, the sarcopside may also contain mixed-valence Fe. This substitution has yet to be quantified.

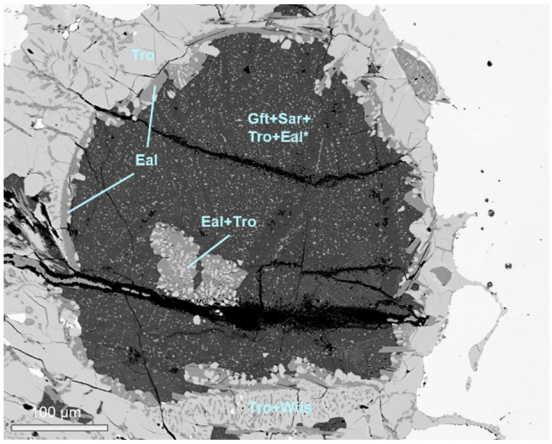

Figure 1. BSE image of an inclusion in El Ali showing troilite-wüstite symplectites (Tro+Wüs), wüstite-free troilite (Tro), elaliite (Eal), and graftonite (Gft)-sarcopside (Sar)-troilite-elaliite intergrowths.

Elaliite appears to have nucleated at the interface of the S-rich and O-rich melts, presumably where the O (and thus Fe^{3+}) content was highest. In smaller (<200 µm) inclusions there is a similar occurrence of troilite±wüstite and elaliite at the margins of the inclusions. In this case, however, elkinstantonite appears to form instead of graftonite/sarcopside. Notably, elkinstantonite and graftonite are similar in composition, with the only difference being that elkinstantonite has one additional "FeO" per unit formula.

Acknowledgements: Funding was provided by Natural Sciences and Engineering Research Council of Canada grant RGPIN-2018-04902 to CDKH. We thank the Nick Gessler (Duke Univ.), and numerous contacts within Somalia and elsewhere for providing access to the material used in this research.

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