

THE EVOLUTION OF THE IAB IRON–WINONAITE PARENT BODY AS TOLD BY APATITE.

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Introduction: Primitive achondrites and iron meteorites accreted between time zero of the solar system (4567.30 ± 0.16 Myr, [1]) and the accretion of planetary embryos (e.g., [2-3]). These meteorites provide valuable archives of incipient metal-silicate separation and core formation on small bodies (e.g., [4]), record the effects of partial melting within planetary interiors and crusts [5], and provide information about the nature of the precursor materials to the planets. Based on identical oxygen isotope compositions (e.g., [6]) and similar mineralogy, mineral compositions, and textures (e.g., [7]) it is believed that the winonaites and silicate inclusions in IAB iron meteorites originated from a common parent body (hereafter the IAB-W parent body), with the IABs being products of metal-silicate differentiation and winonaites residues left behind from partial melting of their parent body. The post-accretion history of the IAB-W parent body is complex and lacks consensus, but likely involved combinations of partial melting, collisional break-up, reassembly, fractional crystallization, and thermal metamorphism (e.g., [7-8]). Ascertaining the character and evolution of volatiles (H, F, Cl, S) in primitive achondrites is essential for building a complete picture of how parent body processes affected volatiles and from which sources those volatiles arrived in the inner solar system. Here we present our initial findings of Caddo County; a IAB silicate-bearing iron meteorite.

Sample and Methods: A thin section of Caddo County was acquired from the Institute of Meteoritics (IOM) at the University of New Mexico (#IOM 937). A JEOL 7600F scanning electron microscope (SEM) at NASA JSC was used to perform full-section energy dispersive X-ray spectroscopy (EDS) and backscattered electron (BSE) mapping. Hotspots of P and Ca were identified from the X-ray maps and were studied as regions of interest using BSE imaging and EDS. Imaging allowed for textural analysis and EDS permitted phase identification. A JEOL 8530F electron microprobe analyzer (EPMA) at NASA JSC was used to determine the chemical composition of phosphates using protocols outlined in [9]. A CAMECA nanoscale secondary ion mass spectrometer (NanoSIMS 50L) at NASA JSC was used to measure Cl isotopes during two analytical sessions (2019 and 2021) following protocols in [10].

Results: The inclusion studied in Caddo County is angular and silicate rich. Apatite ($\text{Ca}_5(\text{PO}_4)_3(\text{F}, \text{Cl}, \text{OH})$) occurs in three textural settings in Caddo County – as inclusions in metal-sulfide veins (crystal length 50–100 μm); at the terminus of metal-sulfide veins (up to 750 μm in length); and as crystals (up to ~1mm in length) containing silicate inclusions that are associated with metal-sulfide veins. The chemical composition of apatite ranges from 0.62–1.00 apfu F, up to 0.12 apfu Cl, and up to 0.31 apfu missing component. Ce_2O_3 and Y_2O_3 are at or below detection. The Cl isotopic composition of apatite ranged from ~+4 to +9 ‰, with an average of $+7 \pm 1.5 \pm \%$ (SD).

Discussion: The chemical composition of apatite is similar to that reported by [11]. The Cl isotope compositions are fractionated compared to bulk chondrites and are like those reported from ungrouped achondrite Graves Nunataks (GRA) 06128 [12] and eucrites [13]. In addition, the Cl isotopic values for Caddo County are more ³⁷Cl-rich than the bulk-rock Cl isotope compositions reported by [14] for magmatic IAB irons. Gargano and Sharp [14] suggested that the $\delta^{37}\text{Cl}$ values measured (ca. –4 to –6‰) reflected a nebular source of chlorine. Our results on the other hand, suggest it is possible that parent body processes could have (i) produced the F-rich apatite compositions and (ii) fractionated the isotopes of chlorine. Our study of Caddo County will be complemented by H isotope data and will be compared to the forthcoming isotope data from [11] on both winonaites and IAB irons.

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