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An X-ray and electron microprobe study of Fe, Ni, Ga, and Ge distribution and local structure in a section of the Canyon Diablo iron meteorite

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Abstract

Using X-rays produced by a third generation synchrotron at the Pacific Northwest Consortium Collaborative Access Team (PNC-CAT), Advanced Photon Source (APS), Argonne National Laboratory, the distribution of Fe, Ni, Ga, and Ge in a sample of the Canyon Diablo iron meteorite has been mapped microscopically in situ with a 5 μm × 5 μm spatial resolution. The principal phases investigated were kamacite (αFe/Ni alloy, <6 wt% Ni), cohenite [a carbide, $(Fe,Ni,Co)_3C$], and schreibersite [a phosphide, $(Fe,Ni)_3P$]. A non-microscopic X-ray absorption analysis at the P edge indicated the presence of both phosphide and phosphate in the sample. Extended X-ray absorption fine structure (EXAFS) analysis of Fe in kamacite reflects the known bcc structure of kamacite. EXAFS analysis of Ni, Ga, and Ge indicates that these elements substitute for Fe within the kamacite bcc structure. Absorption edge shifts for these same elements are generally small relative to the metals themselves, suggestive of a metallic environment. Initial findings also suggest that Ga preferentially partitions into schreibersite (phosphide) rather than cohenite (carbide), whereas Ge behaves differently and is found principally in the kamacite. These observations further the understanding of the Ge and Ga budget within the Canyon Diablo meteorite, and the work also illustrates the potential of the X-ray microprobe technique for the study of meteorites. Other potential uses of the X-ray microprobe are indicated.