Distribution and Speciation of Minor and Trace Elements in Iron Meteorites

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Introduction

Meteorites are extraterrestrial samples of the solar system. Knowledge of their elemental compositions from bulk analyses has provided understanding about the origin of the Earth itself. Iron meteorites represent a major class of meteorites, which can be further classified into 13 groups on the basis of structure and Ga, Ge, and Ni content.[1,2] Detailed knowledge of the concentrations of these indicator elements and their spatial distribution at microns scale should lead to a greater understanding of the conditions of their formation. Herein x-ray microscopic examination of a specimen of the Canyon Diablo meteorite, focused on the distribution and speciation of gallium and germanium relative to the major elements iron and nickel, was undertaken. XAFS spectra were collected at selected points on the sample.

Methods and Materials

The measurements were performed on the PNC-CAT undulator beamline (20-ID-B) with a focusing KB mirror pair producing a spot size of approximately 5 μm. X-ray fluorescence signals were collected with a 13-element Ge (Li) detector (PGT), attenuated with aluminum foils to reduce the iron signal. The sample was a previously prepared electron microprobe mount of Canyon Diablo, which belongs to Group IAB of iron meteorites.

Results and Discussion

Previous analyses reported the presence of several minor and trace elements with Ga averaging 80 ppm and Ge 330 ppm.[1,2] Optical examination of the specimen reveals two visually distinguishable phases or minerals (Fig. 1). Our electron microprobe examination of the specimen (using spot sizes of 5-10 μm) revealed the presence of three phases; the matrix, a P-bearing inclusion, and a rim around the inclusion, but we were unable to detect Ga or Ge. The PNC x-ray fluorescence microprobe was used to map the distribution of Ga, Ge, Ni and Fe in the area outlined by the box in Fig. 1, an area containing all three major phases. The distributions are shown in Fig. 2, displayed as false-color gradient maps. This refined spatial resolution should provide better interpretations of the cooling history of iron meteorites.

FIG. 1. Two areas on Canyon Diablo specimen chosen for x-ray microprobe analysis.

XAFS traces were collected at four spots; representative matrix, representative inclusion, and two spots (A and B) that showed unusual concentrations of Ni, Ga, or Ge. The preliminary Ni XAFS spectra indicate a difference in the local environment around the Ni matrix, rim, and inclusion areas. The Ni, Ga, and Ge K-edge shifts up to 10 eV also indicate differences in environment and character. Further analysis of the entire set of data is in progress. Future studies will investigate other minor and trace elements in Canyon Diablo and in other iron meteorites.

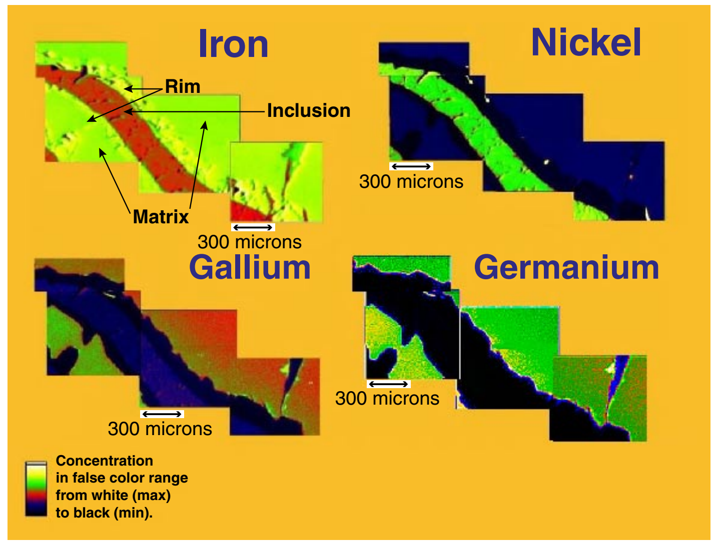

FIG. 2. Element distribution across the selected area on Canyon Diablo. Concentration ranges are displayed in a false-color scale which ranges from white (max) to black (min).

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