METAL-CARBIDE ELEMENTAL PARTITIONING IN IRON METEORITES

A. Gangopadhyay, M. Humayun, R.E. Goddard (FSU, NHMFL & Geological Sciences)

Introduction

Iron meteorites are fragments of asteroids that were once hot enough to have undergone melting in the early solar system. The chemical composition of the metal phase in iron meteorites is used to classify irons into 13 major groups, with many minor grouplets and ungrouped meteorites. Iron meteorites are rich in alloyed Ni (5-18%), so that the metallic phase exsolves into two co-existing Fe-Ni alloys: a bcc-phase with Ni<8% (kamacite) and an fcc-phase with higher Ni (taenite). In addition to iron metal, other phases that may be present include Fe-sulfide, Fe-phosphides, Fe-carbide (cohenite), chromite, phosphates and silicates. Iron meteorites crystallized from a Fe-Ni-X liquid, where X=S, C, and/or P. There are many trace elements present in the liquid, and those that prefer iron metal are termed siderophile (iron-loving). The partitioning of siderophile elements in iron metal is strongly influenced by the amount of S in the liquid. Recent experiments have shown that C in the liquid can perturb that pattern. Elements that prefer a Fe-C liquid were termed anthracophile (from Greek, carbon-loving) by Chabot et al. (2005).

The influence of C on the partitioning of siderophile elements in natural iron meteorites has not been documented. In this study, we have determined the concentrations of 19 elements in cohenite [$(Fe, Ni, Co)_3C$] and host metal (kamacite) in two IAB iron meteorites (Canyon Diablo and Odessa), using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). These two samples were selected because of their high C contents (up to ~10 mg/g) and abundant relatively large crystals of cohenite (up to ~ 1mm) that facilitated precise determination of concentrations of these elements.

Analytical Techniques

Polished meteorite slabs were imaged by environmental scanning electron microscopy using an ElectroScan E-3 at the Microanalysis Facility of the NHMFL. Cohenite was identified via quantitative analysis of Fe and Ni. Cohenite crystals ~1mm or larger were selected for LA-ICP-MS analyses. A CETAC LSX-200™ (266 nm frequency-quadrupled Nd-YAG) UV laser ablation system coupled to a Finnigan Element ICP mass spectrometer (NHMFL) was used for the analyses. A 10 Hz pulsed laser beam with a diameter ~ 50 µm, scanned over the surface at 10 µm/s, was used to ablate the sample, and the aerosol was transported to the Element with Ar gas. A line scan of ~1mm length was performed for each analysis of a cohenite-kamacite pair. Standardization was accomplished via analyses of two natural iron meteorites (Hoba and Filomena), using values from Campbell et al. (2002).

Results, Discussion, and Conclusions

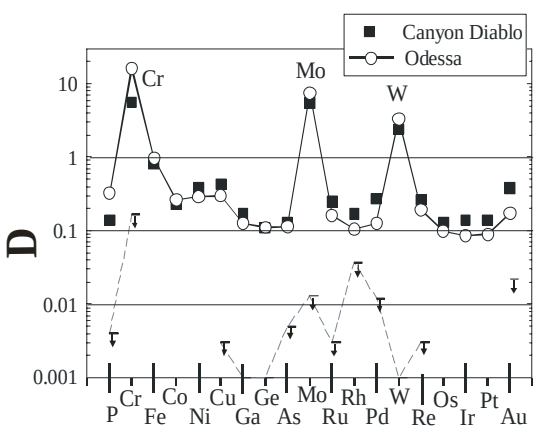

Fig. 1. Plot of partition coefficients (D) of elements between cohenite and kamacite determined for the Canyon Diablo and Odessa iron meteorites. The grey dashed line connects the estimated detection limits (arrows).

Our results (Fig. 1) show that Cr, Mo and W exhibit relatively strong anthracophile behavior in solid state partitioning between iron carbide (cohenite) and bcc-iron (kamacite). These results extend the experimental results of Chabot et al. (2005) to the solid state and to lower temperatures for the Fe-Ni-C system. The stable metal carbides of Cr, Mo and W are known. No other trace elements exhibited anthracophile behavior. Our results demonstrate for the first time that Cr, Mo and W can be fractionated from other siderophile elements in the presence of C during the cooling of natural iron meteorites.

References

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