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Application of SR-XRF to trace element analysis of iron-type cosmic spherules

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Introduction

Iron-type (I-type) spherules are extraterrestrial material smaller than 1mm on the Earth, and are completely melted by frictional heating in the upper atmosphere. Their mineral assemblages and major-element abundances are simple: Fe-oxides are predominant and occasionally Fe-Ni metal occurs as a metal core. One possible precursor is iron meteorites, which consist of Fe and small amount of Ni. Evidence of formation of I-type spherules from iron meteorites can be limited, due to simple mineralogy and major elemental chemistry. Therefore, the origin and the formation process can be elucidated from signature of trace element abundances. However, there have been only a few reports on analyses of trace elements [1, 2]. Trace element (Cr, Ni, Co, Ga, and Ge) abundances of I-type spherules and an ablation product of Odessa IA iron meteorite, which simulates formation of I-type spherules from iron meteorites were analyzed by X-ray Fluorescence method using Synchrotron Radiation (SR-XRF).

Experiments

Trace element analysis of the samples was performed using a white X-ray microbeam with a beam size approximately 1 mm x 1 mm at the beamline 4A. The samples were attached to nucleopore filters using a acetone-soluble bond. The background concentrations of the trace elements were measured and confirmed to be very low in the pore filters and bond. Odessa meteorite, whose trace element concentrations are well known, have been used for standard samples in analysis of the I- type spherules and the ablation products. X-ray fluorescence from samples were reflected by (001) planes of a single graphite crystal and detected by a position sensitive proportional counter. Quantitative concentrations of the trace elements were obtained through X-ray intensity calibrations between samples and standards and X-ray absorption corrections for differences in surface areas and material matrix of the samples. Major elements concentrations (Fe and Ni) were determined by electron probe microanalyzer.

Results

SR-XRF analyses on 43 spherules showed that Cr and Co were detected from all spherules and concentrations are 700 and 200 ppm in average and range up to 9000 and 500 ppm, respectively. Both Ga and Ge were detected from 8 samples and average concentrations of these samples are 20 and 15 ppm, respectively. The elemental abundances of the spherules were normalized to Cape York IIIAB iron meteorite, that is the largest group in iron meteorites, and decreases in the order of Cr, Ni, Co, Ga, and Ge. Cr are detected in all samples and shows large excess up to 1000. For Co and Ni, abundance in the spherules seems slightly lower than that in Cape York, and it scatters from 0.01 to 1. Ga and Ge abundances are apparently lower in the spherules than in Cape York. Volatilities of these elements and oxides at temperatures at temperatures over 1650 K are in the order of Cr_2O_3 < Ni ~ Co < Ga_2O_3 < GeO_2 and this volatility trend shows a good agreement with relative elemental abundance trend of trace element concentration in I-type spherules, suggesting that the spherules have lost elements by vaporization and the degree of losing is proportional to the volatilities of elements (Fig.1). An ablation product

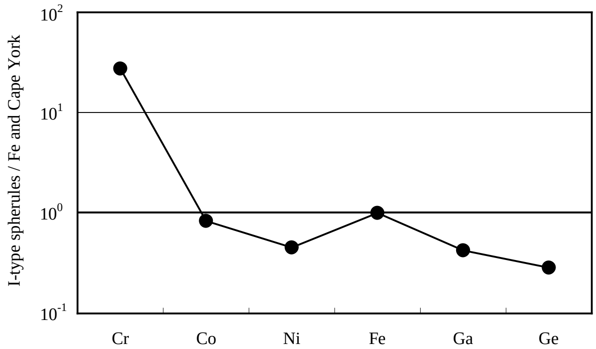

Fig. 1. Trace element abundances in I-type spherules normalized to Fe and CapeYork iron meteorite.

of Odessa have metallic core and oxide mantle that is similar to I-type spherules. Trace element analysis showed that the oxide mantle is enriched in Cr and depleted in Ni, Co, and Ge compared to the metal core. These elemental fractionations between metal core and oxide mantle are similar to those observed in the I-type spherules with metal core.

Refferences

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