Intra-chondrite Elemental Variations of Fine-grained Matrices in Carbonaceous Chondrites.

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Introduction:

Fine-grained matrix materials are susceptible to the effect of aqueous alteration and thermal metamorphism. The variations of chemical composition of fine-grained minerals thought to reflect the degree of aqueous alteration [e.g. 1]. However, elemental redistributions are still controversial.

We have observed variations of chemical composition of fine grains (<~μm) in matrices among carbonaceous chondrites group comparing with Acfer 094, which is one of the most primitive chondrite. We reported that compositions of Al, S and Ca contents of fine-grained matrix minerals are highly variable among carbonaceous chondrite groups [2,3,4]. In this study, we compared intra-chondrite elemental variations in fine-grained matrix among carbonaceous chondrites using several paired chondrites.

Experimental:

Polished thin sections of ten carbonaceous chondrites were prepared; CM: Y-980051, Y-980091; CO: Y-81020; CV: Y-980145, Y-980147; CH: Acfer 214, CH/CB$_b$: Isheyevo, C-ung.: LEW 85332, NWA 5958, Sahara 00182. Most of Antarctic chondrites in this study were pairing with previous samples (CM: Y-980085, Y-980086, Y-980091, Y-980093, Y-980094; CO: Y-81020, Y-81025; CV: Y-980145, Y-980146, Y-980147).

The matrices were analyzed by X-ray elemental mapping technique using an energy dispersive X-ray spectrometer (EDS, Oxford INCA Energy) attached on a field-emission type scanning electron microscope (FE-SEM, JEOL JSM-7000F). X-ray elemental maps of C, O, Na, Mg, Al, Si, P, S, Ca, Cr, Fe and Ni were prepared for from one to fifteen regions of 45 × 60 μm^2 matrix area for each thin section. The X-ray maps were acquired by 15 kV electron probe with 10 nA beam current. These X-ray maps are composed of 0.2 μm/pixel resolution, but spatial resolution of the maps is about 1 μm due to the electron beam broadening in the thin sections. The measurement time for each pixel was about 0.5 s. Calculations of chemical compositions from X-ray spectra were performed by a commercial application "INCA Quant map". We defined the value of histogram peak as average value of a fine-grained matrix.

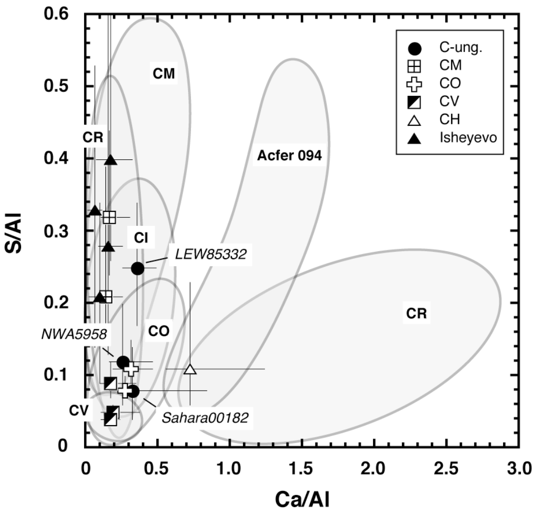

Fig. 1. Ca/Al vs. S/Al for matrices of various carbonaceous chondrite groups normalized to CI chondrite. Each symbol shows average value of matrix. Error bars correspond to half maximum full width of the average value on composition histogram. Shaded areas are from previous work [4].

Results and Discussion:

Figure 1 shows Ca/Al vs. S/Al ratios for matrices normalized to the bulk composition of CI chondrite. The plots show that of newly analyzed chondrites and shaded areas correspond to the range of each chondrite group studied in the previous study [4]. New data of CM and CO chondrites are plotted in the regions of CM and CO chondrites observed in the previous study, respectively. The data of CV chondrites are also plotted in the previous CV region excepting for one of the map of Y-980145 matrix, which shows slightly higher S/Al ratio. Four distinct matrix clasts from a CH/CB$_b$ chondrite Isheyevo show low Ca/Al ratio and large variation of S/Al ratio that is similar to aqueous altered chondrite groups.

Figure 2 shows intra-chondrite variations of minor elements in the fine-grained matrices for five chondrite groups. The data of CM, CO and CV chondrites were obtained from each paired chondrite described above. The data of CR is obtained from a CR chondrite NWA 530. Although the matrices of CM chondrite group have large variation of S/Al ratio, the average composition of matrix in a CM chondrite is almost homogeneous. This trend is also observed in CO and CV chondrite matrices. The average compositions of fine-grained matrix are plotted onto Fe-Si-Mg ternary diagram, which are major elements in chondrite matrices (Fig. 3a). Major elements of CO and CV chondrite matrices show slight variations in each chondrite although those of CM chondrite matrix are almost homogeneous. On the other hands, minor elements of Acfer 094 and NWA 530 CR chondrite matrices have heterogeneities in these chondrites even excluding their dark inclusions (FI. If dark inclusions are included in matrices, heterogeneities in major elements of Acfer 094 and NWA 530 CR chondrite seem to be large (Fig. 3b). However, most part of Acfer 094 matrix excepting dark inclusions shows very uniform major element composition. Because Acfer 094 matrix has high abundance of amorphous material [5], major element distribution of matrix in each chondrite would reflect the degree of crystallization and/or crystal growth of matrix materials. Minor element heterogeneities of fine-grained matrix can be lost during aqueous/thermal alteration on the parent bodies.

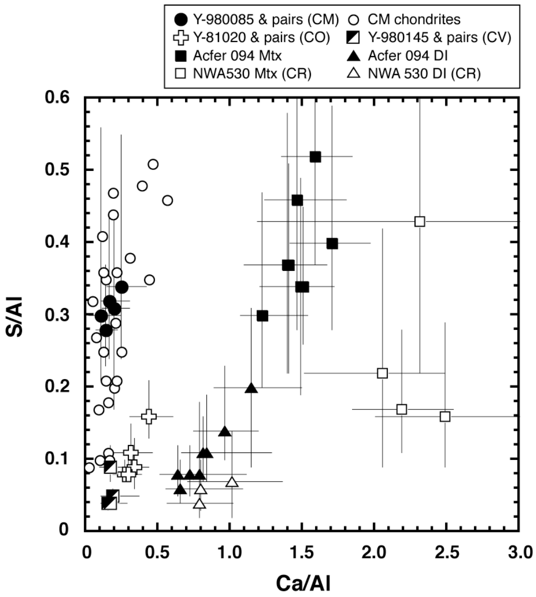

Fig. 2. Intra-chondrite variations of minor elements in fine-grained matrices for five chondrite groups. All CM data (open circle) are shown for reference of inter-chondrite variations.

References:

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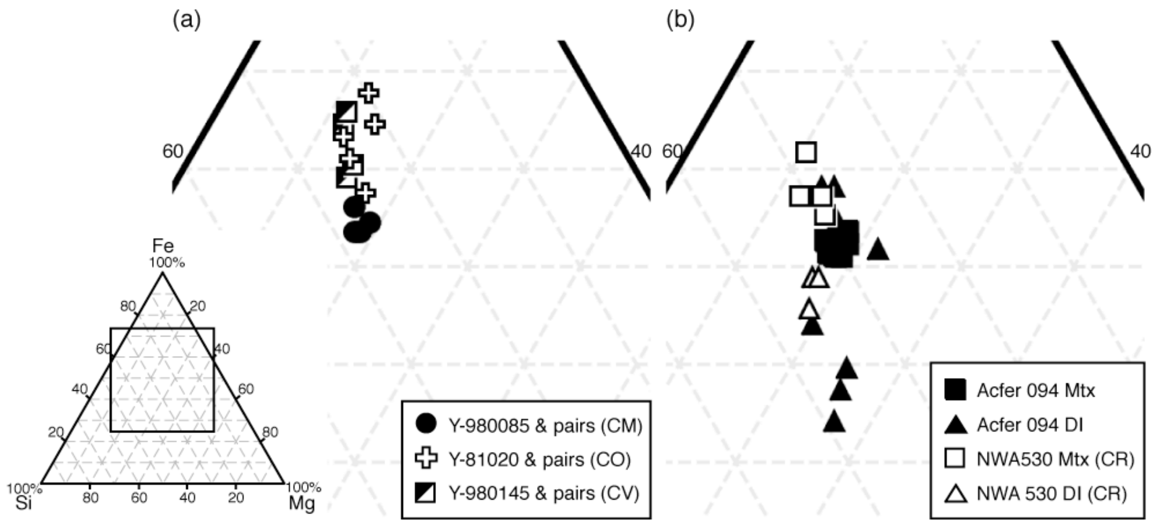

Fig. 3. Ternary Fe-Si-Mg wt% diagram plotted on the average composition of fine-grained matrices in (a) CM, CO and CV chondrites, (b) Acfer 094 and NWA 530.