

Variations of Chemical Composition of Matrices among Carbonaceous Chondrites. K. Abe¹, N. Sakamoto², H. Kojima³, A. N. Krot⁴ and H. Yurimoto^{1,2} ¹Department of Natural History Sciences, Hokkaido University, Sapporo 060-0810, JAPAN. E-mail: abeken@ep.sci.hokudai.ac.jp, ²Isotope Imaging Laboratory, Creative Research Institution Sousei, Hokkaido University, Sapporo, 001-0021, JAPAN, ³Antarctic Meteorite Research Center, National Institute of Polar Research, Tachikawa, Tokyo 190-8518, JAPAN, ⁴Hawai'i Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawai'i at Manoa, Honolulu, HI 96822, USA.

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 ($\sim \mu\text{m}$) in matrices among various carbonaceous chondrites 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]. In this study, we newly studied 5 CM, 5 CR, 3 CO, 1 CV and 1 CH Antarctic chondrites in addition to the previous work [3].

Experimental:

Polished thin sections of 17 carbonaceous chondrites were prepared; CM: Y-790032, Y-790123, Y-791190, Y-791191, Y-793321; CR: A-881595, A-881828, Y-790112, Y-793495, Y-8449, NWA 1180; CO: Y-791717, Y-82050, Y-82094; CV: Y-980146, Efremovka; CH: A-881691.

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 microprobe (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 three regions of $45 \times 60 \mu\text{m}^2$ 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 $0.2 \mu\text{m}/\text{pixel}$ resolution, but spatial resolution of the maps is about $1 \mu\text{m}$ 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 with most pixels as average value of a fine-grained matrix.

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

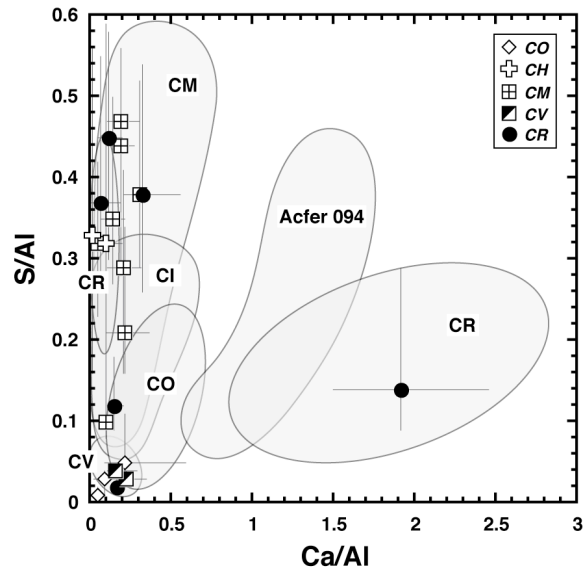


Fig. 1. Ca/Al vs. S/Al for matrices of various carbonaceous chondrite groups normalized to CI chondrite. Each symbol shows average value of matrix. Error bars correspond to half maximum width of the average value on composition histogram. Shaded areas are from previous work [3].

chondrites and shaded areas correspond to the range of each chondrite groups studied in the previous study [3]. All CO chondrites having higher petrologic types (3.2, 3.3 and 3.5) are plotted around the CV region. Two distinct matrix clasts from a CH chondrite A-881691 are plotted around aqueous altered chondrite regions including CI and CM groups. New data of CM and CV chondrites observed in the previous study, respectively. CR chondrites in this study are also plotted around the CR region of the previous study except for A-881595, which is probably affected by shock metamorphism.

Figure 2 shows all data for CR chondrites and Acfer 094 including the previous study [3]. Two distinct regions for the CR chondrites obtained again in high Ca/Al and low Ca/Al regions plotted across the Acfer 094. Although main mass of Acfer 094 largely escaped from aqueous alteration [4], aqueous altered dark inclusions are rarely existed in Acfer 094. Dark inclusions have higher Al content than the matrix (Fig. 3b). Al contents in the matrix and dark inclusion of Acfer 094 are homogeneously

distributed in each area. S content of dark inclusions is lower than that of matrix and inversely correlated with Al content (Fig. 3c). Ca is also inversely correlated with Al and homogeneously distributed in the matrix of Acfer 094 while local concentration of Ca such as Ca-phosphate and/or Ca-carbonate was observed from dark inclusions (Fig. 3d). Therefore, aqueous alteration would increase the Al content and decrease the S and Ca contents. This trend was also observed in the matrix and dark inclusions from CR chondrite NWA 530, which has high Ca/Al ratio (Fig. 3e-h). Al content in the matrix of Y-793495 is lower than that of Y-790112 (Fig. 3j,n) having low Ca/Al and S contents are inverted (Fig. 3k,o). This trend is similar to the relationship between the matrices and dark inclusions in Acfer 094 and NWA 530. However, Ca contents in the matrices of Y-790112 and Y-793495 are depleted and observed as Ca-phosphates and/or Ca-carbonates (Fig. 3l,p).

In conclusion, CR chondrites can be divided into two distinct groups with Al, S and Ca contents from our results.

References:

[1] Zolensky M. et al. (1993) *Geochim. Cosmochim. Acta* 57, 3123-3148. [2] Abe K. et al.

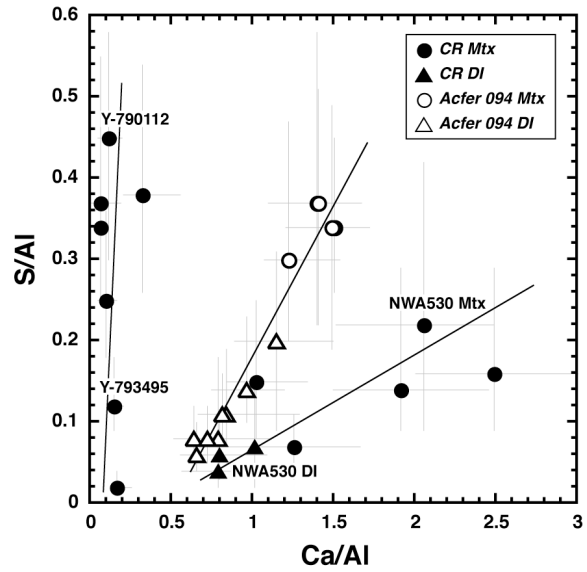


Fig. 2. Ca/Al vs. S/Al of the matrices and dark inclusions of Acfer 094 and CR chondrites.

(2009) The 32nd Symposium on Antarctic Meteorites, 1. [3] Abe K. et al. (2010) The 33rd Symposium on Antarctic Meteorites, 1. [4] Greshake A. (1997) *GCA* 61, 437-452.

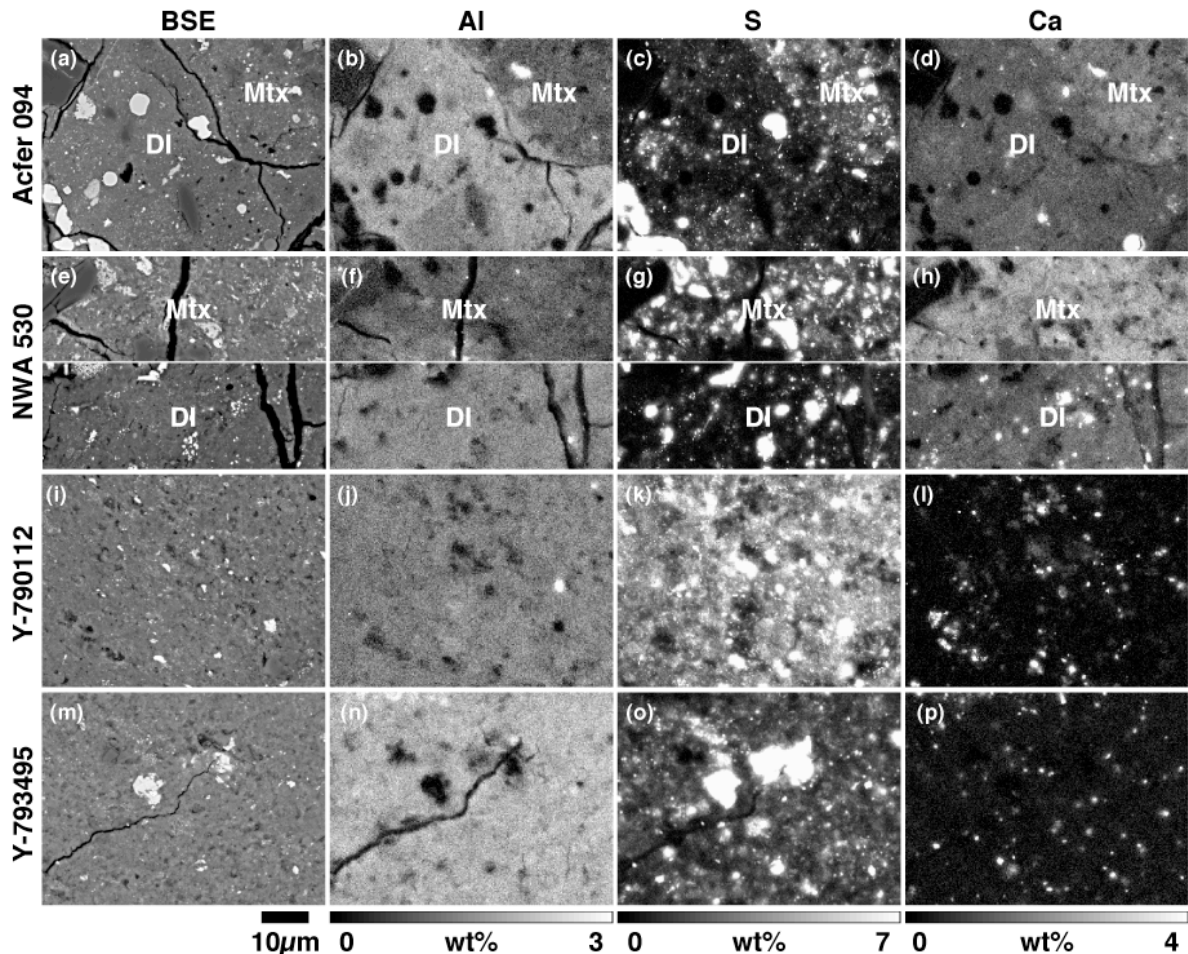


Fig. 3. BSE and quantitative elemental maps of Al, S and Ca from Acfer 094 (a-d), NWA 530 (e-h), Y-790112 (i-l) and Y-793495 (m-p).