SI FRACTIONATION OF CHONDRITE PARENT BODIES BY BIPOLAR OUTFLOW. H. Yurimoto[1] and K. Kuramoto[2], [1]Laboratory for Planetary Sciences, Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro, Tokyo 152, JAPAN, yuri@geo.titech.ac.jp, [2]Center for Climate System Research, University of Tokyo, Meguro, Tokyo 153, JAPAN.

It is believed that chemical classes of chondritic meteorites related to heterogeneity of the proto-solar nebulae. The chemical classes are divided into two different sequences in Si/Al vs. Mg/Al diagram (Larimer and Wasson, 1988). One sequence is explained by addition of refractory materials such as Ca, Al-rich inclusions (CAIs) to the solar (or CI) composition. Chemical variations of carbonaceous chondrites are interpreted by this process. Another sequence is subtraction of the materials with Mg/Al and Si/Al ratios lower than the CI values from the solar composition. Ordinary and enstatite chondrites are plotted on the trend. One candidate of materials with such a composition is amoeboid olivine aggregates (AOAs). The variation among the chondritic classes is commonly ascribed to cosmochemical fractionation, but the mechanism have not been specified.

To survey the processes for cosmochemical fractionation we have recompiled the variation in Mg/Al and Si/Al among chondrites from bulk meteorite analyses (Fig. 1). Positions of average composition of each chondritic class are consistent to those of previous compilation by Larimer and Wasson (1988) except for that of E chondrites. The discrepancy of E chondrite may be due to new data from Antarctic meteorites and new analyses. Variation of Mg/Si ratio for E chondrites are, however, similar to the previous one. The characteristics of Fig. 1 are as follows: (1) Mg/Si ratios are plotted in small range in each chondritic class, and (2) are plotted separately among the classes. (3) Scattering of Al component is large even in the same class, and overlapped one another.

The variation of scattering among these elements may be due to difference of abundance in meteorites, i.e. abundance of Al is roughly ten times smaller than those of Si and Mg. Thus relatively large variation of Al is due to heterogeneous distribution of Al host minerals, which is mainly plagioclase. Since sampling for bulk analysis is performed with special care (e.g. Jarosewich, 1990), most of the variation should result from heterogeneity of mineral assemblage in hand specimen scale. The heterogeneity may be achieved during accretion of dusts, chondrules, and particles to chondrite parent bodies. Therefore, the average composition reflects the nebulae composition of the accreted region of each parent body.

Variation of Al content among each meteoritic classes could occur by addition of refractory materials such as CAIs. The mechanism should correlate to formation process of CAIs. Recently Yurimoto et al. (1994) clarified intra- and inter-crystalline distribution of O isotopes, and concluded that at least two-stage crystallization was necessary to construct whole CAI structure. At the first stage ^{16}O-enriched minerals (spinel and fassaite) crystallized probably from liquid, and then ^{16}O less enriched minerals (melilite and anorthite) solidified from liquid at the second stage. The first liquid should be different in composition as well as in O isotopes from the second one. Chemical equilibrium calculation of the solar composition indicates that the mineral assemblage of first stage is less refractory than that of second stage (Wood and Hashimoto, 1993). Therefore, to form CAI structure the temperature increase process is necessary. Such condition could be performed when dusts (dust balls) were falling to proto-sun at inner edge of the solar nebulae. Some of the dusts were lifted by bipolar outflow, and reentered into the nebulae at great distances from the original launch radius (Watanabe, 1994; Shu et al., 1996).

When the proto-sun was active, the inner edge temperature of nebulae may reach to over 1700K. Under such high temperature silicate dust balls were completely evaporated even in CAIs. However, tar-enriched silicate dust will be survived as SiC grain (Wood and Hashimoto, 1993). The SiC grains were launched by the bipolar outflow and reentered into the nebulae. The Si component of reentered region increases gradually with time. The degree of SiC addition by atomic fraction into solar dust composition is shown in Fig. 1. The addition of 15 % of SiC into the solar dust composition is enough to attain Si/Mg ratio of E chondrite. The degree of SiC addition would control redox state of the chondrite parent body. The order of Si/Mg ratio among meteoritic classes are consistent with the redox state among chondrites.

In conclusion, cosmochemical fractionation presented in Fig. 1 are explained by following two processes in the solar nebulae: (1) SiC addition and (2) CAIs addition. These proc-

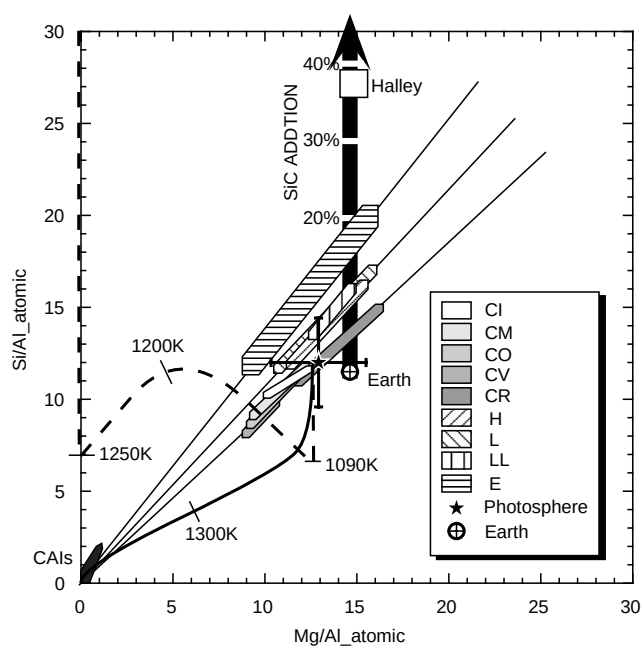

Fig. 1. The mixing diagram for Al, Mg, and Si. Solid and dotted lines represent equilibrium condensation curve calculated from Wood and Hashimoto (1993). Meteoritic data were compiled from Wiik (1969), Jarosewich(1990) and Haramura (1995).

esses occurred in this order. The bipolar outflow of early solar system is plausible to generate these chemical fractionation.

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