MAGNESIUM ISOTOPIC FRACTIONATION IN THE OLIVINES FROM ALLENDE CHONDRULES AND ISOLATED GRAINS : A. KOGA[1)], H. NAGAHARA[1)], H. YURIMOTO[2)], AND O. KOIKE[2)], (1)Geol. Inst., Univ. Tokyo, Hongo, Tokyo 113, Japan, (2) Inst. Geosci, Univ. Tsukuba, Tsukuba, Ibaraki 305, Japan.

Evaporation experiments have shown that isotopic fractionation takes place when solid silicates are heated at high temperatures in vacuum, and the maximum degree of isotopic fractionation from solid is estimated to be several to ten per mill [1]. Much larger isotopic fractionation has been reported for a molten silicate [2]. Although isotopic fractionation in CAIs has been intensively studied [summarized in 3], very few studies have been made for chondrules except for silicon isotopes [3]. Kinsey *et al.* [4] and Esat and Taylor [5] investigated Mg isotopic compositions of chondrules from Bjurbole, Murchison, and Semarkona, but did not find evidence for isotopic fractionation. Because heating temperatures and cooling rate for formation of chondrules and type B1 CAIs are similar [6], there is a possibility that chondrules possess records of isotopic fractionation induced by partial evaporation during chondrule formation.

In order to search isotopic fractionation in chondrules, we have studied isolated olivine grains and chondrules in Allende. A polished thin section was newly prepared. Detailed petrographic work with an SEM-EDS was done before SIMS work, and all the objects larger than 40 μm were studied. The thin section contains 113 objects excluding CAIs and amoeboid olivine inclusions, which consists of 13 isolated grains, 66 porphyritic chondrules, 29 granular chondrules, and 5 barred to radial olivine chondrules. Isolated grains are olivine with sizes ranging from 50 to 250 μm; three of them have irregular outline and two have partly straight crystallographic surface. They are Fo>93 showing iron enrichment in thin outermost layer of grains and along cracks. Porphyritic chondrules range from 100 to 1620 μm; 9 of them contain almost pure forsterite (Fo>99), and most of them contain 99>Fo>(95-85) olivine. They are characterized by the presence of opaque phases and plagioclase. Granular chondrules consist mainly of anhedral olivine, and range from 100 to 930 μm. 13 out of 29 have Fo>99 olivine and 3 are of type II (Fo<70). They are characterized by the coexistence of clinoenstatite and minor abundance of opaque phases and plagioclase. Barred to radial olivine chondrules contain clean to devitrified glass and often have thick rim. They are magnesian having Fo>95 olivine.

Magnesium isotopic compositions of olivine grains, particularly forsteritic olivine, of those four different occurrences were measured with a Cameca IMS-3f ion-microprobe at the University of Tsukuba with the analytical method described by Koike *et al.* [7]. Masses 24, 25, and 26, were measured but 27 was not measured. Because the instrumental mass fractionation changes depending on many factors, we have analyzed olivine from San Carlos as a reference sample of which isotopic composition has been known [8]. After one day, the instrument got very static, and the instrumental mass fractionation for the reference and the same unknown grain was nearly constant. Therefore, the results are plotted without any correction (Fig. 1). The cross in the box represents average value of the reference and the box is 1σ of four reference measurements made at the beginning and the end of a series of analysis. Error bars of unknown samples are 1σ of each analysis which is made of 90 cycles. The results are normalized against the reference sample, which locates at the original point of the graph. In this plot, a slope for fractionation incudes instrumental mass fractionation, and therefore, it does not necessarily be 1/2.

There was neither systematic isotopic difference among olivines with different occurrence, nor heterogeneity within grains in spite that the Fo value varies from highly magnesian (Fo>99) to less magnesian (Fo<95). These results show that the isotopic composition of olivines in chondrules and isolated grains had been achieved before crystallization of chondrules, which should have been established at least at the highest temperature stage of chondrule formation or before that. The results form a nearly straight line, suggesting that the

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effect of instrumental mass fractionation is constant through the analyses and there is no excess ^{26}Mg derived from decay of radioisotopic ^{26}Al. An interesting result is that most data are located at the upper right portion along the line; that is, almost all olivine have heavier isotopic compositions than the reference. Heavy isotopic composition suggests that the olivines are either evaporation residues or higher temperature condensates. The latter possibility, however, seems to be incompatible with recent low temperature solar nebular models. Thus, the evaporation residue origin may be plausible for the isotopically heavy olivines. The maximum degree of fractionation for the olivines is about 10‰, which well coincides with the value estimated for isotopic fractionation formed through evaporation of solid material in vacuum with the evaporation degree of more than 80% [1]. Alternatively, isotopic fractionation up to 10 ‰ could be achieved if molten silicates evaporated at a smaller degree [2]. Although the present results cannot be directly compared to the experimental results because the experiments were carried out with single crystals and because natural chondrules might possess records of precursors, melting and crystallization, this is the first report that chondrules and isolated olivine grains show magnesium isotopic fractionation which could have generated during heating event in the solar nebula.

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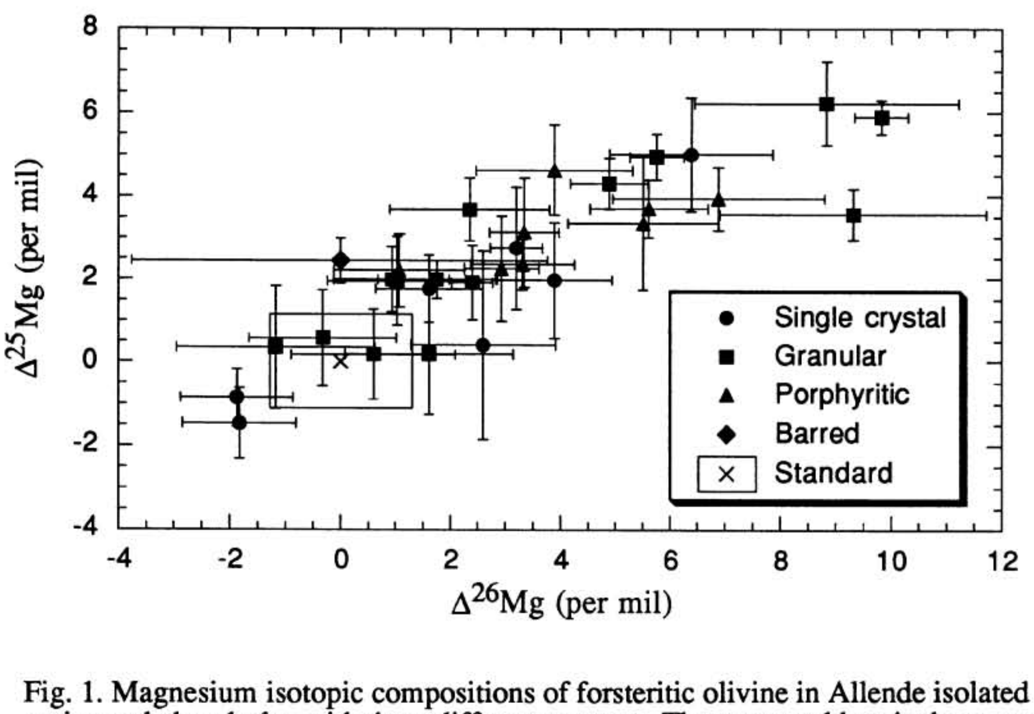

Fig. 1. Magnesium isotopic compositions of forsteritic olivine in Allende isolated grains and chondrules with three different textures. The cross and box is the average and 1σ of four standard measurements made at the beginning and the end of a series of unknown measurements. The error bars are 1σ of 90 cycles for one analysis.

$$\Delta^{25}\mathrm{Mg}=1000*\left[\frac{(^{25}\mathrm{Mg}^+/^{24}\mathrm{Mg}^+)_{\mathrm{MEAS}}}{(^{25}\mathrm{Mg}/^{24}\mathrm{Mg})_{\mathrm{REF}}}-1\right] \text{ and } \Delta^{26}\mathrm{Mg}=1000*\left[\frac{(^{26}\mathrm{Mg}^+/^{24}\mathrm{Mg}^+)_{\mathrm{MEAS}}}{(^{26}\mathrm{Mg}/^{24}\mathrm{Mg})_{\mathrm{REF}}}-1\right].$$