INITIAL 26AL/27AL RATIOS IN CARBONACEOUS CHONDRITE CHONDRULES

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Introduction: Ion-probe studies of chondrules in ordinary chondruites (OCs) have shown small excesses in ^{26}Mg that correlate with the Al/Mg ratio; from these data initial ^{26}Al/^{27}Al ratios of (5-10)x10^{-6} have been inferred [1-4]. Only one well defined ^{26}Al-^{26}Mg isochron has been reported for a carbonaceous chondrite (CC) [5]; the initial ratio is similar to the lowest ratios reported for ordinary chondrites. Because chondrules provide the best estimate of the maximum ^{26}Al/^{27}Al ratio present when asteroids formed, it is important to determine this ratio in carbonaceous chondrite chondrules. We therefore studied the ^{26}Al-^{26}Mg system in one of the most primitive carbonaceous chondrites, CO3.0 Yamato 81020 (Y81020) [6]. Our preliminary results show that the initial ratios in CC are lower than those in OC dhoncrules.

Experimental: The ^{26}Al-^{26}Mg isotope microanalyses on chondrule plagioclase were performed by secondary ion mass spectrometry with the Cameca IMS-1270 instrument at UCLA. A primary ion beam of 23 keV $^{16}O_2^-$ was focused to a diameter of ~5 µm with an ion intensity of 30 - 90 pA. Positive secondary ions corresponding to $^{24}Mg^+$, $^{25}Mg^+$, $^{26}Mg^+$, and $^{27}Al^+$ were analyzed in a peak-jumping mode. The Mg ions were determined by pulse-counting with an electron multiplier and the Al ions were detected by a Faraday cup. A relative sensitivity factor (= 1.2) for converting measured $^{27}Al^+/^{24}Mg^+$ ion ratios to atomic values was determined by analyses of a synthetic glass of anorthite composition [7]. The Mg-isotopic ratios of chodrule olivine were measured with a multi-collection system using Faraday cups. The primary ion beam size was 25 µm with 25 nA intensity. Measured Mg-isotope ratios were corrected for linear mass fractionation by normalization to the terrestrial value [8].

Results: Four ferromagnesian chondrules from Y81020 were analyzed for their Al-Mg isotopic systematics. CHD-51A00 is a ~200x160 µm-size fragment of a type-II porphyritic-olivine chondrule that contains one large (>150 µm) euhedral olivine phenocryst, numerous small olivine grains, Ca-rich pyroxene, metal, and sodic plagioclase (An9-17). The small olivine grains are mainly formed within the Ca-rich pyroxene. CHD-51A02 is also a ~350x200 µm-size type-II porphyritic-olivine chondrule that includes seven (>50 µm) euhedral olivine phenocrysts, many smaller olivine grains, Ca-rich pyroxene, metal, glass, and moderately sodic plagioclase (An32-41). CHD-51A05 is a ~200x200 µm-size type-II porphyritic-olivine chondrule: that contains two large large (>80 µm) euhedral olivine phenocrysts, several smaller olivine grains, Ca-rich pyroxene, metal, and moderately sodic plagioclase (An29-41). CHD-51A06 is a ~180x80 µm-size chondrule fragment that contains FeO-rich (Fo42-68) olivine phenocrysts as well as FeO-poor (Fo85) olivine phenocrysts rimmed by fayalitic olivine. It contains fragmented olivine grains, Ca-rich pyroxene, metal, glass, and moderately sodic plagioclase (An20-30). Two plagioclase grains in this chondrule are subhedral and fragmented.

The Mg-isotopic data for the four Y81020 chondrules are plotted on an Al-Mg evolution diagram (Fig. 1). A weighted isochron fitted to all the data yields an initial ^{26}Al/^{27}Al ratio of (3.5±0.7)x10^{-6}. Because of minor instrumental problems this ratios may still need significant revisions.

Discussion: Studies of LL3.4 Chainpur revealed ^{26}Mg excesses in only one of seven Al-rich OC chondrules [1, 2]. In contrast, all five studied ferromagnesian chondrules in LL3.0 Semarkona showed clear ^{26}Mg excesses [3]. The mean initial ^{26}Al/^{27}Al ratio of OC chondrules is ~7x10^{-6}, seven times lower than that of CAIs. It is possible that the heterogeneous distribution from Chainpur may reflect parent-body metamorphism. To estimate the initial ^{26}Al/^{27}Al ratio of chondrules from carbonaceous chondrites, we therefore analyzed chondrules from one of the least-altered chondrites, Y81020 [6, 9, 10]. Because this chondrite preserves the nebular record with great fidelity, it is highly probable that parent-body alteration has had a minimal effect on the Al-Mg system.

Our data suggest a siginificantly lower ratio in CC compared to OC. If this difference holds up through complete data processing, it indicates either that CC chondrules formed later than OC chondrules or that the nebular initial ^{26}Al/^{27}Al ratio was heterogeneous.

Because chondrules formed in the solar nebula, initial ^{26}Al/^{27}Al ratios in chondrules provide upper limits on the amount of ^{26}Al available to heat asteroids. Already the OC results showed that only under the most optimum accretion rates can ^{26}Al provide a major contribution as a heat source of the asteroids. Our results may show that this source is still less adequate for heating carbonaceous chondrite asteroids.

References: [1] Russell et al. (1996) *Science* **273**, 757-762. [2] Huss et al. (2001) *MAPS* **36**, 975-997. [3] Kita et al. (2000) *GCA* **64**, 3913-3922. [4] Mostefaoui et al. (2002) MAPS **37**, 421-438. [5] Yurimoto et al. (2002) *GCA* **66**, 4355-4363. [6] Kojima et al. (1995) *Proc. NIPR Symp. Antarct. Neteorites* **8**, 79-96. [7]

Armstrong et al. (1982) In *Microbeam Analysis (ed. K. F. J. Heinrich), San Francisco Press*, 205-209. [8] Catanzaro et al. (1966) *J. Res. Nat. Bur. Standards* **70a**, 453-458. [9] Chizmadia et al. (2002) *MAPS* **37**, 1781-1796. [10] Itoh et al. (2002) *LPSC* **33**, 1490 (abstract).

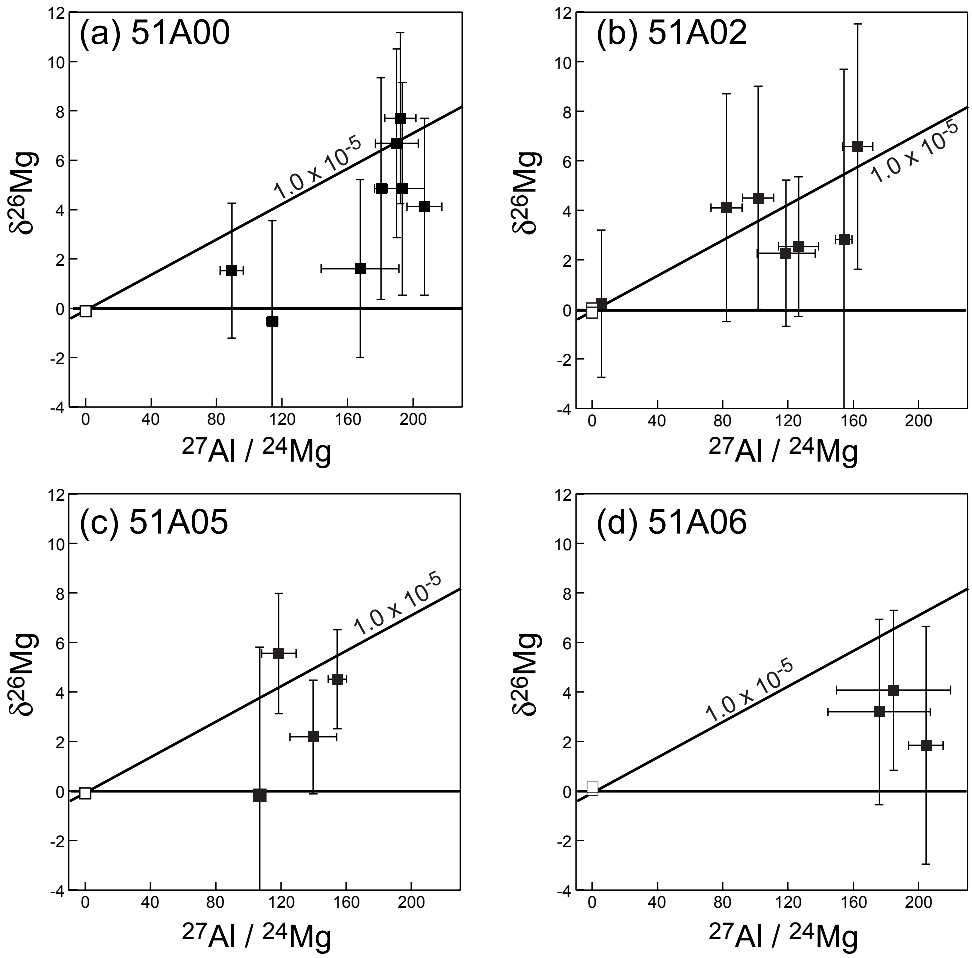

Fig. 1: Al-Mg isochron diagrams for individual chondrules from Yamato 81020 (CO3.0). Open rectangles are olivines, filled rectangles are plagioclase. Lines correspond to initial $^{26}Al/^{27}Al$ isotope ratio of 1.0×10^{-5} are shown.