FE/MN SYSTEMATICS OF CHONDRULE OLIVINE: SIGNIFICANT DIFFERENCES BETWEEN TYPE II CHONDRULES IN CO, CR, AND ORDINARY CHONDRITES. Jana Berlin, Rhian H. Jones and Adrian J. Brearley, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131, U.S.A., e-mail: jberlin@unm.edu

Introduction: In most primitive chondrites, we find chondrules of the same textural types (e.g., porphyritic olivine/pyroxene chondrules). Several studies have shown that oxygen isotopic compositions of chondrules from different chondrite groups are significantly different [e.g., 1]. But how different (or similar?) are their mineral and bulk chondrule compositions? If there are systematic differences, are they related to differences in chondrule precursor materials, to the oxygen fugacity of the formation region in the solar nebula or to processes that affected the chondrule populations before they got incorporated into their parent bodies? In order to find answers to these questions, we studied mineral and bulk compositions of porphyritic chondrules from Kainsaz (CO3.2), MET00426 (CR3) and MET00526 (H3.05).

Method: Olivine analyses were obtained with a JEOL 8200 electron microprobe, using an accelerating voltage of 15 kV and a beam current of 20 nA. Bulk chondrule compositions were determined by modal recombination after collecting quantitative analyses of all mineral phases present.

Results: As is typical for ordinary and most carbonaceous chondrites [e.g., 2], Kainsaz (CO), MET00426 (CR) and MET00526 (H) contain two distinct populations of porphyritic chondrules: FeO-poor (type I) and FeO-rich (type II). Histograms of Fa-contents in PO and POP chondrules are shown in Fig. 1. In the more primitive chondrites (MET00426 and MET00526), type I chondrule olivines have Fa<4, whereas higher Fa-contents in Kainsaz type I chondrules are the result of Fe-Mg exchange with the surrounding FeO-rich matrix [e.g., 3]. Fa-contents of type II chondrule olivines exhibit large ranges in all three meteorites, and mean Fa-contents decrease from CO (Fa_{34}) > CR (Fa_{29}) > H (Fa_{19}).

Fig. 2 shows Mn vs. Fe [afu] in olivines of type II chondrules. Our data compare well with previously published data for ALHA77307 (CO3.0) [4], the CR2 chondrites EET92105 and EET87770 [5] and Semarkona (LL3.0) [6]. Type II chondrule olivines in CO and ordinary chondrites show very distinct trends, whereas two populations can be identified in CR chondrites represented by different meteorites (MET00426/ EET87770 vs. EET92105). Interestingly, type II chondrule olivines in MET00526 (H) and Semarkona (LL) are indistinguishable.

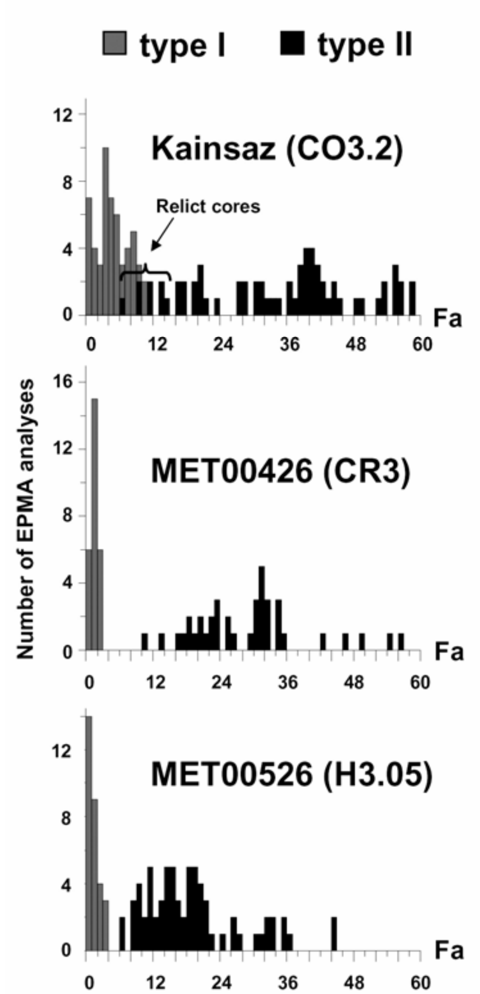

Fig. 1. Histograms of olivine compositions in PO and POP chondrules in Kainsaz (11 type I and 6 type II chondrules), MET00426 (9 type I and 2 type II chondrules + 5 type II chondrule fragments) and MET00526 (7 type I and 9 type II chondrules).

When plotted as molar Fe/Mg vs. Fe/Mn (Fig. 3), CO and H/LL type II chondrule olivines show trends fairly parallel to the x-axis, implying simple crystallization trends [7]. CR type II chondrule olivines show two populations again, each with Fe/Mn decreasing as Fe/Mg increases, which could be explained by reduction and metal loss during crystallization [7]. However, we did not find petrographic evidence (e.g., dusty olivines, zoned grains with Mg-rich rims, reduced metal or metal rims) for such a reduction event.

Bulk chondrule data for type IIA chondrules in Kainsaz (CO) show a spread in Fe- and Mn-contents among individual chondrules. Preliminary data for MET00426 (CR) chondrules are very similar to the CO data, whereas MET00526 (H) chondrules show significantly lower bulk Fe- and higher Mg-contents.

Discussion: Olivine compositions in type II chondrules show significantly different trends in Fe-Mn-Mg plots for OC and CO chondrites. CR chondrites show two distinct populations with properties intermediate between OC and CO chondrites. Mean Fe/Mn ratios as well as mean Fa-contents of chondrule olivines increase from H/LL<CR<CO. Fe-Mn relations suggest significantly different sources for type II chondrules in OC versus CC chondrites, but the source materials of type II chondrules within each chondrite class are fundamentally related.

The observed trends in Fig. 2 for OC, CR and CO chondrites are very similar to the trends for martian (slope 0.0217), terrestrial (slope 0.0134) and lunar (slope 0.0095) basalts [8,9]. Because Mn/Fe ratios in olivines and pyroxenes of planetary basalts correlate with their parent bodies' distance from the Sun, [8,9] interpreted these trends as being controlled by the volatility of Mn (being depleted in the inner solar system), while oxygen fugacity and metal separation (core formation) appear to have a secondary effect.

Explaining the chondrule trends with comparable volatility of Mn becomes difficult, as we would need to form CC chondrules at terrestrial distances from the Sun and OC chondrules at Mars distances. Also, if chondrites formed in the asteroid belt between Mars and Jupiter, one would expect that all chondrules would fall left of the Mars trendline (slope 0.0217 [8,9]). We did find some OC chondrules which plot there (not shown in Fig. 2), but they clearly show evidence for reduction, such as dusty olivines, and grains with Fe-rich cores and Mg-rich rims.

The trends could represent different oxygen fugacities, but Fe,Ni-metal is present in many CO, CR and H/LL type II chondrules (even though its modal abundance is small), restricting the fO_2 to lie close to the IW buffer in all three cases. However, [10] did find different Cr^{2+}/Cr^{3+} ratios in type II chondrules of Semarkona (0.3) and ALHA77307 (0.9), implying different oxidation states. We are currently investigating whether different initial bulk Fe-contents or different proportions of silicate vs. metal/sulfide in the precursor material [e.g., 11] could be responsible for the different trends.

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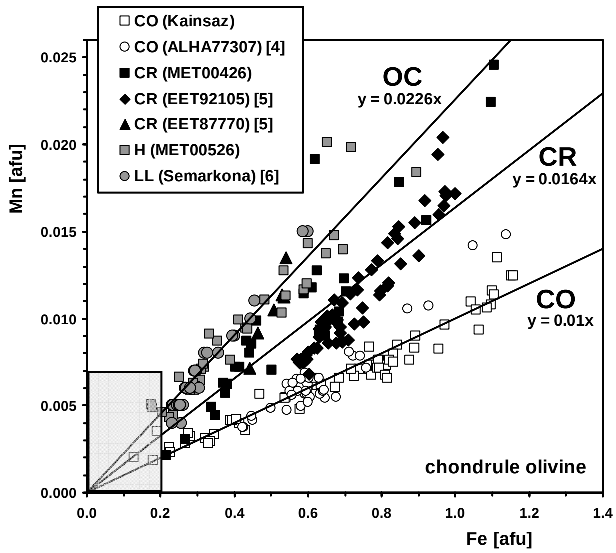

Fig. 2. *Fe vs. Mn [afu] in type II chondrule olivines. Best-fit zero intercept trend lines are shown for all OC, CR and CO data. The box represents data for type I chondrule olivines.*

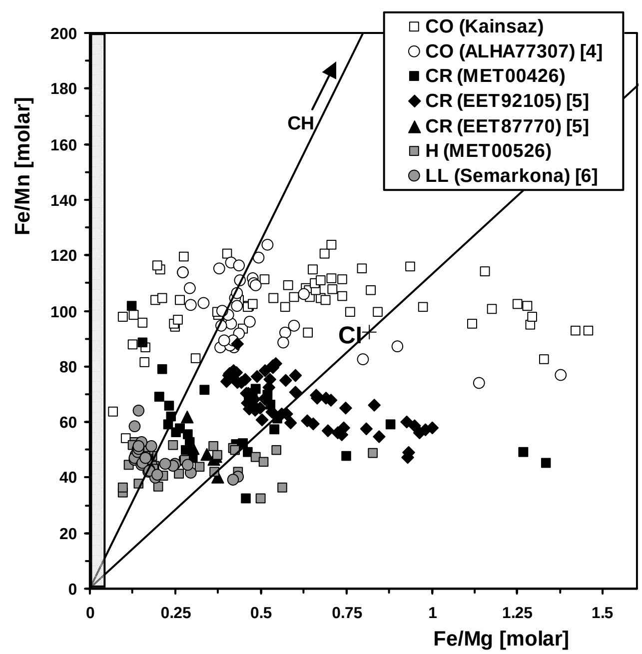

Fig. 3. *Molar Fe/Mg vs. Fe/Mn of type II chondrule olivines. The box represents the array in which CR and H type I chondrule olivines plot. Kainsaz type I chondrule olivines have slightly higher Fe/Mg ratios. CI and CH lines [7] are shown for comparison.*

References: [1] Clayton R.N. (2003) In: *Treatise on Geochemistry, Vol. 1,* 129-142. [2] Jones R.H. et al. (2005) In: *Chondrites and the protoplanetary disk,* 251-285. [3] Scott E.R.D. and Jones R.H. (1990) *GCA, 54,* 2485-2502. [4] Jones R.H. (1992) *GCA, 56,* 467-482. [5] Burger P.V. (2005) *M.Sc. thesis,* UNM. [6] Jones R.H. (1990) *GCA, 54,* 1785-1802. [7] Goodrich C.A. and Delaney J.S. (2000) *GCA, 64,* 149-160. [8] Papike J.J. (1998) In: *Planetary Materials,* 7-1–7-11. [9] Papike J.J. et al. (2003) *Am. Min., 88,* 469-472. [10] Sutton S. R. et al. (1996) *LPS, 27,* 1291-1292. [11] Schmitt R.A. and Laul J.C. (1973) *The Moon, 8,* 182-209.