spectrum of collected particles distinguishes between olivine and matrix fragments. Nineteen fragments, ~40–350 µm in size, analyzed in two aerogels from shots 961001 and 961004, indicate that all nine fragments <100 µm are matrix.

If these results are directly applicable to asteroids having a carbonaceous chondrite structure, then the preliminary results suggest that those asteroids might preferentially overproduce olivine-rich debris at the size scale of the chondrules and that olivine might be underrepresented in the debris at substantially smaller sizes. Further experiments, using meteoritic material as the targets, are required to understand the catastrophic disruption of inhomogeneous, porous targets and the contribution of chondritic parent bodies to the interplanetary dust.

References: [1] Kortenkamp S. J. et al. (1996) in *Physics, Chemistry, and Dynamics of Interplanetary Dust*, pp. 167–170, ASP Conf. Series 104. [2] Britt D. T. and Consolmagno G. (1996) *BAAS, 28*, 1106. [3] Flynn G. J. et al. (1996) *LPS XXVII*, 369–370.

EFFECTS OF PRESSURE AND DUST ENRICHMENT ON SILICATE-LIQUID STABILITY.

D. S. Ebel[1] and L. Grossman[1,2], [1]Department of the Geophysical Sciences, University of Chicago, 5734 South Ellis Avenue, Chicago IL 60637, USA, [2]Enrico Fermi Institute, University of Chicago, Chicago IL 60637, USA.

Several lines of evidence suggest that most chondrites formed at O fugacities significantly higher than that of solar gas [1–4]. Enrichment of previously condensed dust relative to gas, followed by its vaporization, emerges as the only reasonable mechanism for such an enhanced oxidation state [1–3]. Although enrichment of dust relative to gas stabilizes FeO in olivine, such enrichment is even more conducive to silicate liquid stability. We have begun a systematic study of the temperature-pressure-composition conditions at which silicate liquids are stable condensates from fully speciated 23-element gases. Details of our method were reported in [5]. Here, we compare results for solar gas enriched 200× and 500× in dust of C1 chondrite composition, at $P^{tot} = 10^{-3}$ and 10^{-6} bar.

Results at 200× dust enrichment and $P^{tot} = 10^{-3}$ are nearly identical to those reported for $T > 1590$ K in [5] for an 18-element system. Liquid appears at 2000 K, olivine (ol) at 1850 K, metal alloy at 1730 K, orthopyroxene (opx) at 1670 K, spinel (sp) at 1660 K. Once metal condenses, the proportion of the total Fe condensing as FeO increases less rapidly with falling temperature, continued condensation of SiO_2 into the liquid causes its FeO and MgO concentrations to fall with decreasing temperature, and X_{Fa} and X_{Fs} of co-condensing ol and opx level off. This assemblage persists until feldspar (fsp) appears at 1450 K and clinopyroxene (cpx) at 1430 K. At 1500 K, the liquid is 36 mol% of the oxide condensates, with 59.4 wt% SiO_2, 0.72% TiO_2, 15.2% Al_2O_3, 10.9% MgO, 12.7% CaO, 0.80% FeO, 0.024% Na_2O, 0.064% K_2O. Olivine is Fo_{95}, opx is En_{97}. By 1420 K, the liquid is 6.6 mol% of the oxide condensates, with 0.74% FeO, 0.19% Na_2O, and 0.23% K_2O. Olivine is Fo_{94}, opx is En_{96}, fsp is An_{92}. The solidus is just above 1390 K, as in all cases investigated here.

Decreasing P^{tot} to 10^{-6} decreases the temperature of liquid appearance to 1550 K, that of opx to 1450 K, and that of metal to below the solidus. At 1500 K, the liquid has 0.15 wt% FeO, and ol is Fo_{100}. By 1420 K, the liquid has 0.15% FeO, ol is Fo_{98}, and opx is En_{98}. Virtually no K_2O or Na_2O condense above 1400 K.

Increasing the dust enrichment to 500×, at $P^{tot} = 10^{-3}$, causes most phases to appear at higher temperatures. Liquid, at 2130 K, and ol, at 1940 K, are joined by metal at 1780 K, sp at 1760 K, and opx at 1700 K. Feldspar and cpx appear at 1430 K, and pyrrhotite ($Fe_{0.877}S$, forming at the expense of metal) at 1420 K. At 1500 K, the liquid is 35 mol% of the oxide condensates, with 4.49% FeO, 0.32% Na_2O, and 0.17% K_2O; ol is Fo_{87}, opx is En_{91}. At 1420 K, the liquid is ~1.5 mol% of the oxides, with 3.42% FeO, 2.16% Na_2O, and 0.5% K_2O. Olivine is Fo_{85}, opx En_{89}, and fsp An_{69}.

At $P^{tot} = 10^{-6}$ bar, in the 500× case, liquid appears after sp, at 1640 K, followed by ol at 1610 K. At 1500 K, the liquid has only 0.14% FeO and ol is Fo_{98}. Opx appears at 1490 K. By 1420 K, neither metal nor sulfide have condensed, and the liquid has 3.0% FeO and virtually no alkalies. Olivine is Fo_{89}, opx is En_{92}, and fsp is An_{100}.

In all four cases, silicate liquid is stable over a wide temperature range, with a solidus just above 1390 K. Both increasing P^{tot} at constant dust enrichment and increasing dust enrichment at constant P^{tot} cause increases in the condensation temperatures of metal and silicate melt, the temperature where significant FeO, Na_2O, and K_2O enter the liquid, and the maximum FeO content of the liquid.

References: [1] Fegley B. Jr. and Palme H. (1985) *EPSL, 72*, 311–326. [2] Wood J. A. (1967) *GCA, 31*, 2095–2108. [3] Rubin A. et al. (1988) in *Meteorites and the Early Solar System* (J. F. Kerridge and M. S. Matthews, eds.), pp. 488–511, Univ. of Arizona, Tucson. [4] Weinbruch S. et al. (1990) *Meteoritics, 25*, 115–125. [5] Ebel D. S. and Grossman L. (1997) *LPS XXVIII*, 317–318.

RARE-EARTH-ELEMENT ABUNDANCES IN ENSTATITE CHONDRITES: IMPLICATIONS FOR THE FORMATION OF THE PARENT BODY.

M. Ebihara, K. Shinotsuka, P. Kong, and T. Shingen, Department of Chemistry, Graduate School of Science, Tokyo Metropolitan University, Hachioji, Tokyo 192-03, Japan.

Enstatite chondrites are comprised of EH (high-Fe) and EL (low-Fe) groups. Before the recognition of an EL5 chondrite in the Antarctic meteorite collection, all EHs were assigned to petrologic types 3–5 and all EL were classified as type 6. Nonoverlapping of petrologic types between EH and EL, the continuous variation of mineral composition, and the gradual decrease in volatile-element abundance from EH to EL (and further to aubrite) suggest a single parent body. The newly recognized petrologic types EL3 and EL5 strongly suggest that each of the two groups has its own genetic sequence.

Enstatite chondrites have several characteristic features in elemental abundances compared with other chondrite groups, one of which is the fractionation of REE in the bulk chondrite sample. Recently, a relatively small, but distinct fractionation among REE was observed in Allende bulk sample [1]. For enstatite chondrites, however, not just one, but several meteorites of the EL6 group were found to have fractionated REE abundance [2], which is characterized by a gradual increase with increasing atomic number from La to middle REE (Sm) on the CI-normalized abundance plot. Now that the grouping of enstatite chondrites has been considerably extended, it is important to survey REE abundances over a wide range of enstatite chondrites. In this study, REE (including Y), Th, and U were precisely determined by ICP-MS for bulk samples of 12 enstatite chondrites (3 EL3, 1 EL5, 2 EL6, 4 EH3, 1 EH5 and unclassified LEW 87223). INAA study of their bulk and metal separates was previously performed [3].

The previous analysis of two non-Antarctic EL6 chondrites (Blithfield and Atlanta) by RNAA showed a characteristic light-REE-depleted abundance pattern. This pattern is also characterized by a negative Eu anomaly. We observed essentially the same abundance patterns for one EL5 as well as two EL6 chondrites. These three meteorites are from Antarctica, suggesting that the REE abundance in enstatite chondrites is scarcely disturbed by weathering on Antarctica. In spite of grouping to EL, none of three EL3 chondrites have fractionated REE abundance, implying that the fractionated REE abundance is not a common feature to the EL clan. Like EL3, all EH meteorites have a completely flat, unfractionated REE abundance pattern.

Based on the INAA data for bulk samples and metal separates, we argued for a single parent body for enstatite chondrites [3]. According to this model, the parent body initially had a shell structure, with EH5 (or 6) being innermost, followed by EH3, EL3, EL5, and EL6 toward the outer shell. As EL5 and EL6 chondrites have no evidence of total melting, the fractionated REE abundance cannot be explained in terms of igneous processes on the parent body. Apparently the fractionation must have occurred in the nebula. Oldhamite is a major carrier phase of REE in enstatite chondrites [4], but its contribution varies from group to group. Essentially all REE are hosted by oldhamite in EH5, whereas silicate (possibly diopside) competes with oldhamite for the REE (especially heavy REE) in EH3. This change seems to be continuous. In EL6, the heavy REE are distributed into oldhamite and silicate (possibly pyroxene). From these all observations coupled with previous INAA data, we propose the following scenario for the formation of the enstatite chondrite parent body. If condensation is assumed to have occurred, it must have occurred under the normal redox condition. The reductive nature was acquired at the later sulfidation stage. During the accretion, which