OLIVINE AND THE THERMAL HISTORY OF THE E CHONDRITE PARENT BODY. M.K. Weisberg[1,2], M. Kimura[3], T.J. McCoy[4] and Y. Lin[5]. [1]Dept. Physical Sciences, Kingsborough College, City University of New York, Brooklyn, NY 11235. (mweisberg@kbcc.cuny.edu). [2]Dept. of Earth and Planetary Sciences, American Museum of Natural History, New York, NY 10024. [3]Faculty of Science, Ibaraki University, Mito 310-8512, Japan. [4]Dept. Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington DC 20560-0119. [5]Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China.

Introduction: Olivine is a major mineral in ordinary and carbonaceous chondrites and its degree of compositional equilibration is widely used as an indicator of metamorphic grade. The least altered chondrites with heterogeneous olivine compositions are classified as type 3 [1]. Type 3 chondrites are subdivided into 3.0-3.9, with the least equilibrated, most primitive chondrites designated 3.0 [2]. Minor element trends in olivine, e.g., Cr, appear to be useful for distinguishing the most primitive type 3.0 chondrites from higher petrologic types in O and C chondrites [3]. However, in the type 3 enstatite chondrites (EH3 and EL3), olivine is a minor mineral, while it is completely absent in the higher petrologic type E 4-6 chondrites. The questions we address here are whether olivine has potential for petrologic classification of the E chondrites and could it be used to identify the most primitive E chondrites. Our goals are to establish a petrologic type classification scheme for E chondrites and understand the thermal history of the E chondrite parent body.

Results: *Experimental and Samples:* The presence of olivine has been used to distinguish E3 from E4-6 chondrites [e.g., 4]. This is consistent with other petrologic indicators such as the presence of glassy mesostases in chondrules [5]. We are currently studying 16 meteorites that meet this criterion and are considered to be E3 chondrites. As of this writing we have electron probe analyses of olivine in 5 of them. The samples studied include Allan Hills 85119 (ALH85119) EH3, Elephant Moraine 83322 (EET83322) EH3, MacAlpine Hills 88136 (MAC88136) EL3, Yamato 691 (Y691) EH3 and Lewis Cliff 87234 (LEW87234) ungrouped E3. Analyses of the remaining 11 are in progress. Results are shown in Fig. 1-3.

Petrography: Olivine makes up 2 to 7 volume % of E3 chondrites [6]. It occurs in chondrules associated with enstatite, as isolated fragments and in rare barred olivine chondrules and their fragments. Some olivine contains blebs of low Ni, Fe-metal associated with areas of more magnesium-rich forsterite, suggesting reduction of Fe from the olivine. In some cases, metal blebs and forsterite are oriented along structural features, such as parting planes or fractures within the host olivine, as previously described [7].

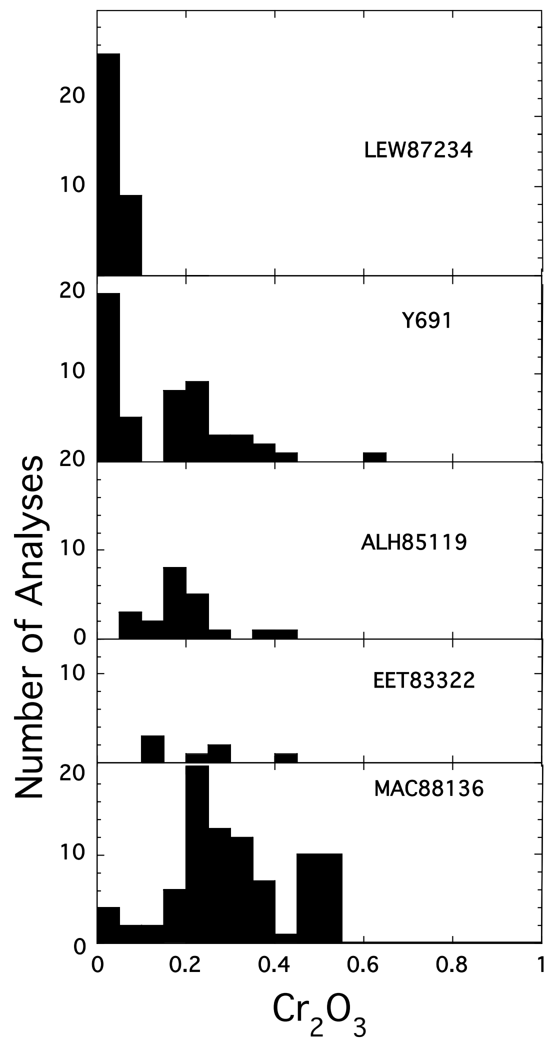

Figure 1. Histogram of Cr_2O_3 content (wt. %) in olivine in five E3 chondrites. Meteorites arranged from least to most equilibrated, based on their olivine compositions.

Mineral compositions: The olivine in E3 chondrites ranges in composition from near-pure forsterite to FeO-rich ($Fa_{0.1-15}$). Minor elements (range in wt.%) include MnO (below detection to 0.4) and Cr_2O_3 (below detection to 0.6). The distribution of Cr content in the olivine appears to differ among the 5 samples studied (Fig. 1). Olivine in Y691 and LEW87234 has a clear peak at low Cr values with Y691 having a slightly wider spread in Cr values than LEW87234. Olivine in ALH85119, EET83322 and MAC88136 has a wider range in Cr, with MAC88136 having a peak at 0.2 - 0.3 wt. % Cr_2O_3.

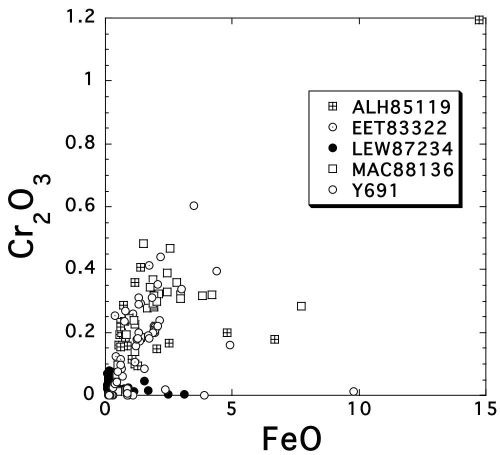

Figure 2. Cr_2O_3 vs. FeO (wt. %) for olivine in E3 chondrites.

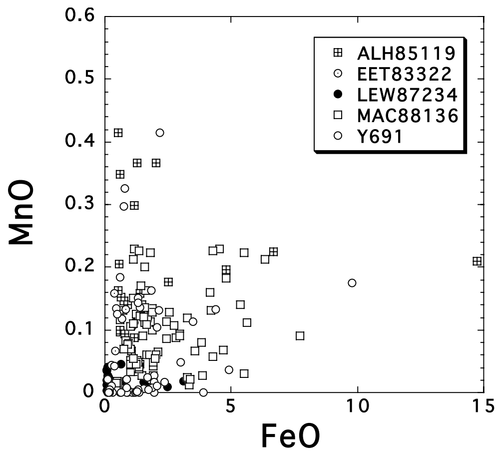

Figure 3. MnO vs. FeO (wt. %) for olivine in E3 chondrites.

Cr shows a positive relationship with Fe (Fig. 2). However, the relationship between Mn and Fe in the olivine appears to be weaker (Fig. 3). Some olivine with low FeO has relatively high MnO with Fe/Mn ratios as low as 1.2.

Discussion and Conclusions: Grossman [3] showed that the Cr contents of olivine in the least equilibrated ordinary chondrites, such as the Semarkona LL3.0 chondrite, show a wide distribution with a central peak at about 0.5 wt. % Cr_2O_3. For olivine in CO3.0 carbonaceous chondrites, the distribution of Cr values is similar but the peak is at 0.3 to 0.4 wt. % Cr_2O_3. In higher petrologic types (≥3.2), olivine shows a narrower distribution and lower contents of Cr, suggesting migration of Cr from olivine during metamorphism. The distributions of Cr in olivine from the five E chondrites studied are similar to Cr distributions in olivine in type 3 ordinary and carbonaceous chondrites. The wide distributions of Cr in olivine in ALH85119, EET83322 and MAC88136 are similar to the Cr distributions of olivine in petrologic type ≤3.1 O and C chondrites, shown by Grossman [3], but the peaks are at 0.2 to 0.3 wt. % Cr_2O_3. The lower peaks are not surprising since the olivine in the E3 chondrites has lower Fe than the Type II olivine measured in the Grossman study. Therefore, if Cr is a useful indicator of petrologic type, these three E chondrites may be very primitive. The Cr distributions of olivine in LEW87234 and Y691 are more similar to those of olivine in type >3.2 chondrites, having narrower distributions and lower values of Cr. We caution that the results are preliminary and we are not yet ready to classify these meteorites according to petrologic subtype. We conclude that (1) ALH85119, EET83322 and MAC88136 are less equilibrated than LEW87234 and Y691 and (2) Cr content of olivine has potential as an indicator of the most primitive E chondrites. However, mobilization of Cr during reduction may be the main process responsible for the low Cr values in LEW87234 and Y691 olivine. Olivine shows variable degrees of reduction within a single meteorite suggesting some olivine suffered reduction during chondrule formation, prior to accretion. Therefore, it is not clear if the compositional variations in the olivine are due to primary nebular processes or parent body metamorphism, or both.

The presence of low Ni, Fe-metal blebs associated with more magnesian compositions in the olivine indicates that reduction is a major process that affected olivine compositions. The lack of relationship between Fe and Mn with low Fe/Mn ratios in some olivine (Fig. 3) suggests that the primary olivine compositions have been overprinted by reduction of Fe from the olivine. The positive relationship between the Cr and Fe in the olivine (Fig. 2) suggests that some Cr was mobilized along with Fe from the olivine during reduction. Reduction of olivine in E3 chondrites probably occurred both during chondrule formation and during parent body metamorphism. Absence of olivine in the equilibrated E4-6 chondrites is likely due to reduction of olivine to form enstatite.

References: [1] Van Schmus and Wood (1967) GCA 31, 747-765. [2] Sears et al., (1980) Nature 287, 791. [3] Grossman (2004) LPSC XXXV, #1320. [4] Prinz et al. (1985) Meteoritics 20, 731-732. [5] Kimura and Lin (1999) Antarc. Meteorite Res. 12, 1-18. [6] Weisberg et al., (1995) LPSC XXVI, 1481-1482. [7] Weisberg et al., (1994) Meteoritics 29, 362-373.