Origin of Enstatite Chondrites and Implications for the Inner Planets

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Over 90% of EC chondrules are enstatite-rich. Some enstatite was initially Fs_5 to Fs_{30}, and was reduced after formation, probably by interaction with a vapor in which reduced matrix phases were thermodynamically stable (Lusby *et al.* 1987; Weisberg *et al.* 1994). We are interested in the nature and nebular location of such a reducing vapor, in which EC minerals (e.g.- CaS, MgS) might have been stable.

Ebel and Grossman (2000) mapped dust enrichment conditions for thermodynamic stability of FeO-rich silicates using a CI chondrite dust composition. The highly unequilibrated, anhydrous, interstellar organic- and presolar silicate-bearing cluster IDPs (C-IDPs) may be closer to the primordial dust composition than CI dust, as suggested by observed C depletions, relative to solar, in dense interstellar clouds. C-IDPs are relatively reduced, with low FeO and high C contents. Alexander (2002) noted modest enrichments of C-IDP-like dust would create conditions reducing enough to stabilize EC minerals, unless ice was also concentrated. Also, recent solar photosphere measurements suggest a 25% lower O abundance than previous estimates (Prieto *et al.* 2001).

We calculated condensation using a C-IDP-like dust composition at dust enrichments of 10, 100 and 1000 times solar at $P^{tot}=10^{-3}$ bar. Oxygen is calculated from a 75% solar baseline. The dust is H-, N-free CI, with all S as FeS, and O sufficient to make rock-forming oxides of the remaining Fe, Si, Mg, etc. At 100x enrichment, CaS is stable below 1290K, and MgS below 1180K. At 1290K, modal pyroxene (Fs_0) and olivine (Fa_0) are approximately equal. Although the system tracks $f(O_2)$~(IW-4) above 1720K, $f(O_2)$ drops to (IW-8) by 1290K. Surprising! Silicate FeO *de*creases with decreasing T.

These results suggest that at the time the asteroids were forming, the snow line was near the inner edge of the asteroid belt, the presumed location of EC parent bodies. Bodies forming inward of the snow line would have been reduced, unless during high-T processing the dust enrichments relative to gas were modest. This has implications for the terrestrial planets' inventories of highly and moderately volatile element (and water) sensitive to reducing *versus* oxidizing conditions.

References

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REE, Th and U abundances in individual chondrules from Dhajala, Allegan and Bjurböle chondrites

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It is apparent that chondrules once experienced melting processes of the precursor material. As relict minerals are still present in chondrules of some UOCs, these chondrules may provide us information concerning the precursor materials and melting episodes. Chondrules in EOCs have experiences thermal metamorphism on their parent bodies and, hence, may help us to understand their metamorphic activities. In this study, we separated chodrules from Dhajala (H3.8), Allegan (H5) and Bjurböle (LL4) and studied them for trace element compositions and mineralogical/petrological characteristics.

Chondrules were separated mechanically, embedded in acetone-soluble resin and sawed into three portions. One portion was used for determining REE, Th and U by ICP-MS. Another portion was used for mineralogical and petrological descriptions by SEM and EPMA.

REE, Th and U abundances in Dhajala chondrules are generally unfractionated from and higher than those in the bulk sample. Eu anomaly (negative) is commonly but not ubiquitously observed. There seems no apparent correlation between REE abundances and mineral/petrological characteristics. In contrast, REE, Th and U abundances are largely variable in chondrules of Allegan and Bjurböle even though chondrule types are identical. Lanthanoids (REE) (with positive Eu anomaly) and actinoids (Th and U) are generally fractionated, with REE being relatively depleted. Our study suggests that REE, Th and U abundances in chondrules inherited those from the precursor material. During thermal metamorphism on ordinary chondrite parent bodies, REE migrated into surrounding minerals much faster than Th and U.