FE AND MN SYSTEMATICS IN EXPERIMENTAL ANALOGUES OF MURCHISON AND A 65% H CHONDRITE-35% CM CHONDRITE:

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Partial melting experiments on Murchison and 65% H chondrite-35% CM chondrite analogues can produce eucritic melts with good compositional matches for all major elements and for the Fe/Mn ratio. The H-CM mixture is a good precursor that matches the phase equilibris as well as the oxygen isotope constraints on eucrite precursors. The main problem is an over abundance of Na. The H-CM composition also satisfies many trace element constraints and produces eucritic melts at oxygen fugacities between IW -0.5 and IW -1.5 and at temperatures from 1180 to 1300°C.

INTRODUCTION: Boesenberg and Delaney (1993), following up on the work by [2] and [3], investigated the Mn and Fe systematics of eucritic compositions and the evolution of eucrites from the simple partial melting of a chondritic precursor, specifically a Murchison analogue. We proposed that iron alloying to the platinum wire used in experimental runs could simulate a reducing atmosphere and further simulate the subsequent fractionation of the Fe-metal from a parent body. The effect of Fe removal reduces the Fe/Mn ratio and Fe/(Fe+Mg) of the resulting glass, while preserving most other elements in eucritic proportions. New experiments, using inert platinum-iron wire and at oxygen fugacities of iron-wustite (IW) -0.5 log unit and IW -1.5 log unit confirm that the Fe/Mn and FFM of the minimum melt for a chondritic precursor can be controlled and produce eucritic compositions. Additional experiments tested the new chondritic precursor proposed by [4]. This composition was designed to resolve the major oxygen isotope problem associated with eucrites. No simple chondritic precursor has oxygen isotopes compatible with eucritic precursors [5], but a mixture of H and CM compositions can produce an appropriate oxygen isotope ratio. This mixture also has a bulk composition very similar to the most useful parent body composition [6] and has an initial Fe/Mn ratio compatible with eucrite compositions. Experiments on the CM chondritic meteorite, Murchison, by [2] showed that a eucrite-like composition could be derived from such material. The experiment's of [2], however, showed that the Murchison composition fails to produce appropriate Fe/Mn ratios. In an attempt to account for this discrepancy, [4] calculated a possible eucritic precursor based on oxygen isotopes and the Fe/Mn ratios. The result was a composition containing 65% H chondrite and 35% CM chondrite. This composition satisfies all of the requirements for a precursor except the over abundance of volatiles, specifically Na. The Murchison differs from the 65H-35CM by having approximately 3.5 wt% less SiO2, 0.1 wt% greater TiO2, 6 wt% greater FeO, 4 wt% less MgO, 0.6 wt% greater CaO, and 0.55 wt% less Na2O.

METHODS: The Murchison analogue and 65H-35CM analogue experiments were run using a vertical muffle tube CO-CO2 gas mixing furnace. The experiments were run at three temperatures (1180°C, 1200°C, and 1300°C), and two oxygen fugacities (IW -0.5 and IW -1.5). Most of the experiments were run for a duration of about one week to allow the experiments to reach equilibrium. Using the partition coefficient calculations of [7] on Fe, Mn, and Mg in the olivines and glasses, all of the experiments showed that they were either at or very near equilibrium.

RESULTS: The results of both the Murchison analogue and the 65H-35CM analogue experiments demonstrate the independent effects of Fe loss and olivine crystallization on the bulk composition (Figure 1A and 1B). They show that with a decreasing oxygen fugacity, more Fe-metal is fractionated from the melt, causing both the Fe/Mn ratio and Fe/(Fe+Mg) (FFM) of the bulk to decrease. This compositional change follows the predicted Fe loss path seen in Figure 1. Equilibrium olivine compositions for points on the Fe loss path have higher Fe/Mn and lower FFM ratios corresponding to those produced in these experiments. The residual liquid compositions have higher FFM ratios reflecting mass balance constraints as well as equilibrium partitioning. These redox controlled Fe changes leave most other elements unaffected, except Cr which is also redox sensitive.

A comparison between the experimental glasses and mean eucrites (Figure 2a and 2b) [8] showed that, in general, the Murchison composition is not as good of a candidate for a precursor as is the 65H-35CM composition. The partial melts of the Murchison precursor have Mn and Al depletion that deviate significantly from eucritic compositions. The 65H-35CM precursor, on the other hand has glass/eucrite ratios of about one for most elements except Na at temperatures of 1180-1200°C. The wide Na2O variation within both sets of experiments reflects the volatility effects on Na. The 65H-35CM composition is strongly enriched in Na2O content but shows great variabilty caused by Na volatilization. The 1300°C

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experiments show the more variable compositions caused by the glass becoming increasingly olivine normative at higher temperatures. The higher Cr2O3 content of these higher temperature experiments reflects a decrease in the chromite content of the bulk composition, and the presence of Cr^{2+} at these low fugacities. The Cr^{2+} enrichment in the glasses is enhanced in the lower fugacity experiments. The increase of Cr in the melt correlates with a decrease of the silica content of the glasses, reflecting increased solution of Cr^{2+} bearing olivine in the melt. The compositional differences give the 65H-35CM a more appropriate Fe/Mn and FFM for eucrites and better agreement with the TiO2 content. The Na2O content of 65H-35CM, however, is far too high for eucrites, since the volatility effect of Na should be negligible on a parent body sized object.

CONCLUSIONS: A eucritic composition that will produce appropriate Fe/Mn ratios and FFM ratios, can be made from chondritic precursors under reducing conditions. The effect of this reduction shows little or no change to the remaining composition. This reduction alters the bulk melt Fe/Mn ratio and FFM along the Fe loss path in the predictable manner. Based on these experiments, the 65H-35CM composition of [4] appears to be a better precursor than a carbonaceous chondrite, such as Murchison, despite the over abundance of Na. The 65H-35CM composition, designed to satisfy oxygen isotope and trace element constraints is also an appropriate precursor for production of eucritic melts at "realistic" oxygen fugacities and temperatures. Comparison of the experiments carried out between IW -0.5 and IW -1.5 suggest that the eucritic melts may be produced at any of these oxygen fugacities.

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ACKNOWLEDGEMENTS: NASA: NAG9-304 (JS Delaney) is gratefully acknowledged.