CONSTRAINING THE FORMATION CONDITIONS OF SILICATE-BEARING IRON METEORITES.

G. K. Benedix[1] and T. J. McCoy[2], [1]Dept. of Geological Sciences, Virginia Tech University, Blacksburg, VA 24060, USA, gbenedix@vt.edu; [2]Dept. of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington DC, 20560-0119, USA.

Introduction: Most groups of iron meteorites exhibit small ranges for a variety of siderophile trace elements (e.g., Ga, Ge, Ir) when plotted against Ni. These elemental trends almost certainly originated during fractional crystallization of a common metallic body and provide strong evidence for core formation. In contrast, a smaller number of iron meteorites (e.g., IAB, IIE, IIICD) exhibit much wider ranges for Ni and certain siderophile trace elements than the other groups. In addition, they also contain abundant silicate inclusions which are broadly similar in chemical composition to the chondritic material from which their parent bodies must have formed. These features indicate a formation by one or more mechanisms which may not have operated on the parent bodies of the more common "magmatic" iron meteorites.

We have argued for a model for IAB-IIICD irons that explains these apparently contradictory features by invoking incomplete melting and separation of the Fe,Ni-FeS cotectic and basaltic partial melts from the chondritic to ultramafic residues, followed by catastrophic impact, to produce these silicate-metal mixtures [1]. This model provides a broad framework for interpreting the genesis of these meteorites, particularly their textural features, but leaves a number of questions unanswered. In this work, we are attempting to constrain the temperature-oxygen fugacity conditions under which these meteorites formed and using these constraints to examine the physical formation environment.

Method: Olsen et al. [2] capped a career of observations on iron meteorites by noting the diverse mineralogy of inclusions in IIIAB irons. In particular, these authors noted the range of occurrences and oxidation states for a variety of elements that occur in iron meteorites. Notably, Cr occurs within single inclusions in iron meteorites in daubreelite ($FeCr_2S_4$), chromite and chromian diopside. Likewise, phosphorus can coexist in both the phosphide schreibersite and a vast array of Fe, Mg, Mn, Ca, Na and K phosphates. Many of these inclusions also contain graphite and are hosted in an Fe,Ni matrix while having FeO in the mafic silicates. Thus, these elements can occur as siderophile, chalcophile and lithophile elements. While bulk chemical composition must be a strong control on the occurrence of these elements, temperature and oxygen fugacity must also play a role.

Our method relies on constraining the oxygen fugacity-temperature space in which an iron meteorite formed by bounding it in fO_2-T space by the appropriate buffer curves (e.g., Cr_2O_3-Cr; P_2O_5-P, FeO-Fe and CO-C) and the temperature of formation (e.g., two-pyroxene temperature). The exact position of the buffer curve is dependent on the composition of the system and, thus, we intend to measure the compositions of silicates, daubreelite, chromite, schreibersite, and phosphates in places where oxidized and reduced carriers of a common element coexist in intimate contact. In some cases, multiple buffer curves may constrain the temperature, providing an independent measure of the temperature.

Initial Work: Silicate minerals in the IAB irons are characterized by relatively reduced compositions with olivine ranging from $Fa_{1.0}$(Pine River) to $Fa_{8.0}$(Udei Station) and low-Ca pyroxene ranging from $Fs_{1.0}$(Kendall County) to $Fs_{8.7}$(Udei Station). Our initial study was conducted on the Udei Station IAB iron meteorite, since it contains both the oxidized and reduced phases of Cr and P (i.e. chromian diopside-chromite-daubreelite and phosphate-phosphide minerals), in addition to having the most oxidized silicate mineralogy forming an end member. The clast in which these minerals occurs is particularly interesting, since it is depleted in high-Ca pyroxene and plagioclase and is probably an olivine-rich residue formed at relatively high temperature. New X-ray maps of the distribution of phosphorus also show that both phosphate and phosphide are present. Mosaics of combined Mg, Ca, Cr, P, Al, and S x-ray maps reveal certain textural relationships. Chromite is scattered throughout the inclusion, but in only one case is it in contact with high-Ca pyroxene. Phosphates can be found completely within the inclusions, but also occur on the edges of the inclusion, in contact with the metallic matrix.

Future Work: For this project we have 3 goals: 1) Calculate buffer curves for Udei Station using the compositions of the various co-existing minerals, specifically to constrain the fO_2-T conditions under which this inclusion formed. 2) Because the inclusions are surrounded by metallic matrix, the conditions of formation will be local to that inclusion. To compare how local conditions vary within the parent body, many IAB inclusions will be examined to establish the conditions under which each formed. This database will be used to establish the range of fO_2-T conditions during formation. 3) Once the range of conditions is constrained, melting experiments of chondritic starting materials will be undertaken to determine if the mineral assemblages found in the IAB silicate inclusions can be reproduced.

References: [1] Benedix G.K. et al. (2000) *Meteoritics & Planet. Sci.*, *35*, 1127-1141. [2] Olsen E. J. et al. (1999) *Meteoritics & Planet. Sci.*, *34*, 285-300.