SILICATE INCLUSIONS IN IRONS AND METAL-SILICATE ASSEMBLAGES

M. Prinz[1], C.E. Nehru[1,2], J.S. Delaney[1]. (1) Dept. Min. Sci., Amer. Museum Nat. Hist., NY, NY 10024. (2) Dept. Geology, Brooklyn College, CUNY, Brooklyn, NY 11210.

INTRODUCTION. Silicate inclusions in IAB and IIICD irons have been described as a new type of chondritic material (e.g., **1,2,3**). Winonaites (**4**) are closely related to silicates in IAB irons, and were interpreted as primitive achondritic. Acapulco, a Winonaite (**4**) with unique oxygen isotopes (**5**), was interpreted to have "formed in the early stages of incipient melting of a chondritic parent body" (**6**). Silicates in IIE irons are both chondritic (Netschaëvo) and fractionated (5 others) (**7,8**). What is less well known is that silicates (also oxides or phosphates) are found in many other iron groups. Many of these materials are poorly studied, and represent a wide spectrum of types ranging from chondritic to modified chondritic to primitive achondritic to fully achondritic. This paper reviews some of the characteristics of the silicates in metal-silicate groups, citing known characteristics (including new data from our group), but noting also problems to be solved. We hope to stimulate research on these silicates, and caution against interpretation as new types of chondritic materials simply because they are present in iron meteorites and do not fit into established classification.

SILICATES IN IAB IRONS AND WINONAITES. IAB irons are a large group, about 90 members, and at least 38 contain silicates (**9**). Twelve have been petrologically studied (**10,11**), and less than half of these have been studied for trace elements, ages, or oxygen isotopes. They are magnesian, compositionally between H and E chondrites, have no chondrules, are 4.5 b.y. old, are usually associated with graphite and often sulfide, and can be up to 40 vol.%. Only Campo del Cielo has documented evidence of partial melting, petrologically and in trace elements (**1,11,12**), but there has been little discussion of the implications of this modification on interpretation of this group of silicates. A different kind of assemblage is found in Canyon Diablo. It contains krinovite and ureyite, as well as rutile, chalcopyrite, mackinawite, and other phases (**9**). Its relationship to other IAB silicates is not known.

A group of 6 Winonaites was defined (**4**), of which some have oxygen isotopes like IAB irons while others are widely scattered. Petrologic data for all, and trace element data for some, reveals a close relationship (**1,4,6,13,14**). A shock melt origin for silicates in IAB irons (and Winonaites) and in IIICD irons has been suggested (**2**), but this hypothesis needs testing and evidence that shock melting does not modify the original materials is lacking.

SILICATES IN IIICD IRONS. Of about twelve IIICD irons only two (Carlton and Dayton) are known to have silicate inclusions. Data on these silicates are very sparse (**15,16**), but they are nevertheless considered chondritic and linked with silicates in IAB irons (e.g. **2**). New data on a 1-cm wide inclusion in Carlton has: 35% ol (Fo_{91}); 43% opx (En_{90}); 21% plag (An_4); 0.8% farringtonite (previously unreported). Dayton has: 18% opx (En_{87}); 4% plag (An_4); 0.14% SiO_2; 12% merrillite; 27% panethite; 38% brianite. Large $(FeNi)_3P$ crystals border all inclusions. Carlton and Dayton differ widely from one another and from IAB silicates. No other data exist for these assemblages. Wasson and co-workers consider the metal to be non-magmatic, but this does not mean that the silicates are chondritic, as suggested. Dayton has a remarkably P-rich assemblage, which is clearly non-chondritic.

SILICATES IN IIE IRONS. IIE irons are a small group (12 to 14 meteorites) and 6 contain silicate inclusions. They are discussed in more detail in an accompanying abstract on Sombrerete (**17**). The ages of the inclusions in Weekeroo St. and

Colomera are 4.5 b.y. and Netschaëvo and Kodaikanal are 3.8 b.y. (**18**). Data on Sombrerete, and its relationship to other silicate-bearing IIE irons suggests that the silicates are achondritic, possibly derived from H-chondrites (**17**), but further data are needed.

SILICATES IN IVA IRONS. Bild (**20**) studied inclusions in Sao João Nepomuceno ("Nepo") and found only opx (En_{88}) and tridymite, an assemblage very similar to the Steinbach stony-iron, which has IVA metal with opx (En_{86}) and tridymite (**21**). Tridymite is found in Bishop Canyon and Gibeon (**9**). Further search in IVA irons may reveal more silicates. There are presently no other data on any of these assemblages, and their origin is unclear although unlikely to be chondritic. Trace element and oxygen isotope studies are now underway on Nepo (with K. Fredriksson) and Steinbach (with R. Ganapathy).

SILICATES IN IIB IRONS. The only IIB iron known to have silicate inclusions is Sikhote-Alin (**9,22**). Silicates include opx (En_{82}) and olivine (Fo_{81}), and differs from any other silicate assemblage in an iron. Inclusions of chromite (up to 8 cm) are found (**9**). Further data are needed, and a search for inclusions in other IIB irons is warranted.

SILICATES IN IIIAB IRONS. Both pallasites and mesosiderites have unequivocally achondritic silicates (**23-25**) included with about ~50% metal. The metal of pallasites is fractionally crystallized IIIAB (**26,27**), while that of mesosiderites was probably IIIAB prior to extensive modification by metal-silicate interaction (**25,28-30**). Mesosiderites and pallasites are another example of the association of achondrites with an iron group, a more common relationship then generally realized.

Other IIIAB irons do not appear to contain silicates. However, SiO_2 has been found in Cape York (**31**). Oxygen isotopic determination of any silicate in a IIIAB iron would be very important to test its relationship with basaltic achondrites.

SILICATES IN IIA AND IID IRONS. Bild (**22**) noted SiO_2 polymorphs have been found in some IIA and IID meteorites. These examples and these groups should be further explored.

Si-BEARING IRONS WITH SILICATES. There are very few Si-bearing irons, which formed under highly reducing conditions. Two contain silicates which have been studied. Mt. Egerton was related to the aubrite parent body (**32**), and contains opx ($En_{99.1}$), cpx ($En_{55}Wo_{45}$), Cr-rich troilite, brezinaite and alabandite. Tucson is a unique Si-bearing iron meteorite, and is discussed in an accompanying abstract (**33**). The silicates have remarkable compositions, and the assemblage was derived by partial melting of an aubritic assemblage and accompanying metal-silicate interaction. This group again illustrates the interaction of achondritic or modified chondritic assemblages with an iron meteorite group.

CONCLUSIONS. This brief survey of silicates in irons, and other metal-silicate assemblages, illustrates the complexity of these assemblages, and the variety of scenarios which exist. Silicates associated with abundant Fe-Ni metal have sometimes been ascribed to chondritic origin without enough substantiation. Also, the origin of the iron group does not necessarily determine the origin of the silicates. These meteorites offer a unique opportunity to explore the transition between chondritic and achondritic parent bodies, and research should reflect careful consideration of all working hypotheses.

REFERENCES. Due to lack of space references are not cited. For references please write to M. Prinz.