Opaque rich clasts in primitive mesosiderites

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Mesosiderites are enigmatic. Often, the silicate part is considered to have been derived from Vesta and the metal was derived from a molten core. But there are difficulties with such models. Primitive mesosiderites give chances for understanding the early history of mesosiderites that tends to be erased by thermal metamorphism in many mesosiderites.
Here we report the presence of opaque-rich clasts in primitive mesosiderites (NWA1878 and Crab Orchard). Although they contain opaques (and hence easily identified in BE Image), its main (more than ˜90% by volume) constituent mineral is pyroxene (px: Ca-rich and Ca-poor). Note that the majority of clasts in primitive mesosiderites are devoid of opaques.
The opaques are mostly FeS and metal. Silica mineral is ubiquitous. Variable amounts of small chromite and plagioclase (pl) are often observed. Typical size of these minerals is 10 microns or less. Often augite lamellae of various thickness are observed in px. In addition, grainy augite (˜10 microns in size) is often observed. There may be some void spaces but they could be artifact.
A fine-grained clast in NWA1878 is unique in that it contains many small opaques nearly homogeneously and the clast is large (more than 6 mm in size). It is located at one end of a polished section and such a clast is not found elsewhere in NWA1878 nor in other primitive mesosiderites. There are other opaque-bearing clasts in NWA1878 and Crab Orchard that are classified based on the texture as follows: type I (normal zoning), type II (reverse zoning) and type III (plagioclase-rich).
Type I clasts have clean, Mg-rich central area. The Fe’ =Fe/(Fe+Mg) of px increases toward the rim and the peripheral area contains some opaques. Such clasts are probably igneous pyroxene that suffered slight modification of the periphery. Type II clasts contain opaques nearly homogeneously and the Fe’ decreases toward the rim. Type III clasts contain a fair amount (several % by volume) of relatively small (˜10 microns) pl. It is to be noted that this pl size is much less than that in the general matrix. Opaques and pl are nearly homogeneously distributed in the clasts.
Origin of FeS and metal is not obvious. FeS and metal coexist in most clasts. Ni-poor kamacite is observed in some clasts, suggesting metal production by in-situ reduction. A reducing condition in mesosiderites associated with merrillite formation is well known. But there are px clasts of similar Fe’ values that do not show opaques. Therefore, the metal production in these clasts need a special condition. We suggest that high porosity/permeability was the condition that conduced to the metal production. This is supported by the following observation. In two clasts, small chromite (˜10 microns in size) is abundant (˜2 wt. %) and homogeneously distributed in the clasts. (These clasts also contain a fair amount of pl.) Such amounts of chromite cannot exsolve from px. Therefore, the chromite must have been mixed in the precursor material. In other words, the precursor was a mixture of small amounts of fine-grained chromite and pl in a large amount of px. Put it another way, it looks like the fine-grained clast in NWA1878 (see the 3rd paragraph), although the abundance of each mineral may be different.
Summary: We propose the following scenario for opaque-rich clasts. Initially, it was a porous mixture of small amounts of minor minerals in a predominant amount of px. Accretion of P-bearing metal produced reducing environment. Clasts were reheated to close to the solidus temperature producing kamacite from px. At the same time, the peripheral parts of the clasts were reduced to result in reverse zoning. FeS could be produced at any time after the metal production, since the sulfur fugacity was high in mesosiderites. If

this scenario is correct, it means that a fine-grained soil layer existed on the mesosiderite parent body. But we have to make much more observations to confirm all the observations are consistent.

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