

Multiple heating of mesosiderites

*naoji sugiura¹, Tomoko Arai¹

1. Chiba Institute of Technology

Mesosiderites are the most enigmatic meteorites and there are various schools of thought on their origin. In particular the source of the metal and the heat for their metamorphism are not well known. If metal from a molten core was the heat source, reheating could occur only once. If, however, reheating is due to induction heating due to changing magnetic field, reheating could occur multiple times. Petrographic features may distinguish single vs. multiple reheating history of mesosiderites. For instance, a Bondoc metal nodule contains idiomorphic merrillite which appears to have crystallized quickly from a silicate+phosphate melt. Since phosphate in mesosiderites is produced by a reaction between P in metal and Ca in silicates at temperatures below ~1100C (Harlow+,1982) after the metal mixing, the idiomorphic merrillite in the Bondoc nodule suggests that a quick heating occurred after the merrillite formation, i.e. at least two heating events are required. Here we present more petrographic features of mesosiderites that seem to be useful for recognizing the reheating.

Cordierite is a solidus phase in a Ca-poor silicate system, which was presumably produced by formation and isolation of abundant merrillite. In other words, the presence of cordierite suggests that heating occurred at least twice. But cordierite is rare in mesosiderites.

The presence of cordierite suggests a high Al activity as a result of merrillite formation using Ca in plagioclase. Even if cordierite is not stabilized, high Al activities that were produced by this merrillite formation reaction, are recognized as high Al concentrations in various minerals. For instance, high Al concentrations are observed in pyroxene and chromite in some mesosiderites. However, such a high Al activity, by itself, could be produced by slow cooling during a single heating episode. To confirm that multiple heating events occurred, we need evidence for quick cooling in conjunction with the high Al activity.

Thin pyroxene lamellae: Pyroxene in primitive mesosiderites show fine lamellae, with augite thickness of much less than 1 micron. This is direct evidence for quick cooling.

Chromite texture: Silicate inclusions in chromite and the convoluted boundary against silicates mean melting and quick cooling through the solidus. This texture is not easily erased by metamorphism.

Excess silica in plagioclase: This is produced by quick cooling through the solidus under high silica activities but is often erased by metamorphism.

In four mesosiderite samples (NWA2924, NWA2924 metal nodule, NWA1878, Dong Ujimquin Qi), we observed evidence for quick cooling (fine pyroxene lamellae, chromite texture, excess silica) together with high Al in pyroxene and chromite. This means that multiple heating events, followed by quick cooling, occurred in these mesosiderites. (The Al content in chromite in the NWA2924 nodule is limited and excess silica in the NWA2924 sample is not high. These may require additional/different explanations.)

Estherville A3/4 is known to be well metamorphosed, and our criteria for cooling rates for Estherville are consistent with this metamorphic degree. Crab Orchard (A1) is supposed to be primitive but the pyroxene lamellae are decomposed. Also, the excess silica is subdued. Therefore, it is not clear if the conventional metamorphic degrees are consistent with the criteria for quick cooling of this study. More studies on other mesosiderites are needed.

In conclusion, petrographic features suggest multiple reheating events for mesosiderites and induction heating, rather than molten metal is the heat source for mesosiderite reheating.

Harlow G.E., 1982, GCA 46,339-348.

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