

Texture and compositions of chromite in mesosiderites

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Mesosiderites were heated after/at the mixing of metal and silicates. The conventional view is that the molten metal was the heat source (e.g. Haba+,2019). But, petrography of some mesosiderites suggests multiple reheating. For instance, idiomorphic merrillite in a Bondoc nodule must have formed by melting of pre-existing solid merrillite. Since merrillite forms from P in metal and Ca in silicates mostly at subsolidus temperatures after the metal mixing, a second heating event to above solidus is required. Similar arguments can be made based on pyroxene overgrowth that likely occurred in a Ca-, P-rich melt (Mayne+,2009). This also requires melting of merrillite. The main reheating event occurred at ~40 Ma after CAI (Haba+, 2019; Koike+, 2017), when there were not many heat sources in the solar system. To shed light on the heat source, here we describe chromite in mesosiderites. They provide evidence on thermal histories from above the solidus down to several x100 degrees C because of the relatively quick diffusion.

Spherical silicate inclusions in chromite are observed in many mesosiderites and are considered as strong evidence for quick melting and cooling through the solidus. In many cases (7 out of 12 mesosiderites with such inclusions), the presence of spherical inclusions in chromite is associated with excess silica in plagioclase (e.g. Dong Ujimqin Qi) that is consistent with the quick cooling. If the excess silica is not associated, slow cooling below solidus and/or prolonged reheating to near solidus is suggested. For instance, Estherville shows no excess silica and it shows high Na in merrillite, that are interpreted as a result of prolonged reheating.

There are 5 mesosiderites (Vaca Muerta, NWA 1827, NWA 1951, NWA 8234 and Asuka 87106) for which spherical silicate inclusions in chromite are rare/absent. In such mesosiderites, small granular plagioclase grains in the matrix suggest that they were once molten and became granular by reheating. Pyroxene compositions are also well equilibrated. Therefore, the lack (or paucity) of spherical inclusions in the chromite is explained by their exclusion during strong metamorphism (either slow cooling or reheating). In summary, the presence/absence of spherical inclusions in chromite is explained by the degree of metamorphism after a partial melting event.

Chromite compositions ($Cr' = Cr/(Cr+Al)$, $Fe' = Fe/(Fe+Mg)$) are informative about thermal history at lower temperatures. Both inter- and intra- mesosiderite variations in Cr' are observed. Asuka 87106 is the most equilibrated, showing only ~1.5% relative deviation in Cr' , while a Bondoc nodule shows nearly a factor 2 variation from the lowest to the highest Cr' values. This variation in the Bondoc nodule is much larger than those in eucrites (Arai+, 1998; Yamaguchi+, 2009), and is associated with a variation in Fe' . Chromites in other mesosiderites also show similar but smaller variations in Cr' and Fe' . Such variations are probably related to phosphate formation in mesosiderites. If Ca in plagioclase is used for phosphate formation, it results in high Al activities. Also, pyroxene, containing ferrous iron, is used for phosphate formation, it results in reducing conditions. Thus, during cooling through intermediate temperatures where phosphate forms, the environment in mesosiderites changes significantly. Chromite is able to accommodate to such changes and shows the variations in Cr' and Fe' . Using the information given by such chromites, the thermal history of the mesosiderite parent body may be elucidated.

References

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Keywords: mesosiderites, thermal history