

An additional petrographic study of a metal nodule in the Bondoc mesosiderite

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Introduction

Bondoc is a mesosiderite of petrologic class B and metamorphic grade 4. In a previous report on a metal nodule in Bondoc (Sugiura et al., 2017), we examined globular inclusions (nearly completely molten) and angular inclusions (less molten). We found that the globular inclusions have bulk compositions close to the eutectic in the olivine-silica-anorthite system. In contrast, angular inclusions seem to have compositions away from the eutectic. Hence the melting degrees of inclusions (and the appearance) are explained by the differences in solidus/liquidus temperatures. Globular inclusions have phosphates crystallized from a silica-rich melt and/or partially dissolved into a silicate-rich melt. This implies that phosphate existed before the main reheating event, suggesting that reheating occurred repeatedly on the mesosiderite parent body. Here we report more detailed petrographic observations of the angular inclusions in the metal nodule.

Experimental

A polished section of the Bondoc nodule was observed with a SEM and the mineral compositions were measured by EDS.

Results

Some of the reversely zoned pyroxenes have high Al concentrations (up to 2.2 mol. %). Some chromites also have high Al contents. Furthermore, cordierite is found in many angular and globular inclusions. The Al concentrations in some pyroxenes and some chromites are highest ever reported for mesosiderites. Cordierite has been reported only for a shock heated mesosiderite (Petaev et al., 1992). These suggest that the Al activity was high in the Bondoc nodule, which is presumably due to formation of merrillite using Ca in plagioclase. This could be caused either by higher temperatures or exhaustion of Ca in pyroxene by extensive reactions (longer time at the same temperature) with phosphorus.

Silica grains in angular inclusions in the nodule have inclusions of plagioclase-like compositions with irregular shapes. This is interpreted as a solidification product from the eutectic melt of the silica-plagioclase binary system. The bulk silica grains also show subtle difference in brightness in BEI which is caused by small differences in Al and/or Fe concentrations. This is interpreted to be produced by cristobalite to tridymite transformation. (This has to be confirmed by a crystallographic study.) Some plagioclase also contains silica particles which are interpreted to have formed by exsolution during rapid cooling. These structures in silica and plagioclase in the nodule are unusual in mesosiderites and suggest that the Bondoc nodule cooled very rapidly. It is to be noted that such structures in silica and plagioclase are not observed in the matrix.

The inferred high temperatures (and/or longer reheating time) and very rapid cooling suggest that the heat source was located on/outside the parent body. Together with the repetition of the heating as

inferred in the previous report (Sugiura et al., 2017), plausible heat sources appear to be either induction heating due to changing magnetic field or solar radiation on the parent body with an eccentric orbit. Quantitative estimates of the cooling rates may distinguish these two possible sources.

References

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