A petrographic study of the NWA 2924 mesosiderite

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Recent chronological studies [1,2] revealed that reheating of mesosiderites occurred significantly later (~30 Ma) than the solidification of the magma ocean (~4563 Ma) on the parent body. At this age, 26-Al cannot be a significant heat source. Also, metal cannot be the heat source because even if it was derived from a core, its composition should have been fractionated by this time. (Mesosiderite metal is not fractionated in siderophile elements.) Therefore, an alternative heat source has to be looked for. Here we report petrography of a mesosiderite which was largely molten by the reheating event, based on which we discuss the heating process.

NWA 2924 has not been studied in detail. But it is noteworthy that it suffered only minor shock effects (Meteoritical Bulletin). Two polished sections (one metal nodule and one matrix) were observed with a SEM and the mineral compositions were analyzed with an EDS. The areal silicate fractions are plagioclase=0.380, pyroxene=0.534 and silica=0.086. This corresponds to the type A mesosiderite. Sub-classification of mesosiderites by degrees of reheating is rather confusing [3]. In our opinion, melt-rock mesosiderites should be classified as type 3. (Type 4 is eliminated.) They can be easily distinguished from type 2 by the absence of olivine coronas and by the presence of silica/plagioclase needles that penetrate into metal. By this definition, NWA 2924 is a type 3A mesosiderite.

Chromite in NWA 2924 shows three types of petrographic features. (1) Some chromites contain ubiquitous spherical silicate inclusions. (2) Some chromites contain similar spherical silicate inclusions which are restricted to the outer part of the chromite grains. (3) Clusters of smaller chromite grains which do not include much silicate inclusions are present. Such clusters are often observed in silicate inclusions inside metal nodules. The spherical silicate inclusions are considered to be produced as follows. Chromite and surrounding silicates were heated to above the solidus temperatures of silicates, and chromite was dissolved into the silicate melt. Shortly afterwards, it cooled rapidly and silicate melt was trapped in the growing chromite. In case (1), the heating was just enough for complete melting of chromite. In case (2), only the outer part of chromite was dissolved. In case (3), chromite was completely dissolved and the dissolved chromite component diffused away considerably, so that new chromite grains formed upon individual nucleation sites (that are located nearby), resulting in a cluster of small chromites. Such chromite features are different from those in shock-heated chondrites [4]. In shocked chondrites, chromite appears as fine (micron size) granular fragments because it is brittle.

This petrographic observation is important in 3 ways. First, it suggests that the heating was very brief. Second, it seems that chromite in metal nodules was molten more extensively, suggesting different environment such as higher temperatures and/or different melt compositions and volumes than the matrix. Third, shock heating is an unlikely mechanism for reheating mesosiderites, although it may be preferred solely based on the briefness of the heating.

Since radiogenic heat, accreting hot metal and shock heating are all ruled out as a heat source for mesosiderite reheating, we suggest that induction heating due to changing solar-wind magnetic field (joule heating by eddy current) is a plausible mechanism for mesosiderite reheating. We certainly need more observations of chromite in melt-rock mesosiderites and other shocked meteorites.

[1] M.Koike et al., G.R.L. 2017, in press. [2] M.K. Haba et al., 79th Metsoc, 2016, #6139. [3] R.Hewins, J.G.R.1984, 89, C289-C297. [4] X.Xie et al., Eur. J. Mineral. 2001, 13, 1177 - 1190.

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