A PRELIMINARY PETROGRAPHIC STUDY OF SEVERAL MESOSIDERITES. N. Sugiura, Department of Earth and Planetary Science, University of Tokyo. sugiura@eps.s.u-tokyo.ac.jp.

Introduction: Mesosiderites are stony-iron meteorites whose origin is largely unknown. The silicate part is igneous (basaltic or gabbroic) similar to eucrites. The metal is chemically not strongly fractionated. Therefore, it could be chondritic although usually it is assumed to be derived from a molten core. Most mesosiderites were strongly reheated after mixing of the silicates and the metal. This is based on petrographic observations such as olivine corona [1] and abundant Ca-phosphate [2]. The heat source for this reheating is not well known although hot metal is often considered as a heat source. Shock heating was also suggested by some workers [3]. Mesosiderites cooled rapidly after the reheating event. This is mainly based on diffusion profiles in minerals [4]. Therefore, mesosiderites have to be located close to the surface of the parent body. Also, brecciated nature of the silicates in many mesosiderites is consistent with the near-surface origin. Cosmogenic rare gases [5] and isotope anomalies due to neutron capture effects [6] are also consistent with the near-surface origin, and indicate a very shallow depth of < 2 m for some mesosiderites during 2π exposure to cosmic rays. The timing of the reheating is not well known but it could be very early 4563+/-15 Ma if the Pb-Pb age of zircon grains [7] dated the reheating event. Later on, at lower temperatures, mesosiderites cooled very slowly as evidenced by the metallographic cooling rates [8].

In this study, I made preliminary observations of several mesosiderites. The aims are 1) to find a primitive mesosiderite which has not been strongly affected by the reheating event and hence might have preserved evidence at the time of metal-silicate mixing, and 2) to see if shock heating could be the heat source for the reheating event.

Samples: Northwest Africa (NWA) 1878, ALH 77219, Northwest Africa 2924, Asuka 882023, Asuka 881154, Asuka 87106 and Northwest Africa 4747 were examined. The polished sections were observed by SEM-EDS. ALH 77219 has been studied in detail and classified as type B1 [9].

Results: A conspicuous feature of NWA 4747 is sulfide-pyroxene (Ca-poor) mixture (Fig.1) that is considered to be strong evidence for shock melting. This is ubiquitously observed in this meteorite, but the other mesosiderites do not show such texture. This mesosiderite contains olivine clasts some of which show "corona" around them. The corona is considered to be produced by sub-solidus reactions between the olivine and the surrounding matrix during cooling of the reheating event [1]. Although the cooling from the reheating event is said to be quick, the feature shown in Fig.1 suggests that the cooling from the shock melting was much quicker than that required for corona formation. Therefore, the corona around olivine in NWA4747 has to have formed before the shock heating event. This suggests that shock heating is not the main heat source for mesosiderite reheating. The exact age of this shock heating event is not known at present. The metallographic cooling rate of NWA 4747 appears to be similar to those of the other mesosiderites. Therefore, the shock heating occurred after the reheating event and before the slow cooling at low temperatures.

It seems that the origin of mesosiderites has not been clarified because most mesosiderites have been strongly reheated and their historical records before the reheating event have been largely erased. We need to study the most primitive mesosiderites. For this end, we need criteria that indicate primitiveness of mesosiderites. Previously, mesosiderites have been classified from type 1 to type 4 [10], in the order of increasing degrees of reheating. However, the criteria for this classification have not been well quantified.

Therefore, in this preliminary study, I looked for petrographic features that could be used for quantitative/qualitative classification of mesosiderites. The possible quantitative criteria include (1) olivine heterogeneity, (2) pyroxene heterogeneity, (3) plagioclase heterogeneity, (4) pyroxene lamellae width and (5) the metal grain size. Qualitative criteria include (6) absence of silica + olivine, (7) absence of phosphide and (8) development of olivine corona.

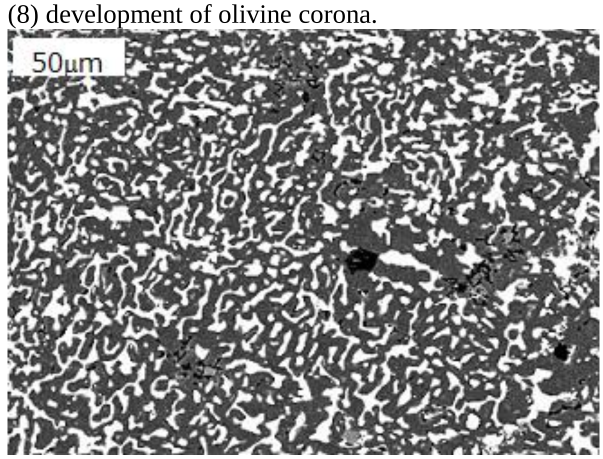

Fig.1 Sulfide (white) – pyroxene (grey) mixture in NWA4747.

These features were examined using 6 mesosiderite (excluding NWA 4747 which is strongly affected by shock heating).

(1) Olivine composition heterogeneity is a potentially good criterion of reheating because its diffusion properties are well understood. However, olivine clasts are not numerous in many mesosiderites and heterogeneity of the precursor olivine is hard to evaluate.

(2) The effect of heterogeneity of precursor pyroxene clasts seems to be dominant.

(3) Plagioclase compositions are in a rather restricted range. A wider range could be an indicator of weaker reheating, though it could also be due to stronger heterogeneity of the precursor material. At present we could not rule out the latter possibility but this seems to be a promising criterion.

(4) Pyroxene lamellae width also seems to be a promising criterion. But in order to make this a quantitative criterion, bulk pyroxene composition effects have to be corrected because the exsolution temperature depends on the bulk composition.

(5) The metal grain size seems to be a good criterion for relatively primitive mesosiderites which show spheroidal grains. As the grain size grows by sintering, the metal shape becomes more irregular and quantitative estimates become more difficult.

(6) Absence of both olivine and silica is solid evidence for strong reheating if a large area of a mesosiderite is available for investigation.

(7) Phosphide is expected to be converted to phosphate during slow cooling through ~1000 C [2]. Hence its absence appears to be a promising criterion for slow cooling. In the case of Antarctic mesosiderites, however, weathering effects have to be considered. Also, heterogeneity (different abundance of phosphide) in the precursor material (metal) among various mesosiderites is hard to evaluate at present.

(8) If a large area of a mesosiderite could be investigated, corona development is a good qualitative measure of reheating.

Based on the above evaluations, mainly based on criteria (3, 4, 5, and 8), NWA1878 is the most primitive one among the 6 mesosiderites. It shows the largest heterogeneity in plagioclase composition. Its lamellae in Fe-rich pyroxene is not thicker than 1 μm. The average metal diameter is the smallest (Fig.2: ~250 μm). An olivine corona could be recognized but it does not contain chromite, suggesting very incipient formation of a corona. Compared with ALH 77219 which is classified as type B1, NWA 1878 is definitely more primitive. Further studies of this mesosiderite may reveal its history before/during the reheating event.

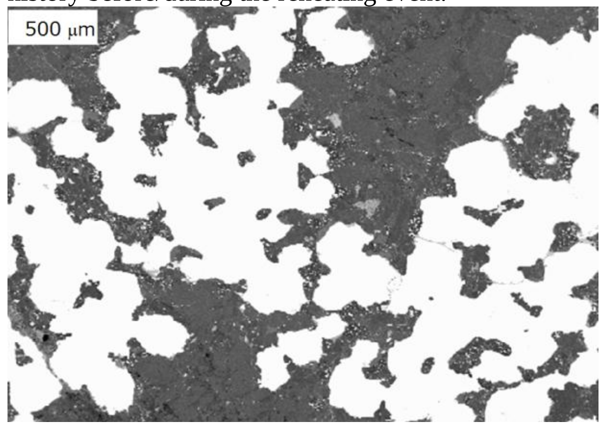

Fig.2 Spheroidal metal grains in NWA 1878.

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