NORTHWEST AFRICA 4747, AN UNIQUE MESOSIDERITE.

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Introduction: Origin of mesosiderites is not yet well understood. In particular, the heat source for their reheating is not known. Therefore, petrographic observation concerning their reheating and subsequent cooling is important. Here we report petrographic features of a polished section of the Northwest Africa 4747 (NWA 4747) mesosiderite. The observation was made with a SEM (JEOL JSM6510) and elemental compositions were measured with EDS.

Observation and interpretation: Metal nodules up to 3 mm in size are present. In contrast to most metal nodules in other mesosiderites, those in NWA 4747 do not contain silicate inclusions. They contain small spheroidal FeS grains near the center of nodules. It is possible that the nodules grew in situ from smaller metal grains by partial melting and sintering. The FeS abundance in NWA 4747 is estimated 7.9 +/- 2.7 (1 sigma) wt.% based on the sulfur X-ray maps for an area of ~11.6 mm^2. FeS abundances are variable in mesosiderites, ranging from less than 1 wt.% to more than 12 wt. % [1], and the formation mechanism is not well understood. FeS in NWA 4747 is more abundant in silicate-rich areas than in metal-rich areas. Taenite is often observed in the FeS-rich areas. Fine-grained FeS + pyroxene mixture, replacing olivine, similar to that reported by [2] is observed, but it is minor in abundance. Most FeS seems to have formed by sulfidation of Fe-Ni metal. All together, we think that sulfur was introduced as S_2 gas, and sulfidation proceeded efficiently in silicate-rich permeable areas. Occasionally, chromite is found in metal nodules and Cr diffusion profiles are observed over ~10 μm in the surrounding kamacite. This suggests that the reheating event was short-lived and the subsequent cooling was rapid. Olivine clasts are not rare and are Fe-rich and Mn-rich. Many olivines show Fe/Mg > 0.6 and Fe/Mn < 30. In contrast, most olivines in mesosiderites are Fe/Mg < 0.6 and Fe/Mn ~ 40 [1]. The high Fe contents suggests oxidizing conditions. Phosphide and rutile are absent in NWA 4747, also suggesting oxidizing conditions. Phosphate exists as tiny grains in the matrix, suggesting formation from a silicate melt. This is in contrast to phosphate in other mesosiderites where it is mostly attached to metal surface. The phosphate occurrence suggests that the reheating occurred at least twice. This is because P was initially in metal and stays in metal at high (>1100C) temperatures and phosphate forms only at <1100C during cooling [3]. A second heating is needed to dissolve the phosphate into a silicate melt. There are interesting varieties of Ni profiles in metal grains. Isolated taenites show M-shape Ni profiles. But the central Ni vs. size plot does not follow the trend expected for mesosiderites [4]. In composite grains consisting of kamacite and taenite, Ni profiles in taenite are nearly flat at ~50% Ni. Therefore, a metallographic cooling rate cannot be determined from taenite. However, Ni in kamacite shows gradients due to the Agrell effect and the gradients are similar to those reported for mesosiderites by [4]. Therefore, there is no doubt that NWA 4747 cooled very slowly and therefore it is a mesosiderite in spite of various unique features. It should be emphasized that phosphide is not detected in the metal in NWA 4747. It is well known that Ni diffusion rates in P-poor kamacite and taenite are much lower than those in P-saturated metals of most mesosiderites [4]. The apparently similar Ni gradients in NWA 4747 kamacite to those in P-saturated metals in other mesosiderites might mean that NWA 4747 cooled more slowly than other mesosiderites.

Summary: Sulfidation of NWA 4747 occurred early. Sulfur fugacity was high at the peak reheating temperature. Either abundant FeS was present before the main reheating event, or sulfur was introduced during the main reheating event that was caused by an impact. A difficulty of the impact heating model is that mesosiderites do not show textures of shock. Since metals in mesosiderites are contiguous, induction heating could be efficient on the mesosiderite parent body. Induction heating is brief and repetitive, which is attractive attribute for explaining the petrologic features of NWA 4747. NWA 4747 is probably the first mesosiderite that does not contain phosphide. Source materials for mesosiderite silicates was more variable in terms of redox conditions than hitherto considered.

References:

[1] Mittlefehldt D.W. et al. (1998) Chapter 4. In *Planetary Materials* ed. Papike J.J. [2] Zhang A-C. et al. (2018) *Geochimica Cosmochimica Acta* 220: 125-145. [3] Harlow G.E. et al. (1982) *Geochimica Cosmochimica Acta* 46: 339-348. [4] Hopfe W.D. and Goldstein J.I. (2001) *Meteoritics & Planetary Science* 36:135-154.