SHOCKED MESOSIDERITES: HIDDEN IN PLAIN SIGHT?

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Introduction: The origin and formation conditions of the mesosiderites, a type of stony-iron meteorites, is still a very much debated question in the planetary science community. Mesosiderites are made up of approximately equal parts of metallic and silicate components, with varying metamorphic grade and plagioclase/pyroxene content, thought to be mixtures of core and crustal materials, with little or no mantle materials [1]. The involvement of shock is common for most mesosiderite formation theories—ranging from the mixing of metal and silicates in a catastrophic collisional event, to impact gardening—yet evidence of shock effects is only reported for a handful number of mesosiderites, apart from brecciation present in all but the igneous mesosiderites [2]. The aim of this work was to fully classify four mesosiderites—namely Acfer 265, Lamont, MacAlpine Hills 88102 (MAC 88102), and Queen Alexandra Range 86900 (QUE 86900)—for which classification was incomplete, and to search for potential shock effects in these meteorites.

Methods: Sections of Acfer 265 and Lamont were obtained from the NHM Vienna, while MAC 88102 (split 6) and QUE 86900 (splits 26 and 39) were lent by Johnson Space Center, NASA. Petrographic analyses were completed using a polarized microscope and a scanning electron microscope (SEM) equipped with an Oxford Instruments XMax 80 mm SDD energy-dispersive X-ray spectroscope (EDX) located at Lund University, Sweden. Sections were also analyzed using a Horiba LabRAM Evolution confocal Raman spectrometer to verify silica polymorphs. For the classification, 4 to 7 areas, with a representative matrix, were selected for mineral point counting, using a 400 by 400 grid together with SEM and EDX images. Silicate modal percentages were normalized to non-metal/troilite minerals.

Results: Acfer 265 displays a fine-grained (< 50 µm) and cataclastic silicate matrix surrounding metal patches, with 29 vol.% plagioclase. Lamont shows a coarse-grained (> 100 µm) igneous and subophitic silicate matrix, surrounding coarse (> 500 µm) networks of Fe-Ni metal, with 22 vol.% plagioclase. MAC 88102 displays a coarse-grained (> 100 µm) igneous and subophitic silicate matrix, surrounding coarse (> 1 mm) veins and patches of Fe-Ni metal, with 30 vol.% plagioclase. Finally, QUE 86900 shows a fine-grained (< 50 µm) silicate matrix with angular grains, together with variable-sized (from 1 µm to 500 µm) Fe-Ni metal regions and large amounts (11 vol.%) of troilite, with 30 vol.% plagioclase. Possible effects of shock metamorphism were observed in both Lamont and QUE 86900. In the case of Lamont, sets of planar lamellae occur in most silica (cristobalite) grains—often with < 500 nm spacings, and filled with an iron-rich mineral—which crosscut the "fish-scale" fractures. In addition, a few high-An plagioclase grains contain several sets of closely spaced (> 1 µm) planar lamellae. QUE 86900 hosts a pervasive, but heterogeneously distributed, melted, and quenched silicate emulsion containing pyroxene hopper crystals—the emulsion surrounds matrix fragments, melt droplets and metal networks, and also infiltrates a large lithic clast. Maskelynite was also noted, as well as closely spaced (< 2 µm) planar microstructures in pyroxenes.

Discussion and conclusions: Using the classification scheme of [3], Acfer 265 and QUE 86900 are classified as A1 mesosiderites, whereas MAC 88102 is classified as an A4 mesosiderite, and Lamont is classified as a B4 mesosiderite. The classification of QUE 86900 is corroborated by [4], while Lamont has been referred to as a B3 mesosiderite by [5]—the B3 classification is likely a remnant from the previous 3-tiered system. QUE 86900 might fit into the group A0, if we consider the new textural class proposed by [6], due to the preservation of emulsion and the presence of highly angular micrometer-sized fragments.

The planar lamellae in both cristobalite and plagioclase as seen in Lamont are interpreted as shock-induced features. Due to the cross-cutting relationship of the cristobalite lamellae, the shock event must have happened some time between the formation of the interstitial cristobalite, from an impact melt, and cooling through the β- to α-transition at ~240 °C [7]. The planar lamellae in plagioclase may also be the first PDFs observed in a high-An plagioclase, as PDFs are generally absent in e.g., anorthite [8]. The melt droplets in QUE 86900, composed of vermicular troilite in semicrystalline pyroxene, are interpreted as coeval with the mixing event. The emulsion is interpreted as a quenched impact melt that post-dates the metal-silicate event, due to its heterogeneous nature—twin lamellae in pyroxenes may be related to the same shock-event. An alternative explanation is that the emulsion is an invading melt from nearby, which would explain the general lack of shock effects. Further investigations, using EBSD, are planned to elucidate the processes that produced these textures.

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