

## MORE SHOCK RECOVERY EXPERIMENTS ON MESOSIDERITE ANALOGS

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Mesosiderites, a small but unique group of stony-iron meteorites with affinities to howardites, eucrites and pallasites [1], remain enigmatic in terms of their petrogenesis. They are composed of approximately equal weight proportions of Fe-Ni metal plus troilite and gabbroic, basaltic and orthopyroxenitic materials. The metal and silicates, which display variable grain sizes and shapes, are delicately intermingled, forming irregular grain boundaries that have been attributed to a wide range of origins from subsolidus metamorphism [1] to supersolidus igneous processes [2]. Perhaps the most relevant question regarding the petrogenesis of mesosiderites is: what is the source and duration of heating that could produce the unequilibrated textures and chemistry of these meteorites? A leading candidate appears to be impacts of metallic core fragments with a differentiated asteroidal surface [2, 3]. This provides not only a suitable source of heat, but also the metal component uniquely required by mesosiderites. We have continued a series of shock recovery experiments on mesosiderite analogs initiated earlier [4] and have found textural and chemical similarities that support an impact-derived origin for these unusual meteorites.

**Method:** The experiments involved shock loading a metal-silicate powder mixture in a 20 mm bore propellant gun following the techniques described in [4, 5]. The silicate fraction for all of our experiments was a Bushveld gabbro [5] ground and sieved to 75-150  $\mu$ m. Three series of experiments were performed in which the metal fraction (sieved to 75-150  $\mu$ m) was varied from 1. Stainless steel 304 (SS304), 2. SS304 plus troilite and 3. Meteoritic Fe-Ni metal. For the first two series, the starting mixtures consisted of equal weight proportions of gabbro and SS304. The troilite in the second series was added to each gabbro-SS304 mixture in 5% increments from 5 to 15%. For the last series, the starting mixture was equal weight proportions of gabbro and Fe-Ni metal from Antarctica mesosiderite RKPA79015. Thin sections were made of the recovered samples for textural studies (optical microscope and scanning electron microscope) and chemical analyses (electron microprobe).

**Results:** In the first series of experiments (SS304) the overall textures ranged from a compacted, non-porous, non-melted network of interlocking grains in which the metal filled the spaces around the silicates (104 kbars) to a frothy, vesicular mixture of melted metal and silicates (436 kbars). The first evidence of melting of the metal appeared at 148 kbars where some metal formed minute, rounded veinlets and even rarer sponge metal. Sponge metal as defined in the preliminary work [4] consists of rounded metal blebs full of elliptical to spherical silicate inclusions. The size of the inclusions is variable from sub-micron to tens of microns in diameter and some of the larger inclusions (>10  $\mu$ m) contain metal spheres. The silicates in the 148-kbar sample were brecciated and generally subhedral. In the 302-kbar sample, melted SS304 is common as veinlets, sponge metal and isolated metal spheres. Zones of elongated sponge metal blebs and streams of spheres are evidence that flow developed in the sample. The streams of spheres are usually contained in melted pyroxenes that have surrounded and partially invaded plagioclase grains. Some of the silicates have melted and tend to be vesicular. In the 436-kbar sample these melt textures are more abundant. Chemical analyses of the sponge metal showed depletions in Cr and Mn and small enrichments in Si, Cu and Co relative to Fe. Some of the silicates showed highly variable enrichments of FeO and Cr<sub>2</sub>O<sub>3</sub>, but negligible additions of NiO. Analyses of silicate inclusions in the sponge metal of the 436-kbar sample showed consistent enrichments in Cr<sub>2</sub>O<sub>3</sub> and MnO and depletions in SiO<sub>2</sub>. These chemical variations suggest that the SS304 was being oxidized and mixed with the silicate.

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In the second series (SS304 + troilite), the textural changes as a function of increasing pressure were similar to the first series. In the low pressure (~150 kbars) samples most of the troilite occurs as sub-angular, pitted, isolated grains that have not reacted with the SS304 or silicates. The higher pressure (~300 and 450 kbars) samples show increasing degrees of melting and mixing of the troilite with the SS304, such that Fe-Cr-S-rich rims were formed around the melted SS304. Some of these rims branched out from the main metal masses to form thin veins along cracks and grain boundaries in the silicates.

In the third series (meteoritic metal), the textures are similar to those seen in the first series, but the pressures required for significant melting are higher. The first evidence of melting is observed in the 280-kbar sample which has similar textures as the ~150 kbars samples from the first two series. Abundant melt textures are seen in the 710-kbar sample versus the ~300-450 -kbar samples from the first two series. Preliminary chemical analyses revealed enrichments of FeO and NiO in some of the melted silicates.

**Conclusions:** Our textural and chemical analyses indicate that the shocked analogs possess some significant similarities to mesosiderites, particularly when comparing the unique and intricate metal textures. An impact origin of these meteorites seems plausible, although not conclusive. The sponge metal and veins as noted previously [4] are similar to some mesosiderite textures. The sponge metal and the streams of metal spheres would also help provide a way to prevent efficient metal-silicate segregation that models involving the formation of large impact-melt sheets [2, 6] require. The isolated troilite that is abundant in the lower pressure samples is similar to the troilite in mesosiderites described by [1] that led to a subsolidus metamorphic model, while the Fe-Cr-S rims and veins found in higher pressure samples are texturally similar to the anastomosing troilite veins in mesosiderites described by [2] that led to an impact-melt model. These comparisons suggest that different mesosiderites may be showing different degrees of shock pressure and subsequent heating. Finally the compositional variations in the sponge metals and silicates within the sponge metals suggest that redox reactions produced these changes; these observations fit well with the theory that FeO reduction occurred simultaneously with metal-silicate mixing in mesosiderites [7].

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