Scarce Shock Metamorphic Indicators in Mesosiderites and Implications for Timing of Deep Burial

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Introduction

Mesosiderites are some of the more puzzling meteorite groups—they are impact breccias composed of one part core-derived metal and one part crustal lithologies, such as basalt and pyroxenite, yet include few or no mantle materials. Many scenarios have been suggested for their formation (Hewins 1983 and references therein), most containing a collisional element—however, despite being impact breccias, mesosiderites show very limited signs of shock metamorphism (Haack et al. 1996). Low shock levels has been attributed to early burial on the parent body, thus protecting the material from impact overprinting (Haack et al. 1996).

Aim and results

To investigate whether shock features in minerals are missing from the whole meteorite group, we studied over 40 different mesosiderites with a focus on possible shock features. Our initial findings show that heterogeneous melt textures are common, while regular shock metamorphic indicators—such as planar fractures, planar deformation features, mosaicism, and high-pressure polymorphs—are generally not present. Among the melt textures we have observed are quenched chromite-silicate assemblages, quenched troilite-silicate assemblages, and quenched silicate melt pockets. The overall textures of the different melts seem to indicate that they have formed in-place, rather than having been incorporated in the breccias as clasts. Annealed troilite/metal/chromite veinlets are also common, indicating earlier silicate darkening by shock. Graphic troilite-pyroxene textures in the cores of olivine pseudomorphs may also indicate shock melting between olivine and troilite—this interpretation is supported by the finding of fine-grained (quenched) varieties of these textures in several mesosiderites.

Discussion and conclusions

High shock pressures and high overall post-shock temperatures that allow the formation of the melts should also have induced the development of solid-state shock features in minerals, the fact that the latter are largely absent is puzzling. We argue that a combination of two factors may be at play: (1) Mesosiderites experienced thermal annealing for a very long period of time, erasing most shock indicators—similar to what was proposed for equilibrated ordinary chondrites by Rubin (2004)—and (2) it is possible that shock impedance plays a role in moderating effective shock pressures in silicates, considering the mixture of materials with vastly different densities in mesosiderites (e.g., Wittmann et al. 2021). Assuming this is correct, we argue that it is possible that mesosiderites were buried later than previously thought.

References

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