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SPECIAL COLLECTION: BUILDING PLANETS: THE DYNAMICS AND GEOCHEMISTRY OF CORE FORMATION

Shock-induced mobilization of metal and sulfide in planetesimals: Evidence from the Buck Mountains 005 (L6 S4) dike-bearing chondrite†

Alex Ruzicka[1,2,*], Ryan Brown[1], Jon Friedrich[3,4], Melinda Hutson[1,2], Richard Hugo[2] and Mark Rivers[5]

[1]Cascadia Meteorite Laboratory, Portland State University, 1721 SW Broadway, Portland, Oregon 97207, U.S.A.
[2]Department of Geology, Portland State University, 17 Cramer Hall, 1721 SW Broadway, Portland, Oregon 97207, U.S.A.
[3]Department of Chemistry, Fordham University, Bronx, New York 10458, U.S.A.
[4]Department of Earth and Planetary Sciences, American Museum of Natural History, New York, New York 10024, U.S.A.
[5]Consortium for Advanced Radiation Sources, University of Chicago, Argonne, Illinois 60439, U.S.A.

Abstract

The conditions under which metal cores formed in silicate-metal planetary bodies in the early Solar System are poorly known. We studied the Buck Mountains 005 (L6) chondrite with serial sectioning, X-ray computed microtomography, and optical and electron microscopy to better understand how metal and troilite were redistributed as a result of a moderately strong (shock stage S4) shock event, as an example of how collisional processes could have contributed to differentiation. The chondrite was recovered on Earth in multiple small pieces, some of which have a prominent, 1.5–3 mm wide holocrystalline shock melt dike that forms a jointed, sheet-like structure, as well as an associated shock vein network. The data suggest that metal and troilite within the dike were melted, sheared, and transported as small parcels of melt, with metal moving out of the dike and along branching veins to become deposited as coarser nodules and veins within largely unmelted host. Troilite also mobilized but partly separated from metal to become embedded as finer-grained particles, vein networks, and emulsions intimately intergrown with silicates. Rock textures and metal compositions imply that shock melts cooled rapidly against relatively cool parent body materials, but that low-temperature annealing occurred by deep burial within the parent body. Our results demonstrate the ability of shock processes to create larger metal accumulations in substantially unmelted meteorite parent bodies, and they have implications for the formation of iron meteorites and for core formation within colliding planetesimals.

Keywords: Lunar and planetary studies, shock metamorphism, L6 chondrite, petrography, chondrite, olivine, kamacite, taenite, troilite, electron microscopy, FeNi metal