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Identification of micrometeorite candidates in altered 1.45 Ga Mesoproterozoic carbonates

DANQIU CHEN, ROGER BUICK, DON BROWNLEE, DAVID C. CATLING AND JADEN R UNRUH

University of Washington

Presenting Author: chendq@uw.edu

Iron-type (I-type) micrometeorites should be commonly preserved within sedimentary rocks over Earth’s history, thus providing an archive for reconstructing ancient atmosphere composition. Upon entry into Earth's atmosphere, frictional heat can partially or completely melt these micrometeorites, allowing them to incorporate oxygen atoms from the surrounding atmosphere. This process occurs rapidly, typically within a few to several seconds, thereby recording the coeval atmospheric oxygen and/or carbon dioxide levels.

Here we report the discovery of twenty-nine I-type micrometeorite candidates from Mesoproterozoic carbonates, with diameters ranging from 15 to 120 microns. These candidates exhibit spherical morphologies and both exterior and interior dendritic magnetite (Fe_3O_4) crystals, indicating rapid cooling from high temperature metallic-oxide liquids. The interiors of some spheres contain irregular and interconnecting cavities, suggesting the entrapment of gases during melting and subsequent rapid crystallization. Compared to modern I-type micrometeorites, the spheres lack detectable nickel or wüstite crystals, which may be due to dissolution and complex geochemical exchange during carbonate deposition, diagenesis and metamorphism. Aluminum (0.2-2.2 wt%), silicon (0.1-5.1 wt%), calcium (0.1-1.6 wt%), manganese (0.2-1.4 wt%), sodium (0.1-0.6 wt%), potassium (0.1-0.3 wt%), and magnesium (0.1-0.2 wt%) are detected without and within the micrometeorite candidates, suggesting potential contamination during post-depositional alteration. In particular, the silicon content varies between the magnetite dendrites and their interstitial regions, which could be related to slow silicification as pore fluids percolated through fissures within the spheres. This geochemical alteration complicates their identification as ancient micrometeorites, yet it transforms them into more stable assemblages that could be preserved for eons within sedimentary strata.