Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37392

A Martian record of impact plume condensation in a spherule from NWA 7475

FLOYD DANGER MAUTLE[1], STEFFANIE SILLITOE-KUKAS[2], MUNIR HUMAYUN[3] AND DESMOND E. MOSER[4]

[1]University of Western University
[2]Florida State University
[3]National High Magnetic Field Laboratory
[4]University of Western Ontario

High-temperature, spheroidal condensates from impact plumes on Earth and the Moon preserve rare records of target-atmosphere interactions, but no such records have yet been identified on Mars. Impact spherules are known from the NWA 7533 martian regolith breccia meteorite and paired stones [1-3], and here we characterize one of the largest, ZAP1, a ~5.3 mm vitrophyric lapillus embedded in NWA 7475. ZAP1 exhibits a concentric three-shell structure formed by melting of mafic and sedimentary lithologies [2] and incorporation of lithic crystals and multiphase microspherules with microkrystite- and lapilli-like textures. Innermost Shell 1 has a bulk mafic composition resembling transitional Martian basalts (e.g., LAR 06319, Adirondackclass), and is depleted in volatile Ga and Ge and slightly in Zn. Shell 2 is distinguished by the highest FeO (~25.5 wt.%) and lowest SiO_2 (~42.9 wt.%), and its contact with Shell 1 is decorated with anhedral, micron-scale aggregates of zircon and titanomagnetite, recrystallized or condensed from target material. Outermost, mafic Shell 3 has the lowest relative abundances for elements concentrated in the heavy mineral fraction of sands (TiO_2, Zr, Hf, Nb, Ta, and REEs), reflecting target compositional heterogeneity. Cr spinel grains at the extremities of Shell 3 exhibit Cr-rich cores (up to 47 wt.% Cr2O3) and recrystallized, Mg-enriched polycrystalline rims likely produced by the transient, latent heat and Mg-rich matrix. The microspherules stand out compositionally from the shells and bulk breccia regarding Fe/Mn and Ni/Mg ratios, and Zn contents (~1,000 ppm), higher than in martian igneous meteorites. They further have REE patterns parallel to but exhibiting a range of depletions down to 20 times lower than that of the bulk spherule with prominent positive Eu anomalies (Eu/Eu* = 1-6). These fractionated chemical signatures are seen as inherited from the pre-impact sedimentary history of the target, rather than syn-plume effects. These characteristics and other textural features support formation of ZAP1 from a high-temperature impact plume on Mars, and inform the interpretation of spherules identified by surface missions.

References

[1] Humayun et al. (2013) . *Nature,* 503, 513-516.
[2] Sillitoe-Kukas et al. (2019). *LPSC* 50.
[3] Wittmann et al. (2015). *MAPS* 50*,* 326–352.