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Origin of metal in lunar impactites using siderophile element abundance analysis

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Siderophile element abundances, in particular for highly siderophile elements (HSE), in metal grains found in lunar impact melt rocks and breccias provide constraints on impact processes and potential exogenous contributions in the lunar crust.

Lunar feldspathic breccia Adrar 012 contains abundant glassy spherules and basaltic impact melt rock clasts along with lithic olivine, pyroxene, and anorthite enclosed within a clastic to glassy matrix. We found a large Fe-Ni grain (790 × 490 µm) lacking troilite and schreibersite inclusions in the matrix. The composition of the Fe-Ni grain is $Fe_{91.8\pm0.1}Ni_{7.7\pm0.1}Co_{0.4\pm0.1}P_{0.1\pm0.1}$ in wt% using EPMA. We developed a method to determine trace element abundances in Fe-Ni metal using an ESI NWR 193 nm laser ablation system coupled with a Thermo Fischer Scientific iCap TQ ICPMS at BGI. The spot analysis consists of a 20-second background measurement, followed by 700 burst counts at 15 Hz, 100 µm spot size, and fluence of 5 J cm^{-2}. Reference materials include NIST SRM 610 glass and North Chile (IIAB) and Hoba (IVB) iron meteorites. The detection limit and reproducibility (2SE) performance for low-abundance HSE such as Re, Os, Ir, Pt and Au are ~0.03 and ~0.02 ppm, respectively.

We find that the HSE abundances (except for Ga and Ge) of the Adrar 012 Fe-Ni grain match well those of the main group of IAB iron meteorites, which have been interpreted as melt pools generated by impacts on a chondritic megaregolith[1]. The precursor of the metal found in Adrar 012 experienced approximately 55 wt% Ga and 96 wt% Ge depletion that may be related to impact remelting and rapid cooling. Evaporation experiments on Fe-Ni liquid indicate that Ga and Ge depletion in IAB metal can occur over a range of temperatures and evaporation durations during impacts[2]. Our results support that non-carbonaceous (NC) iron in complement to other NC chondrite-like materials from the inner Solar System contributed to the HSE reservoir of the Moon and Earth during late accretion[3].

References

1. Choi et al. GCA **59**, 593–612 (1995).
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3. Bermingham et al. GCA **392**, 38–51 (2025).