Simeio: LA-ICP-MS Analysis of the First Stardust Metal Particle from a Comet

Humayun, M. (FSU, Earth, Ocean & Atmospheric Science; NHMFL Geochemistry); Goldstein, J.I.; Mubarok, A. (University of Massachusetts); Westphal, A.J.; Gainsforth, Z. (UC Berkeley, Space Sciences Lab); Sutton, S.R.; Lai, B. (Argonne National Lab; Advanced Photon Source); Silver, E. (Harvard-Smithsonian Center for Astrophysics); Stroud, R.M. (Naval Research Lab)

Introduction

The NASA Stardust mission returned samples from Comet 81/P Wild 2 that included an extraordinarily diverse assortment of minerals with broad compositional ranges sampled from the outer solar system. *Simeio* was a ~10 µm x 15 µm Fe-Ni grain from Track 41, the largest metal particle yet recovered from Stardust tracks. It is characterized by low-Ni (2.2 wt %), a nearly chondritic Co/Ni ratio [1]. Upper limits on Ga, Ge and As contents were previously reported [1]. Here, we report new results by LA-ICP-MS.

Experimental

For laser ablation ICP-MS (LA-ICP-MS) analysis, *Simeio* was extracted from its aerogel keystone, mounted in epoxy, and polished. LA-ICP-MS analysis were performed using an ESI New Wave™ UP193FX excimer LA-ICP-MS system at the Plasma Analytical Facility, FSU [2]. The spot size was 20 µm, with 5-second dwell time at 50 Hz, and 1.7 GW/cm^{2}power density. A spectron Ni Jet sampler cone and Ni-X skimmer cone were used which enhanced the Fe-Co-Ni signal by a factor of 10, and the Ir signal by a factor of 3, relative to normal cones. Prior to analyzing Simeio, metal grains ≤20 µm in diameter in the chondrites Semarkona LL3.0 (n=40) and Paris CM (n=16) were analyzed for comparison.

Results and Discussion

The LA-ICP-MS data for Co, Ni, Ga, Ge and Ir, complement data obtained by Synchrotron X-Ray Fluorescence (SXRF) measurements on Co, Ni, Cu, Ga, Ge and As [1]. *Simeio* is a very unusual metal grain compared with cosmic abundances having a low Ni/Fe ratio, chondritic Co/Ni ratio, somewhat depleted in moderately volatile elements like Cu, Ga and Ge (Fig. 1). Although Ir was not detected, *Simeio* is depleted by at least a factor of 5 in Ir relative to cosmic abundances. Its elemental abundances are a poor fit to most chondritic metal, but it has some compositional semblance to metal from ureilites, an enigmatic group of carbon-rich rocks that underwent intense melting, reduction, and explosive volcanism [3]. In ureilites, the low Ir abundances occur in metallic liquids that are removed from the interior of the body by streaming CO formed by reduction of Fe from silicates during smelting reactions.

Conclusions

The first metal particle to be analyzed from a comet, *Simeio*, is of unusual composition that might be derived from explosive volcanism associated with meteorites known as ureilites. A plausible explanation is that such metal is released widely into the accretion zones of outer planets by impact heating during collisions in the Kuiper Belt, and was then swept up by the accreting comet. If this match is proven correct with further studies of additional grains, then the high carbon contents of ureilites may be linked to comets, a very unexpected result.

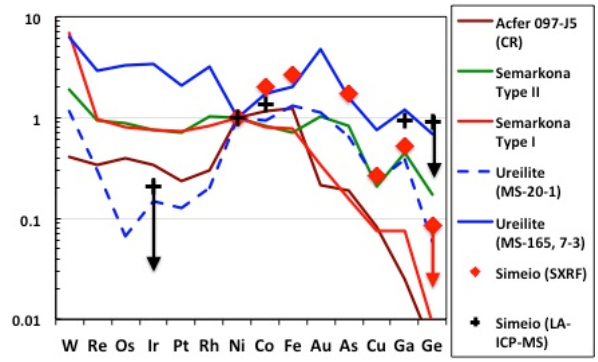

Fig.1 CI-chondrite normalized abundances of siderophile elements in selected metal from chondrites, ureilites [3], and Simeio. Upper limits (Ir, Ge) are indicated by arrows.

Acknowledgements

The FSU portion of the research was supported by NASA Cosmochemistry Program (NNX13AI06G).

References

[1] Westphal, A.J., *et al*., Meteoritics & Planetary Sci., **175**, abstract# 5309 (2012).
[2] Humayun, M., *et al*., Lunar & Planetary Sci. Conf., **46**, abstract# 2298 (2015).
[3] Horstmann, M. et al., Meteoritics & Planetary Sci. **49**, 1948-1977 (2014).