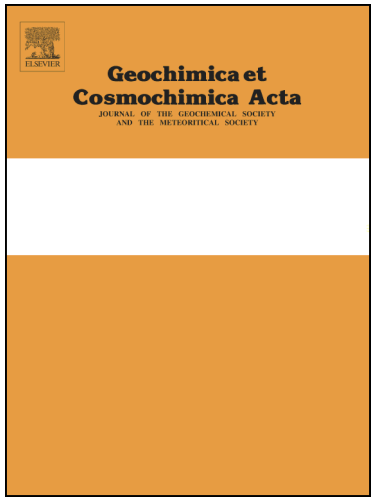

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PII: S0016-7037(16)30672-X
DOI: http://dx.doi.org/10.1016/j.gca.2016.11.030
Reference: GCA 10038

To appear in: *Geochimica et Cosmochimica Acta*

Accepted Date: 17 November 2016

Please cite this article as: Daly, L., Bland, P.A., Dyl, K.A., Forman, L.V., Evans, K.A., Trimby, P.W., Moody, S., Yang, L., Liu, H., Ringer, S.P., Ryan, C.G., Saunders, M., In situ analysis of Refractory Metal Nuggets in carbonaceous chondrites, *Geochimica et Cosmochimica Acta* (2016), doi: http://dx.doi.org/10.1016/j.gca.2016.11.030

In situ analysis of Refractory Metal Nuggets in carbonaceous chondrites

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Abstract

Micrometre to sub-micrometre-scale alloys of platinum group elements (PGEs) known as refractory metal nuggets (RMNs) have been observed in primitive meteorites. The Australian Synchrotron X-ray Fluorescence (XRF) beamline, in tandem with the Maia detector, allows rapid detection of PGEs in concentrations as low as 50-100 ppm at 2 µm resolution. Corroborating these analyses with traditional electron microscopy techniques, RMNs can be rapidly identified *in situ* within carbonaceous chondrites. These results dispute the assumption of most previous studies: that RMNs are unique to Ca-Al-rich inclusions (CAIs). We find that RMNs are, in fact, observed within all components of carbonaceous chondrites, such as the matrix, chondrules (consistent with observations from Schwander et al. (2015b) and Wang et al. (2007)), and sulphides; though the majority of RMNs are still found in CAIs. The chemistry of RMNs reveals a complex diversity of compositions, which nevertheless averages to CI chondrite abundance ratios. This implies that RMNs are the dominant, if not sole host phase for PGEs. One hundred and thirteen RMNs from this study are combined with reported compositions in the literature, and compared to condensation model compositions similar to Berg et al. (2009), RMNs derived experimentally by precipitation (Schwander et al., 2015a), host phase and host meteorite. Comparisons reveal only weak correlations between parent body processes (sulphidation) and nebular processes (condensation and precipitation) with RMN compositions. It appears that none of these processes acting in isolation or in tandem can explain the diversity observed in the RMN population. Our interpretation is that the Solar Nebula inherited an initially compositionally diverse population of RMNs from the Giant Molecular Cloud; that a variety of Solar System processes have acted on that population; but none have completely homogenised it. Most RMNs have experienced disk and asteroidal processing, but some may have retained a primordial composition. RMNs have been identified in pre-solar graphite grains (Croat et al., 2013). We anticipate that pre-solar RMNs will be present elsewhere in primitive meteorites.

Keywords: `Refractory Metal Nuggets, Solar Nebula, Solar System, Origin, Meteorites, carbonaceous chondrites`

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