**IN SITU ANALYSIS OF REFRACTORY METAL NUGGET CRYSTALLOGRAPHY PROVIDING CLUES TO EARLY SOLAR SYSTEM EVENTS.**

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**Introduction:** Refractory metal nuggets (RMNs) are thought to be the first solids to condense from a cooling nebular gas [1]. Here we present *in situ* analysis of RMNs revealing new observations, which may assist in the interpretation of how they form.

**Method:** RMNs were extracted from samples of Allende, Vigarano, and ALH77307 in the form of a 100 nm thick TEM lamella using a Focused Ion Beam (FIB). The samples were analysed using Transmission Kikuchi Diffraction (TKD) and Transmission Electron Microscopy (TEM) techniques.

**Results and discussion:** Analyses of RMNs *in situ* revealed new textures that have not previously been documented:

*Twinning in Vigarano RMNs:* We observed twins in RMNs hosted within a 'fluffy' Type A CAI. They are most likely annealing twins due to the 60° misorientation about the [111] axis across the twin boundary. Annealing twins form under high-temperature, low-pressure conditions. No experimental data exists for the compositions of interest; in FePt nanoparticles annealing begins around ~500 °C [2]. Assuming similar or higher temperatures were required for Vigarano RMNs, we can say that this is significantly higher than estimates for Vigarano parent body metamorphism [3], and therefore that annealing must have occurred before the CAI was incorporated into the chondrite. The mineral phase hosting the RMNs also exhibits annealing textures, but the whole CAI does not. We suggest a very short-lived nebular heating event as a mechanism.

*RMN alignment in Allende and ALH 77307:* RMNs found in ALH 77307 CAIs and Allende chondrules exhibit a crystallographic relationship with their host phase. In ALH 77307 the RMN [002] axis is parallel to the [201] axis in the host Åkermanite phase. The RMN <c> axis is parallel to a secondary FeMoOs phase exhibiting apparent super-cooling textures. The origin of this preferred alignment is interpreted as nucleation of CAI phases around the RMN. A secondary heating event followed by very rapid cooling formed the new mineral phase. The orientation in Allende is more complex; the RMNs are perfectly aligned with each other but exhibit no crystallographic relationship with the host sulphide phase. However, they do share a [100] axis with the neighboring forsterite. This is tentatively interpreted as nucleation of forsterite about RMNs producing a shared alignment via a minimisation of surface energy. This alignment is preserved during secondary sulphidisation.

**Conclusion:** *In situ* analysis of RMNs is providing us with a detailed picture of how these most refractory materials, and their host inclusions formed and were subsequently altered.

**References:** [1] Grossman L. and Ganapathy R. 1976. *Geochimica et Cosmochmica Acta* 40:331-344. [2] Dai Z., Sun S. and Wang Z. 2001. *Nano Letters* 1:443-447. [3] Cody G. et al. 2008. *Earth and Planetary Science Letters* 272:446-455