METAL NODULES IN EL3 AND EH3 PRIMITIVE CHONDRITES:CONGLOMERATES OF MICRO PEBBLE METALS WITH A MENAGERIE OF SULFIDE ASSEMBLAGES; GRAPHITE FEATHERS AND VARIOUS SINOITE MORPHOLOGIES, METAL CLASTS. NO EVIDENCE FOR MELTING.

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Introduction: Metal nodules in primitive enstatite chondrites (50-650µm in size) are oblong or round multiphase objects that didn't atract adequate petrological attention in the past. Their nature; contents and structure are poorly constrained and their origin is hence disputed, if nebular condensates [1] or produced by impact of their parent asteroids or alternatively by preaccretionary melting [2-4]. We investigated in very detail 43 metal nodules in EL3 chondrites from Almahata Sitta asteroid fragments MS-17, MS-177, more than 35 metal-sulfide nodules in the very primitive EH3 ALHA77295 and in the Antarctic EL3 chondrite MAC88136 by BSE-SEM; EPMA, Raman spectroscopy and nanoSIMS 50 L.

Results: Structure and mineral inventories in EL3 and EH3 chondrites are fundamentally different. Nodules in EL3 abundantly consist of numerous carbon-bearing concentrically zoned micro-pebbles whereas EH3 nodules abundantly consist of metal clasts whose surfaces are individually decorated by micro-enstatite crystallites. Metal clasts are tightly intergrown with troilite, niningerite, djerfisherite, sphalerite, oldhamite and daubréelite fragments. Numerous nodules in EL3 MS-17 and MS-177 samples from Almahata Sitta asteroid consist of concentrically zoned carbon-bearing metal pebbles (<20 µm) each decorated by micro sinoite crystallites. In MS-17 and MS-177 we identify four distinct novel nodule types: (1) Nodules enclosing crystallographically-controlled topotactic intergrowth of oldhamite and sinoite encapsulated in enstatite and/or diopside, (2) Nodules dominated in their interior by numerous large (≥50 µm) stubby or prismatic crystals of sinoite, (3) Nodules with inclusions of idiomorphic prismatic sinoite crystals that in turn entirely enclose rounded oldhamite fragments and (4) Metal nodules containing fluffy wickerwork of idiomorphic prismatic sinoite. Texture indicates that latter sinoite formed subsequent to stubby variety prior to enclosure in the metal nodules. High magnification BSE-SEM and nanoSIMS ion mapping reveal for the first time that feathery graphites encapsulate sinoite crystals and fragments thus indicate the nucleation sequence oldhamite ⇨sinoite ⇨feathery graphite hence pointing to abrupt increase of the C/O ratio of more than 0.83 but ≤ 1.03 in the source medium where they nucleated and grew. We encounter in none of the investigated EL3 and EH3 samples any of the different five quenched immissible melts experimentally produced during melting of the Indarch EH4 chondrite [5] Melting experiments by [5] revealed metallic and sulfide quench melts (S-rich, C-rich, P-rich, Si-rich and S-rich and significantly enriched in lithophile elements). Their entire absence from metal nodules in EL3 and EH3 samples unambiguously negates any melting episode in the samples investigated. Isotopic mapping by nanoSIMS 50 L revealed hetergeneous variation in δ^{13}C and δ^{15}N in the feathery graphite crystallites.demonstrating lack of equilibration induced melting.

Conclusions: Our documentation and results have far reaching consequences: (1) NanoSIMS measurements unambiguously indicate light isotopic composition and δ^{13}C variation between -6 and -26 ‰ in feathery graphite. This isotopic heterogeneity negates any melting scenario of metal nodules in MS-17 and MS-177. (2) Metal nodules in both Enstatite chondrite subgroups are convincingly accretionary conglomerates and never passed the melt rigime, dynamic or at nebular pressure, (3) These results can best be explained by condensation at high C/O ratio in the solar nebula and are not discrepant with theoretical calculations [6].

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