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Metal - Forsterite Nodules and the H-L-LL Trend: Clues in Bennu!

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We ask: What primitive precursor materials were lost from the H, L, and LL ordinary (OC) chondrite-forming reservoirs prior to chondrule formation and accretion? Potential primitive precursors include amoeboid olivine aggregates (AOA) made of two nodule types, both surrounded by a ^{16}O-rich, Fe-poor olivine (Mg_2SiO_4) rind. One type "SMP" has cores of discrete refractory Ca-, Al-, Ti-rich CAI-like mineral assemblages. The other type "McO" has an Fe-metal alloy core, also surrounded by Mg-olivine (Figure). Strikingly similar "McO" nodules or "donuts" have been reported in samples returned from the highly primitive asteroid Bennu by the OSIRIS-REx mission.

Compared to the carbonaceous chondrites (CC), all OCs are depleted in Mg, refractory lithophiles, and in ^{16}O. The OCs form a trend from high metal (H), to low total iron (L), to low total iron and low metal (LL) compositions. Depletions in refractory siderophiles mimic the Fe depletion. We surveyed many chondrites for AOAs and AOA-like nodules and obtained detailed chemical and isotopic evidence on a few. We find relatively large metal grains with olivine rims forming isolated (Figure) or clumped nodules in AOAs in many CCs including the highly primitive Acfer 094. In discrete regions and times in the protoplanetary disk, differing drift velocities of these 10s of micron scale components could have caused correlated loss of both refractory siderophile (in metal cores) and lithophile elements and ^{16}O (in olivine and CAI-like cores). Varying degrees of loss of these nodules from the chondrule-forming reservoirs from which H, L, and LL chondrites accreted could explain multiple trends in their chemical and isotopic compositions.