

SULFIDE-METAL NODULES IN EH3 CHONDRITES.

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Introduction: The enstatite chondrites (EC) have highly reduced mineral assemblages [e.g., 1] that likely formed in equilibrium with a reducing vapor. Another intriguing aspect of the EC is that they appear to share the same oxygen isotopic reservoir as the Earth and Moon [2, 3]. A wide variety of sulfide-metal assemblages in EC record primary and secondary processes [4]. Here we focus on the origin of sulfide-metal nodules in Sahara 97096 and Kota Kota (both EH3) in relation to chondrule formation and nebular condensation under reduced conditions. We previously described sulfide-metal nodules in Sahara 97096 [5].

Results: Sahara 97096 and Kota Kota are among the most primitive EH3 chondrites, based on modal abundances (>6 vol.%) and compositions (>0.2 wt.% Cr₂O₃) of their olivine [6]. Sulfide-metal nodules are roughly circular in thin section with sharp, well-defined boundaries. Nodule sizes range from ~50 to 300 μm, slightly smaller than the chondrules (up to ~700 μm). Sulfide-metal nodules contain a wide variety of sulfides including troilite ± oldhamite (CaS), ± niningerite [(Mg,Fe,Mn)S], ± ferroan sphalerite [(Zn,Fe)S], ± djferfisherite [(K,Na)₆(Cu,Fe,Ni)₂₅S₂₆Cl], in association with Si-bearing kamacite ± schreibersite, ± perryite [(Ni,Fe)_x(Si,P)_y]. Many of these sulfides are also present in EH3 chondrules. Troilite is generally the most common sulfide in the nodules ± exsolution of daubreelite [(Fe,Cr)₂S₄]. Schreibersite generally occurs as small inclusions in oldhamite or niningerite and occasionally in troilite. Nodules generally contain ubiquitous grains of silica and enstatite. Some have small amounts of graphite. One unusual nodule in Kota Kota contains 7 vol.% ferroan sphalerite and small grains of a Na-rich feldspathic component. Some nodules have concentric layered structures with oldhamite or niningerite cores, as previously reported [7].

Discussion and Conclusions: Sulfide-metal nodules are sensitive indicators of metamorphism of E3 chondrites. Oldhamite is predicted to be the highest-temperature Ca-bearing phases to condense from a cooling solar gas under reducing conditions [8], consistent with its occurrence in the cores of some layered nodules [7] and its enriched REE abundances [9]. Sulfide-metal nodules may be the equivalent of refractory inclusions under reducing conditions. Alternatively, the nodules formed as immiscible sulfide-metal liquids during chondrule formation.

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