

METAL-RICH NODULES IN EL3 CHONDRITES AND ALMAHATA SITTA EL3 CLAST MS-177.

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Introduction: Metal in EL3 chondrites occurs as discrete nodules enclosing complex mineral assemblages, not associated with the chondrules. The origin of EL3 chondrites and their metal-rich nodules has been controversial. EL3's have been interpreted to be breccias with impact melt and their metal-rich nodules as products of impact melting formed by mobilization and injection of metal into pores in the EL3 regolith [1]. It has also been argued that EL3 metal-rich nodules are primary Solar System materials [2, 3, 4]. Here we present a study of metal-rich nodules in EL3s and an EL3 clast from Almahata Sitta.

Results: Metal-rich nodules in EL3s (ALH 85119, EET 90092, MAC 88136, PCA 91020, QUE 93351) are distinct from those in EH3 [2]. They are ~ 200-300 μm in size and constitute ~ 10 vol% of EL3's. They generally have sharp outlines and enclose different combinations of enstatite, diopside, albitic plagioclase, silica, schreibersite, troilite, daubreelite, oldhamite, albandite and/or graphite. Enstatite occurs as needles and laths, and is generally dominant in the metal. However, nodules vary, for example, in some nodules graphite dominates. The Almahata Sitta EL3 clast (MS-177) we studied appears to be among the most primitive EL3 chondrites, indicated by occurrence of olivine and sharply bound chondrules. However, wavy extinction in its silicates, parallel fractures in olivine and shock darkening suggest a moderate degree of shock. Its metal-rich nodules are different from those in other EL3 chondrites. Some metal-rich nodules in MS-177 have irregular outlines with boundaries that seem to grade into surrounding silicates. They generally contain laths and needles of enstatite \pm graphite, laths and euhedral stubby sinoite ($\text{Si}_2\text{N}_2\text{O}$) crystals, laths of diopside and albitic plagioclase, enclosed within low-Ni metal. Sulfide is minor. Silicates are isolated crystals and in assemblages of enstatite \pm diopside \pm plag enclosed in metal. In some cases, sinoite is abundant, occurring as large euhedral crystals, up to 60 μm .

Discussion: Almahata Sitta clast MS-177 is a primitive, moderately shocked, EL3 chondrite. The MS-177 (and MS-17 [3,4]), metal-rich nodules contain sinoite, which is not common in other EL3 nodules. There is no evidence of impact melting in the MS-177 clast. The textures of the minerals and range of isotopic compositions of graphite in the nodules [3] would not survive melting or high degrees of thermal alteration. This supports the primitive nature of MS-177. The metal-rich nodules in MS-177 may be aggregates of condensates [3,4] and/or phases that crystallized in a metallic (chondrule-like) melt. In the latter case, molten metal may have acted as a flux for growth of the silicate laths and needles and other crystals [e.g., 5].

References: [1] Van Niekirk, D. and Keil, K. (2011) *Meteoritics & Planetary Science* 46, 1487-1494. [2] Weisberg M. K. et al. (2013) 44th Lunar & Planetary Science Conf. Abstract #287. [3] El Goresy A. et al. (2012) 75th Meteoritical Society Meeting. Abstract # 5108. [4] Lin Y. et al. (2011) 42nd Lunar & Planetary Science Conf. Abstract # 9040. [5] Weisberg M. K. et al. (1997) 28th Lunar & Planetary Science Conf. 1523-1524.