Dual energy nano-XRF quantification in EL-3 fragments of the Almahata Sitta TC3 asteroid

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Introduction: We studied sinoite-bearing fragments of the MS-17 and MS-177 primitive EL-3 enstatite chondrites of the Almahata Sitta TC3 [1] second generation asteroidal conglomerate of various meteorite types accreted from destroyed asteroids. We worked towards settling the current debate between accreted solar condensate fragments [2] and "*impact melt breccia*" of preexisting proto-asteroids [3]. The latter model was often revised from ***fully*** [4] to **pre-accretionary** impact controlled metamorphism [5]. Both EL-3 fragments contain FeNi nodules which feature oldhamite, encapsulated in a spray of idiomorphic sinoite needles in MS-17 or in stubby prisms in MS-177, and graphite as well as several accessory minerals: enstatite, oldhamite, possibly alabandite, schreibersite, caswellsilverite, wassonite, daubreelite.

Experimental methods: A dual energy X-ray beam of spot size 200 – 900 nm^2, of flux ($\leq 1\cdot10^{10}$ ph/s) was used at both 2.7 and 7.5 keV energies to perform fluorescence mapping at the ID21 beamline of the ESRF synchrotron in Grenoble, France. Dual energy mapping is the only way to record both low Z element abundances as well as separating their lines from the low energy lines of higher Z elements. We obtained the previously unknown elemental inventory of sinoite, in particular the sequence Fe-Mg, down to O and N, including volatiles only compatible with the condensation from the solar gas scenario.

Preliminary results: Based on the idiomorphism of the sinoite phases and our elementary abundances, as well as the absence of shock produced polymorphs or veins, we confirm findings of the previous study which favors the condensation sequence scheme $CaS\rightarrow Si_2N_2O\rightarrow$graphite [6]. Wickerwork (mikado) patterns of the sinoite preclude preferential orientation required by shock origin, or subsequent shock metamorphism. Finally, accessory minerals we identified by high resolution fluorescence and element correlation imaging, constrain the mineral condensation temperatures and further validate the nebular condensation origin.

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