

NANOCRYSTALLINE P-BEARING PENTLANDITE AND CHROMIUM NITRIDES FROM CM2 CHONDRITES Y-791198 and Y-793321.

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Introduction: Phosphorous-bearing Fe,Ni sulfides are characteristic accessory phases in CM2 chondrites, but enigmatic in their mineralogy and origin. Extensive textural and microanalytical data has been provided by [1], and a TEM study by [2] has shown that the material is nanocrystalline, but its structure could not be identified. We have prepared several FIB sections of P-bearing sulfides from two selected CM2 chondrites: Yamato(Y)-791198 is an unbrecciated rock with a rather low level of aqueous alteration and no significant secondary heating [3]. On the contrary, Y-793321 is a regolith breccia and has experienced an episode of thermal metamorphism at 250 to 500 °C [4]. This choice is intended to draw conclusions about the thermal stability and the origin of P-bearing sulfides and associated phases.

Results: TEM shows that grains in both meteorites are not homogeneous internally. Besides the nanocrystalline sulfide (<20 nm) we have found in certain grains myriads of <100 nm sized flakes of chromium nitrides. SAED derived d-values are consistent with CrN (carlsbergite) in Y-791198 and CrN+Cr₂N in Y-793321. The presence of chromium and nitrogen has been confirmed by EDX and EELS. This is the first reported observation of chromium nitrides in chondritic meteorites.

SAED patterns of the nanocrystalline sulfides in Y-791198 show two broad rings corresponding to d-values of 0.30 and 0.18 nm. In Y-793321 the principal rings occur at the same positions, but splitting occurs and additional, weaker rings join. The corresponding d-values of strong and weak rings in Y-793321 match to a pentlandite structure. HR-TEM imaging shows that the nanocrystallites in Y-793321 are larger (close to 20 nm) and better defined than in Y-791198. Hence, the difference in SAED patterns is due to better crystallinity in Y-793321, which we interpret as a result of thermal annealing. This is supported by the development of a lattice preferred orientation (LPO) of nanocrystallites in Y-793321, which is evident by circumferential intensity variations along the diffraction rings. The LPO is likely a transitional state during recrystallization toward a single pentlandite crystal. Chemical shift of P K α determined by EMPA-WDS suggests a mix of phosphate and phosphide and EELS indicates abundant oxygen in the sulfide portion. While phosphide is likely incorporated into the pentlandite structure, phosphate groups probably reside on the large internal boundary surfaces. The same likely applies to lithophile trace elements measured by [1].

Conclusions: Comparison of Y-791198 and Y-793321 shows that the nanocrystalline sulfide is thermally not stable and undergoes recrystallization during processing at temperatures below 500 °C. However, the refractory nitrides must have formed at elevated temperatures in excess of 500 °C. This implies a complex, multistage formation history. Scenarios will be discussed.

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References: [1] Nazarov M. A. et al. 2009. *Petrology* 17:101-123. [2] Devouard B. and Buseck P.R. 1997. *Meteoritics & Planetary Science* 32:A34. [3] Nakamura T. 2005. *Journal of Mineralogical and Petrological Sciences* 100:260-272. [4] Nakamura T. 2006. *Earth and Planetary Science Letters* 242:26-38.