

## **Monipite, MoNiP, a new phosphide mineral in a Ca-Al-rich inclusion from the Allende meteorite**

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### **ABSTRACT**

Monipite (IMA 2007-033), MoNiP, is a new phosphide mineral that occurs as one  $1 \times 2 \mu\text{m}$  crystal in a Type B1 Ca-Al-rich inclusion (CAI) ACM-2 from the Allende CV3 carbonaceous chondrite. It has an empirical formula of  $(\text{Mo}_{0.84}\text{Fe}_{0.06}\text{Co}_{0.04}\text{Rh}_{0.03})(\text{Ni}_{0.89}\text{Ru}_{0.09})\text{P}$ , and a  $P\bar{6}2m$  Fe<sub>2</sub>P type structure with  $a = 5.861$ ,  $c = 3.704 \text{ \AA}$ ,  $V = 110.19 \text{ \AA}^3$ , and  $Z = 3$ . The calculated density using our measured composition is  $8.27 \text{ g/cm}^3$ , making monipite the densest known mineral phosphide. Monipite probably either crystallized from an immiscible P-rich melt that had exsolved from an Fe-Ni-enriched alloy melt that formed during melting of the host CAI or it exsolved from a solidified alloy. Most of the original phosphide in the type occurrence was later altered to apatite and Mo-oxides, leaving only a small residual grain. Monipite occurs within an opaque assemblage included in melilite that contains kamiokite ( $\text{Fe}_2\text{Mo}_3\text{O}_8$ ), tugarinovite ( $\text{MoO}_2$ ), and a Nb-rich oxide  $[(\text{Nb},\text{V},\text{Fe})\text{O}_2]$ , none of which has previously been reported in meteorites, together with apatite, awaruite ( $\text{Ni}_2\text{Fe}$ ), and vanadian magnetite.

**Keywords:** Monipite, MoNiP, new mineral, tugarinovite, kamiokite, Allende, carbonaceous chondrites, EBSD, Ca-Al-rich inclusions