DISCOVERY OF A NEW PHOSPHIDE MINERAL, MONIPITE (MoNiP), IN AN ALLENDE TYPE B1 CAI..

Chi Ma*, John R. Beckett, George R. Rossman. Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, USA. *e-mail: chi@gps.caltech.edu

Introduction: During our nano-mineralogy investigation of the Allende meteorite, a new phosphide mineral, monipite (MoNiP), was discovered in a Type B1 Ca-, Al-rich inclusion (CAI). Monipite, the Mo-, Ni-dominant analog of barringerite (Fe_2P), is named for the composition. It is probably a secondary product of the oxidation of Mo-phosphides and/or P-rich alloys and reflects conditions during the alteration of CAIs. The mineral and its name have been approved by the Commission on New Minerals, Nomenclature and Classification of the International Mineralogical Association (IMA 2007-033). We report here the first occurrence of monipite in nature and a new phase for CAIs.

Occurrence, Chemistry, Crystallography: Monipite occurs as one irregular grain, 1.3 × 2.0 μm in size, in the melilite-rich mantle of a type B1 CAI (section USNM 7554). With an empirical formula based on election probe microanalysis of $(Mo_{0.84}Fe_{0.06}Co_{0.04}Rh_{0.03})_{\sum 0.97}(Ni_{0.89}\ Ru_{0.09})_{\sum 0.98}P$. The monipite grain is in contact with apatite, tugarinovite (MoO_2), and a Ru-Mo-Ni metal grain; the surrounding phases include apatite, V-rich magnetite, kamiokite ($Fe_2Mo_3O_8$), tugarinovite (MoO_2), a Mo-Fe oxide with Mo/Fe ~ 2, and Nb-rich oxide ($(Nb,V,Fe)O_2$). This assemblage is bounded by Ni_2Fe on one side and coarse-grained clinopyroxene + spinel on the other. To our knowledge, monipite is the first known occurrence of a phosphide in an Allende CAI; this is also the first reported meteoritic occurrence of kamiokite, tugarinovite, the Mo-Fe oxide with Mo/Fe ~ 2, and the Nb-rich oxide. Electron backscatter diffraction patterns of monipite were matched against the structures of known synthetic phases in the Mo-Ni-P system. The best fit was achieved using the $P\bar{6}2m$ MoNiP structure [1], with a =5.861 Å, c = 3.704 Å, V= 110.19 Å^3, Z = 3. The calculated density is 8.27 g/cm^3.

Origin and Significance: Monipite, together with Ru-Mo-Ni alloy and kamiokite, are surrounded by a ~12 μm diameter rosette composed of apatite, Nb-rich oxide, a Mo-Fe oxide with Mo/Fe ~ 2, V-bearing magnetite, kamiokite, and tugarinovite. The phase distribution is asymmetric with Nb-rich oxide restricted to the pyroxene-spinel bounded side of the assemblage and Mo±Fe oxides concentrated towards the Ni_2Fe alloy side. A simple scenario for the formation of monipite is that a precursor in melilite consisted of a Mo + P-rich alloy ± phosphide, which was oxidized during alteration to produce the observed aureole of oxide and phosphate alteration phases. Ca, Mo, Fe and, possibly, Ni were mobile during metasomatism and, in particular, the aureole supported large chemical potential gradients in Mo over a few μm. It seems likely that monipite would have been destroyed given sufficient time and access to the altering medium. Nevertheless, monipite and its escorts hold new information on the processes to which Allende CAIs were subjected after their formation and, together with other new Allende minerals [2-4], provide new insight into the formation and evolution of the early solar system.

References: [1] Guérin R. and Sergent M. 1977. *Acta Crystallographica* B33:2820-2823. [2] Ma C. et al. 2009. Abstract #1402. 40th Lunar & Planetary Science Conference. [3] Ma C. and Rossman G. R. 2009. *American Mineralogist* 94:841-844. [4] Ma C. and Rossman G. R. 2009. *American Mineralogist* 94:845-848.