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Discovery of terrestrial andreyivanovite, FeCrP, and the effect of Cr and V substitution on the low-pressure barringerite-allabogdanite transition

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Abstract

Iron phosphides with significant variations of Cr (up to 18 wt%) and V (up to 8.6 wt%) contents were detected in gehlenite-bearing breccia at the Hatrurim Complex, Negev desert, Israel. Investigations of the composition and structure of the Fe_2P phosphides showed that when the V+Cr content is higher than 0.26 apfu (atoms per formula unit), a transition from the hexagonal barringerite ($P\bar{6}2m$) to orthorhombic allabogdanite (*Pnma*) takes place. According to the experimental data, allabogdanite is a high-pressure (>8 GPa) polymorph of barringerite. Pseudowollastonite associated with Cr-V-bearing allabogdanite is an indicator of phosphide crystallization at high temperature (>1200 °C) and low pressure. Thus, at the low pressure close to ambient, when more than 13 at% Fe in Fe_2P is substituted by Cr and V, the orthorhombic polymorph is stable. The orthorhombic phosphide with the highest Cr and V contents belongs to the andreyivanovite species with the FeCrP end-member formula. This is the first finding on Earth of that very rare mineral described from the Kaidun meteorite. Some Cr-V-bearing phosphides have an unusual morphology, which cannot be explained by crystallization from a melt. More probably, these phosphides can form in the process of replacing fish bone remains. We believe that sedimentary protolith was not thermally altered and contained a significant amount of bituminous organic matter and phosphorite inclusions. Injecting paralava into the sedimentary rocks determines the conditions for phosphide formation on the boundary of these rocks as a result of the high-temperature carbothermal reduction process.

Keywords: Terrestrial natural phosphides, barringerite, allabogdanite, andreyivanovite, phase transition, Hatrurim Complex