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Discovery of terrestrial allabogdanite $(Fe,Ni)_2P$, and the effect of Ni and Mo substitution on the barringerite-allabogdanite high-pressure transition

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Abstract

Minerals formed at high pressures are sensitive indicators of extreme pressure-temperature conditions that occur in nature. The discovery of the high-pressure polymorph of $(Fe,Ni)_2P$, allabogdanite in the surficial pyrometamorphic rocks of the Hatrurim Formation (the Mottled Zone) surrounding the Dead Sea basin in Israel is the first terrestrial occurrence of a mineral previously only found in iron meteorites. Stepwise annealing experiments demonstrate that allabogdanite is metastable at ambient pressure and that it irreversibly transforms into its low-pressure polymorph, barringerite, upon heating to 850 ± 50 °C. High-pressure, high-temperature diamond-anvil cell (DAC) experiments confirm the results of annealing experiments. The DAC data indicate that Hatrurim allabogdanite is metastable below 7.4 GPa, and the low- to high-pressure phase transition (barringerite → allabogdanite) occurs at 25 ± 3 GPa and 1400 ± 100 °C. The observed transition pressure of Hatrurim allabogdanite is significantly higher than that of pure synthetic Fe_2P (8 GPa) due to partial substitution of Fe for Ni (4 wt%) and Mo (2.5 wt%). Because the influence of substituting impurities on the conditions of phase transitions can be unexpectedly strong, our findings confirm that caution should be exercised when extrapolating data from experiments on synthetic compounds to natural systems. Based on the discovery of terrestrial allabogdanite $(Fe,Ni)_2P$ coupled with experiments probing the phase transitions in this natural composition, we contend that terrestrial allabogdanite formed via transformation from barringerite and posit potential scenarios of its formation.

Keywords: Allabogdanite, barringerite, phosphide, Fe_2P, high pressure, crystal structure, phase transitions, Fe-Ni-P system