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Transjordanite, Ni_2P, a new terrestrial and meteoritic phosphide, and natural solid solutions barringerite-transjordanite (hexagonal Fe_2P–Ni_2P)

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Abstract

This paper is a first detailed report of natural hexagonal solid solutions along the join Fe_2P–Ni_2P. Transjordanite, Ni_2P, a Ni-dominant counterpart of barringerite (a low-pressure polymorph of Fe_2P), is a new mineral. It was discovered in the pyrometamorphic phosphide assemblages of the Hatrurim Formation (the Dead Sea area, Southern Levant) and was named for the occurrence on the Transjordan Plateau, West Jordan. Later on, the mineral was confirmed in the Cambria meteorite (iron ungrouped, fine octahedrite), and it likely occurs in CM2 carbonaceous chondrites (Mighei group). Under reflected light, transjordanite is white with a beige tint. It is non-pleochroic and weakly anisotropic. Reflectance values for four COM recommended wavelengths are [R_{max}/R_{min}, % (λ, nm)]: 45.1/44.2 (470), 49.9/48.5 (546), 52.1/50.3 (589), 54.3/52.1 (650). Transjordanite is hexagonal, space group $P\bar{6}2m$; unit-cell parameters for the holotype specimen, $(Ni_{1.72}Fe_{0.27})_{1.99}P_{1.02}$, are: a = 5.8897(3), c = 3.3547(2) Å, V = 100.78(1) Å^3, Z = 3. D_{calc} = 7.30 g/cm^3. The crystal structure of holotype transjordanite was solved and refined to R_1 = 0.013 based on 190 independent observed [$I > 2\sigma(I)$] reflections. The crystal structure represents a framework composed of two types of infinite rods propagated along the c-axis: (1) edge-sharing tetrahedra [$M(1)P_4$] and (2) edge-sharing [$M(2)P_5$] square pyramids. Determination of unit-cell parameters for 12 members of the Fe_2P–Ni_2P solid-solution series demonstrates that substitution of Ni for Fe in transjordanite and vice versa in barringerite does not obey Vegard's law, indicative of preferential incorporation of minor substituent into $M(1)$ position. Terrestrial transjordanite may contain up to 3 wt% Mo, whereas meteoritic mineral bears up to 0.2 wt% S.

Keywords: Transjordanite, barringerite, phosphide, Fe-Ni-P system, Fe_2P, Ni_2P, crystal structure, phase transitions, solid solution, Vegard's law, pyrometamorphism, meteorite, prebiotic phosphorylation