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Nazarovite, $Ni_{12}P_5$, a new terrestrial and meteoritic mineral structurally related to nickelphosphide, Ni_3P

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Abstract

Nazarovite, $Ni_{12}P_5$, is a new natural phosphide discovered on Earth and in meteorites. Terrestrial nazarovite originates from phosphide assemblages confined to pyrometamorphic suite of the Hatrurim Formation (the Mottled Zone), the Dead Sea basin, Negev desert, Israel. Meteoritic nazarovite was identified among Ni-rich phosphide precipitates extracted from the Marjalahti meteorite (main group pallasite). Terrestrial mineral occurs as micrometer-sized lamella intergrown with transjordanite (Ni_2P). Meteoritic nazarovite forms chisel-like crystals up to 8 μm long. The mineral is tetragonal, space group *I*4/*m*. The unit-cell parameters of terrestrial and meteoritic material, respectively: *a* 8.640(1) and 8.6543(3), *c* 5.071(3), and 5.0665(2) Å, *V* 378.5(2), and 379.47(3) Å^3, *Z* = 2. The crystal structure of terrestrial nazarovite was solved and refined on the basis of X-ray single-crystal data (R_1 = 0.0516), whereas the structure of meteoritic mineral was refined by the Rietveld method using an X-ray powder diffraction profile (R_B = 0.22%). The mineral is structurally similar to phosphides of schreibersite–nickelphosphide join, Fe_3P-Ni_3P. Chemical composition of nazarovite (terrestrial/meteoritic, electron microprobe, wt%): Ni 81.87/78.59, Fe <0.2/4.10; Co <0.2/0.07, P 18.16/17.91, total 100.03/100.67, leading to the empirical formula $Ni_{11.97}P_{5.03}$ and $(Ni_{11.43}Fe_{0.63}Co_{0.01})_{12.07}P_{4.94}$, based on 17 atoms per formula unit. Nazarovite formation in nature, both on Earth and in meteorites, is related to the processes of Fe/Ni fractionation in solid state, at temperatures below 1100 °C.

Keywords: $Ni_{12}P_5$, nickelphosphide, Fe-Ni-P system, crystal structure, pyrometamorphism, meteorite, planetary interiors, nanoprecipitates