American Mineralogist, Volume 110, pages 1640–1648, 2025

Olgafrankite, Ni_3Ge, a new mineral as the carrier of siderophile germanium in reduced systems

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Abstract

Germanium is a classic trace element that rarely forms its own minerals but plays a significant role in geochemical and cosmochemical classification schemes. The geochemical behavior of Ge is very contrasting, depending on the redox environment and sulfur activity in the geosystems. Siderophile germanium, in the form of native germanides, has been reported in several terrestrial and meteoritic occurrences, but the majority of these phases have been poorly characterized. In this study, we report the discovery of Ni_3Ge, a new germanide mineral, named olgafrankite in honor of Olga Victorovna Frank-Kamenetskaya, Saint Petersburg State University, Russia. The mineral, previously mentioned in the Rumuruti meteorite (the prototype of the R-type chondrites), has been discovered and studied in this work from terrestrial basalts of the Dzhaltul intrusion in the Norilsk ore region, Siberia, Russia. Olgafrankite crystals up to 5×7 μm in size were found within magnetite-pentlandite assemblages confined to massive centimeter-sized aggregates of native (telluric) iron. Other associated minerals are graphite, cohenite (Fe_3C), Ge-bearing taenite (γ-Fe,Ni) (more than 1 wt% Ge), tetrataenite (FeNi), and various sulfides. In reflected light, olgafrankite is bright white with a pink tint. The empirical formula of the mineral calculated on the basis of 4 atoms per formula unit is $(Ni_{2.72}Fe_{0.28}Co_{0.01})_{\Sigma 3.01}(Ge_{0.97}S_{0.02})_{\Sigma 0.99}$. Electron backscattered diffraction analysis revealed that olgafrankite is cubic (space group $Pm\bar{3}m$) and isostructural with synthetic Ni_3Ge. Rietveld analysis of the powder X-ray diffraction data has confirmed the space group of olgafrankite and allowed for the refinement of its unit-cell parameter, $a = 3.5784(2)$ Å. The mineral belongs to the perovskite supergroup, *B*-site-vacant single antiperovskites, auricupride subgroup. In terms of crystal structure and chemical composition, olgafrankite is a direct germanium analog of nisnite, Ni_3Sn, and carletonmooreite, Ni_3Si. Here we demonstrate that the new germanide can be an important but still obscure germanium carrier in some reduced assemblages, in particular in iron- and stony-iron meteorites, where the well-known significant correlations between nickel and germanium may be accounted for by the presence of finely dispersed olgafrankite precipitates.

Keywords: Ni_3Ge, nickel, germanium, native iron, Norilsk, meteorite