Allabogdanite, (Fe,Ni)$_2$P, a new mineral from the Onello meteorite: The occurrence and crystal structure

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ABSTRACT

Allabogdanite, (Fe,Ni)$_2$P, is a new mineral from the Onello iron meteorite (Ni-rich ataxite). It occurs as thin lamellar crystals disseminated in plessite. Associated minerals are nickelphosphide, schreibersite, awaruite, and graphite. Crystals of the mineral, up to 0.4 × 0.1 × 0.01 mm, are flattened on (001) with dominant [001] faces, and other faces that are probably [110] and [100]. Mirror twinning resembling that of gypsum is common, with possible twin composition plane {110}. Crystals are light straw-yellow with bright metallic luster. Polished (001) sections look silvery-white against an epoxy background. In reflected light in air, the mineral has a creamy color, with distinct anisotropy from light to dark creamy tint. No bireflectance was observed. R/R2 (λ, nm) in air: 48.4/37.2(440), 46.7/36.8(460), 47.0/37.6(480), 47.5/38.1(500), 47.6/38.8(520), 48.2/39.2(540), 49.0/39.9(560), 49.6/40.7(580), 50.1/41.6(600), 50.5/41.9(620), 51.9/43.0(640), 52.3/44.3(660), 53.7/45.0(680), 54.4/46.2(700). No cleavage or parting was observed. Moh’s hardness is 5–6; the mineral is very brittle, and its calculated density 7.10 g/cm$^3$. Its chemical composition (determined by microprobe methods, average of nine analyses) is: Fe 57.7, Ni 20.7, Co 1.4, P 20.4, Total 100.2 wt%, corresponding to (Fe$_{1.51}$Ni$_{0.50}$Co$_{0.03}$)$_{2.04}$P$_{0.96}$ (three atoms per formula unit). Crystal structure: R1 = 0.040 for 138 unique observed (|F|)$^2$ reflections. Orthorhombic, Pnma, unit-cell parameters refined from powder data: a = 5.748(2), b = 3.548(1), c = 6.661(2) Å, V = 135.8(1) Å$^3$, Z = 4; unit-cell parameters refined from single-crystal data: a = 5.792(7), b = 3.564(4), c = 6.691(8) Å, and V = 138.1(3) Å$^3$. Strongest reflections in the X-ray powder diffraction pattern are [d in Å, (λ) (hkl)]: 2.238(100)(112), 2.120(80)(211), 2.073(70)(103), 1.884(50)(013), 1.843(40)(301), 1.788(40)(113), 1.774(40)(020). The mineral is named for Alla Bogdanova, Geological Institute, Kola Science Centre of Russian Academy of Sciences.

INTRODUCTION

The Onello iron meteorite was found in 1997 in the allu- vium of the Bol’shoy Dolguchan River, Onello River basin, Aldan shield, Sakha-Yakutia, Russia (62° 20’ N, 137° 40’ E) and belongs to a group of nickel-rich ataxites. Its characteristic feature is a high mean Ni content (22.2 wt%), which is rare in natural, with just a few representatives known (Buchwald 1975). Detailed study of the species designated “barringerite” from the Onello meteorite revealed that it is a new polymorph of (Fe,Ni)$_2$P that crystallizes in the Co$_2$Si (or anti-PbCl$_2$) structure type (Geller 1955; Rundquist and Jellinek 1959; Rundquist and Nawapong 1966) and, as such, is a new mineral. The mineral is named allabogdanite, in honor of Alla N. Bogdanova (b. 1947), crystallographer from the Geological Institute, Kola Science Center of Russian Academy of Sciences. (Buseck 1969). The mineral is isostructural with synthetic Fe$_2$P, an end-member of the Fe$_2$P-Ni$_2$P solid-solution series (Novotny and Henglein 1948). Buchwald (1975) suggested that barringerite was formed during artificial annealing of the meteoritic iron and, as a consequence, is not a mineral. Later, terrestrial and lunar occurrences of barringerite were reported by Chen et al. (1983) and Brandstätter et al. (1991), respectively (see also: Nazarov et al. 1998). Both the chemical composition and the powder X-ray diffraction (XRD) pattern were obtained for terrestrial barringerite, but reports of the lunar mineral did not include any structural data, owing to small amounts of the material available.

Detailed study of the species designated “barringerite” from the Onello meteorite revealed that it is a new polymorph of (Fe,Ni)$_2$P that crystallizes in the Co$_2$Si (or anti-PbCl$_2$) structure type (Geller 1955; Rundquist and Jellinek 1959; Rundquist and Nawapong 1966) and, as such, is a new mineral. The mineral is named allabogdanite, in honor of Alla N. Bogdanova (b. 1947), crystallographer from the Geological Institute, Kola Science Center of Russian Academy of Sciences, Apatity, Kola.