

Revize a nové nálezy fosfátů na historickém nalezišti Černovice u Tábora (Česká republika)

A revision and new findings of phosphates from the historical locality Černovice near Tábor (Czech Republic)

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Abstract

An interesting supergene phosphate and uranium mineral association was found on the historical wavellite occurrence Černovice near Tábor (Vysočina region, Czech Republic). Phosphates are bound to cracks and cavities in graphitic gneisses and quartzites. Beraunite forms radially fibrous greenish, greenish brown to reddish brown aggregates up to 1.5 mm in size; its empirical formula is $(\text{Fe}_{0.58}\text{Zn}_{0.08})_{\Sigma 0.66}(\text{Fe}^{3+}_{4.44}\text{Al}^{3+}_{0.56})_{\Sigma 5.00}[(\text{PO}_4)_{3.86}(\text{SiO}_4)_{0.13}(\text{VO}_4)_{0.01}]_{\Sigma 4.00}(\text{OH})_{4.45} \cdot 6\text{H}_2\text{O}$ and refined unit-cell parameters are a 20.647(4), b 5.1332(15), c 19.214(4) Å, β 93.6(3)° and V 2032.3 Å³. Carnotite was found as yellow powdery aggregates up to 1 mm across in association with metatorbernite, phosphosiderite and metavariscite; its empirical formula is $\text{K}_{1.88}\text{Ba}_{0.10}\text{Ca}_{0.01}(\text{UO}_2)_{1.99}(\text{VO}_4)_{2.00} \cdot 3\text{H}_2\text{O}$. Historically known wavellite has been redefined as fluorwavellite. It is the most abundant phosphate in the studied mineral association, it usually occurs as spherical aggregates up to 5 mm in size. Its colour is significantly zonal, from blue in the centre of aggregates to yellow in the marginal part. Its empirical formula $(\text{Al}_{2.74}\text{V}_{0.12}\text{Cr}_{0.01}\text{Fe}_{0.01}\text{K}_{0.01})_{\Sigma 2.89}[(\text{PO}_4)_{1.98}(\text{SiO}_4)_{0.02}(\text{F}_{0.72}(\text{OH})_{0.28}(\text{OH})_{1.57} \cdot 5\text{H}_2\text{O}$ and refined unit-cell parameters are a 9.6285(13), b 17.374(3), c 6.9953(8) Å, V 1170.2(3) Å³. Phosphosiderite-metavariscite forms light green crusts on quartz crystals thickness up to 0.1 mm; its empirical formula is $(\text{Fe}_{0.57}\text{Al}_{0.40})_{\Sigma 0.97}[(\text{PO}_4)_{0.99}(\text{VO}_4)_{0.01}]_{\Sigma 1.00}\text{F}_{0.03} \cdot 2\text{H}_2\text{O}$ and refined unit-cell parameters are a 5.324(14), b 9.83(2), c 8.722(19) Å, β 90.6(3)° and V 456(1) Å³. Caxoxenite occurs as yellow crusts and radial aggregates up to 0.2 mm in size with empirical formula $\text{K}_{0.07}\text{Ca}_{0.06}\text{Fe}^{3+}_{20.21}\text{Al}_{3.89}\text{O}_{6.00}[(\text{PO}_4)_{16.66}(\text{SiO}_4)_{0.28}(\text{VO}_4)_{0.06}]_{\Sigma 17.00}(\text{OH})_{9.75} \cdot 75\text{H}_2\text{O}$ and unit-cell parameters: a 27.556(9), c 10.5570(3) Å, and V 6942.4(8) Å³. Kidwellite occurs as green spherical aggregates up to 0.1 mm in size. Its empirical formula is $(\text{Na}_{0.56}\text{K}_{0.03}\text{Ca}_{0.41})_{\Sigma 1.00}(\text{Al}_{1.16}\text{Ca}_{0.26}\text{Mg}_{0.06}\text{Fe}^{3+}_{8.15})_{\Sigma 9.63}[(\text{PO}_4)_{5.91}(\text{VO}_4)_{0.06}(\text{SiO}_4)_{0.03}]_{\Sigma 6.00}(\text{OH})_{11.20} \cdot 3\text{H}_2\text{O}$ and refined unit-cell parameters are a 20.12(12), b 5.187(18), c 13.974(9) Å, β 107.1(6)° and V 1395(1) Å³. Leucophosphite was found only as a very rare yellow to yellowish green tabular crystals and their aggregates up to 0.01 mm in size on hemispherical beraunite; it was verified only by Raman spectroscopy and qualitative EDS analysis. Metatorbernite forms green tabular crystals up to 3 mm in size; its empirical formula is $(\text{Cu}_{1.13}\text{Ca}_{0.01})_{\Sigma 1.14}(\text{UO}_2)_{1.97}[(\text{PO}_4)_{1.99}(\text{VO}_4)_{0.01}]_{\Sigma 2.00} \cdot 8\text{H}_2\text{O}$ and refined unit-cell parameters are a 6.969(4), c 17.3316(3) Å, and V 841.9(5) Å³. Natrodufrénite was found as dark green to bluish green aggregates with light green or yellowish green zones forming radial aggregates up to 1.5 mm in size; its empirical formula is $(\text{Na}_{0.65}\text{Ca}_{0.13}\text{K}_{0.01}\text{Ca}_{0.21})_{\Sigma 1.00}(\text{Fe}^{2+}_{0.96}\text{Zn}_{0.04})_{\Sigma 1.00}(\text{Fe}^{3+}_{4.44}\text{Al}_{0.34})_{\Sigma 4.78}[(\text{PO}_4)_{3.93}(\text{SiO}_4)_{0.07}(\text{VO}_4)_{0.00}(\text{OH})_{5.33} \cdot 2\text{H}_2\text{O}$ and refined unit-cell parameters are a 25.872(12), b 5.149(3), c 13.785(8) Å, β 111.5(5)° and V 1708(1) Å³. Strengite was observed as spherical aggregates of white, light gray, beige or yellow to orange color up to 4 mm in size in four different mineral associations; empirical formulas of three most common strengites are: $\text{Fe}_{0.77}\text{Al}_{0.21}(\text{PO}_4)_{1.00} \cdot 2\text{H}_2\text{O}$ (strengite I; association with natrodufrénite); $\text{Fe}_{0.92}\text{Al}_{0.06}(\text{PO}_4)_{1.00} \cdot 2\text{H}_2\text{O}$ (strengite II; association with turquoise); $\text{Fe}_{0.84}\text{Al}_{0.10}((\text{PO}_4)_{0.98}(\text{VO}_4)_{0.02})_{\Sigma 1.00} \cdot 2\text{H}_2\text{O}$ (strengite III; association with kidwellite); refined unit-cell parameters for all studied types are comparable a 8.720(4), b 9.877(5), c 10.115(5) Å and V 871.1(7) Å³. Turquoise forms apple green zonal crystals up to 0.1 mm in size; empirical formula $(\text{Cu}_{0.59}\text{Ca}_{0.35}\text{K}_{0.03}\text{Zn}_{0.02}\text{Ca}_{0.01})_{\Sigma 1.00}(\text{Al}_{5.03}\text{Fe}^{3+}_{0.81})_{\Sigma 5.84}[(\text{PO}_4)_{3.64}(\text{PO}_3\text{OH})_{0.35}(\text{SiO}_4)_{0.01}]_{\Sigma 4.00}(\text{OH})_{6.40}\text{F}_{0.37} \cdot 4\text{H}_2\text{O}$ (central parts of aggregates) and $(\text{Cu}_{0.70}\text{Ca}_{0.25}\text{K}_{0.01}\text{Zn}_{0.03}\text{Ca}_{0.01})_{\Sigma 1.00}(\text{Al}_{4.28}\text{Fe}^{3+}_{1.52})_{\Sigma 5.80}[(\text{PO}_4)_{3.73}(\text{PO}_3\text{OH})_{0.25}(\text{SiO}_4)_{0.01}]_{\Sigma 3.99}(\text{OH})_{6.76}\text{F}_{0.13} \cdot 4\text{H}_2\text{O}$ (marginal parts) and unit-cell parameters are a 7.425(8), b 7.628(7), c 9.921(8) Å, α 68.59(7)°, β 69.67(8)°, γ 65.08(7)° and V 461.8(5) Å³. Two varieties of variscite were observed; white variscite forms crusts on the surface of spherical aggregates of the strengite II; its empirical formula is $\text{Al}_{0.87}\text{Fe}_{0.14}(\text{PO}_4)_{1.00}\text{F}_{0.03} \cdot 2\text{H}_2\text{O}$; and green variscite with $\text{Al}_{0.97}\text{Fe}_{0.05}((\text{PO}_4)_{0.98}(\text{SiO}_4)_{0.01}(\text{VO}_4)_{0.01})_{\Sigma 1.00}\text{F}_{0.05} \cdot 2\text{H}_2\text{O}$ was found as light green crusts of thickness up to 1 mm in size. Unit-cell parameters of green variscite are a 9.909(4), b 9.664(3), c 17.184(6) Å, V 1645.5(6) Å³.

Key words: fluorwavellite, variscite, kidwellite, natrodufrénite, strengite, phosphate occurrence, uranium minerals, unit-cell parameters, chemical composition, Raman spectra, Na Zoubku, Černovice, Tábor, Czech Republic

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