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Revalidation of pradetite as a mineral

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Abstract

Pradetite is revalidated as a mineral. It is a lindackerite-type mineral in which the special *M* cationic site is dominantly occupied by Co. Pradetite has the end-member formula $\text{CoCu}_4(\text{AsO}_4)_2(\text{AsO}_3\text{OH})_2 \cdot 9\text{H}_2\text{O}$, it is triclinic $\bar{1}$, $a = 6.434(5)$, $b = 8.059(5)$, $c = 10.399(8)$ Å, $\alpha = 85.70(6)$, $\beta = 79.41(7)$, $\gamma = 84.87(7)^\circ$, $V = 526.9(7)$ Å³, $Z = 1$.

Keywords: pradetite, lindackerite, new mineral, revalidation, Cap Garonne

Introduction

Chiappero (1993) and Sarp and Dominik (1995) redefined lindackerite as being triclinic, based on their work on holotype material (from Jáchymov, Czech Republic) of this mineral, in contrast to the monoclinic symmetry previously attributed by Guillemin (1956). This redefinition of lindackerite implied the discreditation of pradetite, a mineral from Cap Garonne (Var, France) discovered by Halil Sarp, as a cobalt-bearing variety of lindackerite. Pradetite had been approved (on a proposal submitted by Sarp, IMA 91-046) as a mineral by the Commission on New Minerals and Mineral Names (CNMMN) of the International Mineralogical Association (IMA) in January 1992, but its publication had been delayed, pending the work on holotype lindackerite. The CNMMN decided in January 1995 that a redefinition of lindackerite was to be preferred over the use of the name pradetite.

Hybler *et al.* (2003) studied two crystals of new lindackerite material from Jáchymov, one Co-Ni-bearing and one representing the pure Cu end member. Single-crystal structure refinement showed that the five metal *apfu* in lindackerite occupy the three cationic sites, two of these (Cu1 and Cu2) fully occupied by four Cu atoms, and the remaining posi-

tion (the special *M* site) preferably occupied by the substituting Co and Ni atoms. This isomorphous substitution of Co and Ni for Cu in this *M* position is an important feature for the nomenclature of lindackerite-type minerals. This became evident by proposal IMA 2005-053 (approved by the CNMMN in January 2006) by Sejkora *et al.* for such a mineral (to be named veselovskýite) in which the special *M* site is dominantly occupied by Zn instead of Cu.

In their paper on the lindackerite crystal structure, Hybler *et al.* (2003) recalculated the lindackerite analyses of Sarp and Dominik (1995) and used the name “Co-lindackerite” for the material from the Cap Garonne mine, because with their structure model on the basis of 4 As *apfu* the special *M* position has an occupancy of $(\text{Co}_{0.47}\text{Cu}_{0.28})_{\Sigma 0.74}$. Sejkora *et al.* clearly stated in their IMA 2005-053 proposal that this Co-dominant analogue of lindackerite and veselovskýite represents another up to now non-approved mineral species, namely the pradetite discredited by Sarp and Dominik (1995).

The authors of the present paper therefore submitted a revalidation proposal (06-D) for pradetite to the CNMMN, it was approved by the Commission, meanwhile renamed as Commission on New Minerals, Nomenclature and Classification (CNMNC), in August

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2006. The following pages consist of a shortened version of the pradetite data published in 1995 by Sarp and Dominik as Cap Garonne lindackerite, with some additions and corrections resulting from the 2003 paper by Hybler *et al.* and the IMA 2005-053 proposal by Sejkora *et al.*, the most important ones being a change in the setting of the unit-cell parameters by Hybler *et al.* (2003), and the recalculation of the empirical formula based on 25 O+OH by Sejkora *et al.*

Material

Pradetite occurs as a secondary alteration mineral in the Cap Garonne mine near the city of Le Pradet (Var, France), for which the mineral has been named. The mineral forms fibrous aggregates consisting of individual very elongated (parallel to [001]) crystals (0.3 mm × 0.05 mm × 0.15 mm) and massive equidimensional grains (~ 0.2 mm). Crystal forms are {001} and {100}. Twinning not observed. Associated minerals are olivenite, chalcantite, antlerite, covellite and tennantite on quartz gangue. Holotype material has been deposited in the Département de Minéralogie du Muséum d'Histoire Naturelle de Genève, Switzerland (registration no. 477.081).

Physical and optical properties

Pradetite has a green colour, white streak, and vitreous lustre. The mineral is transparent and non-fluorescent. Hardness could not be measured because of the small grain size. Tenacity is brittle, the {001} cleavage perfect, and the fracture conchoidal. The mineral is soluble in HCl. The measured density (by heavy liquids) is 3.33(1) g/cm³, the calculated density is 3.17 g/cm³ (using the powder data and the empirical formula based on 25 O+OH *apfu*). The mineral is optically biaxial (+), α 1.634(2), β 1.662(2), γ 1.720(5) (590 nm), 2V (meas.) = 75(4)°, 2V (calc.) = 72°. Dispersion: r < v, strong. Orientation: X ^ b = 20.5° on (001); X ^ b = 35° on (100). Pleochroism: weak, with Z = green, X and Y = colourless.

Chemical data

Chemical analyses (4) were carried out by means of an electron microprobe (Cameca SX 50, WDS mode, 15 kV, 5.5 nA, 6 µm beam diameter). H₂O was taken by difference from 100.00 wt.%. The mineral is very difficult to analyze with the microprobe because the mineral is destroyed due to evolution of water which increases the apparent values of As and Cu. Therefore, the analyses were done by moving the mineral in the electron beam. This diminished to a minimum the destruction of the mineral.

Table 1. X-ray powder-diffraction data for pradetite (d spacings from 1991, hkl from 2005).

h	k	l	d _{obs.}	I _{obs.}
0	0	1	10.2	100
0	1	0	8.01	60
0	1	-1	6.138	15
1	0	1	5.853	5
1	1	0	5.151	30
1	0	-1	4.997	5
1	-1	0	4.792	10
1	-1	1	4.507	10
0	1	2	4.397	<5
1	0	2	4.397	<5
0	1	-2	4.198	5
0	2	0	4.001	30
0	2	1	3.790	<5
0	2	-1	3.667	60
1	2	0	3.504	5
0	0	3	3.404	35
1	-1	-2	3.324	5
0	2	2	3.258	30
2	0	0	3.151	50
0	2	-2	3.063	50
0	1	-3	3.063	50
2	0	2	2.923	25
2	0	-1	2.865	25
1	-2	2	2.810	<5
0	3	0	2.674	40
0	2	3	2.674	40
1	-1	-3	2.653	5
2	2	1	2.615	35
2	0	3	2.544	10
2	2	2	2.493	10
0	3	2	2.418	<5
2	-2	0	2.387	15
1	2	-3	2.271	5
0	2	4	2.215	5
2	1	-3	2.067	5
3	1	2	2.067	5
0	0	5	2.039	5
3	1	-1	1.957	10
1	4	0	1.957	10
1	3	4	1.922	<5
3	2	0	1.922	<5
0	4	2	1.903	<5
2	-3	2	1.874	<5
2	-2	-3	1.874	<5

The mean analytical results are: CoO 3.39 (3.02-4.05), CuO 33.04 (32.75-33.47), As₂O₅ 44.64 (43.45-45.89), H₂O 18.93, Total 100.00 wt.%.

Sarp and Dominik (1995) calculated the empirical formula based on 26 oxygen *apfu*: (Co_{0.47}Cu_{0.35})_{Σ0.82} Cu₄(AsO₄)_{1.50}(AsO₃OH)_{2.57}·9.72H₂O; Hybler *et al.* (2003) used As = 4 *apfu* as basis: (Co_{0.47}Cu_{0.28})_{Σ0.75} Cu₄(AsO₄)_{1.49}(AsO₃OH)_{2.51}·9.56H₂O; Sejkora *et al.* (2005) used 25 (O,OH) *apfu* as basis:

Table 2. Comparison of lindackerite-type minerals (based on 25 O+OH apfu).

Mineral	pradetite	lindackerite	lindackerite	lindackerite	veselovskýite
Locality	Cap Garonne	Jáchymov J668	Jáchymov MZKJ	Jáchymov	Jáchymov
Reference	this paper	Hybler et al. (2003)	Hybler et al. (2003)	Sarp, Dominik (1995)	IMA 2005-053
M* (ideal)	Co	Cu	Cu	Cu	Zn
M* (meas.)	Co _{0.46} Cu _{0.18}	Cu _{1.21}	Cu _{0.36} Co _{0.25} Ni _{0.14}	Cu _{0.62} Co _{0.17} Ni _{0.07}	Zn _{0.43} Cu _{0.24} Co _{0.13}
n*	9	9	9	10	9
crystal system	triclinic	triclinic	triclinic	triclinic	triclinic
space group	<i>P</i> -1	<i>P</i> -1	<i>P</i> -1	<i>P</i> -1 or <i>P</i> 1	<i>P</i> -1
a	6.434(5)	6.415(1)	6.440(2)	6.453(2)	6.4022(4)
b	8.059(5)	8.048(1)	8.065(3)	8.035(2)	8.0118(4)
c	10.399(8)	10.332(1)	10.411(3)	10.368(4)	10.3665(4)
α	85.70(6)	85.41(1)	85.44(3)	86.17(3)	85.491(3)
β	79.14(7)	79.50(1)	79.38(3)	79.60(3)	79.377(4)
γ	84.87(7)	84.71(1)	84.65(3)	84.83(3)	84.704(5)
V	526.9(7)	521.2(1)	528.1(3)	525.9(2)	519.34(4)
Z	1	1	1	1	1
strongest lines in X-ray powder pattern	10.2/100 8.01/60 4.001/50 3.667/60 3.404/35 3.258/30	-	-	10.2/100 8.02/70 4.001/40 3.668/60 3.399/25 3.264/30	10.185/100 7.974/15 3.987/16 3.637/15 3.395/24 3.238/16
optical data	biaxial +	-	-	biaxial +	biaxial +
α	1.634(2)	-	-	1.632(2)	1.645(3)
β	1.662(2)	-	-	1.662(2)	1.68(1)
γ	1.720(5)	-	-	1.725(5)	1.72(1)
2V	72	-	-	72	88

M*, n* - refer to a general formula $\text{MCu}_4(\text{AsO}_4)_2(\text{AsO}_3\text{OH})_2 \cdot n\text{H}_2\text{O}$; All unit-cell parameters are given in the setting of Hybler et al. (2003).

$(\text{Co}_{0.46}\text{Cu}_{0.18})_{\Sigma 0.64}\text{Cu}_4(\text{AsO}_4)_{1.46}(\text{AsO}_3\text{OH})_{2.45} \cdot 9.36\text{H}_2\text{O}$.
The end-member formula (with H_2O based on structural data by Hybler *et al.*, 2003) is:
 $\text{CoCu}_4(\text{AsO}_4)_2(\text{AsO}_3\text{OH})_2 \cdot 9\text{H}_2\text{O}$.

Crystallography

Precession studies carried out by Sarp and Dominik (1995) gave a triclinic cell (*P*1 or *P* $\bar{1}$), with unit-cell parameters (setting of Hybler *et al.*, 2003) $a = 6.446(5)$, $b = 8.033(9)$, $c = 10.374(7)$ Å, $\alpha = 85.95(13)$, $\beta = 79.62(13)$, $\gamma = 86.21(14)^\circ$, $V = 525.6(1)$ Å³, $Z = 1$. X-ray powder diffraction data (114.6 mm diameter Gandolfi camera, $\text{CuK}\alpha$ radiation) were also obtained by Sarp and Dominik (1995) (Table 1, with new *hkl* indices based on Hybler *et al.*, 2003). Unit-cell parameters were newly refined from the X-ray powder-diffraction data on the basis of the known crystal structure of lindackerite-type minerals (Hybler *et al.*, 2003):

Triclinic: *P* $\bar{1}$, $a = 6.434(5)$, $b = 8.059(5)$, $c = 10.399(8)$ Å, $\alpha = 85.70(6)$, $\beta = 79.41(7)$, $\gamma = 84.87(7)^\circ$, $V = 526.9(7)$ Å³, $Z = 1$.

Compatibility

The Gladstone-Dale relationship $[1 - (K_p/K_c)]$ calculated with the powder data = -0.024, excellent (with empirical formula based on 26 oxygen *apfu*), = -0.039, excellent (with empirical formula based on 4 As *apfu*), = -0.065, fair (with empirical formula based on 25 O+OH *apfu*).

Relation to known species

Pradetite is the Co-dominant analogue (in all three versions of the calculation of the empirical formula) of lindackerite and veselovskýite (Table 2 and Fig. 1).

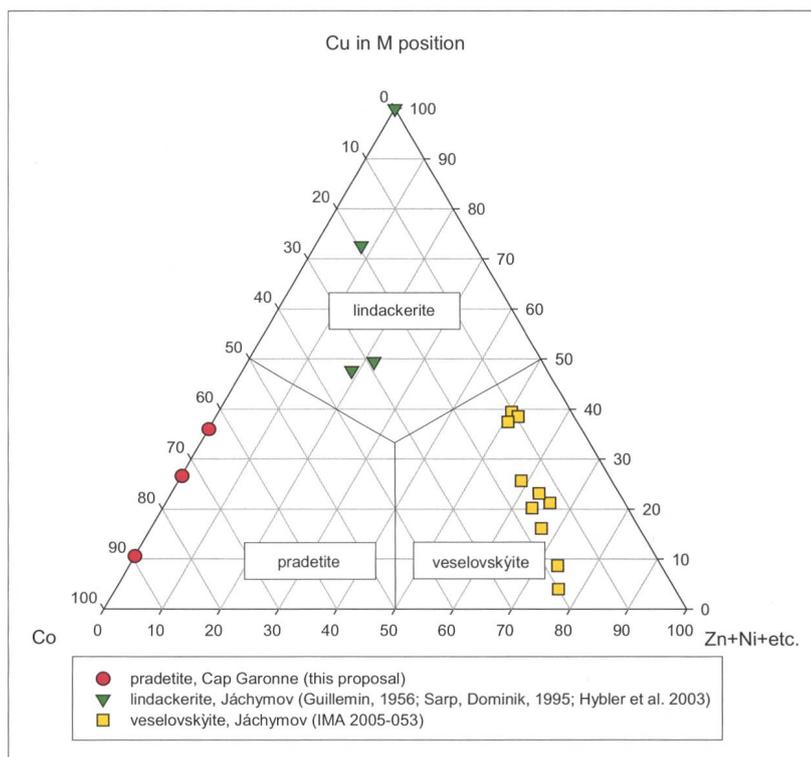


Fig. 1. Ternary graph of cations in the M cationic site for lindackerite-type minerals; ($Zn+Ni+etc. = Zn+Ni+Mg+Ca+Mn+Fe+Al$).

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