

COPARSITE, $\text{Cu}_4\text{O}_2[(\text{As},\text{V})\text{O}_4]\text{Cl}$, A NEW MINERAL SPECIES FROM THE TOLBACHIK VOLCANO, KAMCHATKA PENINSULA, RUSSIA

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ABSTRACT

Coparsite, ideally $\text{Cu}_4\text{O}_2[(\text{As},\text{V})\text{O}_4]\text{Cl}$, occurs in the fumarole "Yadovitaya" (= "Poisonous") in the North Breach of the great fissure Tolbachik eruption (1975–1976), Kamchatka Peninsula, Russia. It occurs as black or dark grey crystals, tabular on (100), elongate in the [010] direction, with well-developed {100}, {110} and {101} forms. Associated minerals are euchlorine, tolbachite, kamchatkite, ponomarevite, minerals from the klyuchevskite–alumoklyuchevskite solid-solution series, hematite, tenorite and vanadian lammerite. The grains of coparsite are found as small black inclusions in emerald-green euchlorine. The mineral has a metallic luster and a brown streak. Non-fluorescent. It is very brittle and thus does not allow measurements of hardness. Cleavage is perfect on the (100) plane. Coparsite is orthorhombic, space group *Pbcm*, a 5.440(1), b 11.154(2), c 10.333(2) Å, V 627.0(3) Å³, Z = 4, D_{calc} = 4.76(1) g/cm³ (based on the empirical formula). Diagnostic lines of the X-ray powder-diffraction pattern [d in Å(hkl)] are: 5.31(30)(010), 4.69(40)(110), 3.70(30)(012), 3.03(60)(310), 2.82(10)(113), 2.62(100)(312), 2.39(40)(022,221), 1.67(20)(324,405). Electron-microprobe analyses yielded: CuO 69.03 (67.68–70.16), Fe₂O₃ 0.17 (0–0.87), As₂O₅ 15.50 (13.13–20.23), V₂O₅ 7.72 (4.06–9.24), SO₃ 0.57 (0.20–0.99), Cl 8.47 (8.17–8.75), subtotal 101.46, O = Cl₂ –1.91 (1.84–1.97), total 99.55 (98.09–101.55) wt%. The empirical formula, normalized to O + Cl = 7 *apfu*, is Cu_{3.89}Fe_{0.01}O_{1.93} [(As_{0.60}V_{0.38}S_{0.03})O₄]Cl_{1.07}, close to the ideal $\text{Cu}_4\text{O}_2[(\text{As},\text{V})\text{O}_4]\text{Cl}$ confirmed by crystal-structure analysis. The mineral is named after its chemical composition: cop(per) + ars(enic).

Keywords: coparsite, new mineral species, arsenate–vanadate, Tolbachik volcano, Kamchatka Peninsula, Russia.

SOMMAIRE

La coparsite, dont la formule idéale est $\text{Cu}_4\text{O}_2[(\text{As},\text{V})\text{O}_4]\text{Cl}$, a été découverte dans la fumarole "Yadovitaya" (= "Toxique") dans la brèche du nord de l'éruption fissurale majeure de 1975–1976 du volcan Tolbachik, péninsule de Kamchatka, en Russie. Elle se présente sous forme de cristaux noirs ou gris foncé, tabulaires sur (100), allongés dans la direction [010], avec les formes {100}, {110} et {101} bien développées. Lui sont associés euchlorine, tolbachite, kamchatkite, ponomarevite, des membres de la solution solide klyuchevskite–alumoklyuchevskite, hématite, ténorite et lammerite vanadifère. Les grains de coparsite forment de petites inclusions noires à l'intérieur de cristaux d'euchlorine, vert-émeraude. Elle possède un éclat métallique et une rayure brune. Elle est non fluorescente. Son caractère très cassant ne permet pas de mesures de la dureté. Le clivage (100) est parfait. La coparsite est orthorhombique, groupe spatial *Pbcm*, a 5.440(1), b 11.154(2), c 10.333(2) Å, V 627.0(3) Å³, Z = 4, D_{calc} = 4.76(1) g/cm³ (pour la formule empirique). Les raies diagnostiques du spectre de diffraction, méthode des poudres [d en Å(hkl)] sont: 5.31(30)(010), 4.69(40)(110), 3.70(30)(012), 3.03(60)(310), 2.82(10)(113), 2.62(100)(312), 2.39(40)(022,221), 1.67(20)(324,405). Les analyses à la microsonde électronique ont donné: CuO 69.03 (67.68–70.16), Fe₂O₃ 0.17 (0–0.87), As₂O₅ 15.50 (13.13–20.23), V₂O₅ 7.72 (4.06–9.24), SO₃ 0.57 (0.20–0.99), Cl 8.47 (8.17–8.75), sous-total 101.46, O = Cl₂ –1.91 (1.84–1.97), total 99.55 (98.09–101.55) % (poids). La formule empirique, normalisée pour O + Cl = 7 atomes par unité formulaire, est Cu_{3.89}Fe_{0.01}O_{1.93} [(As_{0.60}V_{0.38}S_{0.03})O₄]Cl_{1.07}, assez voisine de la formule idéale, $\text{Cu}_4\text{O}_2[(\text{As},\text{V})\text{O}_4]\text{Cl}$, confirmée suite à l'analyse de la structure cristalline. Le nom rappelle la composition chimique, en particulier la présence du cuivre (copper) et de l'arsenic.

(Traduit par la Rédaction)

Mots-clés: coparsite, nouvelle espèce minérale, arsenate-vanadate, volcan Tolbachik, péninsule de Kamchatka, Russie.

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INTRODUCTION

A new cupric oxide chloride arsenate, $\text{Cu}_4\text{O}_2[(\text{As},\text{V})\text{O}_4]\text{Cl}$, has been discovered within a fumarole in the North Breach of the great fissure Tolbachik eruption (GFTE) (1975–1976), on the Kamchatka Peninsula, Russia. The mineral is named *coparsite* after its chemical composition: cop(per) + ars(enic). Type specimens are deposited in the Mining Museum, Mining Institute, St. Petersburg, Russia (catalogue number 3107/2). The mineral and mineral name have been approved by the Commission on New Minerals and Mineral Names, IMA. Coparsite has no analogues amongst minerals or inorganic compounds. In this paper, we describe the physical and chemical attributes of this new species.

LOCALITY AND OCCURRENCE

The GFTE is the greatest basaltic eruption in modern history (Fedotov 1984). It was active in 1975–1976 and consisted of two breaches (North and South) and seven cones (Fig. 1). Coparsite occurs in the products of fumarolic activity on the second cinder cone of the North Breach. The crystals of the mineral were found in exhalative deposits of the fumarole named "Yadovitaya" (= "Poisonous"). The most common mineral in the sample is euchlorine, $\text{KNaCu}_3\text{O}(\text{SO}_4)_3$ (Scordari *et al.* 1989, Bykova *et al.* 1994); other minerals present are tolbachite, CuCl_2 (Vergasova & Filatov 1983), kamchatkite, $\text{KCu}_3\text{OCl}(\text{SO}_4)_2$ (Vergasova *et al.* 1988b), klyuchevskite–alumoklyuchevskite $\text{K}_3\text{Cu}_3\text{Fe}^{3+}\text{O}_2(\text{SO}_4)_4 - \text{K}_3\text{Cu}_3\text{AlO}_2(\text{SO}_4)_4$ (Vergasova *et al.* 1989, Gorskaya *et al.* 1995), and ponomarevite, $\text{K}_4\text{Cu}_4\text{OCl}_{10}$ (Vergasova *et al.* 1988a). Coparsite occurs as small black inclusions in emerald-green euchlorine. Only three well-shaped tabular crystals were found; they do not exceed $0.4 \times 0.2 \times 0.1$ mm in size. Because of the very intimate intergrowth with euchlorine, the selection of a

monomineralic fraction proved to be very difficult. Other identified inclusions in euchlorine are hematite, tenorite, and V-rich lammerite.

CHEMICAL COMPOSITION

Chemical analyses of coparsite were acquired with a Camebax electron microprobe utilizing an operating voltage of 15 kV and a beam current of 20 nA for all elements. The following standards were used: dolerophanite (Cu, S), MgFe_2O_4 (Fe), lammerite (As), shcherbinaite (V), and $\text{Ca}_5(\text{PO}_4)_3\text{Cl}$ (Cl). No elements other than those mentioned above were detected. The results of the analyses are summarized in Table 1. The empirical formula of coparsite, $\text{Cu}_{3.89}\text{Fe}^{3+}_{0.01}\text{O}_{1.93}[(\text{As}_{0.60}\text{V}_{0.38}\text{S}_{0.03})\text{O}_4]\text{Cl}_{1.07}$, calculated on the basis of $\text{O} + \text{Cl} = 7$ atoms per formula unit (*apfu*), is close to the ideal $\text{Cu}_4\text{O}_2[(\text{As},\text{V})\text{O}_4]\text{Cl}$. In all chemical analyses, As

TABLE 1. CHEMICAL COMPOSITION OF COPARSITE

		Average from 21 analyses	Range
CuO		69.03	67.43 – 70.16
Fe ₂ O ₃		0.17	0.00 – 0.87
As ₂ O ₅		15.50	13.13 – 20.23
V ₂ O ₅		7.72	4.06 – 9.24
SO ₃		0.57	0.20 – 0.99
Cl		8.47	8.17 – 8.75
O = Cl ₂		-1.91	-1.97 – -1.84
Total		99.55	98.09 – 101.55
Atomic proportions	As	0.60	0.52 – 0.81
	V	0.38	0.21 – 0.47

Structural formula: $\text{Cu}_{15.55}\text{Fe}_{0.04}\text{O}_{7.72}[(\text{As}_{2.46}\text{V}_{1.52}\text{S}_{0.12})\text{O}_{16}]\text{Cl}_{4.28}$ ($Z = 4$)

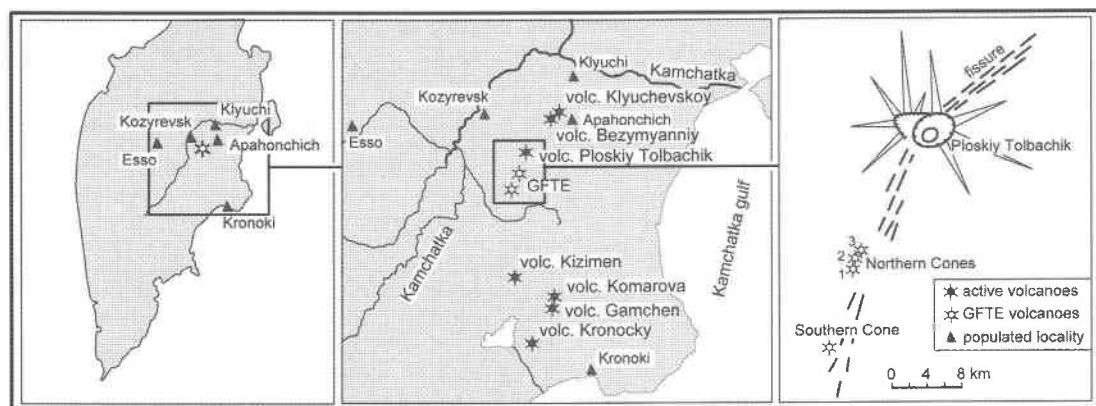


FIG. 1. Location of the Tolbachik cinder cones: Kamchatka peninsula (left), the Klyuchevskaya group of volcanos (center), and the volcanos of the Great fissure Tolbachik eruption (right). See legend on the right panel. Modified after Fedotov (1984).

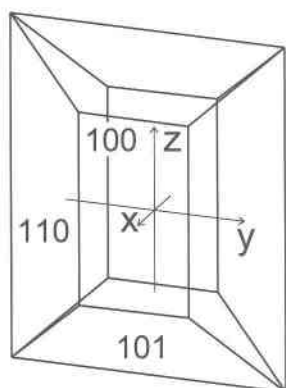


FIG. 2. Habit and crystal forms of coparsite.

predominates over V: As 0.52–0.81; V 0.21–0.47 *apfu*, and the type coparsite thus is a vanadian variety. The chemical formula of coparsite as well as the predominance of As over V are confirmed by the crystal-structure analysis (Starova *et al.* 1998).

CRYSTAL MORPHOLOGY AND PHYSICAL PROPERTIES

Crystals of coparsite occur as tabular plates on (100). These are elongate along [010]. The well-developed forms are {100}, {110} and {101} (Fig. 2). The mineral is black or dark grey in color, with a metallic luster and a brown streak. Coparsite is very brittle, and this property prevented us from measuring the hardness. Reflectance measurements were not attempted because of the very small amount of material, most of which was used for the X-ray-diffraction studies. Coparsite has a perfect cleavage parallel to the (100) plane. The calculated density based on the empirical formula is 4.76(1) g/cm³. Coparsite is stable at room temperature and pressure, and is practically insoluble in water and alcohol. The mineral does not fluoresce in either short- or long-wave ultraviolet radiation.

X-RAY CRYSTALLOGRAPHY

Unit-cell parameters of coparsite were initially determined using a Weissenberg camera and were further refined by crystal-structure analysis. The mineral is orthorhombic, space group *Pbcm*, *a* 5.440(1), *b* 11.154(2), *c* 10.333(2) Å, *V* 627.0(3) Å³, *a*:*b*:*c* = 2.050 : 1:1.899 and *Z* = 4. As a very small amount of material was available for study, X-ray powder-diffraction data were obtained using a Debye–Scherrer camera of 57.3 mm diameter. The experimental data, together with the intensities calculated from the crystal structure, are given in Table 2. The resolution of the X-ray-diffraction pattern and the quality of obtained lines are

TABLE 2. X-RAY POWDER DIFFRACTION DATA FOR COPARSITE

<i>I</i> _{obs}	<i>d</i> _{obs} [Å]	<i>hkl</i>	<i>d</i> _{calc} [Å]*	<i>I</i> _{calc} *
30	5.31	010	5.44	43
40	4.69	110	4.89	30
30	3.70	012	3.746	58
60	3.03	310	3.070	55
10	2.82	113	2.816	33
		401	2.692	21
100	2.62	312	2.639	100
		004	2.583	46
		213	2.580	15
40	2.39	022	2.407	34
		221	2.379	22
20	1.67	324	1.673	19
		405	1.660	23
10	1.55	424	1.555	10
		523	1.542	6
10	1.44	234	1.434	9
		117	1.413	9

$$a \ 5.4(1), b \ 11.0(2), c \ 10.5(1) \text{ \AA}, V \ 626(18) \text{ \AA}^3$$

CoK α radiation, Ge internal standard

* Based on crystal-structure data (Starova *et al.* 1998).

poor owing to the small amount of material available and its poor quality. These factors account for the poor agreement between observed and calculated data.

ACKNOWLEDGEMENTS

The paper was improved following the detailed reviews of F.C. Hawthorne and A.C. Roberts, and the editorial work of R.F. Martin. This work was supported for G.L.S., S.V.K. and S.K.F. by grant 96–05–65576 from the Russian Foundation for Basic Research (RFBR).

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Received December 4, 1998, revised manuscript accepted July 27, 1999.