Dravertite, CuMg(SO$_4$)$_2$, a new mineral species from the Tolbachik volcano, Kamchatka, Russia

IGOR V. PEKOV$^{1,*}$, NATALIA V. ZUBKOVA$^1$, ATALI A. AGAKHANOV$^2$, VASILIY O. YAPASKURT$^1$, NIKITA V. CHUKANOV$^3$, DMITRII I. BELAKOVSKII$^2$, EVGENY G. SIDOROV$^4$ and DMITRY Y. PUSHCHAROVSKY$^1$

1 Faculty of Geology, Moscow State University, Vorobievy Gory, 119991 Moscow, Russia
*Corresponding author, e-mail: igorpekov@mail.ru
2 Fersman Mineralogical Museum of Russian Academy of Sciences, Leninsky Prospekt 18-2, 119071 Moscow, Russia
3 Institute of Problems of Chemical Physics, Russian Academy of Sciences, 142432 Chernogolovka, Moscow region, Russia
4 Institute of Volcanology and Seismology, Far Eastern Branch of Russian Academy of Sciences, Piip Boulevard 9, 683006 Petropavlovsk-Kamchatsky, Russia

Abstract: The new mineral dravertite, ideally CuMg(SO$_4$)$_2$, was found in sublimates of two active fumaroles at the Second scoria cone of the Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia. In the Arsenatnaya fumarole, dravertite (holotype) is closely associated with dolerophanite, euchlorine, tenorite, hematite, langbeinite, steklite, fedotovite, wulfenite, anhydrite and anglesite. In the Yadovitaya fumarole, it is associated with euchlorine, chalcocyanite, steklite, alunoklyuchevskite, pyipite, parawulfenite, cryptochalcite, dolerophanite, hematite, tenorite, vergasovaite, cupromolybdite, yaroshesvskite and ziesite. Dravertite occurs as crude euhedral crystals up to 0.08 mm across forming compact clusters or spherulitic crusts up to 5 × 5 cm$^2$ in area and up to 1-cm thick on basalt scoria. Dravertite is transparent in small grains and translucent in aggregates, with a vitreous lustre. It is light blue to colourless (Arsenatnaya) or light brown (Yadovitaya). The mineral is brittle, with Mohs’ hardness ca. 3½. Cleavage is imperfect, the fracture is uneven. $D_{\text{calc}}=3.508$ g cm$^{-3}$ (based on the empirical formula). Dravertite is optically biaxial (−), $\alpha=1.624(3)$, $\beta=1.661(3)$, $\gamma=1.663(3)$ and $2V_{\text{meas}}=35(10)^{\circ}$. The infrared spectrum is reported. The chemical composition (holotype, average of 7 analyses) is: MgO 11.00, MnO 0.16, CuO 31.16, ZnO 2.62, SO$_3$ 54.76, total 99.72 wt.%. The empirical formula based on 8 O apfu is: Mg$_{0.79}$Mn$_{0.01}$Cu$_{1.14}$Zn$_{0.09}$S$_{1.99}$O$_8$. Dravertite is monoclinic, $P2_1/n$, $a=4.8141(3)$, $b=8.4443(5)$, $c=6.7731(4)$ $\AA$, $\beta=94.598(5)^{\circ}$, $V=274.45(3)$ $\AA^3$ and $Z=2$. The strongest reflections of the powder X-ray diffraction (XRD) pattern $[d, \AA(h k l)]$ are: 4.175(68) (1 1 0), 3.666(64) (1 2 0) and 2.719(24) (0 4 2). The crystal structure, solved from single-crystal XRD data ($R=0.0591$), contains chains of alternating edge-sharing octahedra centred by Cu$^{2+}$ and Mg. The CuO$_6$ octahedra show significant Jahn–Teller distortion while MgO$_6$ octahedra are much more regular. The octahedral chains are connected via isolated SO$_4$ tetrahedra to form a pseudo-framework. In terms of structure, dravertite can be considered as a monoclinically distorted, cation-ordered derivative of orthorhombic (Pnma) chalcocyanite CuSO$_4$. The mineral is named in honour of the Russian mineralogist and geologist Petr Lyudovikovich Dravert (1879–1945).

Key-words: dravertite; new mineral; copper magnesium sulfate; crystal structure; bivalent cation ordering; chalcocyanite; fumarole; Tolbachik volcano; Kamchatka.

1. Introduction

Synthetic simple anhydrous sulfates of medium-size bivalent cations with the general formula $M^2+$SO$_4$, where $M=$ Mg, Mn, Fe, Co, Ni, Cu, Zn or Cd, are well-known (Rentzeperis & Soldatos, 1958; Coing-Boyat, 1961; Will, 1965; Samaras & Coing-Boyat, 1970; Wildner & Giester, 1988; Wildner, 1990; Burns & Hawthorne, 1993; Weil, 2007a,b). However, from these compounds only, chalcocyanite CuSO$_4$ is found in nature. It was reported from deposits of hot fumaroles containing copper oxysalt mineralization at three active volcanoes: Vesuvius in Campania, Italy (type locality), Tolbachik in Kamchatka, Russia, and Izalco in El Salvador (Palache et al., 1951; Anthony et al., 2003). At the same time, no information on natural or synthetic double anhydrous sulfates containing only the above-listed cations that would be ordered in a crystal structure is found in literature and databases. It came therefore as a surprise to find in fumarolic exhalations of the Tolbachik volcano a cation-ordered sulfate with the idealized formula CuMg (SO$_4$)$_2$, structurally related to chalcocyanite.

This new mineral is described in the present paper. It was named dravertite (Cyrillic: дравертит) in honour of the Russian mineralogist and geologist Petr