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Beaverite-(Zn), $Pb(Fe_2Zn)(SO_4)_2(OH)$, a new member of the alunite group, from Mikawa Mine, Niigata Prefecture, Japan

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ABSTRACT

The Zn-bearing beaverite of Sato *et al.* (2008) has been named 'beaverite-(Zn)' in accordance with the alunite supergroup nomenclature of Bayliss *et al.* (2010), and data for the mineral have been approved by the IMA-CNMNC. Beaverite-(Zn) occurs as a dark-brown secondary mineral in the hydrothermal Cu-Zn-Pb ore deposit of the Mikawa mine, Niigata Prefecture, Japan. Electron microprobe analysis gave an empirical formula of $Pb_{0.95}(Fe_{1.88}Al_{0.10})(Zn_{0.83}Cu_{0.30})(SO_4)_2[(OH)_{5.36}O_{0.38}]$ on the basis of S = 2. The Rietveld analysis (Sato *et al.*, 2008) indicated it to be trigonal, $R\bar{3}m$, a = 7.3028(2), c = 17.0517(4) Å, V =787.56(4) Å^3.

KEYWORDS: beaverite, zinc, new mineral, alunite supergroup.

Introduction

THE Zn-dominant analogue of beaverite was found as a thin coating in a cavity in a quartz vein containing Cu-Zn-Pb ore minerals at the Mikawa mine, Niigata Prefecture, Japan (37.47ºN, 139.27ºE). A proposal to establish a new mineral with the name 'zincobeaverite' was submitted to the Commission on New Minerals, Nomenclature and Classification of the International Mineralogical Association (CNMNC) in 2006. Professor Ernst Burke, the Chairman at that time, informed the authors that beaverite should be considered a cuprian plumbojarosite-1*cR*, as Cu^{2+} and Fe^{3+} did not order in the octahedral *G* site under a 'new' possible nomenclature scheme which was being discussed by the CNMNC's alunite subcommittee at the time. Prof. Burke suggested that this Zn-bearing beaverite should not be considered a new species and the proposal was therefore not considered by the CNMNC. Subsequently, Sato *et al.* (2008) described this mineral as 'Zn-bearing beaverite'. Later, the revised nomenclature scheme for the alunite supergroup of minerals (Bayliss *et al.*, 2010) was approved by the CNMNC, while the group nomenclature for the alunite supergroup was introduced by Mills *et al.* (2009). Under the revised nomenclature scheme, the Zn-bearing beaverite was renamed as 'beaverite-(Zn)', and was classified into the alunite group of the alunite supergroup, together with beaverite-(Cu). Since 'beaverite-(Zn)' had not been considered by the CNMNC, Bayliss *et al.* (2010) listed this mineral as a potentially new species, subject to future approval by the CNMNC. The revised proposal for this mineral (IMA2010-086) has now been approved by the CNMNC. The name, beaverite-(Zn), is in accordance with the alunite supergroup nomenclature of Bayliss *et al.* (2010). The type specimen is deposited in the collections of the National Museum of Nature and Science, Tokyo, Japan, with the registered number NSM-M28910.

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TABLE 1. Principal data for beaverite-(Zn).

Appearance and physical properties
Colour: brownish yellow to yellow
Streak: yellow ochre
Lustre: vitreous to subadamantine, transparent
Fluorescence: none
Hardness: could not be measured owing to the small grain size
Tenacity: brittle
Cleavage: none observed
Parting: none observed
Fracture: not observed
Density: 4.25 g cm^{-3} (calculated using the empirical formula)

Optical properties
Birefringent (589 nm), $n > 1.800$
Pleochroism: pale to dark yellow

Chemistry
Empirical formula: $Pb_{0.95}(Fe_{1.88}Al_{0.10})(Zn_{0.83}Cu_{0.30})(SO_4)_2[(OH)_{5.36}O_{0.38}]$ electron microprobe (WDS mode, 15 kV, 20 nA, 1 μm beam diameter)
Ideal formula: $Pb(Fe_2Zn)(SO_4)_2(OH)_6$
IR spectrum: 3400 cm^{-1} (OH^-), 1100 cm^{-1} (SO_4^{2-})

Crystallography
System: trigonal
Space group: $R\bar{3}m$
Lattice parameters: a = 7.3028(2), c = 17.0517(4) Å, V = 787.56(4) $Å^3$, Z = 3
Crystal structure: Rietveld analysis (monochromatized synchrotron radiation (λ = 2.0765 Å), 114.6 mm Gandolfi camera, imaging plate) R_{wp} = 4.54, R_p = 2.83, R_e = 2.34, S = 19.37, R_I = 6.75, R_F = 3.95.
Strongest 5 XRD lines [d(Å), I/I_0, hkl]: (5.930, 100, 101), (3.651, 39, 110), (3.110, 43, 021), (3.072, 61, 113), (2.273, 39, 107).

Mineralogical data

As a detailed description of this mineral has already been made by Sato *et al.* (2008), the principal data are summarized briefly and given in Table 1. Beaverite-(Zn) is a member of alunite group and supergroup (Mills *et al.*, 2009; Bayliss *et al.*, 2010) [Strunz and Nickel class 7.BC.10 (Strunz and Nickel, 2001)]. This is a Zn-analogue of beaverite-(Cu), $Pb(Fe_2Cu)(SO_4)_2(OH)_6$, with a substitution of Zn for Cu at the octahedral G site. Sato *et al.* (2008) pointed out that two substitution mechanisms are observed for the introduction of divalent cations in the D site of alunite group minerals, $(D'^{2+})_{0.5}(D^+)_{-1}$ and $(D'^{2+}G'^{2+})(D^+G^{3+})_{-1}$. An example of the former is plumbojarosite, $Pb_{0.5}Fe_3(SO_4)_2(OH)_6$, with doubling of the c axis, $c \approx 34$ Å. On the contrary, beaverite-(Cu) shows the latter type of substitution with respect to jarosite, $(Pb^{2+}Cu^{2+})(K^+Fe^{3+})_{-1}$. The substitution of divalent Cu for 1/3 of the trivalent Fe in the octahedral G site can compensate for the change in charge balance accompanying substitution of Pb^{2+} for K^+ at the D site. Consequently, Cu is not a mere partial substituent, but is an essential element in beaverite-(Cu). The substitution of Zn for Cu (fig. 2 of Sato *et al.*, 2008) in this mineral with a $-1c$ (one unit cell) structure is, therefore, of significance for the solid solutions of members of the alunite group of minerals with full occupancy of Pb^{2+} at the D site.

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