Sinkankasite, a new phosphate from the Barker pegmatite, South Dakota

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Abstract

Sinkankasite, ideally $H_2MnAl(PO_4)_2(OH) \cdot 6H_2O$, is a new mineral occurring as an alteration product of triphylite at the Barker pegmatite, Keystone, South Dakota. It is triclinic, space group $P\bar{1}$ or $P1$, with cell parameters $a = 9.58(4)$, $b = 9.79(5)$, $c = 6.88(4)$Å, $\alpha = 108.1(2)$, $\beta = 99.6(3)$, $\gamma = 98.7(3)°$, $V = 590(7)$Å^3, and Z = 2. Crystals are elongated on [001], flattened on {100} and twinned on {100}. Sinkankasite is transparent, colorless, has hardness 4 and a good {100} cleavage. The observed and calculated densities are 2.27 and 2.25 g/cm^3, respectively. Optical parameters include: biaxial negative; $2V$ (calc.) = 84°; α = 1.511(2), β = 1.529(2), γ = 1.544(2); dispersion $r < v$; $c \wedge Y \simeq 11°$. The strongest lines in the powder diffraction pattern are (d, I/I_o, hkl): 9.2, 100, 100; 5.41, 50, 11$\bar{1}$; 5.06, 60, 1$\bar{1}$1; 4.58, 40, 200, 1$\bar{1}\bar{1}$; 2.834, 40, 230; 2.701, 40, 130. The name is in honor of Dr. John Sinkankas.

Introduction

The mineral described herein was first found in 1963 by WLR and examined as part of a study of the minerals of the Barker pegmatite (formerly known as the Ferguson pegmatite), which is located east of Keystone, South Dakota. Preliminary examination indicated that it was not a known species. Our subsequent investigation has confirmed that preliminary finding, and shown it to be a new hydrated manganese aluminum phosphate which is apparently unrelated to other known phases.

We take pleasure in naming this new mineral in honor of Dr. John Sinkankas, in recognition of his numerous contributions to mineralogy, in particular the many books he has authored and his many diverse efforts on behalf of the education of amateur mineralogists. The holotype specimen is preserved in the Smithsonian Institution under catalog #149597. The mineral and the name were approved prior to publication by the Commission on New Minerals and Mineral Names, IMA.

Crystallography

Single crystals of sinkankasite were studied using precession and Weissenberg single-crystal diffraction methods. The photographs showed that sinkankasite is triclinic, space group $P\bar{1}$ or $P1$, with $a = 9.58(4)$, $b = 9.79(5)$, $c = 6.88(4)$Å, $\alpha = 108.1(2)$, $\beta = 99.6(3)$, $\gamma = 98.7(3)°$, and $V = 590(7)$Å^3. All crystals studied are twinned by reflection on {100}. Powder diffraction data, listed in Table 1, were obtained using a polycrystalline sample in a 114.6 mm diameter Gandolfi camera, CuK_α radiation and Si as an internal standard. The lattice parameters listed above were obtained by least-squares refinement of powder diffraction data.

Sinkankasite crystals are less than 2–3 mm in length

Table 1. X-ray powder diffraction data for sinkankasite

I/I₀*	d(Obs)	d(Calc)	hkl	I/I₀	d(Obs)
100	9.2	9.22	100	30	2.428
10	7.3	7.31	$1\bar{1}0$	5	2.355
10	5.86	5.86	110	10	2.256
50	5.41	5.42	$11\bar{1}$	5	2.218
60	5.06	5.05	$1\bar{1}1$	20	2.117
40	4.58	4.61	200	10	1.968
		4.58	$1\bar{1}\bar{1}$	2	1.884
20	4.13	4.14	$12\bar{1}$	10	1.839
15	3.97	3.96	$12\bar{1}$	1	1.782
				5	1.755
10	3.81	3.79	210		
		3.78	$2\bar{1}\bar{1}$	5	1.715
20	3.24	3.25	$10\bar{2}$	1	1.665
20	3.06	3.07	300	5	1.607
		3.07	$12\bar{2}$	1	1.566
		3.05	$30\bar{1}$	2	1.548
30	2.943			5	1.521
40	2.834			2	1.411
40	2.701			1	1.397
5	2.534				
2	2.477				

*Intensities visually estimated.

and elongate on [001], tabular on {100} and composed of the forms {100}, {010}, and {001}, listed in order of size development. Indices were determined from optical goniometer measurements made on a crystal oriented using single-crystal X-ray diffraction techniques. Sinkankasite crystals exhibit parallel growth and a representative crystal cluster is shown in Figure 1.

Physical and optical properties

Sinkankasite is colorless. The Mohs' hardness is approximately 4 or slightly less. The density, determined on several crystals of the holotype using heavy liquid techniques, is 2.27 g/cm³, compared with the calculated value of 2.25 g/cm³. There is one perfect cleavage, {100}, which is developed only with difficulty. Sinkankasite crystals part easily along {100} twin boundaries and this effect can, in multiply-twinned crystals, resemble cleavage. Crushed fragments viewed at high power commonly show two or three apparent cleavages at right angles. In addition, crystals have a marked tendency to break at approximately right angles to [001], but careful examination of this feature in broken crystals by scanning electron microscopy failed to reveal evidence of true cleavage. In addition, this apparent plane is not precisely parallel to {001}. Sinkankasite has a vitreous luster on cleavage surfaces and a vitreous to dull luster on crystal faces, many of which are encrusted with an unidentified mineral (Fig. 1). Sinkankasite is very brittle. There is no discernible response to ultraviolet radiation.

Optically, sinkankasite is biaxial negative, with indices of refraction $\alpha = 1.511$, $\beta = 1.529$, and $\gamma = 1.544$ (all ± 0.002). It has $2V$ (calc.) = 84°; dispersion $r < v$, moderate; $c \wedge Y \simeq 11°$. Optical determinations were complicated by the multiple twinning which seems to be intrinsic to this mineral.

Chemistry

Sinkankasite was chemically analyzed using an ARL-SEMQ electron microprobe with an operating voltage of 15 kV and a sample current of 0.025 μA, standardized on brass. The data were corrected using Bence-Albee factors. The standards used were montgomeryite for Al, Ca, Mg, P; manganite for Mn; fluorapatite for F and hornblende for Fe. A microprobe wavelength-dispersive scan indicated the absence of any elements with atomic number greater than 8, except those reported herein. A spectrographic analysis indicated the absence of light elements. The resultant analysis yielded: Al₂O₃ 13.6, FeO 7.5, MgO 0.2, MnO 12.2, P₂O₅ 39.5, F 2.2 percent, with water 31.3% by Penfield method (total weight % = 106.5%). Because the water determinations indicated that 10.93% of the water was very loosely bound and lost at 110°C, we presumed that the very high sum of the analysis given above was due to volatilization of H₂O in the beam of the microprobe, as is common in highly hydrated minerals with loosely bound H₂O. In addition, calculated unit cell contents were approximately 10% too high, supporting such a loss of water in microprobe analysis with concomitant increases in the determined weight percent oxides. Accordingly, we normalized the weight percent oxides to sum (with 31.3% water) to 100.8%. The normalized analysis is: Al₂O₃ 12.6, FeO 6.9, MgO 0.2, MnO 11.3, P₂O₅ 36.5, F 2.0, H₂O 31.3, Sum = 100.8%, less 0.8% O = F, total = 100.0 percent. Calculation of unit cell contents yields: $H_{4.00}(Mn_{1.29}Fe_{0.77}Mg_{0.04})_{\Sigma 2.10}Al_{1.99}(PO_4)_{4.15}(OH_{0.87}F_{0.85})_{\Sigma 1.72} \cdot 11.13H_2O$, or ideally, $H_2MnAl(PO_4)_2(OH) \cdot 6H_2O$ with Z = 2. Sinkankasite is readily soluble in dilute 1:1 HCl.

Through the courtesy of Dr. Paul B. Moore, we were subsequently provided a wet-chemical analysis of sinkan-
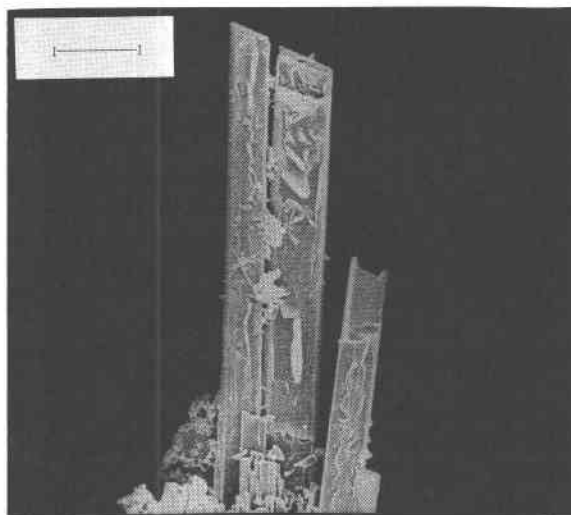

Fig. 1. SEM photomicrograph of a cluster of sinkankasite crystals exhibiting parallel growth and typical habit. Scale bar is 100 μm. Druse coating is of an unknown mineral.

kasite which had been carried out by the late Dr. Jun Ito. This analysis gave MnO 12.5, FeO 7.4, MgO 0.25, ZnO 0.03, CaO 3.31, Na_2O 0.09, Al_2O_3 9.35, P_2O_5 35.30, H_2O^+ 14.6, H_2O^- 16.7, sum = 99.53 percent. Ito's spectrographic analyses showed minor amounts of Si, Pb, Ti, Be and Li, the latter measured at 0.003 weight percent. Calculation of a chemical formula for this sinkankasite on the basis of P = 2, yields: $H_2(Mn_{0.71}Fe_{0.15}Mg_{0.02}Ca_{0.24}Na_{0.01})_{\Sigma 1.13}(Al_{0.74}Fe^{3+}_{0.26})_{\Sigma 1.00}(PO_4)_2(OH)_{1.26} \cdot 6.35H_2O$, or ideally, $H_2MnAl(PO_4)_2(OH) \cdot 6H_2O$. This sample is also from the Barker pegmatite and is quite similar in composition to our sample except that it contains some calcium.

Sinkankasite has also been found at the Palermo pegmatite in North Groton, New Hampshire. The only known specimen had been in the mineral collection of the late Gunnar Bjareby and was provided to us by Dr. Paul B. Moore. Analysis of this material, which has a powder pattern indistinguishable from that of the type sinkankasite, yields the chemical formula, on the basis of P = 2: $H_2(Mn^{2+}_{0.72}Fe^{2+}_{0.24}Mg_{0.05})_{\Sigma 1.01}Al_{0.96}(PO_4)_2(OH)_{0.92} \cdot 5.47H_2O$, in good agreement with that of the type material.

Occurrence and paragenesis

Sinkankasite is found in the Barker pegmatite, located in the SW¼, NE¼, sec 14, T2S, R6E, three miles southeast of Keystone, Pennington County, South Dakota. The primary mineralogy of the pegmatite is rather simple. The geology has been described in detail by Norton (1964).

Sinkankasite occurs as complete pseudomorphs after subhedral to euhedral triphylite and as cavity fillings formed from the partial or complete dissolution of triphylite. These pseudomorphs and cavity replacements range in size from <1 to 10 cm³. Sinkankasite is also found along fractures which cut quartz, microcline, albite, and muscovite. Secondary phosphate minerals associated with sinkankasite include vivianite, hureaulite, carbonate-apatite, strengite, barbosalite, and fluellite.

The secondary phosphate mineralization commenced with very late-stage hydrothermal alteration of triphylite, the primary phosphate. This alteration proceeded from the outside inward, especially when in association with microcline, albite and muscovite which apparently supplied the Al for sinkankasite. The early-formed secondary phosphates are vivianite and hureaulite, with vivianite dominant. They commonly occur as a network of veinlets transecting triphylite and as crystals in small vugs. Vivianite is found as transparent, blue, tabular to bladed 1 mm crystals and hureaulite is found as water-clear, pale-

pink to brown transluscent 3 mm crystals. Carbonate-apatite is younger than vivianite and hureaulite; in the vugs it forms white crusts and delicate boxworks and is composed of colorless, prismatic, bipyramidal crystals up to 0.5 mm in length. Spherulitic aggregates and 1 mm crystals of pink strengite are scattered randomly on the carbonate apatite followed by, if not contemporaneous with, barbosalite in very dark greenish-blue 0.5 mm spherules. Fluellite, which is rather uncommon, appears to have formed with barbosalite and is found as clusters of colorless, dipyramidal, 1 mm diameter crystals, which have large {010} faces. Sinkankasite, which is rather common, is the last mineral in this sequence and is found as colorless, bladed, prismatic crystals up to 4 mm in length. It often occurs as divergent, radial clusters and as spheroidal aggregates. Several specimens, which contain only hureaulite and sinkankasite, have spherules of sinkankasite within hureaulite, indicating that in these specimens, sinkankasite formed just after the onset of hureaulite crystallization, and was contemporaneous with it. Other secondary phosphates found at the Barker pegmatite, but not associated with sinkankasite, are: laueite, torbernite, autunite, and phosphuranylite.

Sinkankasite has been found at the Palermo Mine, in North Groton, New Hampshire, on only one specimen. It occurs as flattened, circular, 2–3 mm sprays of white acicular crystals associated with vivianite in a fracture in massive triphylite. This material was previously described as gatumbaite by Segeler et al. (1981).

References

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