

Hauckite, $\text{Fe}_3^{3+}(\text{Mg},\text{Mn})_{24}\text{Zn}_{18}(\text{SO}_4)_4(\text{CO}_3)_2(\text{OH})_{81}$, a new mineral from Sterling Hill, New Jersey

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Abstract

Hauckite, $\text{Fe}_3^{3+}(\text{Mg},\text{Mn})_{24}\text{Zn}_{18}(\text{SO}_4)_4(\text{CO}_3)_2(\text{OH})_{81}$, is a new mineral found in the Sterling Hill mine. It is hexagonal, with Laue symmetry $6/mmm$ and unit-cell parameters $a = 9.17(4)$, $c = 30.21(9)\text{\AA}$. The strongest lines in the X-ray diffraction pattern (d in \AA , intensity, hkl) are: 3.96 100 200; 7.8 90 100,101; 4.57 60 110; 3.02 60 0,0,10.

Hauckite is light orange to yellow with a light yellow streak. Cleavage is perfect parallel to $\{0001\}$. The Mohs hardness is approximately 2-3. The density determined by heavy-liquid techniques is 3.02, and the calculated value is 3.10 g/cm^3 . Hauckite occurs as euhedral crystals, tabular on $\{0001\}$, with $\{01\bar{1}0\}$ and $\{0001\}$ as the only forms present. The crystals occur in clusters resembling rosettes. Optically, hauckite is uniaxial (+) with refractive indices $\epsilon = 1.638(2)$ and $\omega = 1.630(2)$; it is pleochroic with $O =$ golden brown, $E =$ pale yellow, absorption $O > E$.

The composition, determined by electron microprobe, is: Al_2O_3 0.5, Fe_2O_3 6.0, MnO 17.1, MgO 13.2, ZnO 36.0, SO_3 7.4 percent, with CO_2 2.1 and H_2O 17.7 percent (from the theoretical composition), sum = 100.0 percent. The empirical formula, based on cell dimensions and the calculated density of the pure end-member, is $(\text{Fe}_{2.6}^{3+}\text{Al}_{0.4})(\text{Mg}_{13.5}\text{Mn}_{9.9}\text{Fe}_{0.5}^{2+}\text{Zn}_{0.2})\text{Zn}_{18.0}(\text{SO}_4)_{3.8}(\text{CO}_3)_{2.0}(\text{OH})_{80.8}$, in excellent agreement with the proposed formula.

Hauckite is found only in the Sterling Hill mine and is associated with calcite, serpentine, mooreite, and phlogopite on the type specimen; with pyrochroite, sussexite, and zincite on a second specimen; and with chlorophoenicite on a third specimen. There appears to be no direct relationship to any other species. Hauckite is named in honor of Richard Hauck of Bloomfield, New Jersey.

Introduction

In January 1978, an unidentified orange platy mineral was submitted to us for identification and subsequently found to be a new species. The mineral had been found some years before and is from the Sterling Hill mine in Ogdensburg, New Jersey. It was noted as unique by some mineral collectors in the area, notably John Baum, Alice Kraissl, Richard Hauck, and Fred Parker. Since this mineral is not

easily detected, it might never have been characterized if it were not for the dedication and diligence of these collectors in preserving samples for examination, calling it to our attention, and providing whatever samples were needed for our study.

We take pleasure in naming this new species hauckite in honor of Richard Hauck, mineral collector of Bloomfield, New Jersey. Mr. Hauck has done much to promote awareness of the mineralogy of

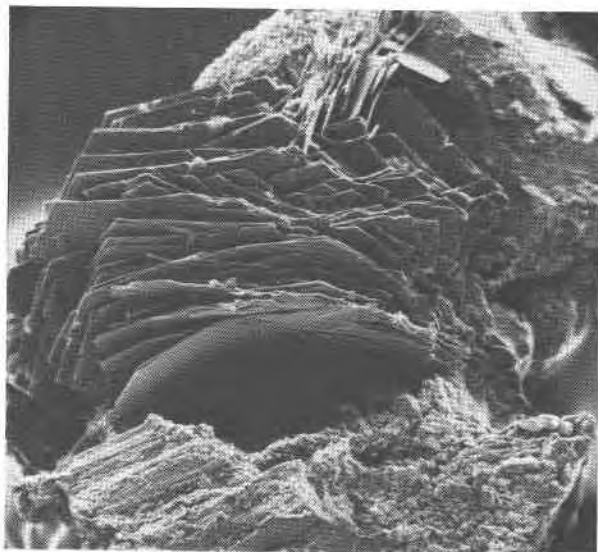


Fig. 1. Scanning electron microscope photomicrograph of hauckite crystal cluster (50 \times).

Franklin and Sterling Hill, and has taken pains to preserve specimens of uncommon parageneses which are frequently overlooked by the unsophisticated collector. The new mineral and the name were approved by the Commission on New Minerals and Mineral Names, IMA, prior to publication. Type material is preserved in the National Museum of Natural History, Smithsonian Institution, under catalog #NMNH 142854. Cotype specimens are deposited in the American Museum of Natural History, New York, under catalog #T45495, and the Royal Ontario Museum, Toronto, under catalog #M35860. The name is pronounced HOW-KITE.

Morphology

Hauckite forms simple euhedral hexagonal crystals, which are extremely flattened on {0001}. The only forms present are the pinacoid {0001} and the second-order hexagonal prism {01 $\bar{1}$ 0}. Examination of the crystals with the scanning electron microscope failed to reveal any additional forms. The crystals occur gathered in highly irregular clusters which resemble rosettes (Fig. 1). They are imperfect and composed of layers which are slightly offset from each other; they showed no striations, etch pits, or epitaxial relationships with other species.

Physical and optical properties

Hauckite is bright orange to light yellow in color. The luster of both external crystal faces and cleavage fragments is vitreous to slightly pearly. The streak is

variable, depending on the color of the mineral; in most samples it is light yellow. Hauckite is quite brittle. The clusters are attached quite firmly to the matrix on the type specimen. The Mohs hardness is approximately 2–3. The density, determined using heavy-liquid techniques, is 3.02 g/cm³; the calculated value is 3.10 g/cm³. The disparity in values is very likely due to the presence of air or liquid trapped between hauckite plates. The cleavage is perfect and very easily produced, parallel to {0001}. Hauckite is neither fluorescent nor phosphorescent in ultraviolet radiation.

Optically, hauckite is uniaxial (+) with refractive indices $\epsilon = 1.638(2)$ and $\omega = 1.630(2)$; pleochroic with $O =$ golden brown, $E =$ pale yellow, absorption: $O > E$. Calculation of the specific refractive energy, using the constants of Mandarino (1976), yields for the chemical analysis the value of $K_C = 0.218$, compared with the value of 0.210 for K_P calculated using measured refractive indices and density. These values give superior agreement using the compatibility index ($1.000 - K_P/K_C$) of Mandarino (1979).

Chemistry

Hauckite was chemically analyzed with an ARL-SEMQ electron microprobe, operating voltage 15 kV and beam current 0.15 μ A. A wavelength-dispersive microprobe scan indicated the absence of any elements with atomic number greater than nine, except those reported herein. A scan by ion microprobe indicated the absence of any elements with atomic

Table 1. Chemical analysis of hauckite

	HAUCKITE	THEORY***
Al ₂ O ₃	0.5	0.00
Fe ₂ O ₃ *	6.0	5.82
MnO	17.1	17.24
ZnO	36.0	35.59
MgO	13.2	13.71
SO ₃	7.4	7.78
CO ₂ **	2.1	2.14
H ₂ O**	17.7	17.72
Total	100.0	100.00

* calculated as Fe₂O₃ from microchemical test, determined as total Fe.

** from theoretical composition.

*** theory for Fe₃⁺(Mg,Mn)₂₄Zn₁₈(SO₄)₄(CO₃)₂(OH)₈₁ with Mg: Mn = 14:10.

Accuracy of data: $\pm 3\%$ of the amount present

number less than ten except for abundant hydrogen, carbon, and oxygen. Microchemical tests indicate that the iron in hauckite is predominantly ferric with only a very weak reaction for ferrous iron. The standards used for the microprobe analysis were hornblende for Fe, Mg, and Al; manganite for Mn; synthetic ZnO for Zn; and celestine for S. The data were corrected using Bence-Albee factors. The analysis is presented in Table 1. Hauckite is homogeneous over 10 μ sample spots.

Analysis by DTA-TGA yielded results in good agreement with the proposed formula. The weight loss up to 810°C is 28.0 percent, which compares favorably with the 27.6 percent weight loss expected from the volatilization of the hydroxyl, carbonate, and sulfate components of hauckite. Hauckite is easily soluble in hydrochloric acid.

The resultant analysis yields the following empirical formula based on unit-cell parameters and the density calculated from the end-member composition: $(\text{Fe}_{2.6}^{3+}\text{Al}_{0.4})(\text{Mg}_{13.5}\text{Mn}_{9.9}\text{Fe}_{0.5}^{2+}\text{Zn}_{0.2})\text{Zn}_{18}(\text{SO}_4)_{3.8}(\text{CO}_3)_2(\text{OH})_{80.8}$. This empirical formula is in excellent agreement with the proposed formula of $\text{Fe}_3^+(\text{Mg},\text{Mn})_{24}\text{Zn}_{18}(\text{SO}_4)_4(\text{CO}_3)_2(\text{OH})_{81}$.

Carbon could not be determined quantitatively due to the paucity of material, but its presence was confirmed by the effervescence of hauckite in HCl. The amount of carbonate in hauckite, and the $(\text{CO}_3):(\text{OH})$ ratio, were assigned by difference in order to bring the total of components to 100 percent, using the comparison of the specific refractive energies K_p and K_c as a guide. Because we could not unambiguously determine a space group due to the poor quality of the crystals, requirements of equipoint ranks could not provide unambiguous guidelines to the amounts of (CO_3) and (OH) per cell. The $(\text{CO}_3):(\text{OH})$ ratio could vary from 1:83 to 6:73 and still be within analytical error. The above chemical formula is therefore tentative pending the discovery of adequate hauckite to permit a complete chemical analysis, or the discovery of better quality crystals which might permit a determination of the crystal structure.

X-ray crystallography

Hauckite was studied using Weissenberg and precession single-crystal techniques. Unfortunately, all the crystals were imperfect, giving rise to broad reflections, and subject to a one-dimensional stacking disorder which caused diffuseness, which made an unambiguous determination of the space group impossible. The Laue symmetry appeared to be $6/m\ 2/$

Table 2. X-ray diffraction data for hauckite

d(Obs)	d(calc)	hkl	I/I ₀
7.8	[7.9 7.7	100 101	90
5.02	5.04	006	50
4.57	4.59	110	60
3.96	3.97	200	100
3.78	[3.78 3.79	008 107	50
3.02	3.02	0,0,10	60
2.67**	2.69	125	5
2.44*	[2.42 2.46	035 217	2
2.36*			2
2.31*			1
1.929*			1
1.829*			1
1.748			30
1.685*			2
1.583			20
1.511			10

*broad
**very broad
Data obtained using a polycrystalline sample in a 114.6mm diameter Gandolfi camera, CuK α radiation, Ni filter, NBS Si internal standard, with intensities visually estimated.

$m\ 2/m$, however, and the lattice parameters were determined to be $a = 9.17(4)$ and $c = 30.21(9)\text{Å}$. The only extinctions which could be reasonably well-defined were for $00l, l = 2n + 1$. There are several space groups consistent with this relation. We can be only reasonably sure that the Laue symmetry is $6/mmm$ and that there is a 6₃ screw axis. There is a pronounced diffuseness of reflections parallel to c^* , as is consistent with disorder in a layered stacking sequence. The lattice parameters were obtained by least-squares refinement of data obtained using a 114.6 mm diameter Gandolfi powder camera. The powder-diffraction data are reported in Table 2.

Occurrence

Hauckite is found in the Sterling Hill mine, Ogdensburg, Sussex County, New Jersey. The type specimen was found in 935 stope, between the 700 and 800 foot levels. On this specimen, hauckite is implanted as almost spherical rosettes on a very vuggy and altered calcite and serpentine matrix. The associated minerals are mooreite and phlogopite, but it is not clear which was the first species to form. At least 12 samples of this paragenesis have been preserved; in addition to the type sample, others repose in the

Baum, Hauck, Kraissl, and Parker collections, all in northern New Jersey.

A second and quite different paragenesis was subsequently found by John Kolic, a miner in the Sterling mine. This occurrence is also near the 700 foot level in 935 stope, but the specimen bears no similarity to the type material. In this paragenesis, hauckite is associated with severely altered sussexite, pyrochroite, and zincite. The sequence of deposition is pyrochroite followed by sussexite, followed by zincite, followed by hauckite.

A third and quite different assemblage was found by Richard Bostwick, then a miner in the Sterling mine. This occurrence was at the 2350 level of the north orebody. In this assemblage, hauckite is deposited on chlorophoenicite which in turn coats a decomposed calcite-serpentine rock.

It is indeed quite uncommon to find a new mineral in three different parageneses in the same mine. Hauckite is among the last minerals to form in each assemblage. The apparent diversity of parageneses and spatial distribution of hauckite might suggest that it is a mineral which has been overlooked in previous years.

In summary, hauckite is a rare sulfate mineral which occurs in a variety of different parageneses in the Sterling Hill mine, and adds one more to the list of 24 species (including kolicite and lawsonbauerite) known to occur only at this deposit, certainly one of the most remarkable ones in North America.

Acknowledgments

We are indebted to many persons for assistance. Robert Ramik performed the DTA-TGA analysis; Richard Johnson painstakingly prepared polished sections of minute crystals; Fred Parker initially called the species to our attention; and Alice Kraissl willingly sacrificed her prized specimen for DTA-TGA analysis. This project was supported, in part, by a grant from Mrs. E. Hadley Stuart, Jr. We are particularly grateful to Ms. Esther Claffy for assistance with many diverse problems concerning Franklin mineralogy.

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*Manuscript received, May 29, 1979;
accepted for publication, September 12, 1979.*