MINERALOGICAL NOTES

NEW DATA ON GUILDITE

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Guildite is monoclinic with $a=9.786$, $b=7.134$, $c=7.263$ and $\beta=105°17'$. Systematic extinctions show the space group to be $P2_1/m$ or $P2_1$. Available evidence points to a probable formula of $2[CuFe(SO_4)_2(OH)\cdot 4H_2O]$.

INTRODUCTION

Guildite is one of a number of secondary minerals formed as a result of a mine fire at Jerome, Arizona. It was originally described by Lausen (1928) and apparently has not been found at any other locality in the succeeding years. Some inconsistencies between the original description and the present work dictate that a re-definition is in order. A complete structural determination is in progress.

TABLE 1. PHYSICAL CONSTANTS FOR GUILDITE

	Lausen (1928)	This Study
Cleavage	(001) (100) } Perfect	same
Color	Honey yellow to deep chestnut brown	same
Streak	Pale canary yellow	same
Hardness	2.5	same
ρ(meas.)	2.725	2.695 ± 0.01
Opt.	Biaxial (+)	same
α	1.623 ± 0.005	1.622 ± 0.001[a]
β	1.630 ± 0.005	1.628 ± 0.001[a]
γ	1.684 ± 0.005	1.681 ± 0.001[a]
Birefringence	0.061	0.059 ± 0.002
Pleochroism	X=pale yellow Y=pale yellow Z=greenish yellow	same
$2V_z$	—	$62\pm2°$ meas.
a	—	9.786 ± 0.002 Å
b	—	7.134 ± 0.001 Å
c	—	7.263 ± 0.001 Å
β	105° 17′	105° 17′ (morph.) 105° 18 $\pm$ 1′ (X-ray)
Volume	—	489.08 Å³
Z	—	2
Axial Ratio	1.037:1:1.407 (morph.)	1.018:1:1.372 (X-ray)

[a] Refractive indices determined using white light filtered through filter of 5930 Å.

Physical properties are tabulated in Table 1 and compared to Lausen's original description (1928). Optics were determined using spindle stage techniques. The specific gravity was determined from multiple weighings of a number of samples on a Berman density balance.

Zero, first, and second level Weissenberg photographs as well as zero level Precession

TABLE 2. X-RAY POWDER DATA FOR GUILDITE

$d_{(meas.)}$	$d_{(calc.)}$	hkl	I	$d_{(meas.)}$	$d_{(calc.)}$	hkl	I
9.46	9.44	100	35	2.549	2.546	$31\bar{2}$	vw
6.50	6.51	$10\bar{1}$	7	2.502	2.502	221	vw
4.998	4.999	011	27	2.355	2.354	$20\bar{3}$	10
4.806	4.807	$11\bar{1}$	7	2.238	2.241	410	7
4.720	4.720	200	7	2.166	2.169	$30\bar{3}$	4
4.493	4.503	$20\bar{1}$	3		2.165	$32\bar{2}$	
4.107	4.109	111	7	2.076	2.077	401	12
					2.075	$31\bar{3}$	
3.812	3.807	$21\bar{1}$	vw	2.001	2.003	$12\bar{3}$	vw
3.606	3.609	$10\bar{2}$	20		2.000	312	
3.565	3.567	020	vw	1.966	1.968	032	4
					1.965	$22\bar{3}$	
3.502	3.503	002	7	1.887	1.888	500	3
					1.887	$51\bar{1}$	
3.336	3.337	120	3	1.806	1.810	$10\bar{4}$	3
3.144	3.148	211	100		1.805	$20\bar{4}$	
3.037	3.034	102	5	1.784	1.784	040	3
2.961	2.960	$21\bar{2}$	4	1.703			3
2.909	2.909	121	11	1.677			vw
2.878	2.879	310	8	1.574			4
2.975	2.976	$22\bar{1}$	3	1.561			vw
2.622	2.624	301	4				

TABLE 3. CHEMICAL ANALYSES

	Lausen (1928)	Microprobe[a]	Conventional[b]
CuO	15.78%	16. ±2%	16.4±.2%
FeO	1.49	—	—
Fe_2O_3	19.12	22. ±2[c]	21.8±.2[c]
Na_2O	1.23	Not detected	<0.005
SO_3	39.68	41. ±4	38.6±.4
Al_2O_3	2.11	2. ±.2	—
H_2O	22.15	—	21.7±.2
Total	101.56		98.5

[a] Correction for absorption, fluorescence and atomic number were carried out using the method described by Smith (1965) utilizing a computer program written by Rucklidge at the University of Toronto in 1967. Values are reported only to the nearest percent since stochiometric proportions were assumed for the standards.

[b] Analyses for copper, iron, and sodium by atomic absorption spectrophotometry; K. V. Rodgers, analyst. Analyses for iron and sulfate by "wet" techniques and water by C.E.C. Moisture Analyzer; R. E. McInturff, analyst.

[c] Total iron reported as Fe_2O_3.

photographs were made on each crystallographic axis using two small cleavage fragments. Systematic extinctions of the type $0k0$ with k odd establish the space group as either $P2_1/m$ or $P2_1$. Morphology indicates that the former is correct.

Lattice parameters were derived from a least squares refinement of measurements made on a Picker FACS-1 automated diffractometer. These values, as well as the axial ratio, are also given in Table 1 and the latter is compared to the value obtained by Lausen (1928). The a and c crystallographic axes have been interchanged from Lausen's orientation, in keeping with modern convention.

Powder data (Table 2) were collected with a 114.6 mm Debye-Scherrer camera using Mn-filtered Fe radiation with Si as an internal standard. Intensities were obtained by planimetering peaks on a powder diffractometer tracing.

CHEMISTRY

The formula for guildite originally proposed by Lausen (1928) was $3(Cu,Fe)O \cdot 2(Fe,Al)_2O_3 \cdot 7SO_3 \cdot 17H_2O$. Written more conventionally, this becomes $(Cu,Fe)_3(Fe,Al)_4S_7O_{30} \cdot 17H_2O$ or $(Cu,Fe)_3(Fe,Al)_4 (SO_4)_7O_2 \cdot 17H_2O$. This formula would require a cell more than twice the volume of that actually found. Additionally, the space group symmetry requires that there be an even number of all atoms.

Approximate analysis by electron microprobe and more reliable work by more conventional methods failed to detect any gross errors in the original analysis. All results are tabulated in Table 3. With the aid of a computer the present analytical data were compared to the calculated analyses of about 87,000 hypothetical idealized formulae. Only one of these is in reasonable agreement with the chemical information, mea-

sured specific gravity, symmetry requirements of the space group, and measured cell volume. This formula also happens to be charge balanced although this was not a strict requirement of the computer program. The postulated idealized formula is $2[CuFe(SO_4)_2(OH) \cdot 4H_2O]$. Ultimate proof of the formula is, of course, the structural determination now in progress.

REFERENCES

LAUSEN, C. (1928) Hydrous sulphates formed under fumerolic conditions at the United Verde mine. *Amer. Mineral.* **13**, 203–229.

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CONFIRMATION OF THE MINERAL SPECIES WHERRYITE

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ABSTRACT

The unit cell of wherryite is $a = 20.82$, $b = 5.79$, $c = 9.17$ Å, $\beta = 91°17'$; space group $C2$, Cm, or $C2/m$. Wherryite may be related to leadhillite.

INTRODUCTION

Wherryite was described in 1950 by Fahey, Daggett, and Gordon on material from the Mammoth mine, Tiger, Arizona. It was described as light green and as having a fine granular texture. The specific gravity was determined to be 6.45 and the chemical formula was given as $Pb_4Cu(CO_3)(SO_4)_2(OH, Cl)_2O$. The validity of wherryite as a mineral species has been doubted (Strunz, 1966). The present work appears to confirm wherryite as a species distinct from caledonite and leadhillite.

SPECIMENS

The present study made use of three specimens from the Mammoth mine which will be referred to in this paper as specimens nos. 1, 2, and 3. Wherryite occurs on spec. no. 1 (USNM spec. no. 8171) as crystals which vary in color from pale yellow to bright yellowish-