HIDALGOITE, A NEW MINERAL*

ROBERT L. SMITH, FRANK S. SIMONS, AND ANGELINA C. VLISIDIS,
U. S. Geological Survey, Washington, D. C.

ABSTRACT

Hidalgoite, a new mineral from the San Pascual mine, Zimapan mining district, Hidalgo, Mexico, is a basic sulfate-arsenate of lead and aluminum, with the formula $PbAl_3(AsO_4)(SO_4)(OH)_6$. Hidalgoite is a member of the beudantite group and is the arsenate analogue of the phosphate hinsdalite and the aluminum analogue of beudantite. The unit cell dimensions for both the hexagonal cell and the corresponding rhombohedral cell are: $a_0=7.04$ Å; $c_0=16.99$ Å; $c_0/a_0=2.41$; $a_{rh}=6.97$ Å, $\alpha=60°40'$.

INTRODUCTION

The new mineral hidalgoite was collected during a study of the Zimapan mining district, State of Hidalgo, Mexico. This study was made during 1948 as part of a cooperative project between the U. S. Geological Survey, operating under the auspices of the Department of State, and the Comité Directivo para la Investigación de los Recursos Minerales de Mexico of the Government of Mexico. During the course of this study Simons collected specimens of a peculiar white to light-gray material from a vein in the San Pascual mine and submitted them to the U. S. Geological Survey in Washington, D. C., for identification. This material was examined in the laboratory by Smith who found one of the constituents to be a new mineral.

In the preliminary stages of the laboratory investigations, qualitative chemical tests showed the presence of substantial amounts of lead, aluminum, sulfate ion, and water. Spectrographic examination by K. J. Murata confirmed lead and aluminum and established the presence of arsenic—these three elements being the principal metallic constituents. Preliminary *x*-ray examination by J. M. Axelrod placed this mineral in the alunite family, with a pattern close to hinsdalite. The above data together with the optical properties and specific gravity indicated a new mineral, and additional material was therefore requested for detailed study. This material was obtained through the courtesy of Carl Fries, U. S. Geological Survey, Mexico City, Mexico.

The Zimapan mining district is in the western part of the State of Hidalgo. It is about 200 km. north of Mexico City on the road to Laredo, Texas. The San Pascual mine is on the northwest side of the Barranca de San José some 9 km. northwest of Zimapan. Its adit is along a north-trending dike of quartz latite. Both dike and mineralization are probably related to a much larger dike-like body of quartz monzonite,

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the NW end of which lies some 300 m west of the mine. The monzonite is intrusive principally into calcareous shale of Cretaceous age; the mine is in overlying fanglomerate of probable Miocene or Pliocene age.

The hidalgoite was found in a meter-wide vertical vein in the footwall of an east-west fault that dips steeply north where it crosses the adit 115 m from the portal. The fault is barren where the hidalgoite-bearing vein cuts it, to the west of the main N-S structure, but to the east it had the largest ore body of the mine, reportedly containing galena, pyrite, sphalerite, arsenopyrite, cerussite, and minor amounts of anglesite, wulfenite, and alamosite.

Description and Physical Properties

Hidalgoite occurs in white porous or cavernous to dense porcelain-like masses. In some specimens it has much the appearance of "bone" magnesite. Much of the material studied is discolored by streaks or blotches of iron oxide. This is especially true of the more porous specimens.

Owing to the fine-grained nature of hidalgoite, cleavage could not be observed either in hand specimen or under the microscope; fracture, irregular in porous specimens to conchoidal in the porcelain-like masses; hardness, $4\frac{1}{2}$; luster, dull; diaphaneity, translucent; tenacity, brittle.

Optical Data

The fine-grained character of hidalgoite precludes the measurement of any optical properties other than a mean index of refraction. Measurements made on several specimens yielded a mean index of refraction ranging from 1.705 to 1.713 for sodium light. Mean n for the analyzed material is $1.713 \pm .002$ Na. The birefringence is quite low.

In some of the hidalgoite specimens small spherulitic growths have developed. Some of these show extinction crosses which, when tested with the gypsum plate, simulate uniaxial positive interference figures.

Chemical Data

Hidalgoite is insoluble in HCl, HNO_3, and H_2SO_4 at one atmosphere pressure. Solution was effected by heating with 3 ml. of concentrated HCl in a sealed Pyrex tube placed in an oven at 150° C. for 3 hours.

The standard procedures of chemical analysis were employed. Lead was determined as the sulfate and sulfur as barium sulfate. Arsenic and antimony were determined as the pentasulfide. Zinc was precipitated as the sulfide, and ignited to the oxide. Alumina and silica were measured by the usual gravimetric methods, and Fe_2O_3 was determined colorimetrically with KCNS. Total water was determined by the Penfield method using anhydrous sodium tungstate (Na_2WO_4) as a flux.

The chemical analysis and ratios of hidalgoite are shown in Table 1. The calculated analysis of $PbAl_3(AsO_4)(SO_4)(OH)_6$ is included for comparison. Although there is slight departure in ratios from the beudantite structure type, hidalgoite conforms to the formula $PbAl_3(AsO_4)(SO_4)(OH)_6$. There is minor substitution of zinc for lead, iron for aluminum, and antimony for arsenic. The analysis shows a departure from the 1:1 ratio between AsO_4 (or PO_4) and SO_4 ordinarily shown by members of

TABLE 1. CHEMICAL ANALYSIS AND RATIOS OF HIDALGOITE

$PbAl_3(AsO_4)(SO_4)(OH)_6$	Hidalgoite*		
Per cent		*Per cent*	*Ratios*
35.68	PbO	32.84÷223.22=0.14712	
	ZnO	0.88÷ 81.38=0.01081	
		0.15793	1.98
24.51	Al_2O_3	24.25÷101.94=0.23788	
	Fe_2O_3	0.57÷159.70=0.00357	
		0.24145	3.02
18.37	As_2O_5	16.27÷229.82=0.07079	
	Sb_2O_5	0.20÷323.52=0.00062	
		0.07141	0.89
12.80	SO_3	15.03÷ 80.07=0.18771	2.35
8.64	H_2O	9.70÷ 18.00=0.53889	6.75
	SiO_2	0.32	
100.00		100.06	

* Analyst, A. C. Vlisidis.

the beudantite group. However, a comparable departure may be observed in some of the published analyses of beudantite and corkite, where SO_4 is predominant over AsO_4 and PO_4, respectively, and in svanbergite, where PO_4 predominates over SO_4. Hidalgoite also has a slight excess of water. Part of the iron may be present as a limonitic impurity.

A qualitative spectrographic analysis of hidalgoite by Janet D. Fletcher showed the presence of Ca, V, Ti, and Cu, in hundredths of one per cent, and Mg, Sr, Ba, B, Cr, and Sc in thousandths of one per cent.

X-RAY DATA AND SPECIFIC GRAVITY

X-ray powder diffraction patterns of hidalgoite were taken using both iron and copper radiation. The iron pattern showed better resolution of

reflections than the copper pattern and thus was used as a basis for calculating the unit-cell dimensions.

Hidalgoite is a member of the alunite family (used here to include the alunite, beudantite, and plumbogummite groups) on the basis of its qualitative chemistry and its similarity in structure, as observed in *x*-ray powder patterns, to other members of the family, especially alunite and hinsdalite. Indexing of the reflections was therefore accomplished on a Bunn Chart, after an axial ratio approximately that of other members of the alunite family was assumed. Reflections were present only when $-h+k+l=3n$, the condition satisfying the conventional setting of the rhombohedral cell indexed on hexagonal axes. Lattice parameters for the larger hexagonal cell were then calculated from the *d*-spacings corresponding to the sharpest diffraction lines and when possible where only one form contributed to the reflection. Calculated *d*-spacings from these parameters are in good agreement with the measured values. The unit cell dimensions for both the hexagonal cell and the corresponding rhombohedral cell are: $a_0=7.04$ Å; $c_0=16.99$ Å; $c_0/a_0=2.41$; $a_{rh}=6.97$ Å; $\alpha=60°40'$. The error for a_0 and c_0 is probably within plus or minus 0.02 Å of the stated values.

The powder pattern was indexed for all spacings greater than 1.32. The values for both calculated and observed *d*-spacings are given in Table 2 along with the observed intensities and the hexagonal and rhombohedral indices.

The specific gravity of hidalgoite was determined as 3.96 with an Adams-Johnston fused silica pycnometer of 5-cm. capacity. The specific gravity as calculated from the chemical analysis and the unit-cell dimensions is 4.27. The discrepancy between these values is rather large, but explanation might possibly be found in the very fine-grained nature of hidalgoite.

Features such as the microcrystallinity, the presence of spherulites and spherulitic aggregates, and in some specimens the presence of mosaics of minute cracks (simulating mud cracks) suggest that hidalgoite crystallized from a very viscous or gelatinous material. Assuming such a condition it seems possible that complete crystallization may not have been accomplished and that there is residual interstitial material that has a lower specific gravity. This condition might also explain the slightly higher water content.

Associated Minerals

The material available for study was collected primarily for the purpose of obtaining enough of the new mineral for chemical analysis, and therefore the associated minerals are probably inadequately represented.

TABLE 2. *X*-RAY POWDER DATA FOR HIDALGOITE
Iron Radiation, Manganese Filter, $\lambda = 1.9373$ Å
Effective Camera Diameter 114.59 mm.

hkīl	$h_rk_rl_r$	Intensity	d (measured)	d (calculated)
$10\bar{1}1$	100	9	5.73	5.74
0003	111			5.66
$01\bar{1}2$	110	1	4.96	4.95
$10\bar{1}4$	211			3.49
$11\bar{2}0$	$10\bar{1}$	9	3.51	3.52
$02\bar{2}1$	$11\bar{1}$			3.00
$11\bar{2}3$	210	10	2.981	2.990
$01\bar{1}5$	221			2.968
$20\bar{2}2$	200	2	2.864	2.869
0006	222	3	2.830	2.832
$02\bar{2}4$	220	4	2.477	2.477
$21\bar{3}1$	$20\bar{1}$	1	2.282	2.283
$20\bar{2}5$	311			2.269
$10\bar{1}7$	322	7	2.257	2.255
$12\bar{3}2$	$21\bar{1}$	4	2.226	2.224
$11\bar{2}6$	321	4	2.204	2.206
$30\bar{3}0$	$21\bar{1}$	5	2.027	2.032
$21\bar{3}4$	310			2.025
$01\bar{1}8$	332	½	2.009	2.006
$03\bar{3}3$	$22\bar{1}$	8	1.911	1.913
$30\bar{3}3$	300			1.913
$12\bar{3}5$	320			1.907
$02\bar{2}7$	331			1.899
0009	333			1.888
$22\bar{4}0$	$20\bar{2}$	6	1.761	1.760
$20\bar{2}8$	422	½	1.746	1.743
$13\bar{4}1$	$21\bar{2}$	2	1.681	1.683
$22\bar{4}3$	$31\bar{1}$			1.681
$21\bar{3}7$	421	4	1.667	1.671
$11\bar{2}9$	432			1.664
$31\bar{4}2$	$30\bar{1}$			1.658
$30\bar{3}6$	411	3	1.651	1.651
$03\bar{3}6$	330			1.651
$10\bar{1}\cdot10$	433	3	1.638	1.637
$13\bar{4}4$	$32\bar{1}$	½	1.570	1.571
$12\bar{3}8$	431			1.562
$40\bar{4}1$	$31\bar{1}$	1	1.514	1.518
$31\bar{4}5$	410			1.514
$04\bar{4}2$	$22\bar{2}$	6	1.496	1.500
$01\bar{1}\cdot11$	443			1.497
$22\bar{4}6$	420			1.495
$02\bar{2}\cdot10$	442	6	1.484	1.484
$40\bar{4}4$	400	1	1.434	1.435
$000\cdot12$	444	½	1.418	1.416
$32\bar{5}1$	$30\bar{2}$	5	1.386	1.394
$04\bar{4}5$	$33\bar{1}$			1.391
$13\bar{4}7$	430			1.387
$30\bar{3}9$	522			1.383
$03\bar{3}9$	441			1.383
$23\bar{5}2$	$31\bar{2}$			1.380
$20\bar{2}\cdot11$	533	2	1.370	1.378
$21\bar{3}\cdot10$	532			1.368
$41\bar{5}0$	$31\bar{2}$	3	1.330	1.330
$32\bar{5}4$	$41\bar{1}$			1.329
$31\bar{4}8$	521			1.323

The following minerals were observed in the specimens studied: limonite, hydromica, orthoclase, tourmaline, beudantite, and a mineral tentatively referred to as ferrian hidalgoite.

Limonite

Limonite occurs as a staining in streaks and blotches throughout most of the hidalgoite. In the highly porous and cavernous specimens it may be found concentrated in small earthy or resinous masses.

Hydromica and Orthoclase

A sericitic mineral identified as a hydromica and an alkalic feldspar, here called orthoclase, were identified on the basis of their optical properties. These two minerals occur either together or separately as fine-grained aggregates in pockets in hidalgoite and are most abundant in the limonite-rich cavernous areas. They appear to have formed earlier than hidalgoite.

Tourmaline

Tourmaline was observed in only one specimen, where it occurs in mats of greenish-gray needles associated with orthoclase and hydromica. This mineral was identified by its optical properties and by x-ray. The optical properties are as follows: indices of refraction, $\epsilon = 1.62 \pm .002$ and $\omega = 1.643 \pm .002$; pleochroism, ϵ = yellow and ω = pale blue. The indices of refraction were measured using white light.

Beudantite

A dark brownish-green mineral was found in exceedingly small quantity on two specimens of hidalgoite. On the basis of its optical properties and association, it was identified as beudantite. The optical properties that could be determined are: mean n 1.95, low to moderate birefringence, anomalous blue interference colors, lemon-yellow to pale-yellow pleochroism.

An x-ray powder pattern was obtained of this mineral which shows a very close similarity to corkite from Beaver County, Utah. The principal difference is the larger cell size of the beudantite.

Ferrian hidalgoite

A mineral tentatively referred to as ferrian hidalgoite occurs in close association with beudantite and hidalgoite. It occurs in small veinlets and spherulitic growths in hidalgoite and in narrow zones surrounding crystals and spherulites of beudantite, separating them from the hidalgoite matrix. This material is light green in color, has a mean index of

refraction of 1.79, and a low birefringence. Enough of this mineral was separated to obtain an *x*-ray powder pattern. This pattern is very close to hidalgoite, but differs in having a slightly larger cell and in the relative positions of a few lines. These few lines show a slight departure from hidalgoite and seem to be related to corresponding lines on the pattern obtained from the associated beudantite.

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