SALESITE, A NEW MINERAL FROM CHUQUICAMATA, CHILE

Charles Palache and O. W. Jarrell,
Harvard University, Cambridge, Mass.

Abstract

Salesite, $CuIO_3(OH)$, is a new mineral from Chuquicamata, Chile. Orthorhombic, $a:b:c=0.4442:1:0.6241$. Habit prismatic. Cell dimensions: $a_0=4.78$, $b_0=10.77$, $c_0=6.70$. Cleavage perfect //{110}. H=3, D=4.77±.05. Color green, $X=a$, 1.706, $Y=c$, 2.070 $Z=b$, 2.075, $r>v$, extreme, $2V=0–5°$. Biaxial negative. Analysis by F. A. Gonyer: CuO 30.62, Na_2O 0.59, I_2O_5 64.79, H_2O 3.68. Named in honor of Reno H. Sales, Chief Geologist of the Anaconda Copper Mining Company.

Salesite is an iodate of copper first found by the junior author in 1936 on the west side of Bench E-4 at the south end of the open pit at Chuquicamata, Chile. The only specimen found was an irregular bunch of crystals weighing about a gram. The only associated minerals are small amounts of quartz and kaolinized plagioclase, although the specimen was found in a part of the mine where atacamite is the most abundant copper mineral.

This specimen was sent to the Harvard Mineralogical Laboratory for further study, optical data having indicated that it was an undescribed species. It was overlooked in the collection until 1938 when Mr. Jarrell returned to Cambridge. He measured the optical characters more exactly, but the small amount of available material made exact determination seem hopeless. The crystal form was established as orthorhombic by the senior author, its specific gravity was determined and the presence of an excellent prismatic cleavage was established. It was only in a somewhat vague hope of gaining a qualitative knowledge of its chemical character that blow-pipe tests were made upon a few minute fragments. A closed tube test immediately showed the presence of iodine and a flame test proved that copper was present. With this knowledge a sample of about .3 gram was prepared and Mr. Gonyer made the analysis given below. It proved to be a basic copper iodate, $CuIO_3(OH)$.

The authors take great pleasure in naming this new mineral salesite in honor of Mr. Reno H. Sales, the well-known Chief Geologist of the Anaconda Copper Mining Company and its subsidiaries. Mr. Sales was responsible for pioneer work leading to the present knowledge of the geology at Chuquicamata and for recommending the drilling that in recent years developed the large reserves of deep sulphide ore.

Crystallography: Salesite is orthorhombic. It occurs in rather stout prismatic crystals with a pyramidal termination. Small crystals are of good quality and have the simple form shown in Fig. 1. The larger crystals show some rounding both of the prism zone and of the edge between prism and pyramid. The principal prism, parallel to which there is an excellent cleavage, is taken as unit prism and the terminal pyramid as unit pyramid. Three crystals were measured and gave the following fundamental angles:

	ϕ	ρ	Range ϕ	Range ρ	No. of faces
110	66°03′	90°00′	65°50′–66°12′	——	9
111	66 03	56 57½	65°33 –66 27	56 50′ – 57 02′	8

From these angles elements were calculated, and the angle table that follows is based upon them.

TABLE 1. ANGLE TABLE OF SALESITE

Salesite—$CuIO_3(OH)$

Orthorhombic; dipyramidal—$2/m$ $2/m$ $2/m$

$a:b:c = 0.4442:1:0.6241$; $p_0:q_0:r_0 = 1.4050:0.6241:1$

$q_1:r_1:p_1 = 0.4442:0.7117:1$; $r_2:p_2:q_2 = 1.6023:2.2512:1$

Forms	ϕ	$\rho = C$	ϕ_1	$\rho_1 = A$	ϕ_2	$\rho_2 = B$
c 001	—	0°00′	0°00′	90°00′	90°00′	90°00′
b 010	0°00′	90 00	90 00	90 00	—	0 00
n 130	36 53	90 00	90 00	53 07	0 00	36 53
m 110	66 03	90 00	90 00	23 57	0 00	66 03
e 023	0 00	22 35½	22 35½	90 00	90 00	67 24½
d 011	0 00	31 58	35 58	90 00	90 00	54 02
p 111	66 03	56 57½	31 58	40 00	35 26½	70 06½
(?) *r* 552	66 03	75 25	57 20½	27 49	15 53½	66 52

The form to which the symbol (552) has been assigned, which is shown as *r* in Fig. 2, is uncertain. It is rounded and the ρ angle varied through 4 or 5 degrees. It is, however, quite characteristic of the larger crystals. The domes *e* and *d* and the basal pinacoid shown in Fig. 2 are minute in size.

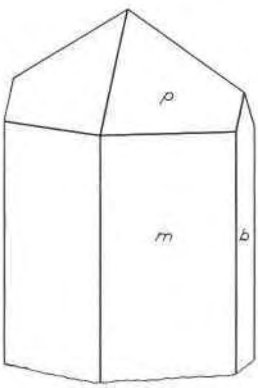

FIG. 1. Crystal of Salesite.

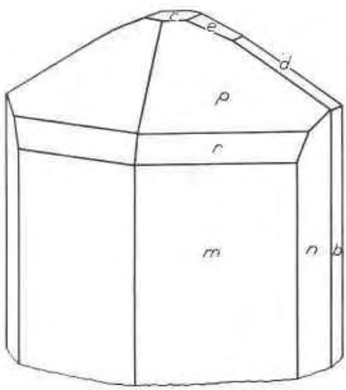

FIG. 2. Crystal of Salesite.

Physical Properties: Cleavage parallel to {110} very perfect. Specific gravity, determined with the micro-torsion balance on several grains that still, however, included some gangue, gave 4.77±0.05. Hardness 3. Color bluish green, very similar to caledonite.

Optical Properties: The optical properties are presented in the following comparative table.

TABLE 2. COMPARISON BETWEEN SALESITE AND ARTIFICIAL COPPER IODATE

	Salesite	Artificial basic copper iodate
Crystal system:	orthorhombic	orthorhombic
Orientation and Pleochroism:	X=*a*=colorless Y=*c*=light bluish green Z=*b*=bluish green	X=*a*=colorless Y=*b*=green Z=*c*=yellowish green
Cleavage:	{110}	{100}
α	1.786±0.005	1.775±.01
β	2.070±.01	2.046±.005
γ	2.075±.01	2.052±.005
2V	0–5° (uniaxial for blue light)	0–5° (uniaxial for blue light)
Dispersion:	$r>v$, extreme	$r>v$, extreme
Optical sign:	biaxial negative	biaxial negative

Chemical Composition: Salesite is insoluble in water but is easily soluble in nitric acid. In the forceps, heated gradually, it darkens and yields a clear green flame of copper iodide. It does not appear to fuse. The residue left after heating on charcoal is readily reduced to metallic copper. In the closed tube, when first heated, it snaps into small splinters and almost at once gives copious purple fumes of iodine which crystallize on the wall of the tube. A small amount of water is also given off.

The chemical analysis was made by Mr. Gonyer on a sample of not more than 0.3 gram of material. For the water a separate sample of 0.11 gram was used. Regarding this determination Mr. Gonyer states: "The method by which the water of the copper iodate was determined is a modification of the Penfield 'Direct Method.' The water and iodine were driven off in a tube and weighed together. Potassium iodide was then used to dissolve the iodine and this solution titrated with sodium thiosulfate. The free iodine thus determined was deducted from the total weight of iodine and water, and the difference was assigned to water."

TABLE 3. ANALYSIS OF SALESITE

	1	2	3	4	5
CuO	30.62	30.72	.3861	.3956	2.06
Na_2O	0.59	0.59	.0095		
I_2O_5	64.79	65.00	.1947	.1947	1
H_2O	3.68	3.69	.2050	.2050	1.068
	99.68	100.00			

1. Analysis of salesite by F. A. Gonyer.
2. Analysis recalculated to 100%.
3 and 4. Molecular proportions.
5. Simplified molecular ratio.

The figures of column 5 yield very exactly the formula $Cu_2I_2O_6(OH)_2$ or $CuIO_3(OH)$.

X-RAY STUDY OF SALESITE

W. E. RICHMOND

The *x*-ray determination of the lattice constants was made on a crystal approximately 0.5 millimeter in the elongation direction. Rotation, zero and first layer-line Weissenberg photographs about *b*[010] and rotation and zero layer-line photographs about *c*[001] were taken using CuK_α radiation. The measurements and calculations of these photographs give the following lattice constants.

$$a_0 = 4.78 \qquad a_0:b_0:c_0 = 0.444:1:0.622$$
$$b_0 = 10.77 \qquad a:b:c = 0.44442:1:0.6241 \text{ (morphologic)}$$
$$c_0 = 6.70 \qquad v_0 = 344.9$$

The space group is D_{2h}^{16}—*Pcmn* derived from the following reflections on the Weissenberg photographs:

(*hkl*) = with all orders present
(0*kl*) = with *k* even
(*h*0*l*) = with (*h*+*l*) even
(*hk*0) = with all orders present

Content of the Unit Cell: The lattice constants together with the analysis by F. A. Gonyer and the specific gravity (4.77), give the unit cell content as shown in Table 4.

TABLE 4. UNIT-CELL CONTENT OF SALESITE

	1	2	3		4	5		6
CuO	30.72	31.14	0.3861	Cu	0.3861	3.85	4.04	4
Na_2O	0.59		0.0095	Na	0.0190	0.19		
I_2O_5	65.00	65.33	0.1947	I	0.3894	3.88		4
H_2O	3.69	3.53	0.2050	H	0.4100	4.08		4
	100.00	100.00		O	1.5751	15.71		16

Calculated density = 4.89
1. Analysis of salesite calculated to 100%.
2. Theoretical composition of $CuIO_3(OH)$.
3. Molecular proportions from column 1.
4. Atomic proportions.
5. Number of atoms in the unit cell.
6. Theoretical number of atoms in the unit cell.

The cell formula is therefore $4[CuIO_3(OH)]$.

Artificial Copper Iodate

Schulten (1904) described an iodate of copper with the formula $CuIO_3(OH)$, and gave the method of preparing it. This substance is orthorhombic with $a:b:c = 0.7124:1:1.7072$. It forms tabular crystals with $p\{001\}$, $g_1\{010\}$, $m\{110\}$ and $a_1\{101\}$ and has cleavage parallel to $\{100\}$. By a different setting of this crystal so that $c' = b$, $b' = c$, $a' = a$, the forms become: $g_1 = \{001\}$, $p = \{010\}$, $a_1 = \{110\}$ and $m = \{101\}$, and the cleavage is still $\{100\}$.

The elements for this position are:

	$a':b':c' = 0.4173:1:0.5859$
Salesite	$a:b:c = 0.4442:1:0.6241$

It is thus possible to bring these two substances into a relation with similar dimensions; but their cleavages are essentially unlike, pinacoidal in the one, prismatic in the other.

Mr. Gonyer made a solution following exactly the directions of Schulten and after about a week a crop of minute green crystals was obtained. These were measurable, and a prism gave the angle $m \wedge m' = 71°03'$, which is closely comparable to $m \wedge m' = 70°56'$ obtained by Schulten. Dr. Berman and the junior author studied these crystals optically and found that they agreed substantially in optical orientation with Schulten's data, so it was evident that we had the same substance as he had made. The optical properties of these crystals are, however, slightly different from those of salesite (see Table 2). Thus the two substances must be regarded as dimorphous since with the same composition they differ both in cleavage and optical properties.

No further attempt was made to reproduce salesite artificially, but after the first crop of the artificial copper iodate crystals was removed by Mr. Gonyer a second crop of blue crystals formed, which, however, were of a different salt, the triclinic hydrated cupric iodate.

Reference

Granger, A. and de Schulten, A., *Bull. Soc. Min. Fr.*, **27**, 137 (1904).