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SULVANITE FROM UTAH

Christy A. Schempp, *Dividend, Utah, and*
Waldemar T. Schaller, *Washington, D. C.*

Introduction

The rare copper vanadium sulphide, sulvanite, was found close to the surface, near the old mining camp of Mercur, Utah, in a fissure in carboniferous limestone, which is underlain by quartzite and overlain by red shale. This is the second authentic occurrence and the fourth reported one for this rare mineral. Sulvanite was first described from Australia and the two doubtful localities are in Argentina and in Siberia.

Most of the sulvanite from Utah occurs as cleavable masses; a few small crystals were found, however, whose measurements showed that the mineral is isometric. This crystallization had previously been suggested by several writers, on the basis of optical examinations by reflected polarized light on polished surfaces of material from Australia.

Occurrence

The specimen from Utah is a breccia of fine-grained black limestone in a matrix of coarsely crystallized white calcite which also cuts the fragments of black limestone as small veinlets. The sulvanite is embedded in the coarse white calcite and also lies at its contact with the black limestone. Aggregates of small crystals of quartz are present in the white calcite.

The sulvanite occurs massive and as rough cubical crystals, somewhat elongated in one direction. The largest exposed cubical cleavage surface of the sulvanite extends for nearly a centimeter and a half. Small crystals are also developed in minor fractures in the white calcite and were isolated by treatment with dilute acid and measured on the goniometer.

Properties

The color of the larger masses of sulvanite is gray, resembling that of certain types of tetrahedrite. Some surfaces have a distinct bronzy appearance, in part iridescent and in part coated with secondary greenish minerals, which also stain the white calcite in places. The secondary minerals are chiefly green malachite and other green and greenish-yellow earthy alteration products. The yellowish color of some of this material suggests the presence of vanadium.

All the large cleavage surfaces of a single mass of sulvanite show two additional rectangular cleavages, so that there are three cleavages present, all mutually perpendicular. The cleavage is cubic, some of the crystals breaking readily into parallel slabs. All the rectangular traces of the cubic cleavage are prominent on the larger cleavage surfaces of the mineral in the matrix, but on some of the small crystals measured the cleavage traces are developed in only one direction.

The three rectangular cleavages have been referred to three pinacoids by Dieseldorf[1] and by Frebold[2] who, however, states that no polarization effects were observed, agreeing with the determinations of Orcel, de Jong, and Short[3] that optically the mineral is isotropic.

The interpretation of the three rectangular cleavages as cubic (isometric) is more in agreement with the other results obtained. The photomicrographs of sulvanite from Australia, shown by Frebold (p. 325) and by de Jong (p. 524) are identical in appearance in "white color," rectangular cleavages, and occurrence of alteration products with that observed on the sulvanite from Utah.

Crystallography

The small crystals, isolated from the fractures in the white calcite, are about a millimeter thick and are somewhat unequal in length in different directions, so that they may be designated as

[1] Dieseldorf, A., Sulvanite, ein primäres Vanadium-mineral: *Zeit. f. prakt Geol.*, **1901**, p. 421. *Zeit. d. Deutsch. Geol. Gesellsch.*, vol. **53**, Mon.-Ber. pp. 43–44, 1901.

[2] Frebold, G., Ueber einige Mineralien der Enargitgruppe und ihre paragenetischen Verhältnisse in der Kupfererzlagerstätte von Mancayan auf Luzon (Philippinen): *Neues Jahrb. f. Mineral. Geol. u. Paleon.*, Beilage Band, vol. **56**, Abth. A, pp. 316–333, 1927.

[3] See p. 560.

slightly flattened and slightly elongated cubes. The surfaces have been somewhat dulled by the acid used in dissolving the calcite matrix but the measurements suffice to show that the crystals are isometric.

The forms present on the small crystals of sulvanite are the cube $a(100)$, the dodecahedron $d(110)$, and the octahedron $o(111)$. Of these, the cube is dominant on all crystals. The usual combination is a, d, small triangular faces of $o(111)$ being observed on only two crystals. Some of the faces of $d(110)$ are not developed and the faces on a single crystal vary in width, though all are much subordinate to the large faces of the cube $a(100)$.

Nearly all the faces of the measured crystals gave poor reflections due to their dullness, sulvanite being appreciably attacked by dilute acids. On the matrix, the natural faces of the crystals are bright as are also the cleavage surfaces, which in part are minutely step-like.

The angles measured on three crystals from Utah are as follows:

Measurements of Angles on Crystals of Sulvanite From Utah

	$a \wedge a'$	$a \wedge d$
	89° 19′	44° 17′
	89 37	44 25
	89 51	44 26
	89 55	44 39
	89 56	44 40
	90 20	44 47
	90 23	45 01
	90 31	45 07
	90 59	45 59
Av.	90 06	44 49
Calc.	90 00	45 00

The small triangular faces of $o(111)$ were so dull that they gave no reflections and were not measured.

It might be contended that the evidence presented does not preclude the possibility of the crystals being orthorhombic. The slight elongation of the crystals, the development on some of them of only one or two cleavage traces, and the absence of all the faces of the dodecahedron on a single crystal suggests a lower symmetry than that of the isometric system. The angular measurements could also be referred, for example, to those of an orthorhombic mineral like anhydrite:

Measured on sulvanite	Anhydrite
$a \wedge a' = 90° \ 06'$	$a(100) \wedge c(001) = 90° \ 00'$ $a(100) \wedge b(010) = 90 \ \ 00$ $b(010) \wedge c(001) = 90 \ \ 00$
$a \wedge d = 44 \ \ 49$	$b(010) \wedge s(011) = 44 \ \ 59$

However, the distribution of the faces of $d(110)$ on the crystals of sulvanite was not that of an orthorhombic crystal. The three rectangular cleavages and the angular measurements, moreover, do not agree with those of enargite, with which sulvanite should be analogous if it were orthorhombic.

Examination of a polished surface of sulvanite from Utah, by Dr. M. N. Short[4] has shown that the mineral is isotropic. Orcel[5] apparently was the first to note that in reflected polarized light sulvanite was strictly isotropic and he therefore considered it to be isometric. A few months later in the same year de Jong[6] published his conclusion, also finding it to be isotropic.

Chemical Composition

An approximate analysis (by Schempp) gave the values shown in column 1. The two analyses by Goyder[7] (2 and 3) and the two analyses by Schultze[8] (4 and 5), all made on sulvanite from Australia, are here reproduced, with the unessential constituents deducted and then recalculated to 100 per cent. The analysis by Ir. J. deVries,[9] also on material from Australia, is given under (6). Under (7) is given the theoretical composition calculated for the established formula Cu_3VS_4.

[4] Personal communication.

[5] Orcel, J., Notes sur les caractères microscopiques des minéraux opaques, principalement en lumière polarisée: *Bull. soc. franc. Mineral.*, vol. **51**, pp. 205–206, 1928.

[6] de Jong, W. F., Die Enargitgruppe. Struktur des Sulvanit, Cu_3VS_4: *Zeit. für Krist.*, vol. **68**, pp. 522–530, 1928.

[7] Goyder, G. A., On sulvanite, a new mineral: *Journ. Chem. Soc.*, vol. **77**, p. 1094, 1900.

[8] Schultze, H., and Steinmetz, H., Über Vanadium-Schwefelverbindungen; Inaug.-Dissert. (H. Schultze) Munich, 1908.
Abstr. in *Zeit. f. Krist.*, vol. **49**, p. 640, 1911.

[9] Quoted by de Jong, *Zeit. f. Krist.*, vol. **68**, p. 524, 1928.

ANALYSES OF SULVANITE

	Utah Schempp	Australia					Cu_3VS_4
		Goyder		Schultze		de Vries	
	1	2	3	4	5	6	7
Cu	50.0	51.57	52.96	51.89	52.66	51.20	51.55
V	14.5	13.46	13.72	13.08	13.40	14.20	13.78
S	30.0	34.97	33.32	35.03	33.94	34.60	34.67
	94.5	100.00	100.00	100.00	100.00	100.00	100.00

The determination of sulphur in column 1 is probably several per cent too low, as indicated by the low summation. The five analyses of sulvanite from Australia are in very close agreement with the calculated percentages for the formula Cu_3VS_4.

Sulvanite being isometric and not orthorhombic, as the chemically corresponding mineral enargite, Cu_3AsS_4, it may be questioned whether the formula of sulvanite should not be written $Cu_{12}V_4S_{13}$, following the formula of isometric tetrahedrite, $Cu_{12}Sb_4S_{13}=5Cu_2S\cdot 2CuS\cdot 2Sb_2S_3$, as written for example by Wherry and Foshag[10] but the analyses of sulvanite from Australia do not support this view.

Sulvanite, then, is chemically analogous to enargite and famatinite but crystallographically it is distinct, these three minerals being representatives of the type formula: Cu_3XS_4, the relationships being as follows:

	ISOMETRIC	ORTHORHOMBIC
Cu_3AsS_4	Green enargite[a]	Pink enargite
Cu_3SbS_4	......	Famatinite
Cu_3VS_4	Sulvanite	......

[a] See de Jong, *loc. cit.*, p. 522. Also Schneiderhöhn, H., *Anleitung z. mikro. Bestimmung von Erzen*, **1922**, p. 240.

OTHER LOCALITIES

The reported occurrence of sulvanite in Argentina has been the cause of some controversy. The occurrence was described by

[10] Wherry, E. T., and Foshag, W. F., A new classification of the sulfo-salt minerals: *J. Wash. Acad. Science*, vol. **11**, p. 6, 1921.

Wiedemann[11] but the identification of sulvanite has been questioned by Frebold[12] who regards the mineral, referred to as sulvanite by Wiedemann, to be galena. Frebold's conclusion was later refuted by Wiedemann.[13]

In view of the determination of the isometric symmetry, with cubic cleavage, of the sulvanite from Utah, and the isotropic character of the mineral from Australia as determined by Orcel, de Jong, and Short, the objections raised by Frebold do not seem to hold. Wiedemann described his material as having a dark cream yellow color on polished surfaces whereas Frebold mentions a white color. The examination of sulvanite from Australia and from Utah, by Short,[14] shows the mineral to have a galena-white color on polished surfaces in reflected light.

Although the occurrence of sulvanite in Argentina should be confirmed, it does not seem justifiable, on the basis of Frebold's remark, to discredit the identification of Wiedemann.

The fourth recorded occurrence of sulvanite, from Siberia, is given by van der Veen,[15] without any description and is questioned by Schneiderhöhn and Ramdohr.[16]

[11] Wiedemann, H. H., Geologische und bergmännische Untersuchung der Vanadinlagerstättin in der Sierra de Cordoba, Argentinien: *Mitteilungen des Roemer-Museums zu Hildesheim*, Nr. **28**, Mai, 1927. The paragraph relating to sulvanite (p. 12) is reproduced by Wiedemann in *Centralbl. Mineralogie*, **1928**, Abt. A, pp. 293–294.

[12] Frebold, Georg, Über das Vorkommen des Sulvanits (Cu_3VS_4) in der Sierra de Cordoba, Argentinien: *Centralbl. Mineralogie*, **1928**, Abt. A, pp. 27–28.

[13] Wiedemann, H. H., *Centralbl. Mineralogie*, **1928**, Abt. A, pp. 293–294.

[14] Personal communication. See also: Short, M. N., Microscopic determination of the ore minerals: *U. S. Geol. Survey, Bulletin* No. **825**, p. 92, 1931. Short describes the Australian sulvanite as isometric, color galena-white, cubic cleavage, not prominent.

[15] van der Veen, W. R., *Minerography and ore-deposition*. The Hague, **1925**, p. 111. (Fig. 126).

[16] Schneiderhöhn, H., and Ramdohr, H., *Lehrbuch d. Erzmikroskopie*, **1931**, p. 460.