

The discreditation of girdite

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ABSTRACT

Girdite, a mineral described by Williams in 1979 from the Grand Central mine, Tombstone, Cochise County, Arizona, USA, has been re-examined by powder X-ray diffraction, single-crystal X-ray diffraction and electron microprobe. Type material from The Natural History Museum, London and the United States National Museum of Natural History (Smithsonian Institution) was examined. The original description of girdite is shown to have been based upon data obtained from at least two and possibly three different phases, one corresponding to ottoite and another probably corresponding to oboyerite, although the latter itself appears to be a mixture. The discreditation of girdite as a valid mineral species has been approved by the IMA-CNMNC, Proposal 16-G.

KEYWORDS: girdite, tellurium oxysalt, Grand Central mine, Tombstone, Cochise County, Arizona, USA, discreditation.

Introduction

GIRDITE was one of four new tellurium oxysalt minerals described from the Grand Central mine, Tombstone, Cochise County, Arizona, USA by Williams (1979), the others being oboyerite, fairbankite and winstanleyite. Girdite was described as occurring in dense, chalky spherules with a “hint” of a crystalline druse on the surface. The spherules of girdite were noted to closely resemble those of oboyerite. One “exceptional” specimen of girdite provided bow-tie-like aggregates of slender tapered prisms. Williams gave the ideal formula of girdite as $\text{H}_2\text{Pb}_3(\text{Te}^{4+}\text{O}_3)\text{Te}^{6+}\text{O}_6$ based upon wet chemical analyses and water determination. From rotation and Weissenberg photographs obtained from a small crystal fragment, Williams reported a monoclinic unit cell with $a = 6.241$, $b = 5.686$, $c = 8.719$ Å and $\beta = 91^\circ 41'$. Optical determinations in S-Se melts, also on crystal fragments, yielded the indices of refraction: $\alpha = 2.44$, $\beta = 2.47$ and $\gamma = 2.48$. The

density measured by Berman balance, presumably on the spherules, was $5.5(2)$ g cm⁻³ compared to a calculated density ($Z = 1$) of 5.49 g cm⁻³. Williams also provided powder X-ray diffraction data (PXRD).

Kampf *et al.* (2010) described the new mineral ottoite, $\text{Pb}_2\text{Te}^{6+}\text{O}_5$, from Otto Mountain near Baker, San Bernardino, California, USA. They noted that the powder X-ray diffraction patterns of ottoite and girdite exhibited significant similarities and, based upon examination of a type specimen of girdite (BM1980,539), they conjectured that Williams based his description of girdite on data obtained from at least two and possibly three different phases, one of which might correspond to ottoite. Herein, we expand upon the initial reinvestigation of girdite by Kampf *et al.* (2010) and propose that girdite be discredited because its original description was severely flawed and was based upon more than one phase.

Type specimens

Williams (1979) stated that about a dozen specimens containing girdite were found, but he did not

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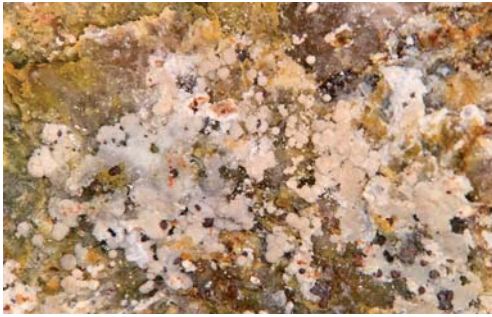


FIG. 1. Drusy ottoite coating buff-white spherules of oboyerite on girdite cotype specimen BM1980,539; field of view 12 mm across.

mention any type specimens. A search of the Catalogue of Type Mineral Specimens (<http://www.smmp.net/IMA-CM/CTMS/ctms.htm>) revealed only one type specimen of girdite, which was deposited in the collections of The Natural History Museum, London (BMNH) under registration number BM1980,539. This specimen was examined by Kampf *et al.* (2010) and was noted to fit the description of girdite as dense buff-white spherules coated with a thin crystalline “druse”; no bow-tie aggregates are present on this specimen; however, in some areas, the crystalline “druse” become more distinct from the buff-white material. These areas are grey-white in colour, highly lustrous and more transparent (Fig. 1). Subsequently, we noted a statement in the description of the new mineral schieffelinite by Williams (1980) that the type specimen of schieffelinite is also a type specimen of girdite. Although schieffelinite is present on BM1980,539, another cotype specimen of schieffelinite in the collections of the United States National Museum of Natural History (Smithsonian Institution) (NMNH), catalogue number R18474, is not recorded as being a type for girdite; however, on this specimen we observed slender tapering prisms that are consistent with the description of the crystals of girdite on the “exceptional” specimen mentioned by Williams (1979).

Powder X-ray diffraction

The PXRD pattern of girdite reported by Williams (1979) is compared to that of ottoite in Table 1. It can be seen that in the girdite pattern there are some additional peaks, the peaks matching those in the ottoite pattern are generally shifted to slightly higher angles (lower *d* values) and in most cases the visually estimated intensities in the girdite pattern

are much higher than the measured intensities in the ottoite pattern; however, overall, the patterns are very similar.

Our powder X-ray diffraction on the spherules on the BM1980,539 girdite type specimen provided a pattern consistent with oboyerite. PXRD on a carefully separated sample of the crystalline crust on this specimen yielded a pattern consistent with ottoite. PXRD conducted on the slender tapering prisms from the R18474 girdite type specimen provided a perfect match with the PXRD for ottoite from Otto Mountain.

Single-crystal X-ray diffraction

From rotation and Weissenberg photographs obtained from a small crystal fragment of girdite, Williams

TABLE 1. Powder X-ray diffraction data for girdite and ottoite.

Girdite		Ottoite		Ottoite structure		
<i>I</i> _{obs}	<i>d</i> _{obs}	<i>I</i> _{obs}	<i>d</i> _{obs}	<i>d</i> _{calc}	<i>I</i> _{calc}	<i>hkl</i>
10	5.027	4	5.060	5.068	6	0 1 1
70	3.118	64	3.131	3.133	53	$\bar{2}$ 0 2
100	3.054	90	3.055	3.071	4	2 0 2
70	2.994	100	3.015	3.068	100	0 1 3
80	2.842	19	2.871	3.011	95	2 1 1
5	2.711			2.862	41	0 2 0
5	2.516					
5	2.390					
50	2.179	19	2.186	2.187	21	2 0 4
70	2.102	29	2.112	2.113	40	$\bar{2}$ 2 2
				2.094	4	2 2 2
10	1.967					
50	1.813					
50	1.802	21	1.810	1.817	13	0 0 6
				1.808	24	$\bar{2}$ 1 5
				1.773	26	$\bar{4}$ 1 1
80	1.765	43	1.773	1.770	11	4 0 2
50	1.731	13	1.739	1.738	19	2 2 4
70	1.682			1.689	21	0 3 3
70	1.670	20	1.686	1.680	21	2 3 1
20	1.562	7	1.568	1.567	7	$\bar{4}$ 0 4
60	1.529	8	1.533	1.534	15	0 2 6
40	1.499	12	1.504	1.506	12	4 2 2
30	1.424	3	1.429	1.431	5	0 4 0
60	1.383	6	1.385	1.386	9	2 1 7
70	1.368	18	1.372	1.374	11	$\bar{4}$ 2 4
				1.370	10	4 1 5
50	1.343	4	1.352	1.348	9	$\bar{2}$ 3 5
50	1.328	6	1.333	1.334	8	$\bar{4}$ 3 1
60	1.295	6	1.301	1.302	9	$\bar{2}$ 4 2

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TABLE 2. Chemical analytical data for girdite, oboyerite and ottoite.

Constituent	Girdite	Oboyerite	BM1980,539	Ottoite
	Williams (1979)	Williams (1979)	This study (spherules)	Kampf <i>et al.</i> (2010)
PbO	63.2	58.0	61.96	68.88
CaO	–	0.3	–	–
TeO ₂	16.5	22.1	–	–
TeO ₃	18.2	16.2	32.54	28.03
H ₂ O	2.1	4.2	5.50*	–
Total	100.0	100.8	100.00	96.95

* by difference.

(1979) reported a monoclinic unit cell for girdite with $a = 6.241$, $b = 5.686$, $c = 8.719$ Å and $\beta = 91^\circ 41'$. Ottoite is monoclinic, $I2/a$, $a = 7.5353(6)$, $b = 5.7142(5)$, $c = 10.8981(12)$ Å, $\beta = 91.330(6)^\circ$. Although the b cell length and β angle of the two cells are comparable, there seems to be no obvious way to obtain his a and c cell parameters from a transformation of the ottoite cell. On the other hand, our own single-crystal study on a slender tapering prism from the R18474 girdite type specimen provided cell parameters nearly identical to those of ottoite.

Chemical analyses

The chemical analyses for girdite and oboyerite reported by Williams (1979) and that for ottoite by Kampf *et al.* (2010) are shown in Table 2, along with the average of seven electron probe micro-analyses (EPMA) of the spherules on specimen BM1980,539 conducted for the present study. The discrepancies between the analyses of girdite and ottoite are significant; however, Williams' reported analysis of girdite is a reasonable fit for the average of our EMPA analyses of the spherules on specimen BM1980,539. It seems clear that the wet chemical analysis reported by Williams was based upon material removed from the spherules and this is further corroborated by our observation that there are gouges through some of the spherules where the material was apparently removed. Furthermore, the analysis of oboyerite reported by Williams (1979) is reasonably close to that which he reported for girdite. This is consistent with our finding noted above that the spherules provide PXRD similar to that reported by Williams for oboyerite.

Examination of the interior of the spherules (Fig. 1) by scanning electron microscopy (energy dispersive mode) indicates the likelihood that at least two phases are present. The EPMA study

showed widely varying Pb:Te ratios from 1.12: 1 to 1.67:1 with the aforementioned average of the analyses providing a Pb:Te close to 1.5:1. By comparison, Pb:Te for ottoite is ideally 2:1 and for oboyerite 1.2:1.

Discussion

It is clear that the description of girdite by Williams (1979) was seriously flawed. His wet chemical analyses were conducted on an impure mixture of phases, which appears to correspond mainly to the same material he described as the new mineral oboyerite. The only descriptive data reported for girdite by Williams that is a reasonable match to data for ottoite are the PXRD data, but even so, extra peaks in his PXRD indicates that his sample was somewhat contaminated. His reported unit-cell, if obtained from crystals of ottoite, was determined incorrectly. His density measurement, $5.5(2)$ g cm⁻³, was probably conducted on the same material that he used for his chemical analyses, and it differs greatly from the ideal calculated density of ottoite, 8.832 g cm⁻³. The average of the indices of refraction (2.463), the ideal formula and the unit-cell parameters for girdite reported by Williams (1979) provide an appallingly poor Gladstone-Dale compatibility of -0.73 .

Conclusion

It is clear that Williams (1979) based his description of girdite on data obtained from at least two and probably more different phases. Because the discriminatory factors that serve to give girdite its unique status (Dunn, 1990) were not determined on a single phase, the International Mineralogical Association Commission on New Minerals,

Nomenclature and Classification has voted to discredit girdite as a mineral species (Proposal 16-G).

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