

cavansite, it certainly took place above 610°C, when complete dehydration took place. The last endotherm at 925°C, in all probability, may be attributed to the formation of cristobalite, and the formation of CaV_3O_7 corresponds with the exotherm at 960°C, reflected in the DTG by gain in weight caused by oxidation. Thus the thermal behaviour of cavansite is highly characteristic and the DTA, TG and DTG may serve as excellent diagnostic patterns, in addition to colour, habit, optical properties and chemistry, for this mineral.

Acknowledgements. The authors express their sincere thanks to Dr V. D. Gogate, Deccan College, Pune, for considerable help in the XRD studies. They are also grateful to Dr Arvind Bhale for his generosity in providing samples of cavansite for the study.

KEYWORDS: thermal behaviour, cavansite, India, vanadium mineral, DTA, DTG, TG.

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[Manuscript received 3 August 1993;
revised 26 January 1994]

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MINERALOGICAL MAGAZINE, SEPTEMBER 1994, VOL. 58, PP 505–508

Choloalite: synthesis and revised chemical formula

CHOLOALITE, a rare secondary double tellurite of Cu(II) and Pb(II), was described by Williams (1981). Type material from the Mina La Oriental, Moctezuma, Mexico, corresponded with other specimens from Tombstone, Arizona, and Arabia. Wet chemical analyses of very small amounts of choloalite led to an assigned formula of $\text{CuPb}(\text{TeO}_3)_2 \cdot \text{H}_2\text{O}$ with the water content determined by the Penfield method on but 156 μg .

As part of a study of the supergene mineralogy and geochemistry of tellurium, we have had occasion to synthesise the majority of the known secondary tellurium minerals for further chemical experiments concerning their stabilities. Choloalite

is one of the minerals that has been synthesised and as a result we have been able to more accurately establish its composition as well as to measure infrared absorption and accurate X-ray powder diffraction data for the pure, synthetic phase.

Synthesis

Choloalite was synthesised by fusion of stoichiometric amounts of CuO, PbO and TeO_2 in a silica crucible. The product was annealed at 500°C for several hours. A deep green, crystalline, but somewhat porous product was obtained, and which proved to be choloalite.

TABLE 1. Powder X-ray diffraction data for synthetic and natural choloalite

$d_{\text{meas}}^{\text{a}}$	$d_{\text{calc}}^{\text{a}}$	$I_{\text{rel}}^{\text{a}}$	hkl^{a}	$d_{\text{meas}}^{\text{b}}$	$I_{\text{rel}}^{\text{b}}$	$d_{\text{meas}}^{\text{c}}$	$d_{\text{meas}}^{\text{d}}$
7.255	7.225	26	111	7.260	5	7.233	7.300
5.611	5.596	6	210				
5.130	5.109	5	211				
4.178	4.171	13	221,300	4.187	2	4.170	4.189
3.962	3.957	4	310	3.975	½		3.933
3.617	3.612	16	222	3.632	3	3.614	3.647
3.474	3.471	22	320	3.490	4	3.472	3.490
3.348	3.345	50	321	3.360	6	3.343	3.358
3.138	3.129	19	400				
3.038	3.035	100	410	3.052	10	3.036	3.053
2.952	2.950	32	411,330	2.964	3	2.952	2.953
2.874	2.871	16	331	2.885	1	2.875	2.874
2.799	2.798	3	420	2.812	½	2.809	
2.733	2.731	14	421	2.746	1	2.734	2.738
2.670	2.668	5	332	2.680	½		2.675
2.503	2.503	2	500				
2.455	2.454	32	510	2.467	5	2.454	2.464
2.407	2.408	4	333,511				
2.325	2.324	5	520	2.339	½		2.330
2.287	2.285	4	521				
2.210	2.272	2	440				
2.179	2.178	6	441,522	2.189	½	2.184	2.195
2.150	2.146	4	530	2.162	½		
2.114	2.115	5	531	2.127	½		2.121
2.086	2.086	4	442,600	2.097	½		2.096
2.059	2.057	3	610				
2.027	2.030	6	611,532	2.059	½		2.046
1.958	1.954	14	621,443	1.966	2	1.954	1.963
1.932	1.931	14	541	1.942	2	1.931	1.937
1.909	1.908	11	533	1.921	2	1.906	1.916
1.887	1.887	8	622	1.897	2	1.888	1.893
1.866	1.865	4	542,630	1.877	1		
1.845	1.845	8	631	1.856	2	1.844	1.851
1.807	1.806	3	444	1.819	1		
1.788	1.788	5	632,700	1.799	1		1.797
1.770	1.770	8	550,534	1.780	2	1.772	1.776
			$(h^2 + k^2 + l^2)$				
1.736	1.735	2	52				
1.719	1.719	5	53				
1.703	1.703	9	54				
1.657	1.658	4	57				
1.650	1.643	4	58				
1.629	1.629	8	59				
1.602	1.602	4	61				
1.589	1.589	11	62				
1.564	1.564	2	64				
1.552	1.552	8	65				
1.507	1.507	3	68				
1.474	1.475	1	72				
1.455	1.455	2	74				
1.445	1.445	4	75				
1.439	1.435	4	76				
1.417	1.417	3	78				
1.391	1.391	3	81				

TABLE 1. *Contd.*

d_{meas}^a	d_{calc}^a	I_{rel}^a	hkl^a	d_{meas}^b	I_{rel}^b	d_{meas}^c	d_{meas}^d
1.374	1.374	2	83				
1.365	1.365	2	84				
1.324	1.326	3	88				
1.318	1.318	4	90				
1.312	1.312	2	91				
1.291	1.291	2	94				

^a Synthetic CuPb(TeO₃)₂, see text; X-ray calibrant is elemental Si.

^b Tombstone.

^c Mexico.

^d Arabia; data for natural material from Williams (1981).

Infrared and thermal studies

A sample of the product was heated to 400 °C on a Stanton Redcroft TG770 thermogravimetric balance. No weight loss was observed. The absence of H₂O in the synthetic material was confirmed by infrared spectroscopy, using a Bio-Rad FTS-7 spectrophotometer, with the sample pressed in a KBr disc. No absorbance was observed above 1000 cm⁻¹. TeO bands were observed at 734 (m), 719 (m), 662 (s) and 638 (m) cm⁻¹, corresponding to ν_{eq}^s , $\nu_{\text{eq}}^{\text{as}}$, $\nu_{\text{ax}}^{\text{as}}$ and ν_{as}^s modes, respectively (Dimitriev *et al.*, 1983; Nakamoto, 1986; Yamaguchi *et al.*, 1988). These observations are consistent with approximate C_{2v} symmetry for a distorted TeO₄ fragment, as with CuTeO₃ and PbTeO₃.

X-ray powder diffraction

The powder diffraction data obtained using a Rigaku DMAX-1B powder diffractometer (Cu-K α radiation, $\lambda = 1.5418\text{\AA}$) unequivocally established the identity of the synthetic phase with the natural mineral (Table 1). A very close match is found for the synthetic material and choloalite from Moctezuma, Tombstone and Arabia (Williams, 1981). Some additional weak reflections were measured for the synthetic phase. These too may be indexed to a cubic cell in the range originally reported (Williams, 1981). A further 23 weak reflections at high angles were also observed to correspond to a cubic cell with $a = 12.514\text{\AA}$ (by least-squares analysis). For this unit cell with $Z = 12$, the anhydrous formula for choloalite, CuPb(TeO₃)₂, gives $d_{\text{calc}} = 6.323 \text{ g cm}^{-3}$, as compared with $6.4 \pm 0.1 \text{ g cm}^{-3}$ for natural material from Moctezuma with $a = 12.519\text{\AA}$ (Williams, 1981). Four measurements by pycno-

metry on synthetic choloalite gave $d_{\text{(meas)}} = 6.26 \pm 0.08 \text{ g cm}^{-3}$. Inspection of the indexed reflections leads to possible space groups $P23$, $Pm3$, $P432$, $P43m$ or $Pm3m$.

A few peaks of very low intensity corresponding to the strongest lines for Cu₃TeO₆ and Pb₃TeO₆ were also observed in the powder X-ray diffraction record of synthetic choloalite. It is evident that minor oxidation of the melt prepared in air takes place during fusion and annealing.

Discussion

It is clear that choloalite is the anhydrous double tellurite CuPb(TeO₃)₂. The water detected during analysis of a very small mass of natural material was most probably adsorbed on the surface of the mineral particles and is not a necessary constituent.

Perusal of the literature has revealed a probable fourth occurrence of choloalite. In the original description of the occurrence of balyakinite, CuTeO₃, Spiridonov (1980) noted its association with teineite, CuTeO₃·2H₂O, and two unnamed Cu(II), Pb(II) tellurites. One of these latter phases analysed as an oxytellurite, CuPb(TeO₃)O. The other gave a microprobe analysis corresponding to CuPb(TeO₃)₂. It seems probable that the latter is also choloalite, and it may be that the mineral has been overlooked in other oxidized material derived from Te-bearing basic metal ores, occurring as it does in tiny amounts and with unremarkable visual characteristics.

Finally, we note that minor amounts of Sb were detected in the Russian sample of CuPb(TeO₃)₂, similar to the choloalite from Tombstone (Williams, 1981). Its presence in the latter was assumed to have caused the slightly larger unit cell dimensions found ($a = 12.57\text{\AA}$), but Sb is not a necessary constituent.

Acknowledgments. This work was funded by an Australian Research Council grant (A39231020). We wish to thank Alexander Basman for help with a Russian translation.

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[Manuscript received 5 October 1993]

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KEYWORDS: choloalite, synthesis, stoichiometry, tellurite.

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MINERALOGICAL MAGAZINE, SEPTEMBER 1994, VOL. 58, PP. 508–512

Comments on 'An unusual octahedral diamond' by A. Yacoot and M. Moore

THE relative development of different crystallographic forms and their constituent faces during the growth history of a crystal has traditionally been studied by polishing successive crystal sections and etching them in an appropriate growth-texture-revealing reagent. Nowadays X-ray topography provides a widely applicable, non-destructive method, the diffraction contrast patterns recorded being sensitive to impurity zoning, which reveals the growth

stratigraphy, and to differences in lattice perfection that are often found associated with material belonging to different growth sectors. Unfortunately, a recent application of the X-ray topographic technique to a natural diamond (Yacoot and Moore, 1992) incorrectly interprets the evidence and thereby misses genuine interesting and unusual features in the specimen concerned. Those features deserve proper description, which is here offered. Salient points are: (1)