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MROSEITE, A CALCIUM TELLURITE-CARBONATE FROM MOCTEZUMA, SONORA, MEXICO

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Abstract

Mroseite is a calcium tellurite-carbonate from Moctezuma, Sonora, Mexico. It is colourless to white with an adamantine lustre and white streak. Hardness is about 4. Density is 4.35 g/cm^3 (measured) and 4.23 g/cm^3 (calculated). Mroseite effervesces in cold, dilute HCl. The mineral is biaxial (–), $\alpha = 1.79$, $\beta = 1.85$, $\gamma = 1.89$, $2V = 74°$, dispersion $r \ll v$, $\alpha = a$, $\beta = c$, $\gamma = b$. Mroseite is orthorhombic, space group *Pbca*, $a = 6.93$, $b = 11.16$, $c = 10.54$Å, $a:b:c = 0.621:1:0.944$, $Z = 8$, $V = 815.2$Å^3. Chemical analysis gave CaO 22.4, CO_2 16.8, TeO_2 61.3, total 100.5 wt. %. This gives a chemical formula of $CaCO_3TeO_2$.

Introduction

The tellurium minerals of the Moctezuma area of Sonora, Mexico have received much attention since the early 1960's. Mandarino & Williams (1961) gave a preliminary report on five new species from the locality. A valuable reference on the geology and mineralogy of the area was published by Gaines (1970). Among the new tellurite species so far described from the locality are: spiroffite by Mandarino *et al.* (1963a), denningite by Mandarino *et al.* (1963b), moctezumite by Gaines (1965), sonoraite by Gaines *et al.* (1968), poughite by Gaines (1968), zemannite by Mandarino *et al.* (1969), and cliffordite by Gaines (1969).

Among the tellurites found at the locality are emmonsite, mackayite, and other new species. This paper describes mroseite, a calcium tellurite-carbonate. The mineral and name have been approved by the Commission on New Minerals and Mineral Names, International Mineralogical Association. The type specimen (ROM No. M33757) is preserved in the mineral collection of the Royal Ontario Museum. It contains about a gram of mroseite. Mroseite is named for Miss Mary E. Mrose, the noted mineralogist of the United States Geological Survey. The name is pronounced MRŌ ZAIT.

General Appearance & Physical Properties

Mroseite is colourless to white and has an adamantine lustre and white streak. It occurs in masses, often with a crude radiating structure. The hardness is about 4 and the density is 4.35 g/cm^3 (Berman balance). Some of the fragments show very poorly developed {100} faces which were helpful in the orientation of fragments for single crystal *x*-ray study. The crude crystals are elongate parallel to [001]. The mineral effervesces in cold, dilute HCl.

In the type specimen, spiroffite was the only other tellurite observed in direct association with mroseite. The mineral is intimately associated with quartz.

Mroseite is biaxial (–), $\alpha = 1.79$, $\beta = 1.85$, $\gamma = 1.89$, $2V$ (measured) $= 74°$, dispersion $r \ll v$. The optical orientation is $\alpha = a$, $\beta = c$, $\gamma = b$.

Chemical Composition

Early in the study, data obtained by emission spectrograph, XRF, and electron microprobe indicated the presence of only Ca and Te. The ratio of CaO:TeO_2 was about 1:1. However, subsequent attempts to analyze small samples of the mineral by microchemical methods failed to yield reasonable totals, although the CaO:TeO_2 ratio of 1:1 was confirmed. The tetravalent nature of the tellurium was confirmed also. Calculation of the molecular weight of the mineral from the density and unit-cell parameters, assuming a Z of 8, gave 51±9 allowing for the probable error in the density determination (±0.15 g/cm^3). The only reasonable oxide constituents within this range from 42 to 60 are SiO_2($MW = 60.08$) and CO_2($MW = 44.01$). An electron microprobe scan using a special set-up

for light-element detection indicated the presence of carbon. Quantitative results could not be obtained, but the presence of CO_2 was subsequently confirmed by chemical tests.

A small sample of mroseite free of any other phases was selected for analysis. The sample, weighing 18.80 mg, was analyzed thermogravimetrically in a Mettler Thermal-Analyzer. The amount of CO_2 was determined by this method and the residue was analyzed for Ca and Te by neutron activation analysis. The result of the thermogravimetric analysis was a weight loss (equivalent to the amount of CO_2) of 3.15 mg. The remaining 15.65 mg of residue was irradiated in the SLOWPOKE Reactor at the University of Toronto for one minute at a thermal neutron flux of $10^{11} n/cm.^2s$. The resulting radioactive sample was then analyzed twice on a Ge(Li) γ-ray spectrometer at arbitrarily chosen delay times of six and twelve minutes. In each case, a counting time of five minutes was used. The radioisotopes ^{131}Te (half-life 24.8 minutes, γ-ray energies 150 and 453 keV) and ^{49}Ca (half-life 8.8 minutes, γ-ray energy 3083 keV) were employed in the analysis.

A standard sample was prepared by mixing 17.10 mg of reagent grade $H_2TeO_4 \cdot H_2O$ and 7.90 mg of reagent grade $CaCO_3$. This standard thus contained the equivalent of 12.90 mg of TeO_2 and 4.43 mg of CaO. This corresponds to 25.56 wt. % CaO and 74.44 wt. % TeO_2 which is very close to the theoretical composition of $CaO \cdot TeO_2$ (CaO = 26.00 wt. % and TeO_2 = 74.00 wt. %). The standard was subjected to exactly the same analytical procedure used for the residue from the thermogravimetric analysis. By direct comparison of the recorded γ-ray intensities, the amounts of CaO and TeO_2 in the residue were calculated as 27.0±1.9 wt. % CaO and 73.6±1.3 wt. % TeO_2.

In summary, the 18.80 mg sample of mroseite contained 3.15 mg of CO_2 (16.8 wt. %) and the 15.65 mg residue contained 4.23 mg of CaO and 11.52 mg of TeO_2. In terms of the original 18.80 mg sample, the weight percentages of CaO and TeO_2 are, respectively, 22.4 and 61.3. These data are given in Table 1, where the chemical formula is derived.

Using the new Gladstone-Dale constants proposed by Mandarino (in prep.) the composition yields a K value of 0.194. The value of K calculated from the mean refractive index and the density is 0.193.

TABLE 1. CHEMICAL ANALYSIS AND DERIVATION OF THE FORMULA OF MROSEITE.

Oxide	Wt.%	Molecular Proportions	Atomic Proportions	Atomic Ratio	$CaCO_3TeO_2$ Theoretical Wt.%
CaO	22.4	0.3994	Ca 0.3994	Ca 1.03	21.59
CO_2	16.8	0.3817	C 0.3817	C 0.99	16.95
TeO_2	61.3	0.3841	Te 0.3841	Te 0.99	61.46
Total	100.5		O 1.9310	O 5.00	Total 100.00

Chemical formula $Ca_{1.03}C_{0.99}O_{3.00}Te_{0.99}O_{2.00}$ or $CaCO_3TeO_2$
Thermogravimetric analysis of CO_2 by Mr. Donald R. McKinnon, Royal Ontario Museum.
Neutron activation analyses of CaO and TeO_2 by Dr. R.G.V. Hancock, University of Toronto.

Crystallography

X-ray studies show that the mineral belongs to the orthorhombic bipyramidal class. As no euhedral crystals were available, transmission Laue photographs were used in the orientation of a tabular fragment (2.5 × 1 × 0.5 mm) having one planar surface which was later shown to be {100}. Rotation and several levels (0-l through 4-l) of Weissenberg patterns were obtained for the three crystallographic axes. These were made in a camera of 5.73 cm diameter using copper radiation. Zero-level Buerger precession films also were obtained along the three major axes, using copper radiation and M = 6 cm. A study of characteristic extinct reflections showed the space group is $Pbca$ ($0kl$ missing with k odd; $h0l$ missing with l odd; $hk0$ missing with h odd). These films were also used to obtain approximate unit-cell values for a preliminary indexing of the powder patterns.

Numerous x-ray powder patterns were made in two cameras of 11.46 cm diameter with filtered copper radiation. The measured interplanar spacings given in Table 2 represent averaged values from four of these films. The cell size was refined from these powder data, which were partly indexed on the basis of the single-crystal values. The unit-cell constants are a = 6.93±0.02, b = 11.16±0.03, c = 10.54±0.02Å, $a:b:c$: = 0.621:1:0.944, V = 815.2Å^3. Using these values all possible interplanar spacings allowed by the $Pbca$ space group were calculated through 1.76Å. The excellent correlation between calculated and observed data is evident in Table 2. Calculated reflections which have no corresponding observed values are very weak or absent on Weissenberg and Buerger precession films.

The density calculated from the unit-cell parameters (Z = 8) and the chemical composition is 4.23 g/cm^3 compared to the measured value of 4.35 g/cm^3. The structure of mroseite is being determined by Prof. Dr. J. Zemann and colleagues and will be published separately by them.

Thermal Properties

As mentioned in the section dealing with chemical composition, an 18.80 mg sample of

TABLE 2. X-RAY POWDER DIFFRACTION DATA FOR MROSEITE.*

hkl	$d_{(calc.)}$	$d_{(obs.)}$	$I_{(obs.)}$	hkl	$d_{(calc.)}$	$d_{(obs.)}$	$I_{(obs.)}$
020	5.58	5.60	6	043	2.19		
002	5.27			240	2.17		
111	5.14	5.14	9	241	2.13		
021	4.93			302	2.12	2.12	2
102	4.20	4.20	8	204	2.10		
121	4.02			321	2.09		
112	3.93			143,151,312	2.08		
022	3.83			214,233	2.06	2.06	4
200	3.47	3.46	1	134	2.05		
122	3.35	3.35	7	242	2.01		
210	3.31			115	1.99		
211	3.16			322	1.98		
131	3.13	3.14	10	025,152	1.97	1.97	8
113	3.02	3.02	7	224	1.96		
023	2.97			331	1.93		
220	2.94	2.93	4	044	1.92	1.91	6
202	2.89	2.88	1	313,125	1.90		
221	2.84			250	1.88	1.87	3
212	2.80			060	1.86		
040	2.79	2.79	2	243,251,144	1.85		
132	2.78			332	1.84		
123	2.73			061,234	1.83		
041	2.70	2.71	½	323,153	1.82	1.82	6
004	2.64	2.64	1	215	1.78	1.78	2
222	2.57	2.56	4	135,161,252	1.77		
230	2.54			006,341	1.76	1.76	½
141	2.51					1.70	4
042,231	2.47					1.68	5
104	2.46	2.46	4			1.65	4
213,114	2.41					1.62	2
133	2.40	2.39	7			1.55	1
024	2.38					1.49	4
142	2.32	2.33	6			1.46	1
232	2.29					1.40	6
223	2.26					1.37	2
124	2.25					1.36	2
311	2.21						

*Filtered Cu radiation. Values of d(obs.) are averages obtained from four films made in two cameras of 11.46 cm diameter.

Space group $Pbaa$, a=6.93±0.02Å, b=11.16±0.03Å, c=10.54±0.02Å
$a:b:c$=0.621:1:0.944, V=815.2Å^3

mroseite was analyzed in a Mettler Thermal-Analyzer. The conditions under which the analysis was performed are as follows: reference material ≈ 20 mg of SiO_2; atmosphere N_2; heating rate 10°C/minute; temperature range ~ 25°C to 880°C. The TGA curve is a simple one-stage weight-loss curve.

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