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Theisite, a new mineral from Colorado

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ABSTRACT. Found by N. Theis at a uranium prospect near Durango, Colorado. Occurs with uraninite, galena, malachite, azurite, etc. Colour pale blue-green, H = 1½, G = 4.25. Optically $2V_\alpha \approx 0°$, $\alpha = 1.755$, $\beta = \gamma = 1.785$; non-pleochroic. Chemical analysis on 1034 μg gave CuO 33.3%, ZnO 33.1, CaO 0.3, As_2O_5 14.8, Sb_2O_5 7.0, H_2O 10.5 leading to $Cu_5Zn_5\{(As,Sb)O_4\}_2(OH)_{14}$. The cell indexes as orthorhombic $a = 8.225$ Å, $b = 7.123$, $c = 14.97$. Strongest lines are 14.97 (9), 7.483 (5), 4.112 (4), 3.741 (10), 2.996 (4), 2.534 (9), 1.830 (5), 1.553 (3). The mineral and name have been approved by the Commission on New Minerals and Mineral Names, IMA.

THEISITE was discovered by Nicholas J. Theis, then a geologist for Bendix Corporation, and M. E. Madson, at a small uranium prospect near Durango, Colorado. The wallrocks at this prospect are marly sediments cut by near-vertical breccia zones that are cemented by sulphides and gangue minerals such as quartz, calcite, and baryte. Primary ore minerals may survive as relicts, and they include uraninite, tetrahedrite, galena, and sphalerite. In most places, however, oxidation has been severe. Sulphides alter *in situ* to partzite, chalcosine, covelline, and cuprite surrounded by malachite, azurite, and kolwezite. Other species noted and only locally present include parnauite, anglesite, cerussite, tenorite, adamite, hemimorphite, chrysocolla, zeunerite, and duftite. Theisite is sparingly present and is one of the very last minerals to form. It occurs in thin seams cutting the oxide assemblage. These structures usually carry no minerals other than theisite.

Theisite resembles tyrolite in appearance. The colour is langite green (RHS 121-A to 121-C) while the streak is nearly white. The Mohs hardness is 1½ and scales of the mineral showing perfect basal cleavage (001) are sectile. The specific gravity was estimated by sink-float in Clerici solution as 4.3.

Chemistry. Preliminary spectrographic analysis showed the presence of Mg and Si in addition to the elements analysed for (see Table I). Anions not readily seen by instrumental methods such as sulphate, nitrate, chloride, and carbonate were sought but not found by microchemical tests. Selenium was shown to be absent by XES analysis.

The results of wet chemical analysis are presented in Table I and lead to the formula $Cu_5Zn_5\{(As,Sb)O_4\}_2(OH)_{14}$. The As:Sb ratio of 3:1 is taken to be coincidental, but it is conceivable that

TABLE I. *Chemical analysis of theisite*

	1	2	3
CuO	33.3%	0.419	33.63%
ZnO	33.1	0.407	33.99
CaO	0.3	0.005	0.29
As_2O_5	14.8	0.064	14.53
Sb_2O_5	7.0	0.022	6.90
H_2O	10.5	0.583	10.66
	99.0		100.00

1. Wet chemical analysis on 1034 μg (M. Duggan analyst); water on 609 μg.
2. Atomic ratios.
3. Theory for $Cu_5Zn_5(As,SbO_4)_2(OH)_{14}$ with Zn:Cu and As:Sb ratios equal to that of analysed material.

TABLE II. *X-ray Powder data for theisite Cr-Kα Radiation, 114 mm Straumanis camera*

I/I_0	d_{meas}	d_{calc}	*hkl*	I/I_0	d_{meas}	d_{calc}	*hkl*
9	14.973	14.970	001	2	2.693	2.692	220
5	7.483	7.485	002			2.697	301
2	7.132	7.123	010	2	2.650	2.650	221
2	6.441	6.432	011	1	2.581	2.580	214
2	5.162	5.160	012			2.580	024
1	5.003	4.990	003			2.574	302
4	4.112	4.112	200	9	2.534	2.533	222
2	3.962	3.966	201	4	2.371		
10	3.741	3.742	004	1	2.264		
2	3.607	3.604	202	4	2.185		
2	3.315	3.313	014	1	2.133		
2	3.218	3.216	212	½	2.042		
		3.216	022	1	1.905		
2	3.170	3.174	203	1	1.868		
4	2.996	2.995	122	5	1.830		
		2.994	005	1	1.702		
2	2.897	2.899	213	1	1.674		
		2.899	023	½	1.654		
4	1.762	2.760	015	5	1.553		
		2.760	204	4	1.535		
				1	1.521		
				2	1.497		

the formula is $Cu_{10}Zn_{10}(AsO_4)_3(SbO_4)(OH)_{28}$; one occurrence of the mineral is insufficient to prove this, however.

Crystallography. Although cleavage plates up to 2 mm across were found, they are curved or crumpled and unfit for single crystal X-ray study. The powder diffraction data were easily indexed by the Ito method as hexagonal with $a = 8.225$ Å, $c = 14.97$, or as orthorhombic pseudohexagonal with $a = 8.225$ Å, $b = 7.123$, $c = 14.97$. The latter cell is used to index the powder data in Table II. Using this cell, and $Z = 2$, the calculated density is 4.45 g/cm^3, in fair agreement with the measured specific gravity.

Optical study sheds no light on the correct symmetry. Basal plates seen in thin section or oils show hexagonal striae and yield a sensibly uniaxial negative figure. Crystals are pale blue-green in thin section and resemble tyrolite or tlalocite. They fail to show pleochroism. The indices of refraction are (for NaD) $\alpha = 1.755$, $\beta = \gamma = 1.785$.

Type material of theisite will be deposited at the British Museum (Natural History) and the Geological Museum, University of Arizona, Tempe, Arizona.

Acknowledgements. I am grateful to Nick Theis for bringing the mineral to my attention as well as providing data on the locality. Dr Theis has an interest of long standing in mineralogy, and the species is named in his honour. My thanks also to Marjorie Duggan for the fine analytical chemistry.

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